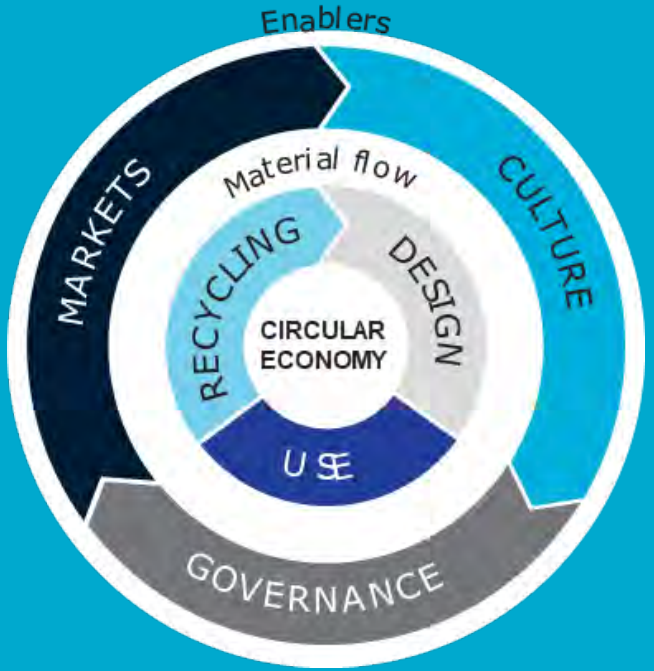
Bio-based materials and services in the circular economy transition

Leverage points for regenerative change

Alessio Miatto, PhD
On behalf of the CSIRO bio circular economy team



Session outline

1) Introduction: Pacific SIDS priorities and alignment with the Jaipur Declaration

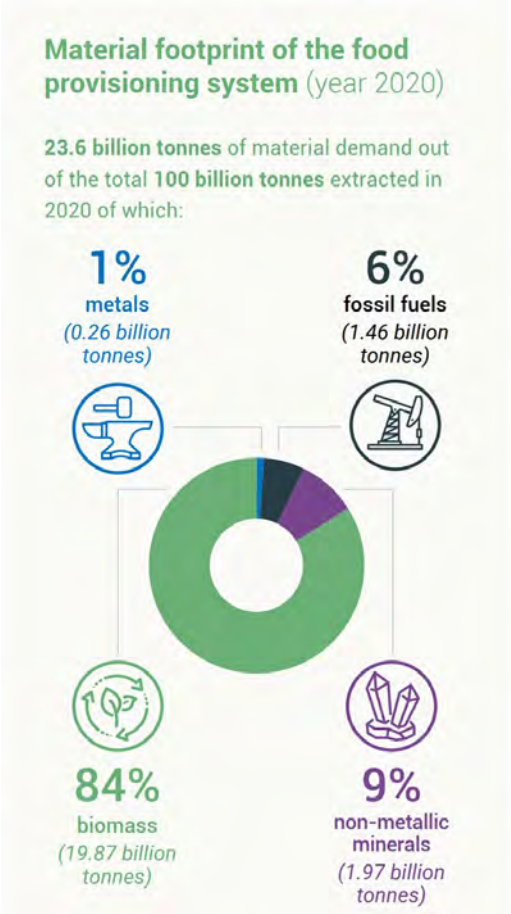
2) What is the biocircular economy and why does it matter?

1) Exploring biocircular economy solutions: Case studies from Australia

1) BioCE examples: Opportunities for innovation, research and development

1) Workshop questions

Problem setting



From: https://www.resourcepanel.org/file/3443/download

The Jaipur Declaration

- The *Jaipur 2035 Declaration on 3R and Circular Economy (2025-2035*) was adopted at the 12th Regional 3R and Circular Economy Forum in Asia and the Pacific (3–5 March 2025 in Jaipur, India)

- A voluntary and non-legally binding declaration which provides a transformative roadmap for sustainable waste and resource management across the Asia-Pacific region (including Pacific SIDS)

- The Declaration calls for a systemic transition toward resource efficiency, waste reduction, and the adoption of circular economy principles

- Opportunity to align Pacific waste management and circular economy initiatives with global frameworks.

Alignment with recent strategies for Pacific SIDS

The **Antigua and Barbuda Agenda for SIDS (ABAS)** 2024-2034: A renewed declaration for resilient prosperity

*New **development agenda** for small island developing States (SIDS) for 2024-2034*

- Three priorities are to build resilient economies, a secure future, and environmental protection and planetary sustainability

Pacific Agriculture and Forestry Strategy (PAFS) 2024-2050 and Implementation Plan

- First-ever Pacific-led regional strategy that sets out a transformative vision for agriculture and forestry through to 2050
- Create healthy, regenerative, and secure systems that protect Pacific identities, ensure sustainable livelihoods, and build resilience for future generations.

New Cleaner Pacific 2035 Regional Waste and Pollution Management Strategy (*in consultation)*

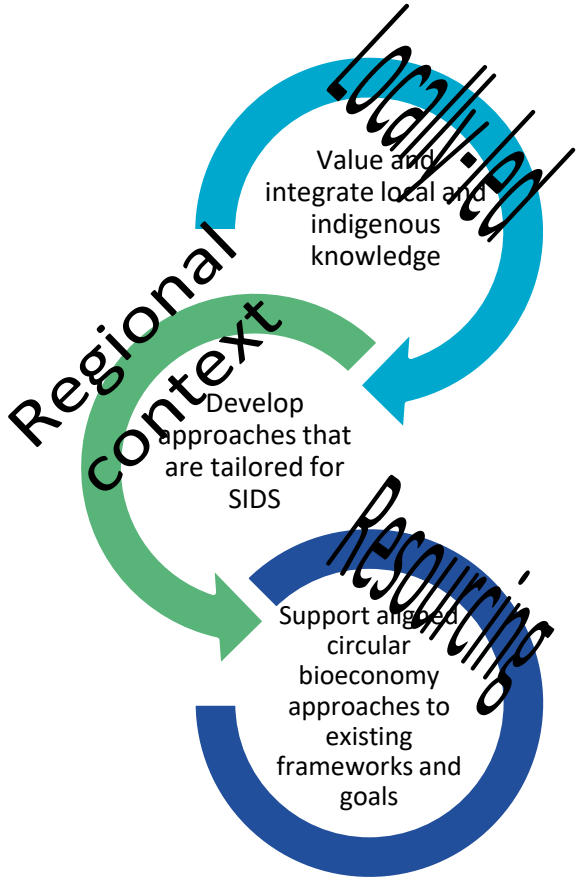
- Clean Environment, Resilient Ocean and Healthy Communities
- Connecting to other SPREP strategies in climate, biodiversity, environmental management

Supporting Pacific SIDS Priorities through biocircular economy

"our vision is a healthy, regenerative and secure Pacific"

Pathways to Achieve the Vision

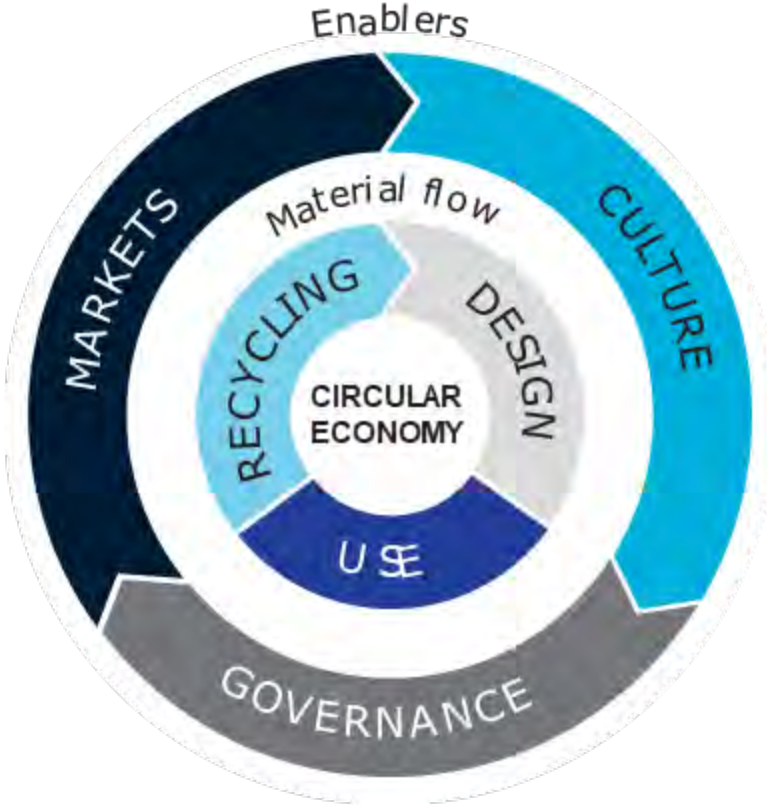
Weaving natural materials to form useful, strong and beautiful tools is part of our Pacific heritage, and an inspiration for us. In this strategy, there are five mutually supporting pathways that will lead us towards our shared vision. We imagine these pathways as interwoven healthy, regenerative and secure practices that guide us towards our desired future of systemic wellbeing, prosperity and resilience. These practices are enveloped by aligned policies and actions that ensure viability, and by enabled women, youth and diverse community, who have the skills, knowledge and resources to assure success.



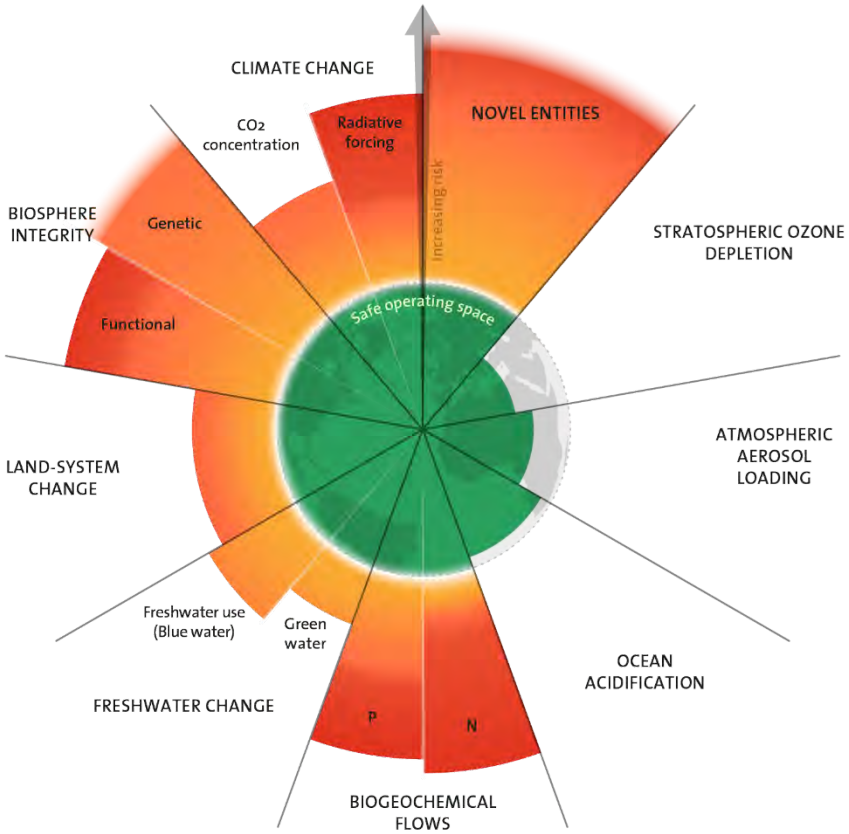
Source: Pacific Agriculture and Forestry Strategy (PAFS) 2024-2050

What is the biocircular economy?

Why is it important?



Convergence of global challenges for agri-food systems



Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2023

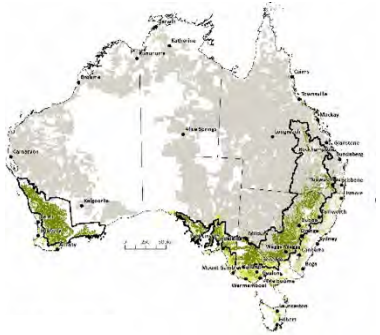
The bio-based economy: Opportunities & obstacles

Decoupling from fossil fuels extends **beyond energy** – there is an increasing need for biologically based, regenerative resources

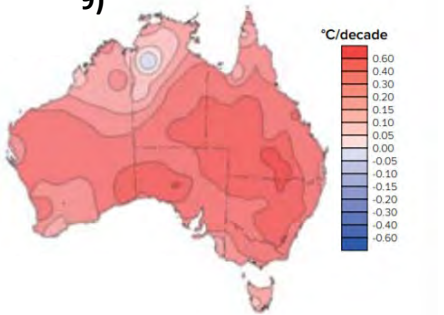
> "Producing and using biological resources to provide sustainable materials and solutions in the transition to a sustainable economy" *UNFAO, 2022*

- How to avoid repeating the same mistakes from the linear economy?
- Pressures on agri-food systems, producers, communities, ecosystems to deliver?

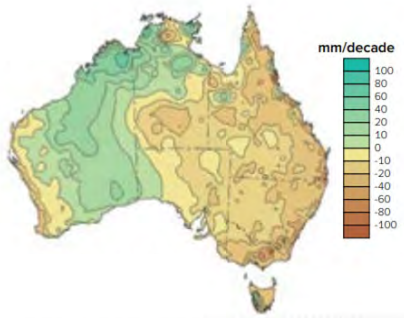
Agricultural land



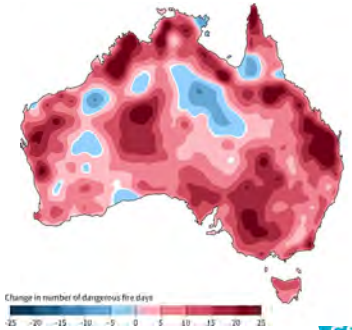
Temperature (1970-9)



Rainfall (1970-2019)



Dangerous fire days (1985-2020)

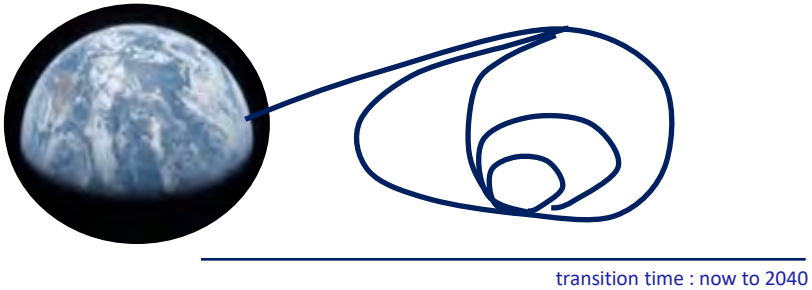


https://soe.dcceew.gov.au/climate/environment

Circular economy principles for the bioeconomy

Focus on
resource cycling

**Resource cycling from the start,
through production, use, end of use**

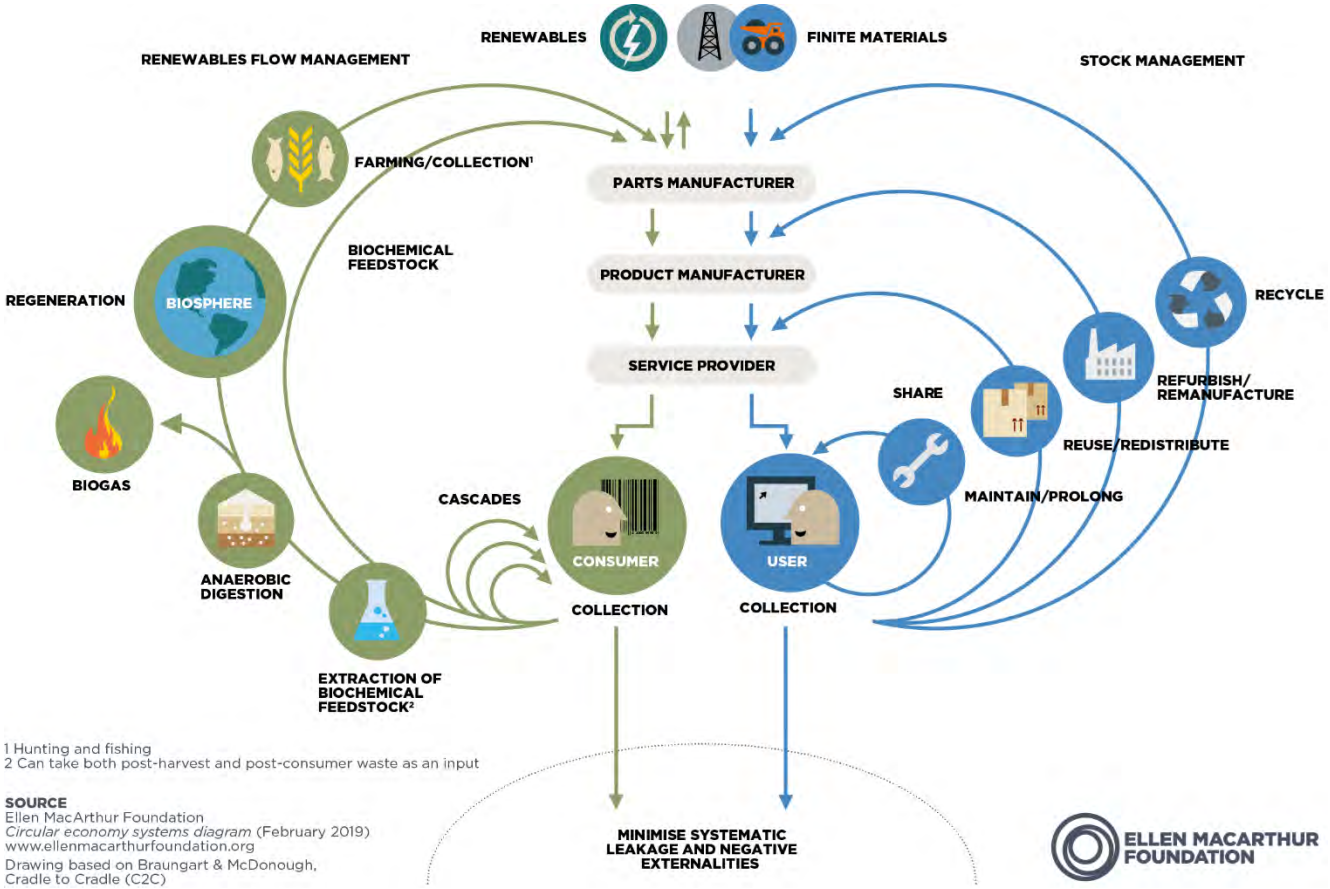


1. Design out waste and pollution,
2. Circulate materials & products at their highest value,
3. Regenerate nature

for economic prosperity and well-being for all

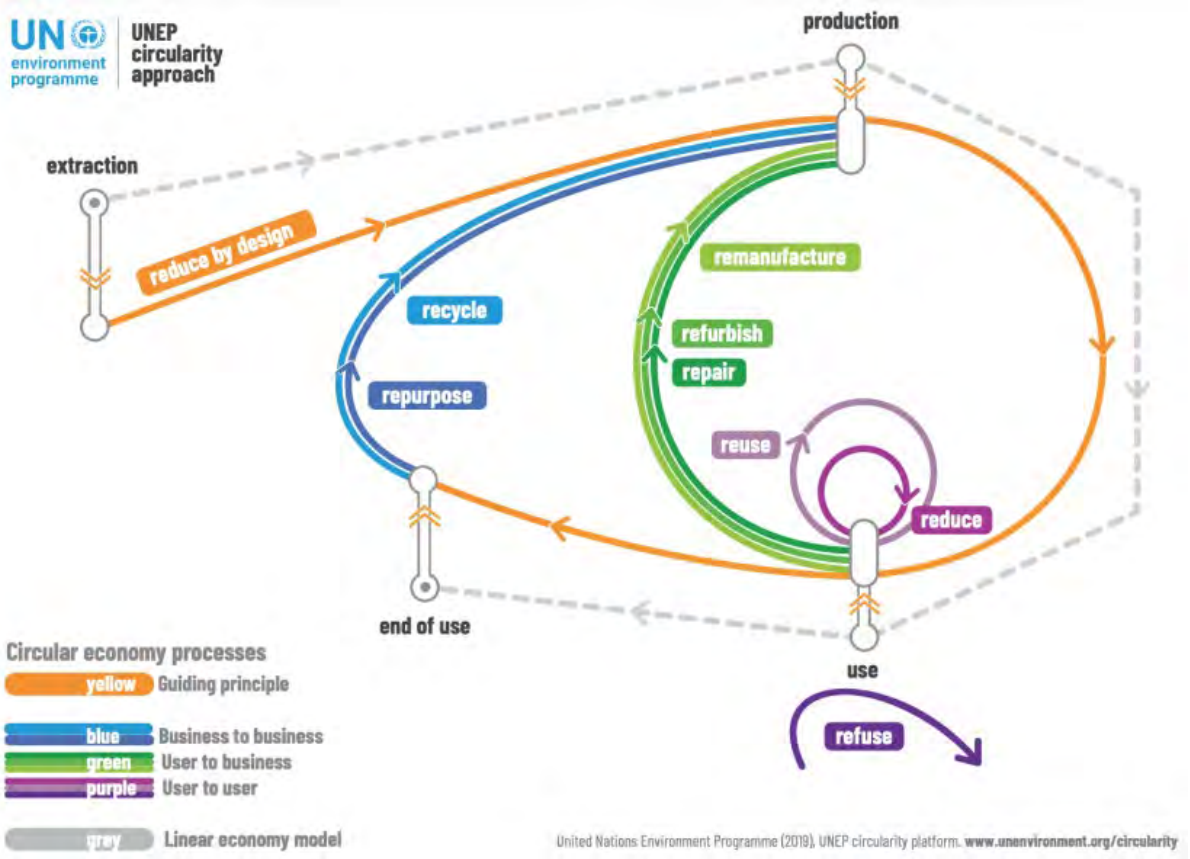
* source: UNEP Circularity Diagram; Ellen MacArthur Foundation CE principles

Ellen MacArthur Circular Economy Systems Diagram



CSIRO

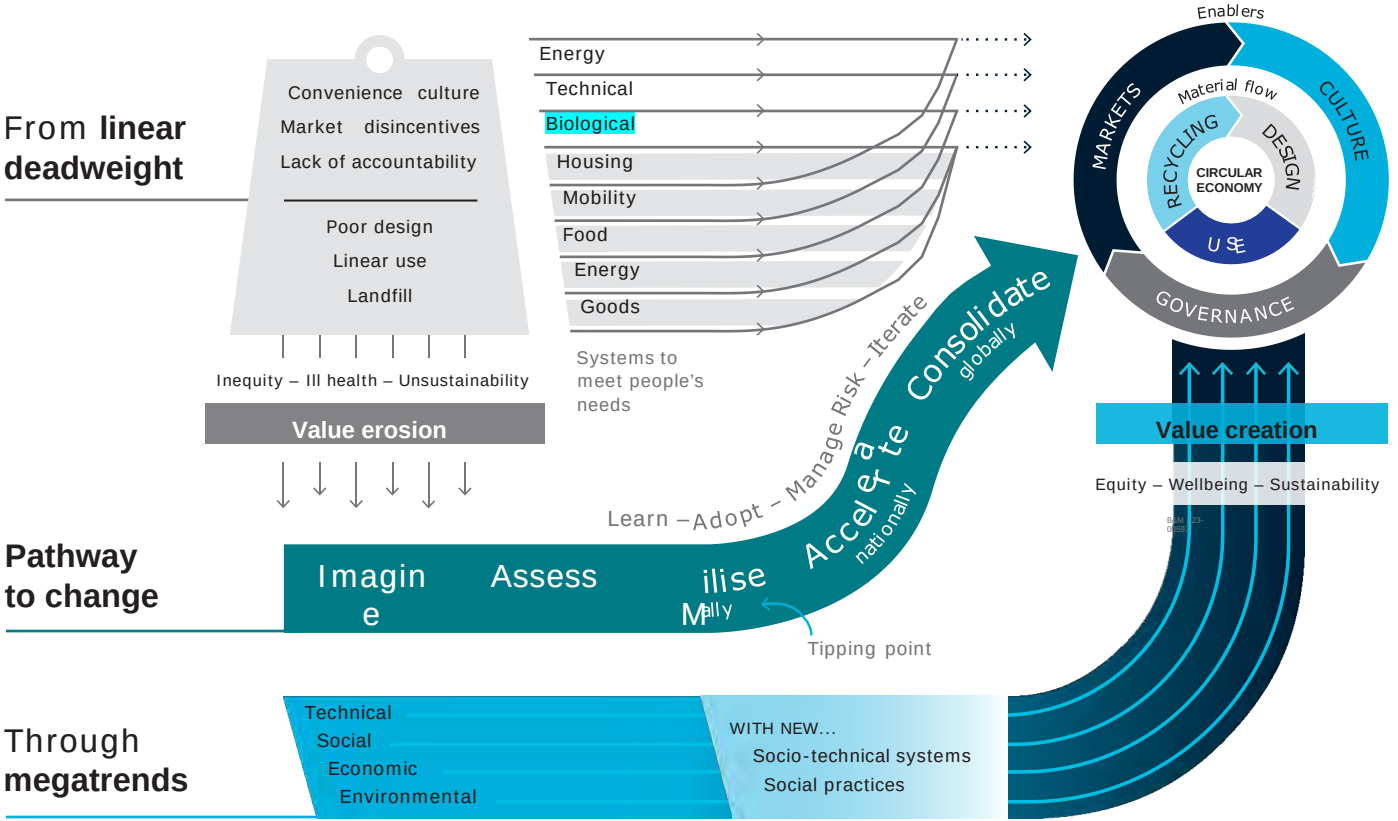
UNEP Circular Economy Approach : with “Rs”



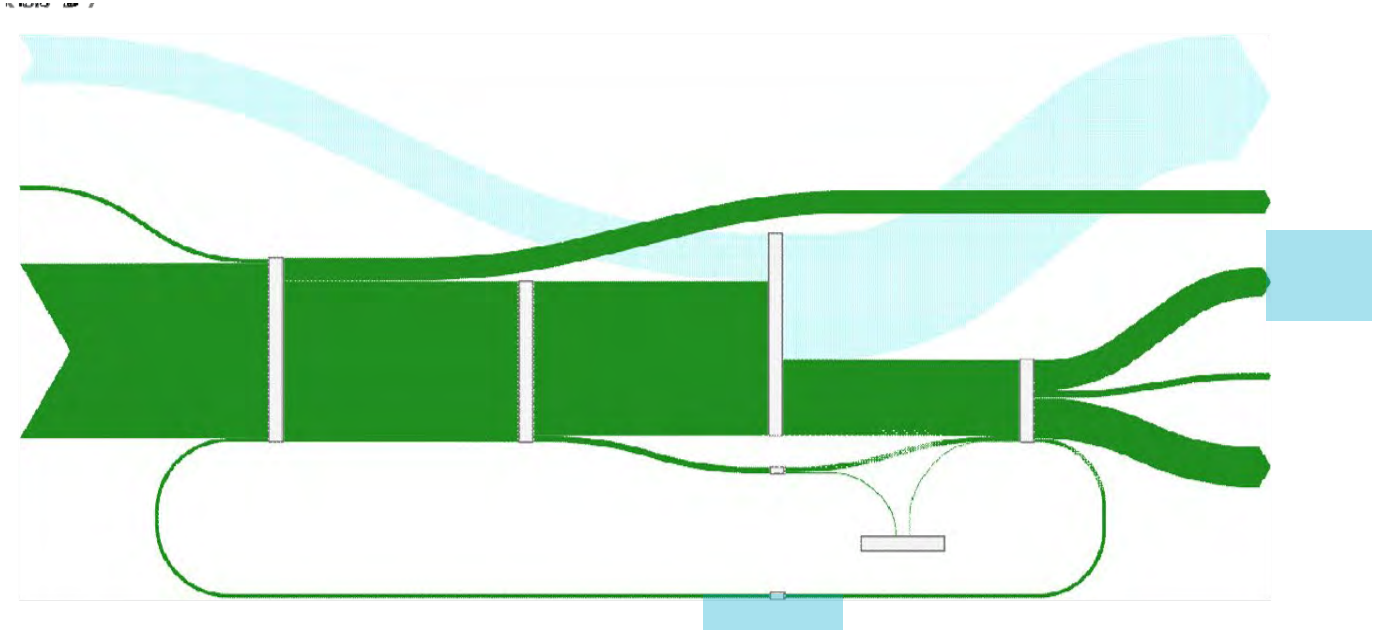
Circular Economy

How can we meet Australia's needs for a circular economy

Theory of Change



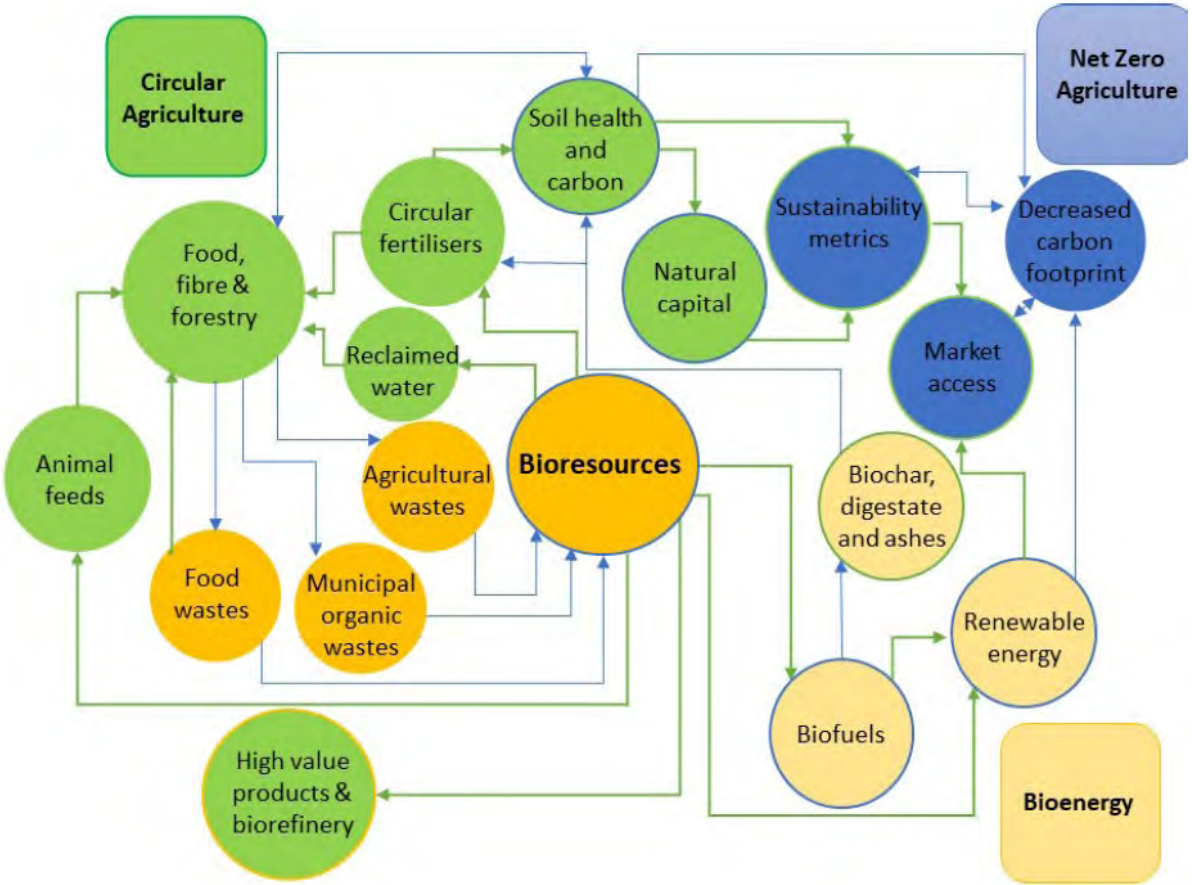
Biomass and the role of agri-food systems



- Agri-food systems are both producers of organic “waste” resources and users
- 64 Mt solid and liquid “wastes” (resources) generated; 7.2 Mt/ 9 Mt recycled on-farm (~80%)
  - *However, only ~11% total resources recycled – supply > market demand*

Miatto A, et al (2024) A comprehensive material flow account for the Australian economy to support the assessment of Australia’s progress towards a circular economy. CSIRO, Australia

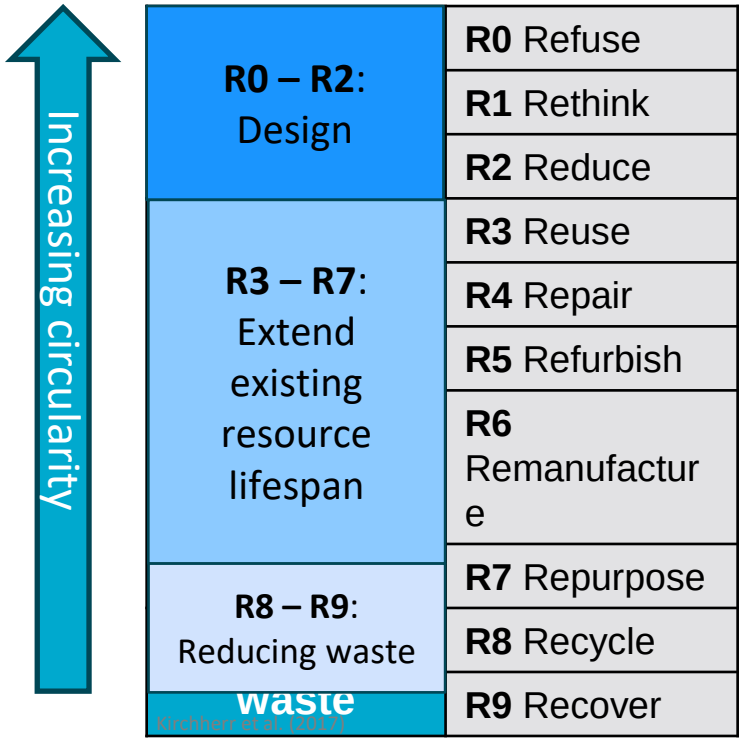
Bioresources sit at the agriculture-energy-climate nexus



Arsic et al. (2022) Farm Policy Journal 19(3): 43-60

Biocircularity aligns with restoring life to the land

Circular economy R-Strategies



Kirchherr et al. (2017)

Reducing land degradation

Avoid new degradation of land by maintaining healthy land

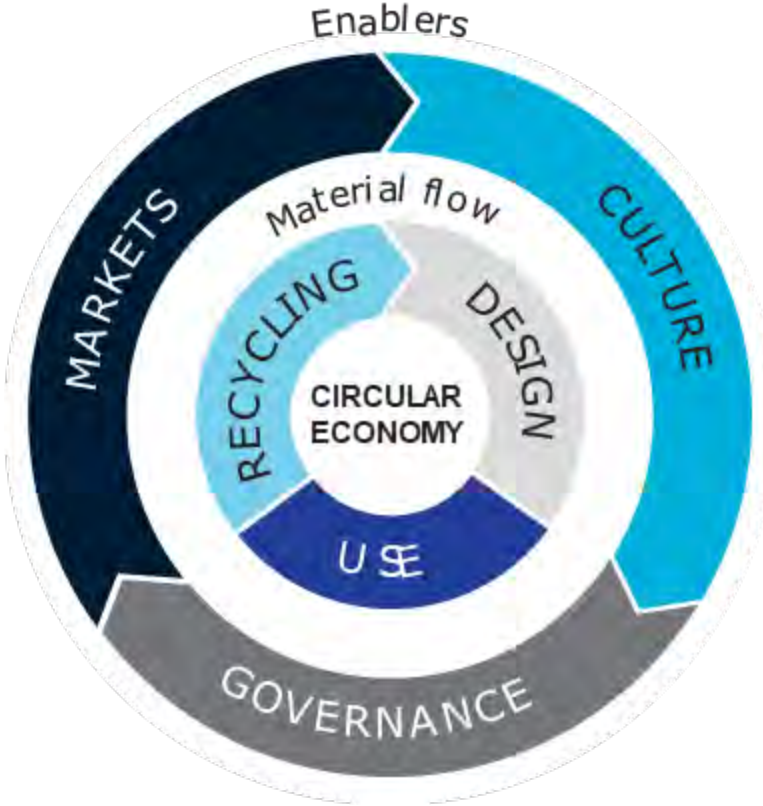
Reduce existing degradation by adopting sustainable practices

Restore and return degraded lands to more productive state

UNCCD 2024

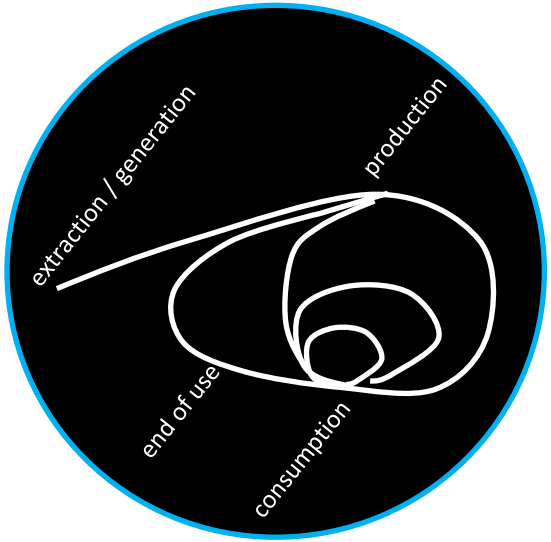
Solutions.

What are some approaches to achieve this?



Systems thinking approaches are essential

What part/s of the value chain?



Explore the UN Circularity Diagram

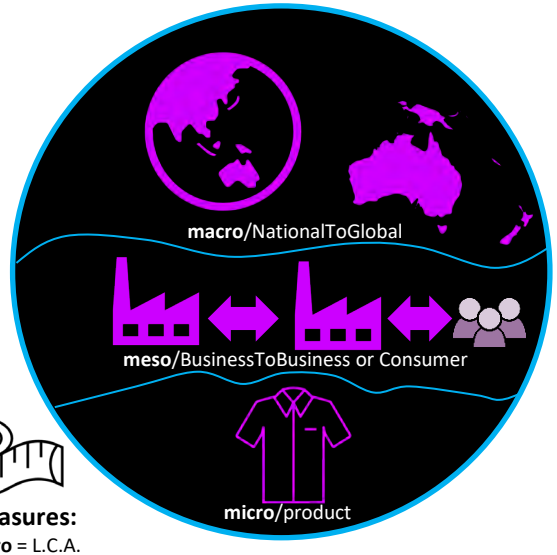
What material/s?

biological, technical, energy

Explore - Ellen MacArthur Foundation Butterfly Diagram

What scale/s?

macro / NationalToGlobal
meso / B2B or B2C
micro / product



Measures:

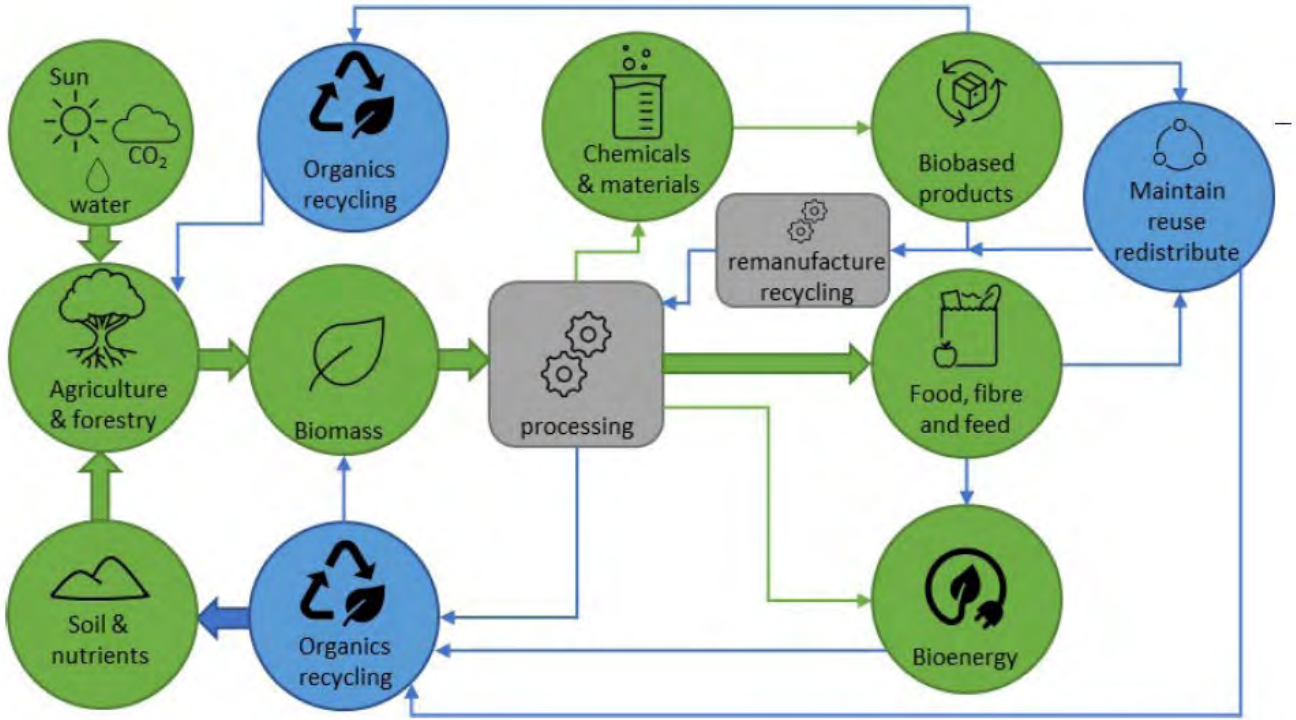
micro = L.C.A.

meso = M.F.A. & L.C.A.

macro = M.F.A. & Circularity Measures

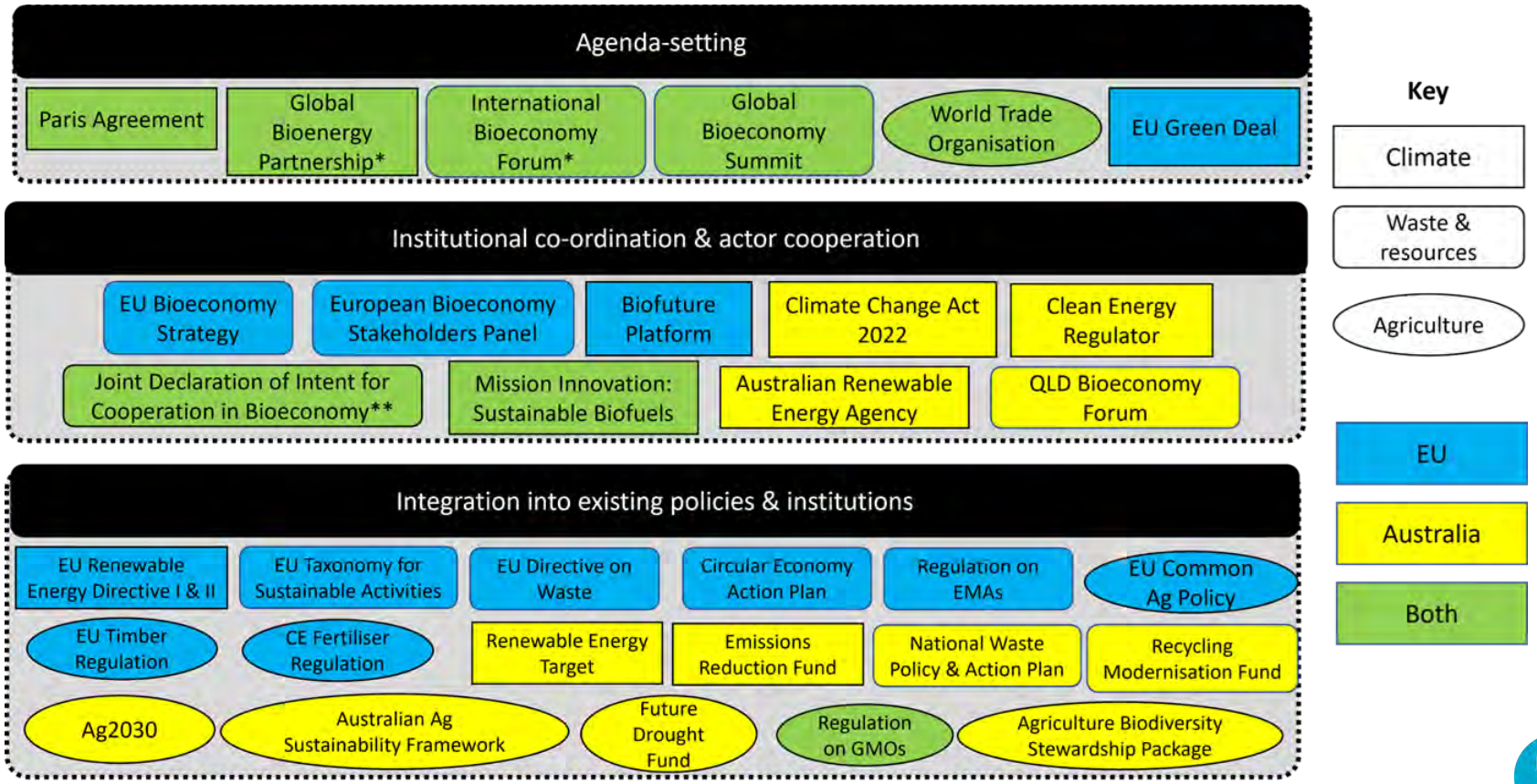
Principles for Circular Economy Metrics [ACE HUB link]

Macro: Opportunities for a circular **bio-based** economy



Arsic et al. (2022) Farm Policy Journal 19(3): 43-60

Macro: Governance spread across waste, agriculture, and climate



Arsic et al. (2023) Detritus 23: 28-34

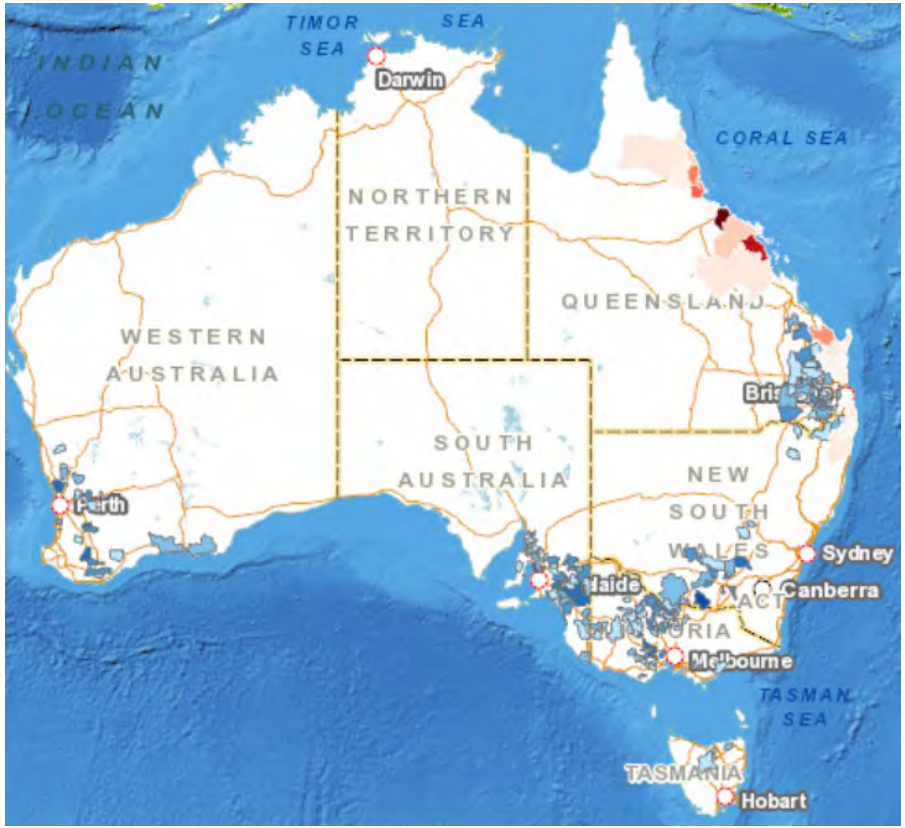
Macro: Circular and bioeconomy strategy and governance

Jurisdiction	Circular economy			Bioeconomy		
	Waste management	Circular economy	Food waste	Bioenergy	Biotechnology	Organics
Federal	✓	✓	✓	✓	✓	
ACT	✓	✓		✓		
NSW	✓	✓		✓		
NT	✓	✓				
QLD	✓	✓		✓	✓	✓
SA	✓	✓	✓		✓	
VIC	✓	✓		✓		
WA	✓	✓		✓		
TAS	✓	✓				✓

- Sectors operating in silos
- Bioeconomy is largely bioenergy driven
- Language inconsistencies
  - Organic waste
  - Organics
  - Residues
  - Food waste/loss
  - FOGO
  - Biomass
  - Bioresources
  - Bio-based
  - Bio-materials…

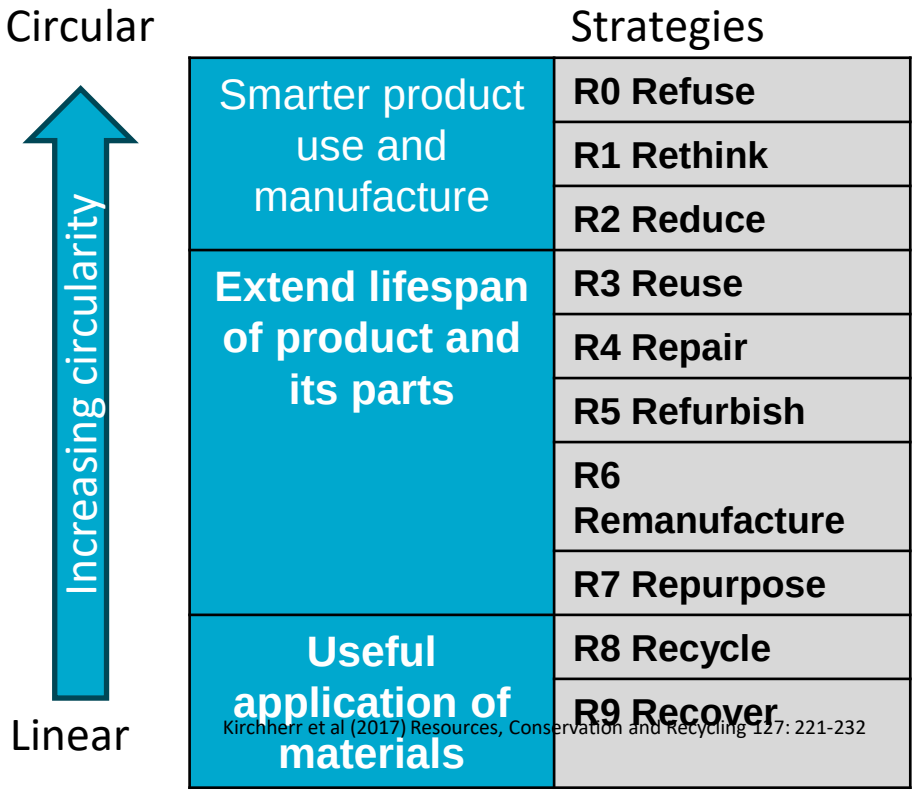
Adapted from Arsic et al. (2022) Farm Policy Journal 19(3): 43-60

Meso: Australian Biomass for Bioenergy Assessment



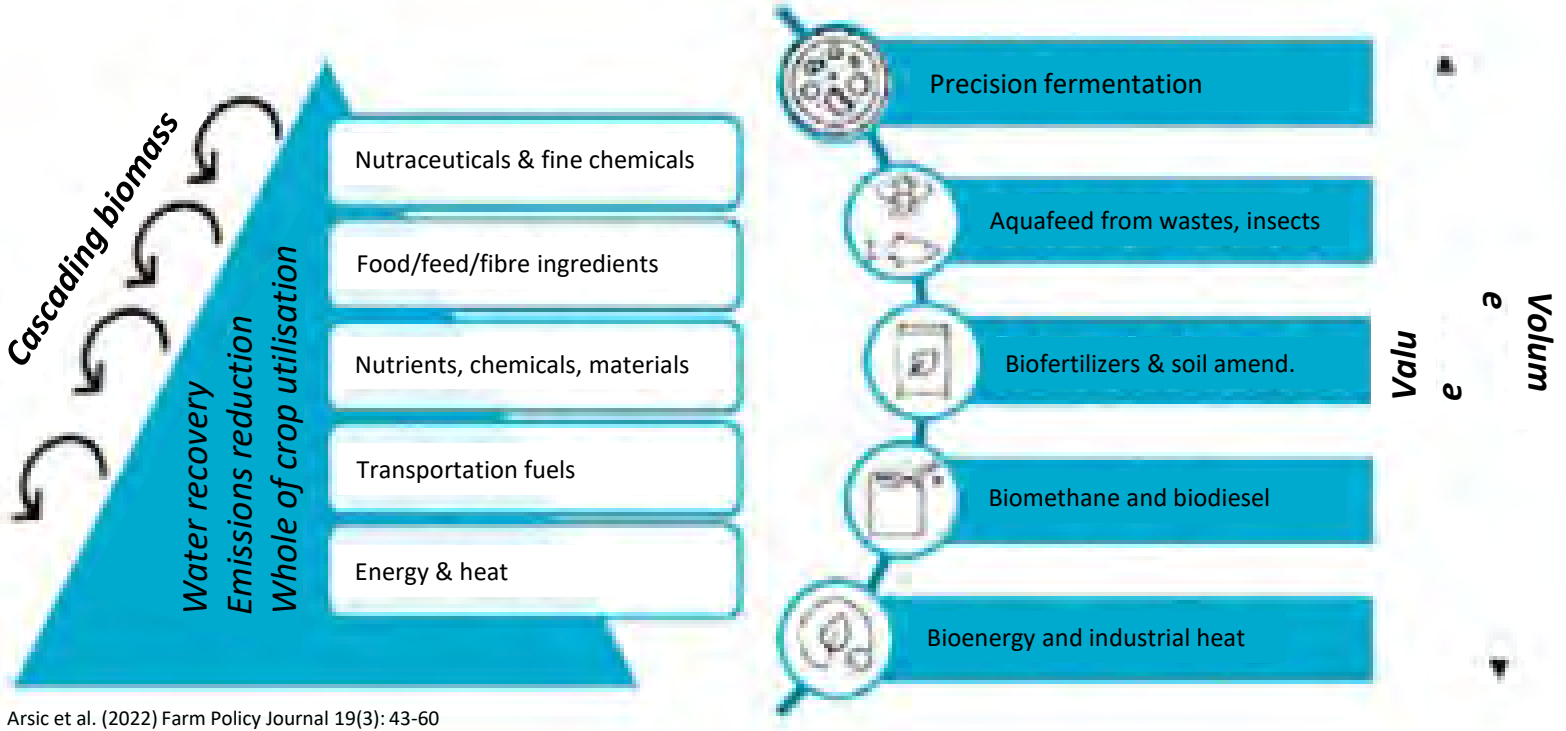
- ARENA funded 2015-2021
- Biomass mapping – feedstocks for bioenergy
- Mostly state and territory based
  - Cropping, organic municipal wastes, horticulture, livestock, forestry, food processing
  - Place-based opportunities (Ind sym.)
  - Technology/processing precincts
- Coordination
  - Across sectors?
  - New industries?

Micro: Circulate bio-based materials at their highest value



Kirchherr et al (2017) Resources, Conservation and Recycling 127: 221-232

Micro: Circulate bio-based materials at their highest value



Arsic et al. (2022) Farm Policy Journal 19(3): 43-60

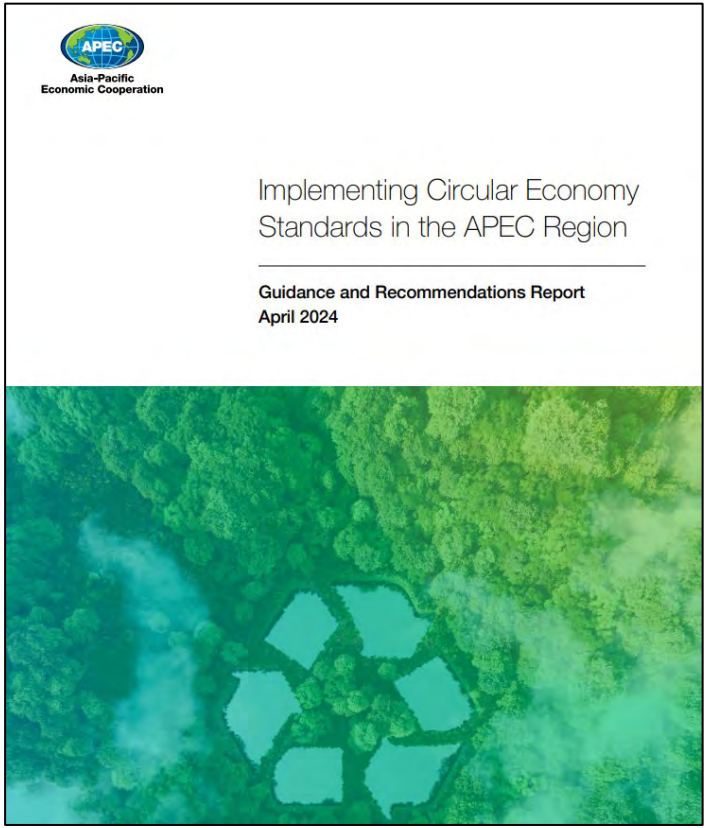
Supporting mechanisms can link biocircular approaches across scales

One example is standards: documents that provide specifications, procedures, and guidelines for products, services, and systems

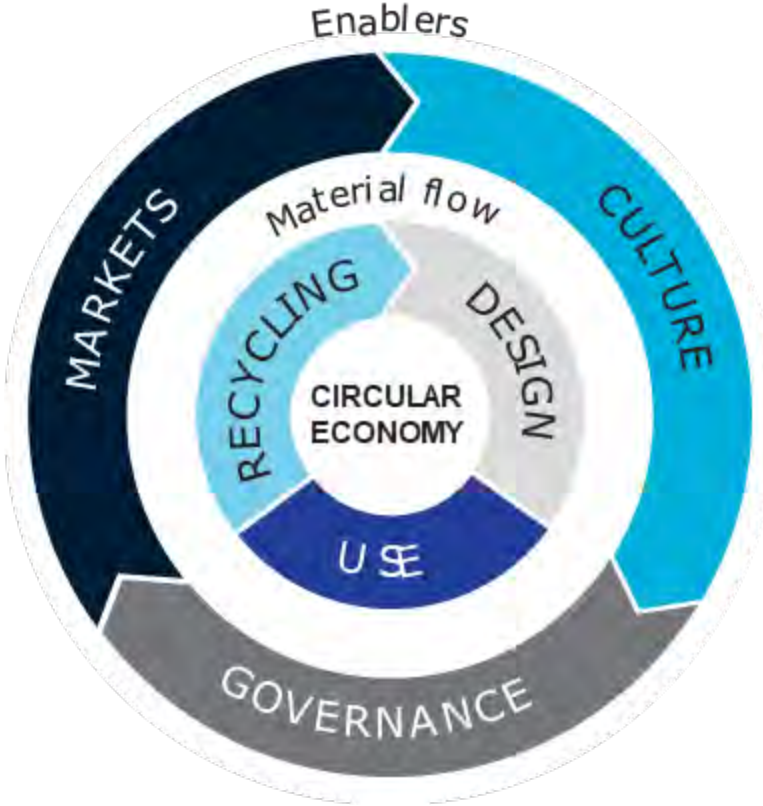
Standards can support the circular economy transition by:

- *Setting foundational principles*
- *Building consumer trust*
- *Ensuring quality standards and safety*
- *Create and strengthen markets for secondary products*
- *Enhancing enabling technologies*
- *Embedding circular economy principles*
- *Providing market access*

The Pacific Islands Standards Committee (PISC) is the first regional standards body for Pacific Islands countries

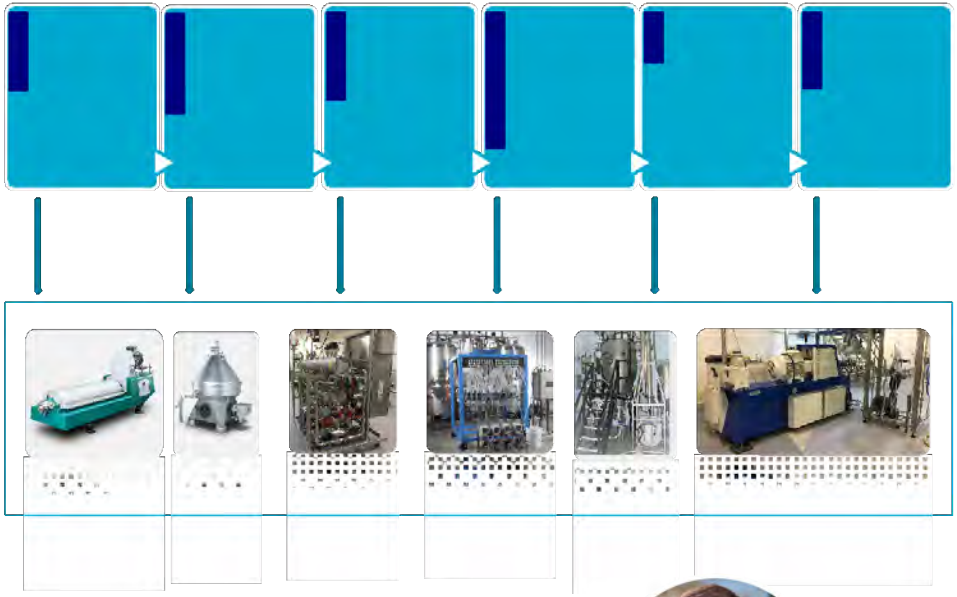


bioCE innovation examples



food materials +

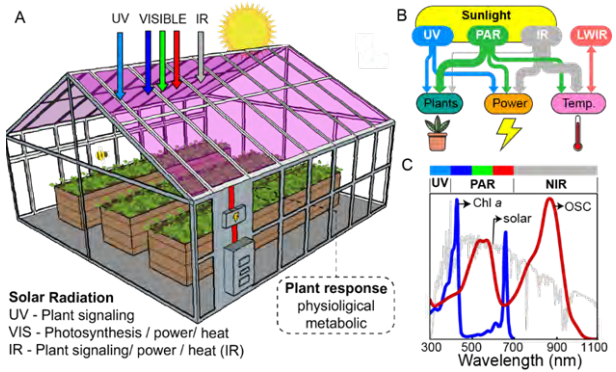
bestie



Pablo Juliano and team

CSIRO

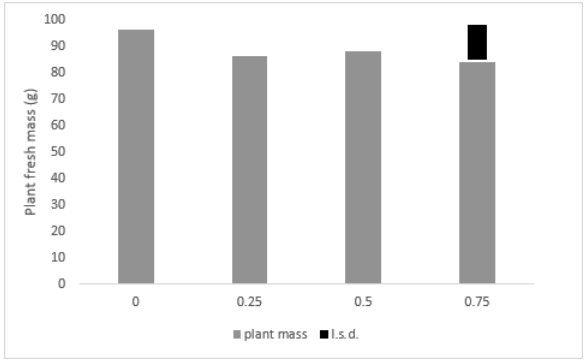
solar-films x greenhouse x crops



Semi-transparent solar films for glasshouses - concept
c.f. (Ravishankar, Charles et al. 2021)

Flexi-solar strips x greenhouse x Cos lettuce. Plant growth 28 days under 0% cover (control) and 75% cover solar film shade treatments.

Cathryn O'Sullivan and team

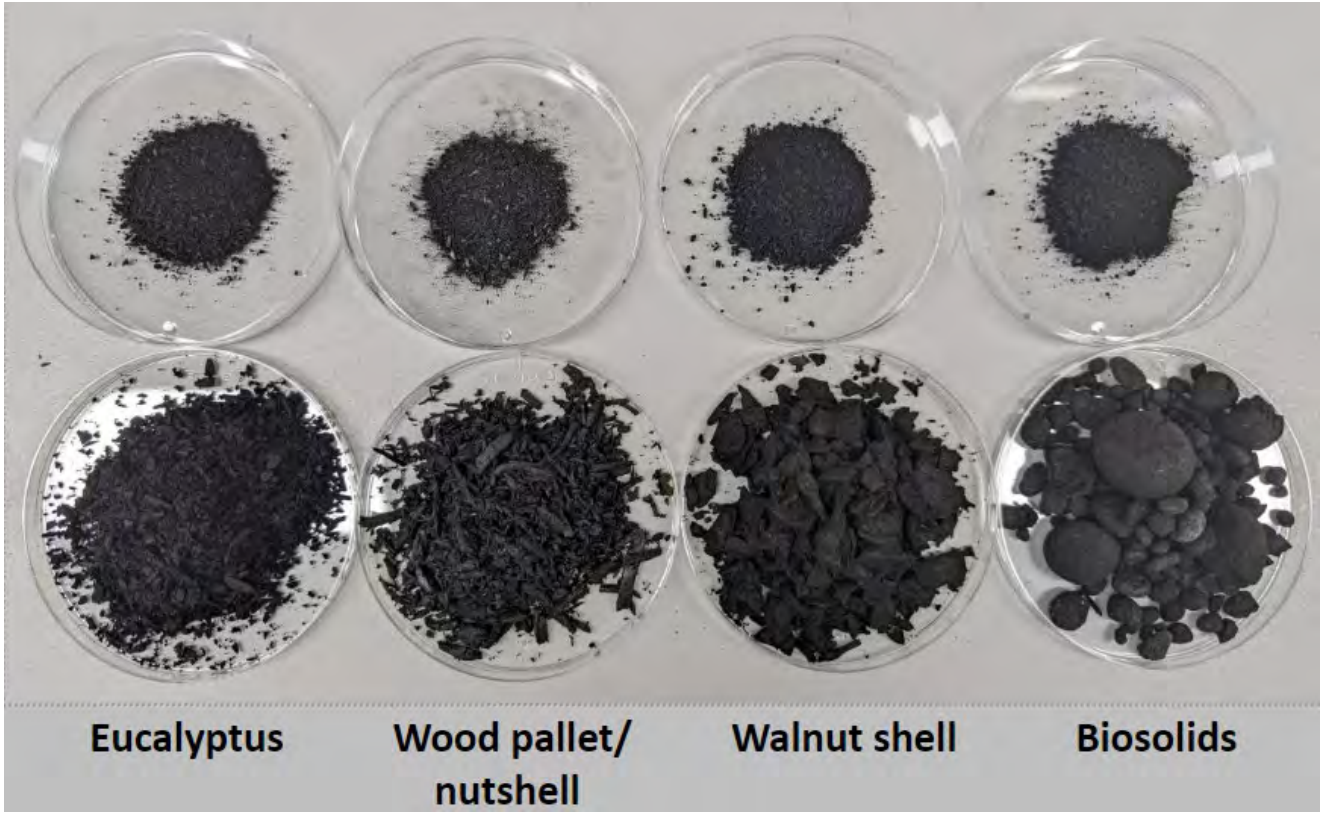


Above ground biomass (g fresh mass) of plants grown under different shade treatments
using first iteration of printed solar films.
Black bar indicates least significant difference at p=0.05. No treatments were statistically different to the control.

Aquaponics = growing fish and vegetables

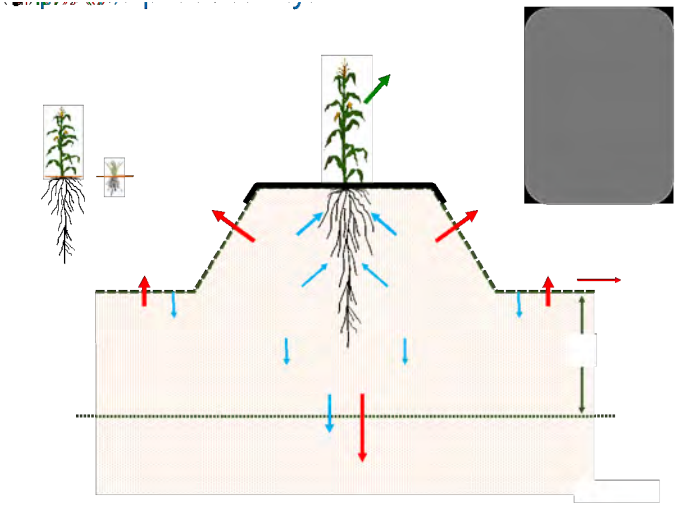
Mauriciano Emerenciano
and team

Biochar by-products from bioenergy production



SBM-TranspiratiONal

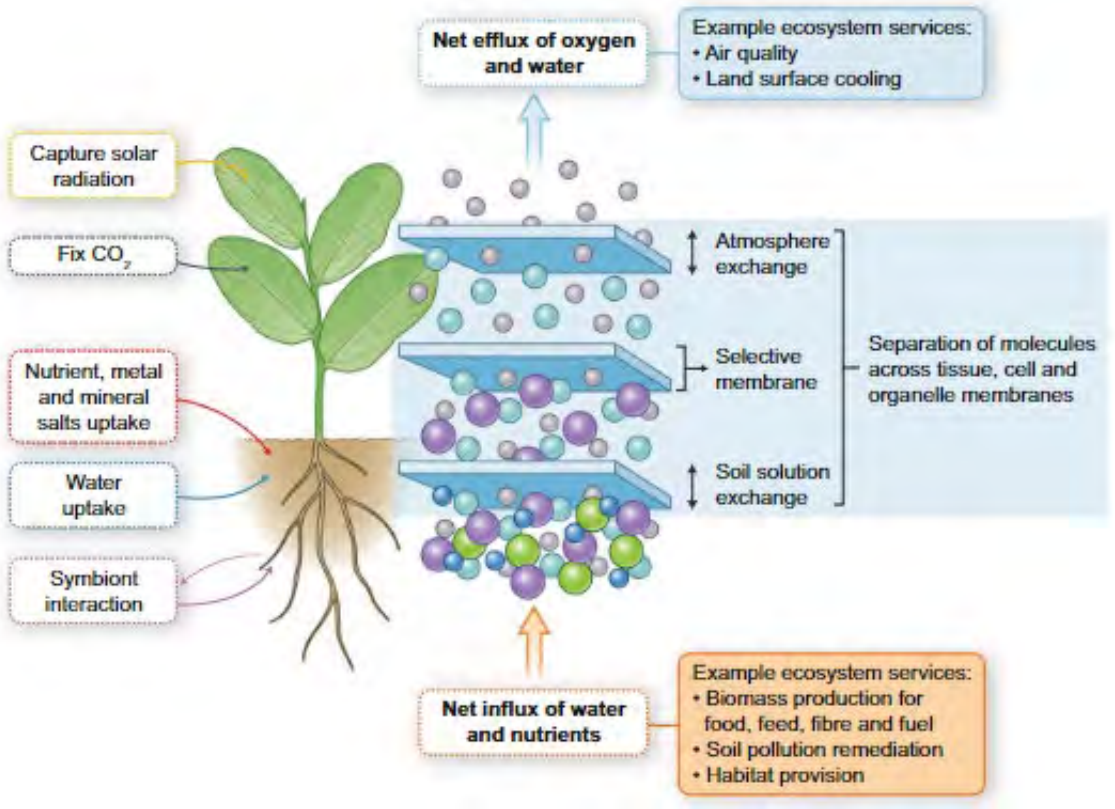
a Sprayable Biodegradable Mulch *to replace plastic mulch films*



- A sprayable biodegradable mulch
- Preserves moisture
- Supresses weeds
- Improves germination temperature
- Patented
- Easy mechanical (spray) application
- Cost parity with biodegradable plastics
- No waste, collection or disposal

Stuart Gordon and team

New membranes for resource separation



fibre redesign

natural & biodegradable fibre

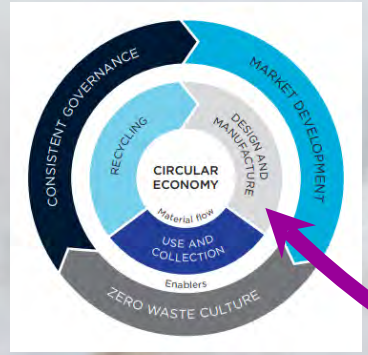
novel plant-based fibres

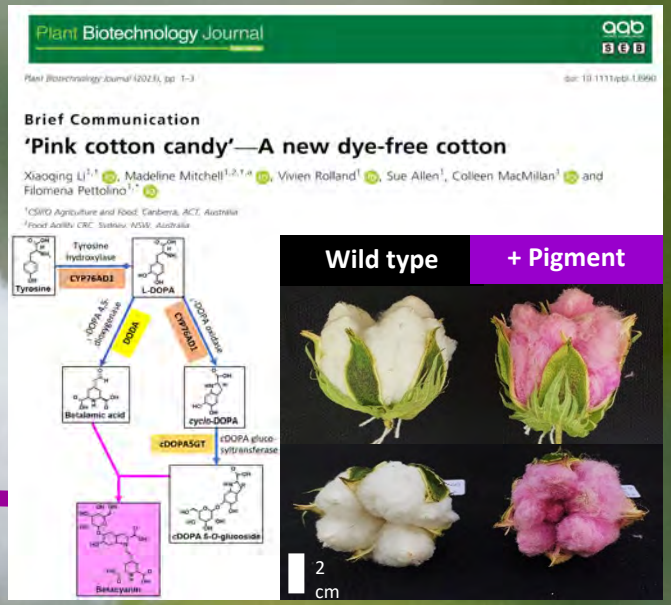
natural & biodegradable

+

functionality of synthetics

CSIRO Synthetic Biology Future Science Platform Novel Fibres
Xiaoqing Li, Filomena Pettolino, Colleen MacMillan, Maddie Mitchell, Viv Rolland plus Sue Allen, Rob Long, Matt Taylor, Tara Southerland, others





Plant Biotechnology Journal

Brief Communication

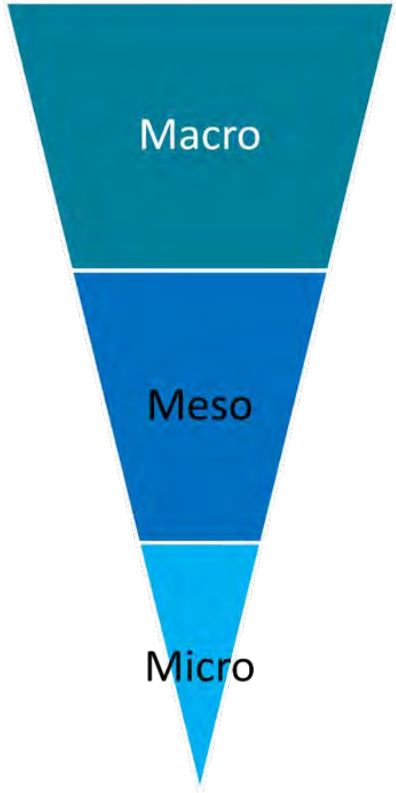
'Pink cotton candy'—A new dye-free cotton

Xiaoqing Li, Madeline Mitchell, Vivien Rolland, Sue Allen, Colleen MacMillan and Filomena Pettolino

Property	Cotton	Polyester
Water absorbing capacity	✓	✗
Breathability	✓	✗
Thermal conductivity (cool summer/warm winter)	✓	✗
Pilling	✓	✗
Elasticity	✗	✓
Weight/Density	✗	✓
Strength/Tenacity	✗	✓
Resilience (crease		

colleen.macmillan@csiro.au; with the team

A framework for circular bioresource systems



Resource producers **Resource users**

Aligning national circular bioeconomy and sustainability strategies

Process and product traceability – *Sustainability*

Digital trading platforms – *Place-based*

Regulation: Waste management & CE

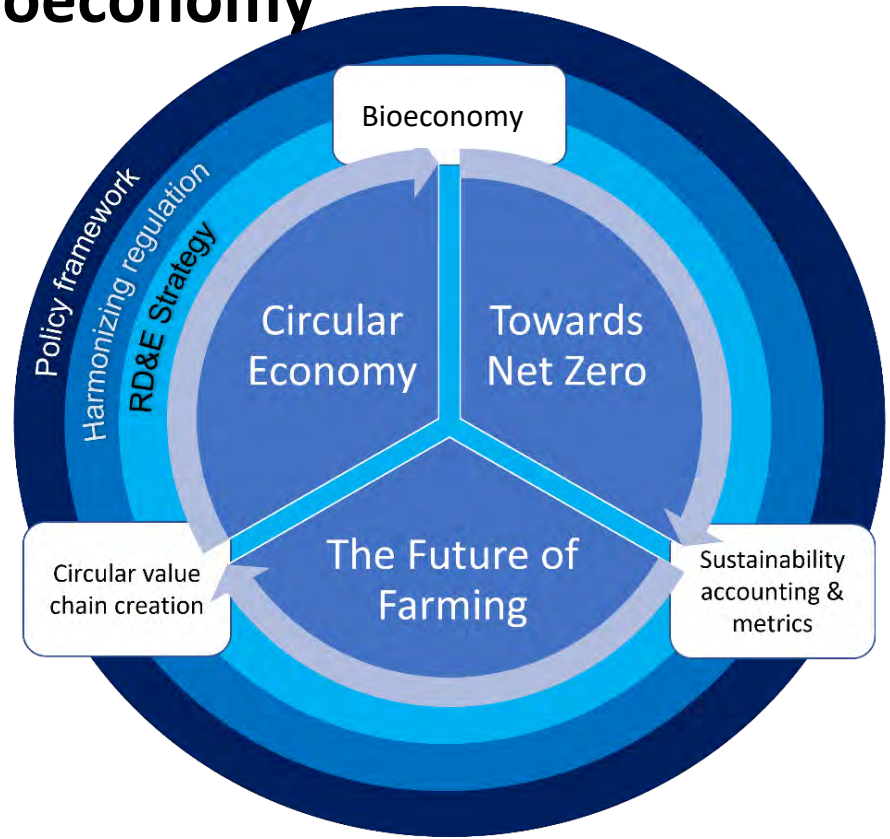
Regulation: Enable biocascades

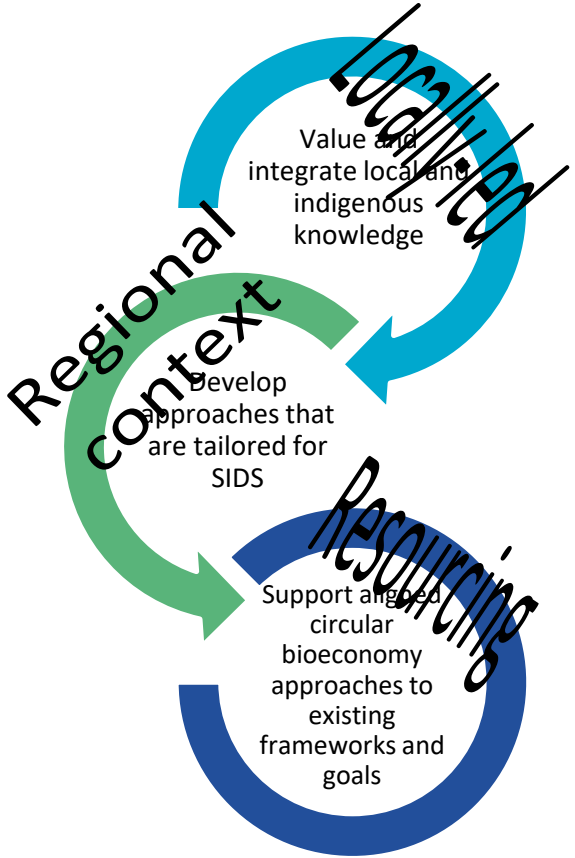
Technology: Aware of regulation

Regulation: Safe & effective products

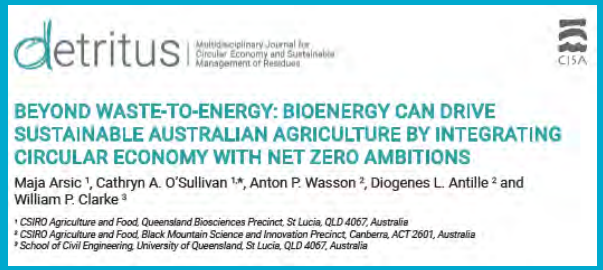
RD&E: Technology to meet both producer & user needs

Science-policy interface shifts towards a circular bioeconomy





Adapted from Arsic et al. (2023) Detritus 23: 28-34



detritus | Multidisciplinary Journal for Circular Economy and Sustainable Management of Residues

CISA

BEYOND WASTE-TO-ENERGY: BIOENERGY CAN DRIVE SUSTAINABLE AUSTRALIAN AGRICULTURE BY INTEGRATING CIRCULAR ECONOMY WITH NET ZERO AMBITIONS

Maja Arsic [1], Cathryn A. O'Sullivan [1,*], Anton P. Wasson [2], Diogenes L. Antille [2] and William P. Clarke [3]

[1] CSIRO Agriculture and Food, Queensland Biosciences Precinct, St Lucia, QLD 4067, Australia
[2] CSIRO Agriculture and Food, Black Mountain Science and Innovation Precinct, Canberra, ACT 2601, Australia
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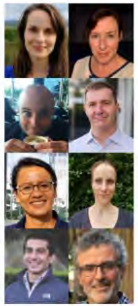
Australia needs a national policy approach to successfully implement circular bioeconomy in agriculture and food systems

Circular economy (CE) and bioeconomy (BE) are overlapping concepts that are receiving attention across various levels of government, industry, and academia. Interest is driven in pursuit of the United Nation's Sustainable Development Goals and an understanding that we cannot feed the growing global population and protect the planet with the current, linear production systems. Circular, climate-friendly farming practices and supply chains are needed to secure market access and meet growing sustainability-values based consumer demands. Current on-farm management practices, and whole-of-life product stewardship, affect sustainability credentials and participation in natural capital markets as well as improving productivity and decreasing waste. Novel bio-based products could be a crucial piece of sustainable future production and energy beyond fossil fuels. However, there are interacting and competing demands for bioresources between the circular economy, bioenergy, and net-zero carbon sectors.

In Australia, these sectors are developing independently of a coordinated policy perspective which is leading to numerous policy and strategy approaches, both overlapping and disconnected, which do not fully encompass Australia's bioresource systems. A coordinated approach could ensure that bioresource utilisation from "wastes" is maximised while minimising competitive trade-offs. There is also an opportunity to address similar barriers (e.g., logistics, governance) across sectors.

A coordinated approach could maximise upcycled product viability and reduce duplication of effort by moving towards cross-sector allocation of bioresources, co-designing processes to recover a suite of resources to optimise recovery and quality, and capturing the full value of opportunities from waste by identifying and working across relevant stakeholders in the agri-food supply chain.

This paper outlines the current policy and strategy developments around circular economy, bioeconomy and waste reduction in Australia and highlights the opportunities for a circular bioeconomy approach that builds a coordinated framework for more efficient and integrated bioresource utilisation.



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CSIRO

Thank you

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Workshop questions

1. Please design a bio-circular economy model that can transform PIC's waste management and resource use over the next decade?

1. What are the key barriers to implementing such bio-circular economy model and how might they be overcome?

1. How can stakeholders (local government, businesses, and citizens) be motivated to adopt circular economy model?

1. What are the financial, operational, and social considerations for scaling up a bio-circular economy model?