



FINAL REPORT

CRDC ID: CSIRO 10628

Project Title: Innovation fibres, their economic viability, sustainability, threats and opportunities – with specific reference to cotton.

Confidential or for public release? For Public Release

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Technical Report

- Three peer review manuscripts have been written for this project. These are listed in the project outputs and pre-publication drafts are appended to this report. The papers form the basis of the Technical Report for this project. The abstracts for each manuscript follow below:
- **Paper 1**
- **Willingness to pay for naturally and sustainably produced clothing: A case study of Australian consumers**
- Global fibre production is expected to grow to 127 million tons (Mt) per annum by 2025. Natural fibres are expected to make up only around 27% of all fibre production by this time. Polyester is the largest segment in the market and its share is expected to grow. As waste, pollution, the environment, and ethical considerations gain prominence in the textile industry, consumers are increasingly looking for environmentally and socially responsible practices in the products they buy. This study presents findings from a willingness to pay (WTP) survey of Australian consumers for a naturally and sustainably produced smart-casual t-shirt. Results suggest that around 57% of Australians were prepared to pay extra for t-shirts made from natural fibres that had sustainable and ethical certifications. Cotton was the preferred fibre. Australians were willing to pay AUD43 more for a cotton t-shirt than a polyester one. They were also prepared to pay around AUD13 more per t-shirt if it had a sustainability certification i.e. minimising impact on the environment and applying decent work principles. The WTP for sustainability features was greater than the WTP for fabric and garment features, e.g. moisture wicking and wrinkle-free fabric properties. In this study, dollar values were used, not to 'commodify' nature, but to help decide whether having sustainability attributes is preferable to having other attributes, in situations where a choice must be made.

Valuing environmental features in this way allows decision makers to make trade-offs based on objective measurement of consumer preferences.

- **Paper 2**
- **Life Cycle Assessment and product circularity. A review with context to the textile supply chain in Australia**
- Life Cycle Assessment (LCA) is a tool for evaluating the environmental impacts of products, processes, and services throughout their life cycles, from resource extraction to disposal. Governed by ISO standards 14040 and 14044, LCA consists of a Life Cycle Inventory (LCI) to collect data on materials, energy, water use, and emissions, and a Life Cycle Impact Assessment (LCIA) to translate these into environmental impact scores. Key concerns include climate change, biodiversity loss, waste, and pollution. This paper reviews how applicable current LCA is when applied to measure the impact of textile production regimes that embrace the principles of circularity. Noted is that LCA approaches are currently designed largely for linear production models that have defined input and output boundaries. This study reviews current LCA approaches for their ability to account for the principles of the circular economy, and associated sustainability development goals (SDGs) with regards to textiles. The study highlights the need for expanded LCA boundaries and impact assessments to evaluate the environmental benefits of circularity effectively. This shift will require comprehensive additions to inventories and assessments, to address fibre production, consumption behaviours, and textile processing in a circular economy context. A review of sustainability reports from leading clothing brands in Australia reveals gaps in the reporting of sustainability and circularity endeavours.

- **Paper 3**
- **Evaluation of potential circularity strategies for an Australian grown cotton t-shirt via Life Cycle Assessment**
- This paper investigates the application of Life Cycle Assessment (LCA) to evaluate circularity strategies for an Australian-grown cotton t-shirt. Growing issues associated with textile waste have highlighted the challenges of the current linear production, consumption and disposal life cycle. This study explores how natural fibres such as cotton can respond to these challenges. A typical garment production and use life cycle in Australia was chosen. This case is a cotton t-shirt, manufactured from cotton cultivated in northwestern New South Wales, exported to Vietnam for manufacture, and returned to Australia for distribution, sale, use and disposal. Various LCA and circularity scenarios are explored, including improved process efficiency, extended garment lifespan, recycling, and end-of-life waste management, including reuse. Results indicate consumer behaviour, particularly the use phase has the most significant impact on environmental outcomes. As expected, increasing the life span reduces the production impacts and rate of waste generation. If coupled with efficiencies for washing and options for recycling, then the environmental impact of an Australian cotton t-shirt can be substantially reduced. Noted is that consumer behaviour and use patterns relied heavily upon standardised assumptions in the LCA to evaluate product performance. There is an opportunity to adjust these assumptions to better align with the specific context and characteristics of the fibre and operative regions. This could also help identify possibilities for developing recycling and reuse options for natural fibres like cotton.

Summary for public release

<p>Executive Summary</p>	<p>This project investigated the interplay between consumer motivations, fibre sustainability, and the environmental impact of textiles, with a focus on Australian cotton and competing fibres, including emerging sustainable and recycled options. The study addresses the growing consumer demand for transparency and ethical practices while highlighting the limitations of current tools like life-cycle analyses (LCA) and the Higg Material Sustainability Index (MSI) when applied to new and legacy fibres. Challenges such as a scarcity of data related to textile processing, consumer wear and washing behaviours and end-of-life disposal, uncertainties in impact assessment, and the lack of industry standards underscore the need for more robust methodologies. Through scenario analysis, the research has evaluated fibre production, processing, and end-of-life practices, emphasizing the potential for circularity. A formal choice experiment (CE) survey linking technical assessments with market preferences was conducted to further assess consumer’s willingness to pay for sustainability attributes.</p> <p>Three peer review papers have been written. The first describes research that underscores the importance of sustainability in consumer decisions and the textile industry. A willingness to pay (WTP) study revealed a majority (>60%) of Australian consumers were willing to pay a premium for cotton t-shirts with sustainable certifications, highlighting the economic value of environmental and ethical features. A research paper has also critiqued existing LCA frameworks for their inadequacy in assessing circular textile systems, advocating for expanded methodologies to address circular economy principles. And a third paper applied LCA to Australian cotton, exploring circularity strategies like recycling and extended garment lifespan while identifying consumer behaviour during the use phase as a critical determinant of environmental outcomes. Collectively, the findings advance knowledge on fibre sustainability, bridging technical insights and consumer behaviour to support a transition towards more transparent, circular, and responsible textile practices.</p>
<p>Objectives</p>	<ul style="list-style-type: none"> • Review Life Cycle Assessments (LCAs) for cotton and competing fibres, covering all stages from production to end-of-life. • Review the production, processing, and distribution systems of both established and emerging fibres to identify sustainability attributes and differences. • Examine the historical trends, policies, legislation, and trade barriers impacting global fibre production and consumption. • Assess consumer willingness to pay (WTP) for sustainability certifications and attributes through a formal Choice Experiment (CE) survey. • Publish findings in a peer-reviewed journal to provide trusted, scientifically validated insights into fibre sustainability and consumer preferences.
<p>Background</p>	<p>Global fibre production will exceed 120 Mt/annum by 2022 and is forecast to grow to 136 Mt/annum by 2025 as developing markets follow the consumption patterns of western EU (23 kg/person/yr), Australia (28 kg/person/yr) and the USA (38 kg/person/yr). Plant and</p>

	<p>bio-based fibres will make up less than 25% of all fibre production by 2025. Polyester is the largest fibre segment in the market, and this is expected to grow. New bio-based fibres are often marketed as sustainable and defer to a range of stories and indices to verify their worth to consumers. Worth here is defined as the fibre, or resulting textile or garment, having a social and/or environmental license. However, there are questions about how well indices such as the Higg MSI and some Life Cycle Analyses (LCAs) properly reflect facts about the production, processing and supply chains of these ‘new’ fibres, and the old, big fibres like cotton. Of note is that the service sector providing these verifications utilise indices and LCAs that are themselves commercial products. Many are behind paywalls and provide no transparency to the methodologies and standards used, or the independence and robustness of the underlying data, even though a LCA’s outcome is entirely dependent on these variables.</p>
Research activities	<p>The project undertook a comprehensive evaluation of cotton’s environmental performance through examination of published Life Cycle Assessments (LCAs) for cotton and its competing fibres. The evaluation included a detailed review of production, processing, and distribution systems, leveraging a wide range of information sources, including peer-reviewed literature, government reports, and industry expertise. Additionally, the project explored the emerging fibre market by assessing the production systems of new fibres and identifying their sustainability attributes relative to established fibres. A formal Choice Experiment (CE) survey was conducted to quantify consumer willingness to pay (WTP) for sustainability certifications and attributes in textiles, providing valuable insights into market dynamics and consumer preferences. The results, integrating technical assessments and consumer behaviour analysis, have been prepared for dissemination through three peer-reviewed publications.</p>
Outputs	<p>See above and below.</p>
Impacts	<p>The project has provided the CRDC with valuable insights into the environmental performance and market potential of cotton compared to competing fibres. By highlighting the sustainability advantages of Australian cotton and identifying areas for improvement through circularity strategies, the research supports more informed decision-making and policy development. The findings on consumer willingness to pay for sustainable and ethically certified cotton products underscore opportunities for growers to enhance market competitiveness and profitability. Additionally, the project’s critiques of existing sustainability assessment frameworks pave the way for more accurate evaluations, ensuring that Australian cotton remains at the forefront of global sustainability efforts in textiles. These contributions bolster the industry’s reputation and value while aligning with the broader public interest in environmental responsibility and economic efficiency.</p>
Key publications	<p>As listed above.</p>