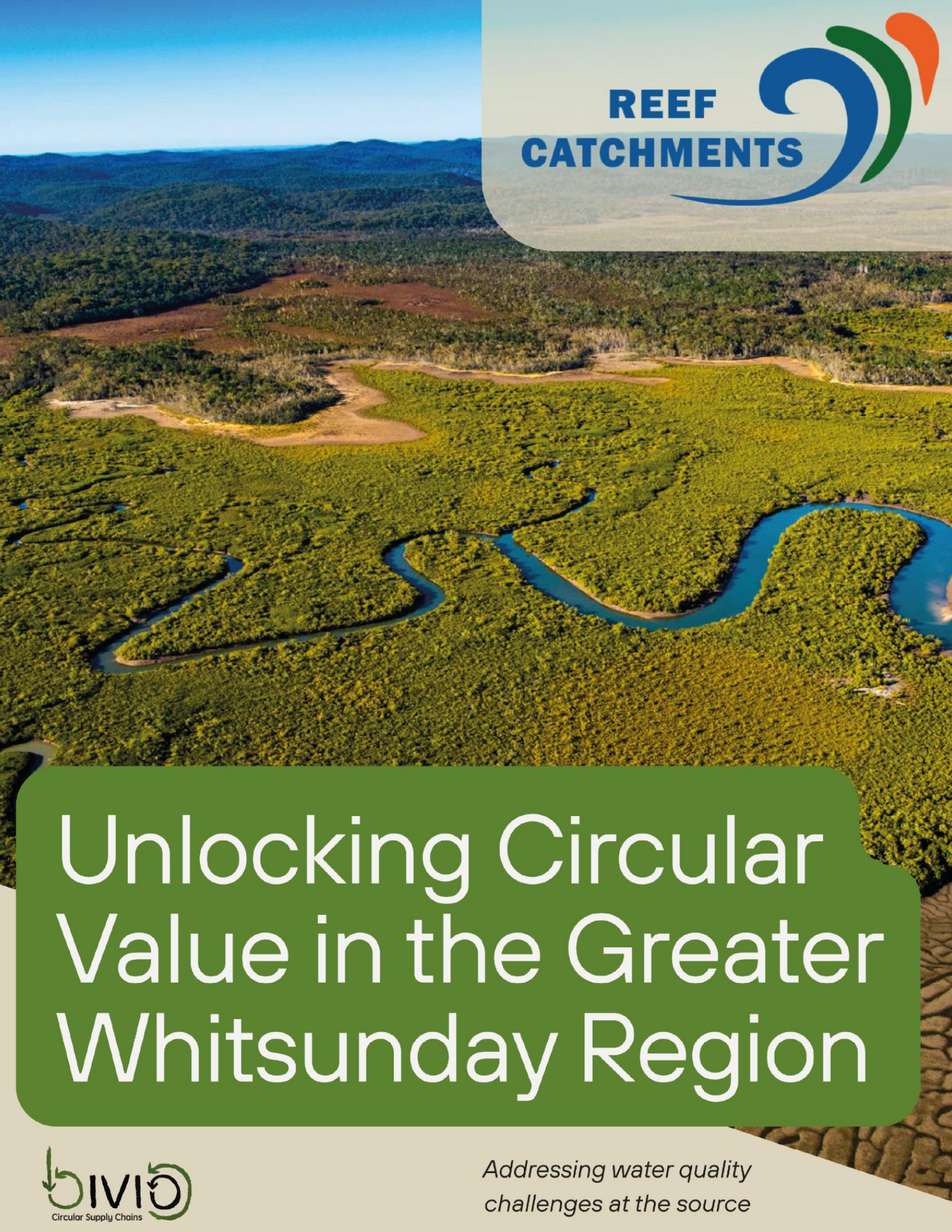




**REEF
CATCHMENTS**



Unlocking Circular Value in the Greater Whitsunday Region

This report has been prepared to support understanding of the Greater Whitsunday regional system and to inform discussion on pathways to unlock circular value and improve water quality outcomes. It draws on available data, stakeholder engagement, and analytical methods applied at a point in time.

While reasonable care has been taken to ensure the information presented is accurate and relevant, no representation or warranty is made as to its completeness or ongoing accuracy. Data used in this report is sourced from third parties, stakeholder inputs, and publicly available datasets where available; its accuracy and completeness couldn't be independently verified in all cases.

The findings reflect system-level analysis and should not be relied upon as detailed technical, financial, or investment advice. Implementation of any initiatives or actions identified in this report is subject to further feasibility, commercial assessment, regulatory approvals, and site-specific conditions. Users of this report should seek appropriate professional advice before making decisions or commitments.

The views expressed are those of the authors and informed by stakeholder inputs; they do not necessarily represent the views of all participating organisations.

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The project was delivered in partnership with Reef Catchments as part of the Proserpine Integrated Project (PIP), which brings together seven initiatives tailored to the Greater Whitsunday Region.

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Executive Summary

Recent global disruptions to fuel, gas and fertiliser supply chains have exposed structural vulnerabilities in regional Australia. Resulting on the realisation that energy transition and regional supply chains are not just about emissions and 'extra value' but a matter of National Security and Future Resilience.

The Greater Whitsunday region is highly dependent on imported inputs, particularly nitrogen fertilisers and energy, making local industries and growers, directly exposed to price volatility and supply uncertainty. This exposure sits alongside ongoing water quality pressures, where nutrient losses from the same regional system continue to impact downstream environments and Reef targets.

At the same time, the region holds significant unrealised potential. The sugar industry alone contributes \$4.4 billion annually and supports over 20,000 jobs, yet its broader role in bioenergy, biofuels and biomanufacturing remains underdeveloped.

Government and industry are aligned on the opportunity to strengthen energy security, build a domestic bio-economy and unlock value from existing feedstocks. However, a recently published Queensland Parliamentary Inquiry confirms that the core challenge is not identifying opportunities, but overcoming fragmented coordination, investment uncertainty, and lack of delivery frameworks.

This report responds directly to that gap. It focuses on how the regional system must change to enable coordinated, scalable delivery.

A leaking system, not a lack of opportunity

There is no lack of ideas or effort in the region, the region is constrained by how its system operates.

The Material Flow Analysis developed as part of our report, shows that large volumes of nutrients enter the system but are not retained as value:

- Approx 12,537 tonnes of nitrogen enter the sugarcane system via fertiliser, with only ~13% showing circularity
- Approx 374 tonnes of pesticides show 0% circularity, flowing directly into waterways
- In aquaculture, approx 151.77 tonnes of nitrogen enter via aquafeed, with partial recovery potential (~43%) not yet realised
- Across both sectors, 70 to 80% of nutrients are not recovered, leaving the system through runoff, wastewater discharge, and under utilised biosolids. These losses are not only an economic inefficiency, but they are also the primary pathway through which excess nutrients enter waterways, directly contributing to water quality challenges in the region.

This creates a structural contradiction:

Growers face rising fertiliser costs, while the system simultaneously loses thousands of tonnes of nutrients already within it. These losses are not isolated. They reflect a broader pattern:

- Value is lost through waste streams instead of being captured
- Existing infrastructure and feedstocks are underutilised
- Strong initiatives remain at pilot stage
- Stakeholders act independently rather than collectively
- The system is not designed to support new industries at scale

The issue is not opportunity. It is a **system that leaks value across physical, economic, and coordination layers.**

An internal project shift (adaptation)

The project was initiated through the Reef Water Quality Program, with the objective of identifying opportunities that could reduce nutrient losses while supporting regional economic outcomes. As we progressed, we found that the region had an abundance of:

- Bioenergy and biofuel concepts
- Nutrient recovery initiatives
- Biomass utilisation pathways
- Active R&D, pilot projects and investment attraction reports

Most proved to be technically viable, but few lacked clear pathways to commercial scale. Subsequent engagement with project proponents and stakeholders revealed a consistent pattern:

-> Projects were acting (and sometimes struggling) alone, and they were constrained by the same system conditions.

This realisation led to a project deliberate shift:

From identifying individual opportunities to understanding how the regional system must change to reduce nutrient losses at scale and enable those opportunities to be delivered.

What is holding the system back

Our process of understanding the current system gave us five key insights:

- **Value from nutrient cycles is concentrated when it enters the system (inputs) and lost when it leaves it (outputs or discharge)** Nitrogen enters through fertiliser (sugarcane), and aquafeed (aquaculture), accumulates in parts of the system (ie. settlement ponds, biosolids) and is ultimately lost through discharge pathways rather than retained as value.
- **Hotspots for circularity are clear, but not activated**

Thousands of tonnes of nitrogen material from sugar industry remains untapped beyond ethanol destinations (ie. Biofertiliser 1274t, Biosolid discharges of 2,064t across key points) present viable recovery opportunities yet remain largely untapped.

- **Stakeholders are engaged but constrained by risk and trust**
Commercial sensitivity, unclear value-sharing and perceived risk lead to parallel efforts rather than coordinated action.
- **Structural barriers are well known but persist**
Capital access, infrastructure gaps, policy fragmentation and lack of secure offtake are not new to the region and acknowledged by all stakeholders interviewed. But despite clarity on why, these barriers are reinforced in the system. We found fragmentation and silo optimisation to be one of the key reasons why.
- **High activity does not translate into outcomes**
The region has strong fundamentals developed over the last three decades: R&D, feasibility studies, strategies and pilots and strong policy headwinds. But the mechanisms to connect them and scale them with clear intent are yet to be developed.

In short:

-> each part of the system is optimised individually, but the system as a whole is not.

A regional system designed for scale

The report proposes a shift from isolated initiatives to a coordinated regional system designed for delivery, built on three components:

- **Clusters** – connected pathways of value (ie. nutrient recovery, bioenergy, biomass transformation)
- **Precincts** – evolved platforms that enable co-location, shared infrastructure and sequencing of projects
- **Enabling conditions** – the financing, policy, infrastructure and governance required to make this work

This builds on existing regional strengths:

- Approx 3 million tonnes per year of biomass feedstock available
- Existing infrastructure with spare capacity (~1 million tonnes at sugar mills)
- Emerging platforms such as the Mackay BioHub, with ~\$1B+ investment potential

-> This report proposes a way to connect what already exists into a regional system that can scale.

What needs to happen next

Four immediate actions are required to shift from concept to delivery:

- **Establish an industrial transition developer**
A coordinating role to align stakeholders, sequence projects and build a coherent investment pipeline. This role can be held by a single entity or a coalition, but must operate with the authority and integration of one
- **Form action-driven coalitions**
Focused on solving specific barriers, including shared infrastructure, cluster identification, feasibility, delivery and, system coordination.
- **Activate precincts as delivery platforms**
Moving beyond land-based industrial zones to curated, shared infrastructure ecosystems that enable co-location and scale.
- **Align enabling conditions to system outcomes**
Shifting from funding individual projects to supporting interconnected industry (ies) development through shared risk, coordinated investment and market development.

Natural Resource Management (NRM) organisations play a critical, structural role in enabling this shift. As trusted system convenors, they bring stakeholders together with credibility and neutrality, acting as connectors across fragmented actors and maintaining a whole-of-system view.

Through their place-based data, on-ground validation and understanding of resource flows, they help de-risk adoption, support project progression from concept to implementation, and link environmental outcomes to economic value creation. In doing so, NRMs enable the conditions required for coordinated action, supporting the transition from pilot to scale.

This reflects a shift from focusing mainly on downstream environmental outcomes to enabling upstream regional system conditions that prevent nutrient loss in the first place.

When the region and its key stakeholders or actors (including NRMs) make the collective decision to move from a fragmented regional system to a coordinated one, it can enable the region to go:

- From isolated projects → to scalable industries
- From feedstock advantage → to value retained in-region
- From investment hesitation → to an investable regional proposition
- From nutrient loss → to improved water quality outcomes
- From volatility → to regional resilience

During the time of producing this report, we found signals of this shift already emerging in the region:

- Policy and industry signals are converging, including a State Government inquiry into bioenergy and growing calls from the sugar sector for ethanol demand mandates and coordinated support.
- ~\$1B+ Bio-futures investment potential
- ~6,640+ jobs projected by 2035
- Strong global demand for bio-based products

Most importantly, **water quality becomes an outcome of a better system, as nutrients are retained and reused upstream rather than lost to waterways.**

The Greater Whitsunday region is at a clear turning point. The opportunities are already visible, the groundwork has been done, and the need to act has never been stronger. However, without a shift in how the system operates, these efforts will continue to stall at the same point. The choice now is not whether to invest, but whether to keep advancing projects in isolation or to come together and build the conditions that allow them to scale.

This is no longer just a regional economic question; it is a matter of regional resilience compounded into national security. This report sets out a practical path to do that. What happens next depends on the region's willingness to align, coordinate, and move forward with intent, turning momentum into delivery and potential into lasting value.

The region has an **abundance** of circular opportunities, but it needs a **system** to deliver them

A matter of regional resilience and national security

WHY THIS MATTERS NOW



Heavy reliance on imported fertiliser and energy



Exposure to commodities global price and supply availability shocks



Ongoing water quality pressure from nutrient loss



The same system driving economic exposure is also driving water quality outcomes

A LEAKING SYSTEM

INPUTS

- Nitrogen**
 - ~ 12,537 Ton Urea+DAP
 - ~ 152 Ton Aquafeed
- Pesticides**
 - 374 Ton

SYSTEM

- 27%** Sugarcane Circularity
 - ethanol+ Bio Dunder, mill mud, rotation crops
- 10%** Aquaculture Circularity
 - Seaweed reclamation (if used beneficially)

LOSSES

70 - 80%
Nutrient loss



Nutrient loss is the primary pathway through which value leaves the system and enters waterways.

WHAT WE FOUND - WHAT IS HOLDING THE SYSTEM BACK

01.

Value enters upstream, lost at discharge

02.

Circular hotspots exist but remain untapped*

03.

Stakeholders active, but acting alone

04.

High activity, low system outcomes**



** "Projects stall & 'bleeds dry'. Proponents exit to other States".
- Regional stakeholder

***2,064 Ton**

Underutilised biosolid discharge - sugarcane

***66 Ton**

Underutilised biosolid from settlement ponds - aquaculture

THE PROJECT SHIFT

How we adapted this project's aim

From:

Identify opportunities



To:

Enable the system for scale

Projects in isolation



Connected clusters

Less water quality downstream



Reduce nutrient loss upstream

THE EMERGING REGIONAL SYSTEM MODEL

A system designed for scale

CLUSTERS

→ What gets done

PRECINCTS

→ Where & how it scales

ENABLING CONDITIONS

→ What makes it possible

ACTION

What needs to happen next

- Establish system orchestrator
 - Form action-driven coalitions
 - Activate precincts
 - Align enabling conditions
- NRMs act as trusted system connecting actors, data and, on-ground delivery enablers

WHAT THIS UNLOCKS

Transformation

- Projects → Industries
- Waste → Value
- Risk → Investable
- Fragmented → Coordinated

Outcomes

- Nutrients retained and reused upstream
- Water quality improves as a system outcome
- ~\$1B+ biofutures potential
- ~6,640 jobs by 2035



Lasting environmental outcomes can be achieved through redesigning the system, beyond treating the symptoms.

Not another strategy, a delivery model for the region

Deliver by:

THIS PROJECT IS PART OF THE PROSERPINE INTEGRATED PROJECTS FUNDED THROUGH THE QUEENSLAND GOVERNMENT'S OLD REEF WATER QUALITY PROGRAM

Deliver for:

Introduction

Natural Resource Management (NRM) organisations play a quiet but critical role in Australia's prosperity. They work at the intersection of land, water, biodiversity, industry and community, coordinating science, local knowledge and practical action to protect ecosystems, improve stewardship, and support resilient regional economies.

The Proserpine Catchment has been identified as a priority area under the Reef 2050 Water Quality Improvement Plan, a **joint Australian and Queensland Government initiative aimed at improving water quality from reef catchments to the Great Barrier Reef, supporting ecosystem health, resilience, and community benefits**. Significant reductions in dissolved inorganic nitrogen and pesticides are still required if the region is to meet the Reef 2050 targets.

While water quality is often approached as an environmental issue to manage, this project adopted a broader perspective:

Water quality is not only an environmental issue; it is a signal of system design. When nutrients leak downstream, economic value is leaking upstream.

This perspective guided engagement with industry, government, and regional stakeholders and informed the approach to identifying both existing and emerging circular opportunities.

This project - Unlocking Circular Value in the Greater Whitsunday Region, forms part of the Proserpine Integrated Project (PIP), bringing together seven initiatives tailored to the Greater Whitsunday Region. The PIP, delivered by Reef Catchments is part of the \$5.5 million Reef Place-Based Integrated Projects initiative funded through the Queensland Government's Queensland Reef Water Quality Program

For Reef Catchments, the regional NRM organisation of the Mackay Whitsunday Issac region, this project complemented existing restoration and practice change programs by exploring the broader regional system shaping water quality outcomes today. The focus was on how nutrient flows could be retained, transformed into value, and leveraged to support coordinated action, delivering environmental improvements alongside economic and industrial development.

The aim is to support more coordinated action towards a shared objective: improving environmental outcomes while supporting economic and industrial development and creating broader value for the region and its communities.

A recent Queensland Parliamentary Inquiry into Sugarcane Bioenergy Opportunities¹ reinforces this position. It confirms that the challenge is not just identifying opportunities, but addressing fragmented coordination, limited investment certainty, and absence of a clear delivery framework required to bring them to fruition.

¹ <https://www.parliament.qld.gov.au/Work-of-Committees/Committees/Committee-Details?cid=270&id=4530>

This report builds that direction at a regional level. It focuses on what needs to change in the Greater Whitsunday system for these opportunities to connect, scale them effectively, and translate them into tangible economic and water quality outcomes.

The structure of this report is summarised in the Figure 1 below:

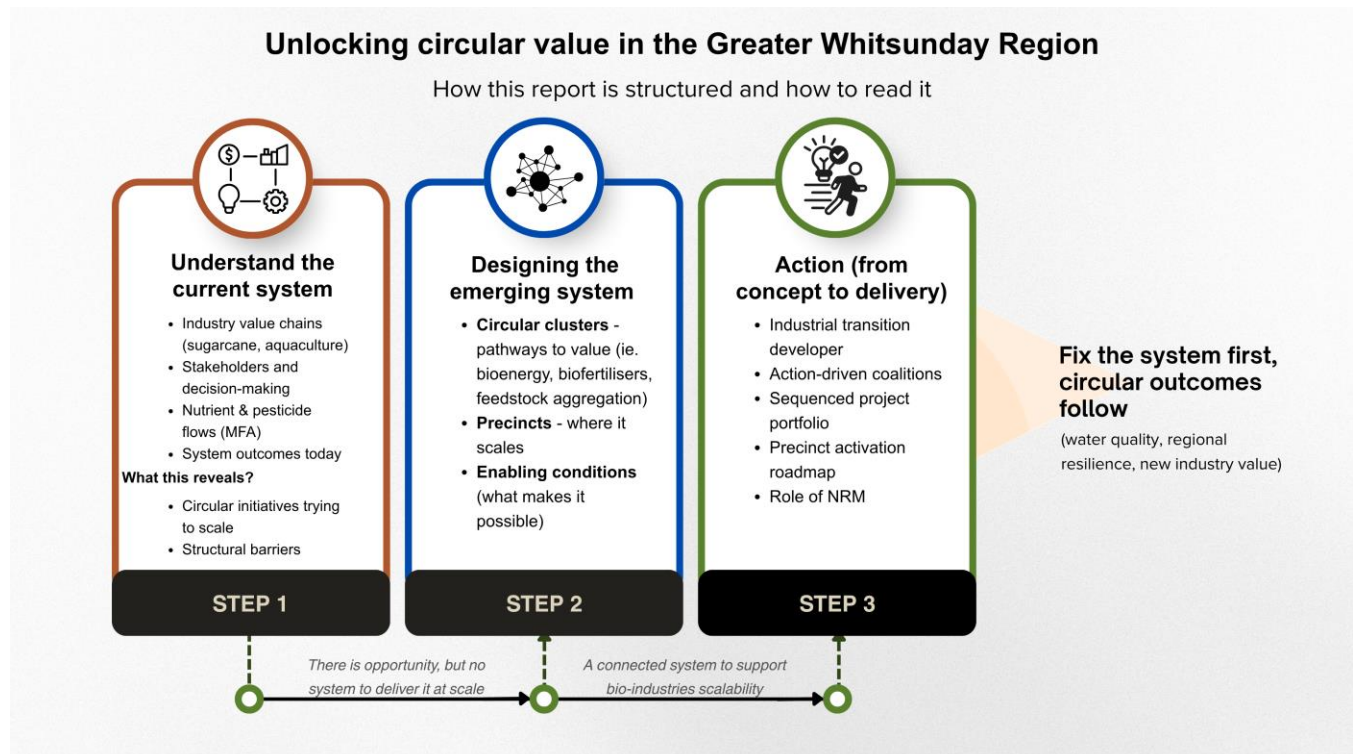


Figure 1: Report structure and how to read it

Understanding the current system

The first part examines how value is created and lost across two priority sectors, sugarcane and aquaculture. How decisions are made in practice by key stakeholders across industry, government and research organisations, which was understood through interviews, workshops and direct engagement.

These sectors were selected for their direct impact on water quality and their role in shaping the region's land use, infrastructure, and social economics.

To complement this perspective, material flow analyses (MFAs) were undertaken to map how nutrients and pesticides move through the regional system. This provided a clearer view of where losses occur, and where intervention points, or "hotspots", exist.

The report then reviews a representative set of existing initiatives in the region. While many show strong technical potential and alignment with regional priorities, they face common challenges in progressing beyond pilot and early-stage development. These insights informed an initial set of structural barriers within the current system.

These barriers were further explored and tested with regional stakeholders through the hotspots workshop, helping to validate how the system operates in practice and its ability to support circular initiatives reaching commercial scale.

Through this process, a clear pattern emerged. The region is not short on ideas or opportunities. What is missing is the system required to enable them to scale.

This led to a **conscious shift in the direction of the project**. Rather than continuing to narrow in on specific circular opportunities, the focus moved to understanding why existing initiatives are not progressing, and what needs to change to enable them to do so.

This reframed the central question of the report:

What needs to change in the Greater Whitsunday Region for circular industries to scale and deliver both water quality and regional economic outcomes? And how do the key actors in the region need to work differently to make this happen?

Designing the emerging system

The second part of the report focuses on what this emerging system could look like.

It introduces three core components required to support circular industries at scale.

First, circular clusters, which group together existing and potential initiatives into connected pathways to value (ie. Bioenergy, biofertilisers, feedstock aggregation and processing, etc). Clusters selection was guided by circular hierarchy principles such as prioritising higher-value uses of materials.

Second, an evolved model for precincts, which provides the physical and organisational platform to bring projects together, sequence development, and enable shared infrastructure.

Third, the enabling conditions required to make this system work in practice, including coordination mechanisms, infrastructure, market development, and supporting policy and investment settings.

Action (from concept to delivery)

The report concludes with a set of recommended actions for the region. These focus on how to begin moving from concept to delivery, starting with the formation of action-driven coalitions, followed by steps to build and sequence a portfolio of projects, and to activate precincts and enabling conditions over time.

METHODOLOGY



Definitions - key concepts used in this report

This first section will provide the concepts that form the theoretical basis of the whole document. More than presenting concepts or definitions, our intent is to tap into a new way of thinking which is instrumental for seeing the underlying systems where each actor operates and the interconnection between them. This mindset shift is essential for working effectively with circular economy (as circular economy is a system's framework)

The table below lists and describes important definitions used throughout this report.

Table 1: Project definitions

Term	Description	Example relevant to this report	Source
Systems Thinking	An approach that looks at how different parts of a system interact and influence each other rather than analysing issues separately. It focuses on relationships, feedback loops and underlying structures that shape outcomes.	Nutrient runoff in the Proserpine catchment is influenced by fertiliser supply chains, farming practices, processing infrastructure, regulation and markets.	Donella Meadows – Thinking in Systems
Circular Economy	An economic model designed to keep materials, nutrients and energy circulating in productive use for as long as possible, reducing waste and maximising resource value.	Using agricultural and aquaculture residues to produce fertilisers, biomaterials or energy instead of disposing of them.	Ellen MacArthur Foundation
Bioeconomy	An economy where biological resources such as crops, residues and organic waste are used to produce food, energy, materials and chemicals.	Using sugarcane biomass or organic residues to produce fertilisers, biomethane or bio-based products.	OECD Bioeconomy
Biomanufacturing	Industrial production processes that use biological materials, organisms or biomass to manufacture products such as fuels, chemicals or fertilisers.	A facility converting organic residues from agriculture into biofertilisers or renewable gas.	CSIRO Bioeconomy
Value Chains	The sequence of activities required to produce, process and deliver a product to market.	The sugarcane value chain includes growing, harvesting, milling, processing and product distribution.	Porter, M. (1985) Competitive Advantage

Term	Description	Example relevant to this report	Source
Industry Value Drivers	The key factors that influence how an industry creates and captures value, such as cost efficiency, productivity, market demand and regulation.	For sugarcane growers, fertiliser cost, yield productivity and global sugar prices influence profitability.	Porter Strategy Framework
Industry By-products	Secondary materials generated during production that are not the main product but may have potential economic value.	Bagasse from sugar mills or organic residues from aquaculture operations.	Industrial Ecology literature
Nutrient & Energy Flows	The movement of nutrients, materials and energy through a production system or economy.	Nitrogen applied as fertiliser flows through crops, soil, waterways and downstream ecosystems.	Industrial Ecology
Material Flow Analysis (MFA)	A method used to quantify flows and stocks of materials within a defined system to understand how resources move through it.	Quantifying nitrogen entering farms, absorbed by crops and lost through runoff in the catchment.	Brunner & Rechberger – Handbook of MFA
Value Leakage	When potential economic value is lost from a system because resources are wasted, underused or exported without value addition.	Nutrients leaving farms as runoff instead of being recovered and reused as fertiliser products.	Circular economy literature
Precincts	An industrial or innovation zone where related activities co-locate to share infrastructure, common services and potentially material flows.	State Development Areas (SDAs), specifically the two in the Mackay Region (Racecourse and Rosella) have been set up to host industrial precincts	Queensland State Development Areas - Mackay

Term	Description	Example relevant to this report	Source
Industry Synergies	Opportunities where outputs or by-products from one industry become inputs for another, creating shared value.	Organic residues from aquaculture used together with agricultural biomass to produce fertiliser products.	Chertow (2000) Industrial Symbiosis
Stakeholder Analysis	A method used to identify actors involved in a system, understand their interests and influence, and assess their role in change.	Mapping growers, mills, aquaculture operators, government agencies and investors involved in circular initiatives.	Freeman (1984) Stakeholder Theory
Waste hierarchy (circular economy)	A tool to prioritise high-value reuse / recovery of materials before recycling / waste to energy and disposal.	Tool used to guide the selection of nutrients/ feedstocks and allocation to different circular clusters	The Waste hierarchy framework (DCCEW)
Investment Logic Framework (ILF / ILM)	It is a structured method used to justify investments by linking identified problems or opportunities to specific, measurable benefits and strategic solutions. It improves value-for-money by ensuring projects, address core issues.	Framework used during the stakeholder hotspots workshop to qualify circular clusters, identify and prioritise structural barriers and shortlist initiatives.	Investment logic mapping guide - QLD

Term	Description	Example relevant to this report	Source
Collaboration	The process of different organisations or stakeholders working together to achieve shared objectives.	Growers, industry, researchers and government agencies jointly exploring circular nutrient solutions.	OECD Collaboration frameworks
Clusters / Circular Pathways	Groups of related circular initiatives that share similar technologies, resources or markets and depend on similar enabling conditions.	Biomethane production, nutrient recovery and biomass processing forming interconnected circular pathways.	Porter Cluster Theory
Interventions / Hotspots in a System	Points within a system where targeted action can significantly influence outcomes or reduce negative impacts.	Areas in the production system where nutrient losses are highest and recovery solutions could be implemented.	Meadows – Leverage Points
Multi-Criteria Assessment (MCA)	A decision-making framework used to compare options using multiple criteria such as cost, environmental impact, feasibility and risk.	Evaluating circular initiatives based on scalability, economic viability, environmental benefit and complexity.	Belton & Stewart (2002)
Industrial Symbiosis	A form of collaboration where waste or by-products from one industry become inputs for another, creating resource efficiency across industries.	A sugar mill supplying organic residues to a nearby biomanufacturing facility producing fertiliser products.	International Society for Industrial Ecology
Regional Industrial Ecosystem	A network of industries, infrastructure and institutions that interact to support economic activity within a region.	The Greater Whitsunday region connecting agriculture, aquaculture, processing, energy and logistics systems.	Regional Innovation Systems literature

Term	Description	Example relevant to this report	Source
Enabling Conditions	The policies, infrastructure, finance, skills and market signals required for industries or technologies to scale successfully.	Access to processing infrastructure, investment capital and regulatory clarity for biofertiliser production.	OECD Innovation Systems

Project scope & system boundaries

Our project began with a clear set of scope components (outlined in the table below). These components served as system boundaries during our initial study and mapping of the current regional system (to be explored in section 3 - Designing the emerging system).

Table 2: Project scope and system boundaries

Scope Component	Name	Why?
Region	Greater Whitsunday	Reef Catchments has a regional focus the Mackay, Whitsunday and Issac region, as a result of its efforts, projects and regional planning is on this specific area.
Catchment	Proserpine	The Proserpine catchment has been identified as a priority area under the Reef 2050 Water Quality Improvement Plan , with dissolved inorganic nitrogen, primarily associated with sugarcane production, recognised as the key pollutant requiring reduction
Industrial Sectors	Sugarcane Aquaculture	Reef 2050 WQIP identifies DIN (dissolved inorganic nitrogen) associated with sugarcane production as the key pollutant requiring reduction to improve water quality outcomes. Additionally, land-based activities such as aquaculture operations are recognised as potential point sources of nutrients affecting coastal water quality.

Nutrient Cycles	Nitrogen (DIN) Pesticides	DIN has been identified as one of the most critical pollutants affecting Reef health with a target to reduce DIN loads by 60% across Great Barrier Reef Catchments. In the Mackay-Whitsunday region, the required reduction is 70% (equivalent to 630 tonnes of DIN by 2025). Catchment modelling shows that the Proserpine River alone contributes an estimated baseline load of around 312 tonnes of DIN. Pesticides are a priority pollutant under the Reef WQIP due to their toxicity to marine life; their target is to ensure end-of-catchment concentrations protect at least 99% of aquatic species.
Stakeholders	• Industry (sectors and their supply chains) • Government (State, Regional, Local) • Economic Development Bodies • R&D • Project Developers (investors)	As the objective of this project was to identify potential system shifts that could enable circular initiatives to scale, consultation was undertaken with actors across the regional system we were mapping. These stakeholders were identified as primary and secondary organisations influencing, and influenced by, the flows, decisions and conditions shaping the current system. See Appendix 1 for the full list of organisations that participated in and contributed to this study.

Approach and Methodology

Our approach followed a structured sequence to understand how the regional system operates today, where value is lost, and what is required for circular solutions to scale.

We began by mapping the sugarcane and aquaculture sectors, analysing value chains, economic drivers and material flows to understand how value is created and lost across the regional system. This was complemented by stakeholder engagement to examine how decisions are made in practice, what has already been tried, and what influences whether initiatives reach commercial scale.

Material flow analysis (MFA) of nitrogen and pesticides was then undertaken to quantify how these materials move through the regional system, identify where losses occur, and locate key hotspots for circular opportunity.

A review of existing circular initiatives revealed a consistent pattern: while many initiatives show strong potential and are technically feasible, most are not progressing beyond early-stage development. This

pointed us to a set of structural barriers, which were further tested and refined through stakeholder engagement and a facilitated workshop (Hotspots workshop).

This led to a deliberate shift in focus. Rather than keep identifying new circular opportunities that could potentially reach the same fate of the ones we analysed, the project focused on understanding why existing initiatives are not scaling, and what needs to change to enable them to do so.

Two frameworks supported this process: the circular economy waste hierarchy (cascade tool), used to prioritise higher-value circular pathways for existing feedstocks, and the Investment Logic Map (ILM), used to structure stakeholder discussions and identify system-level barriers.

Together, this approach combines system mapping, stakeholder insight and quantitative analysis to identify both where opportunities exist and what is required for them to scale.

The table below summarises how this approach was applied across each phase of the project.

Table 3: Approach and methodology

Project Phase	Focus	Main question	Key activities
Phase 1 - Define	Understand the system	How does the current system work today?	- Value chains (sugarcane, aquaculture) - Key stakeholders and roles - What drives decisions
Phase 2 - Analyse	Assess system performance through stakeholder engagement	What has already been tried, by whom and what is getting in the way?	- System level barriers - Current enabling conditions - Priority actions / shifts required
Phase 3 - Develop	Quantify and locate the problem	Where is the value being lost, and where are the biggest opportunities?	- MFA: nutrient flows (nitrogen, pesticides) - System hotspots (nutrient value-add opportunities) - Circular opportunities clusters and pathways to value
Phase 4 - Report	Answer the question	What structural barriers are holding the system back, what needs to change, and how can the region need to work together to design the new system?	- Structural system barriers - Enabling conditions (for scalability and industry development) - Recommended actions, coalitions, precincts required and action roadmap

This structured approach provides the foundation for the sections that follow, starting with a clear definition of the project vision and how success will be measured.

VISION



1.1 Policy context

This project aligns with a range of national, state and regional policy priorities aimed at strengthening Australia's bio-economy, improving water quality outcomes, and supporting regional industry development. Across these policy settings, there is growing emphasis on developing domestic bio-manufacturing capability (through value-adding innovation to our existing rich resource production sector), advancing biofuels and bio-based industries, and unlocking greater value from agricultural and organic resources.

The circular opportunities explored in this project directly support these objectives by identifying pathways to recover nutrients, convert biomass into higher-value products, and enable new bio-industrial activity within the region. In doing so, the project contributes to multiple government priorities, including the development of **biofuels and low-carbon energy at the national level**, the expansion of **biomanufacturing and bio-industry in Queensland**, and regional strategies focused on **water quality improvement, resource efficiency and economic diversification**.

In addition, many of the circular pathways identified in this study contribute to **industrial decarbonisation objectives** by reducing reliance on fossil-based inputs, enabling the production of low-carbon fuels and materials, and improving the efficiency of regional resource use. While decarbonisation is not the primary focus of the project, it represents an important co-benefit that aligns with broader government commitments to emissions reduction and the transition to low-carbon industry.

Figure 2 illustrates how the project sits at the intersection of several policy agendas, including Future made in Australia, Reef 2050 WQIP, QLD's Biofutures Roadmap, Prosper 2050, and regional strategies like State Development Areas (SDA), Mackay Future Foods Biohub, and many within industrial decarbonisation.

Cross-Government Policy Alignment (Local, State, Federal)

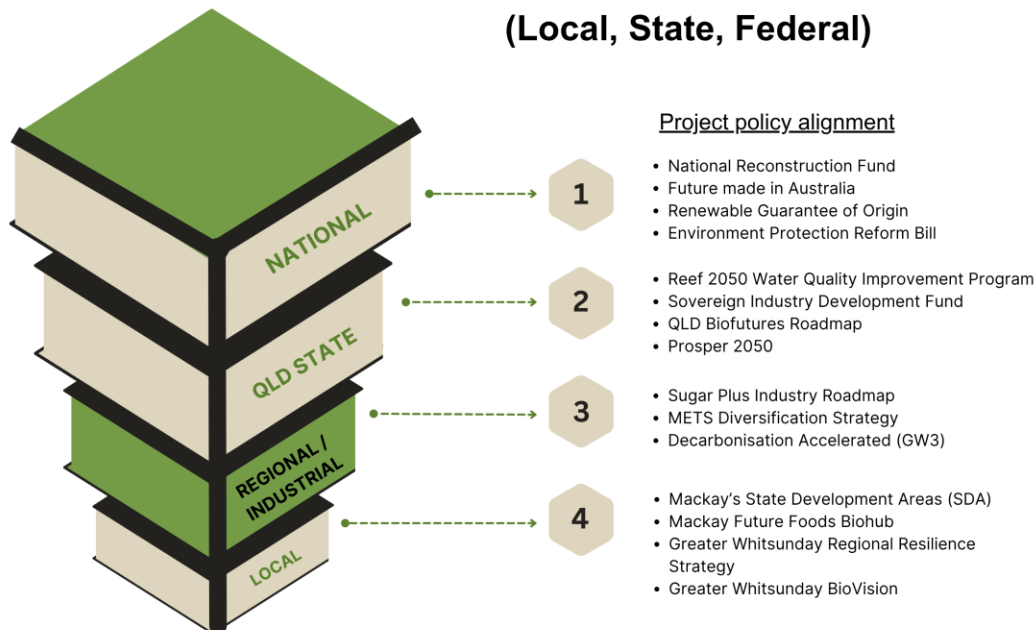


Figure 2: Project policy alignment across all levels of government

Together, these policy priorities provide the strategic context for the project and help shape the vision and measures of success outlined in the following section.

1.2 Goal - what success looks like

This project was initiated and funded by the Queensland Government's Reef Water Quality Program, which tasked Natural Resource Management (NRM) organisations with identifying opportunities that deliver both water quality improvements and regional economic and industry benefits.

While the primary objective remains to support the Reef 2050 Water Quality Improvement Plan target of a 70% reduction in dissolved inorganic nitrogen (DIN), the **project recognised that achieving this outcome requires action beyond traditional approaches**.

This includes moving upstream within the catchment, engaging with large landholders, government agencies, and industrial operators, and identifying opportunities that **capture and reuse excess nutrients before they impact downstream water quality**.

To define the project objective, within NRM and Water Quality context, the following question guided the work:

What role can NRMs play in enabling regional **economic transformation** that delivers environmental outcomes, such as improved water quality, while supporting new industry development aligned with the State's Bio-Futures Strategy and Industry Prosper 2050 Roadmap?

This project responds to that question by focusing on the regional system, rather than isolated projects, to understand what enables circular solutions to scale and deliver both water quality and economic outcomes:

Project Goal

Reduce water quality impacts by enabling circular solutions to scale and create economic value from nutrient recovery

How we will measure success

Water Quality	Partnerships	Added Value
Demonstrate pathways to reduce nutrient (DIN) and pesticide impacts, by identifying circular solutions that prevent nutrient leakage at source.	Enable coordinated partnerships across industry, government and stakeholders to progress circular solutions, align investment, efforts, and share risks and benefits across the system.	Act as a trusted bridge between innovation and practice through validation and supporting certification of bio-fertilisers and bioproducts, unlocking adoption and enabling new markets to develop. Thus, driving regional jobs, investment, and industry development.

The next section maps how the Greater Whitsunday regional system works today, including its industries, stakeholders, nutrient flows, decision making flows and emerging initiatives constraints.

UNDERSTANDING THE CURRENT SYSTEM



2.1 Why this type of project matters now

Global events are exposing how fragile our current system is. The 2026 conflict in Iran and frictions through the Strait of Hormuz has disrupted key supply routes for fuel, gas and fertiliser. Prices are rising quickly and supply is at high levels of uncertainty.

For regions such as the Greater Whitsunday, this is a direct signal of exposure. The agriculturally dominant region remains highly dependent on imported inputs and global supply chains, particularly for nitrogen fertilisers and energy. As prices rise and availability becomes uncertain, the impact is felt immediately by growers, processors and regional industries.

At the same time, momentum for local solutions is accelerating. Industry is actively exploring opportunities to build domestic capability, including biofuels, bioenergy and broader bio-based industries. Recent calls for a national ethanol mandate reflect a growing recognition that Australia must strengthen its energy and input security.

However, rapid momentum also carries risk. In times of pressure, the focus often goes to individual projects, funding grants, backing technologies, moving fast without fully addressing the conditions required for those solutions to scale.

Previously, the region explored many new uses for sugarcane and other organic resources. Most are finding a difficult path to scale. The system is not yet fully aligned to support coordinated delivery. For example, while there is strong interest in scaling bioenergy and biofuels, questions remain around how value, risk, and investment are structured (and would be shared) across the supply chain. This is the challenge - aligning the system, so value, risk, and investment are shared effectively to enable scalable, coordinated delivery.

The region needs to respond, but not just with projects. It needs to strengthen the **system that supports those projects**.

If this is not addressed, there is a real risk that new investments will face the same barriers as past efforts.

The question is not only how to act quickly, but **how to act in a way that we design a system that enables opportunities to scale effectively, deliver shared-value, and build long-term resilience?**

ACTING WITHOUT SYSTEM REDESIGN IS A RISK

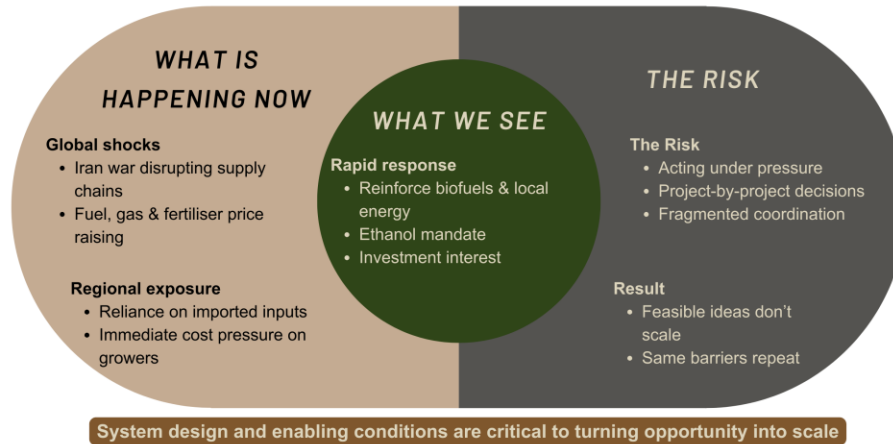


Figure 3: Why this type of project matters now

To respond effectively, we first needed to understand and map the regional system, anchored in the two selected sectors, sugarcane and aquaculture, to see how they operate and where value is created today.

The next section maps the sugarcane and aquaculture regional value chains, outlines the key drivers of value and how those influence the ability to scale new solutions.

2.2 How the regional system works today and what it reveals

How we build the current regional system picture

To understand the challenge, we first needed to step back and map how the regional system operates as a whole.

This section brings together multiple perspectives to build that picture, each providing a different piece of the system:

- **How value is created in the region** - through value chains and the role of key actors
- **Where value is lost, and where the biggest opportunities sit** - through material flow analysis and system outcomes
- **What has already been tried, and what happens when we try to change it** - through existing initiatives and project experience

- **What is holding the system back, and why it doesn't change** - through the identification of structural barriers

Taken together, these perspectives move from understanding how the system works today to explaining why progress has remained limited despite strong intent.

Viewed as a whole, this analysis provides a clear picture of the current regional system and its ability to support circular solutions at scale. Figure 4 shows the process used to map the system, setting out how each part was brought together and how insights emerged as the work progressed:

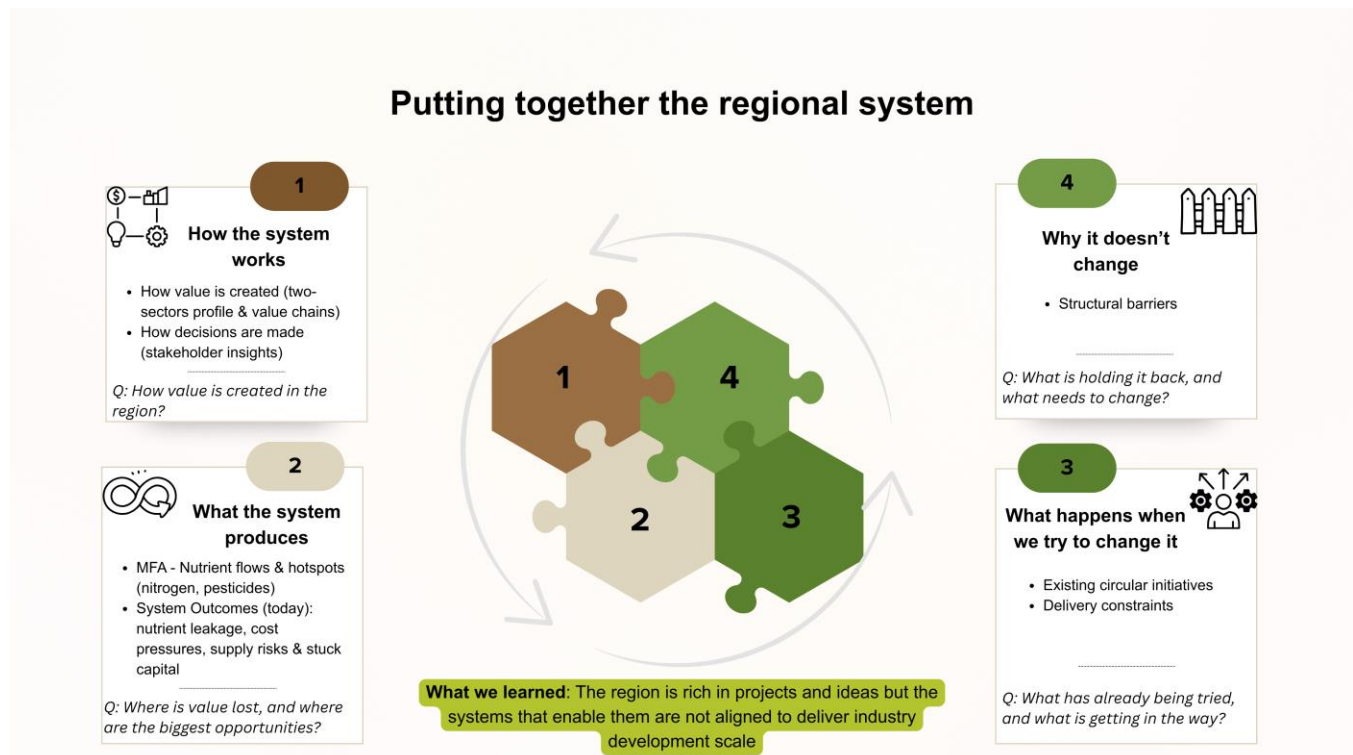


Figure 4: Mapping the current regional system – how we did it

2.2.1 Value chains and industry value drivers

This step examines how each sector's value chain works in practice: where value is created, who is involved, and what drives day-to-day decisions. This includes identifying the key stages in the supply chain, the main stakeholders, and the factors influencing their choices.

We also looked at what has already been tried. This included existing initiatives in resource recovery and value-adding, the challenges they have faced, and where industry sees future opportunities.

Starting here is important. It provides a clear, grounded view of the current system before identifying where and how change could occur.

Through this step, we developed:

- An overview of each sector across regional footprint, economic, social role, and environmental impact.
- The regional system represented by the sugarcane and aquaculture value chains, including key active stakeholders and their value drivers.

These elements are represented below:

A. Sugarcane - Sector Overview & Value Chain

Physical footprint and regional presence

The sugarcane industry produces one of Australia's largest export commodities (accounting for 69% of Australia's exported agricultural production over the past 3 years) . In Queensland, it is an important land user and represents² **more than 35% of all cropping land (~135,000 hectares)**³, making it one of the dominant uses of productive land in the region.

At a local scale, this footprint is clearly visible in Proserpine, where approximately ⁴, producing around **1.5 million tonnes of cane annually**.

This land footprint is tightly coupled with a deeply embedded and immovable infrastructure system. The industry operates through:

- A network of regional mills (5 across the Mackay–Proserpine area)
- Extensive cane rail infrastructure (~800–1,000 km) moving cane from farm to mill
- Bulk export infrastructure centred on the Port of Mackay, where most of the sugar is shipped internationally (predominantly to China)

This combination of land use and fixed infrastructure anchors the industry in the region, largely influencing how the system functions spatially and economically.

Economic Influence

Sugarcane is a foundational economic driver in Queensland, contributing approximately \$4 – 4.4 billion annually and supporting over 20,000–22,000 jobs across the value chain, with around \$1.4 billion in wages. ⁵

The industry is strongly export-oriented, with **around 80–85% of production exported**, embedding the region in global commodity markets and exposing it to international price volatility.

Regionally, its economic concentration is significant:

- 25–30% of jobs in the Whitsunday electorate are linked to the sugarcane value chain

²

³ (Australian Bureau of Statistics 2026)

⁴ (Australian Bureau of Statistics 2026)

⁵ (Greater Whitsunday Alliance, n.d.)

- Sugarcane contributes approximately \$329 million annually to the MIW regional economy ⁶

At the same time, their asset infrastructure is not fully utilised. Existing mills and transport infrastructure have spare capacity (e.g. ~1 million tonnes at Mackay Sugar mills), highlighting unrealised economic potential within the current system.

Social Role and Regional Dependency

The industry plays a critical social role as an employer and stabiliser of regional communities. Mills and associated supply chains support both permanent and seasonal employment, with large workforces mobilised during the crushing season.

However, structural challenges are emerging:

- Ageing grower base (average 65–70 years) without a clear and systematic succession plan in place
- Small average farm sizes (~30 ha)
- Reliance on contractor-based & highly coordinated harvesting systems delivered by specialised contractors servicing multiple farms. A harvesting model that works well under stable conditions but is becoming more sensitive to disruptions across labor, climate and milling operations

These factors point to increasing pressure on workforce renewal, productivity, and long-term system resilience.

Environmental Footprint and Influence

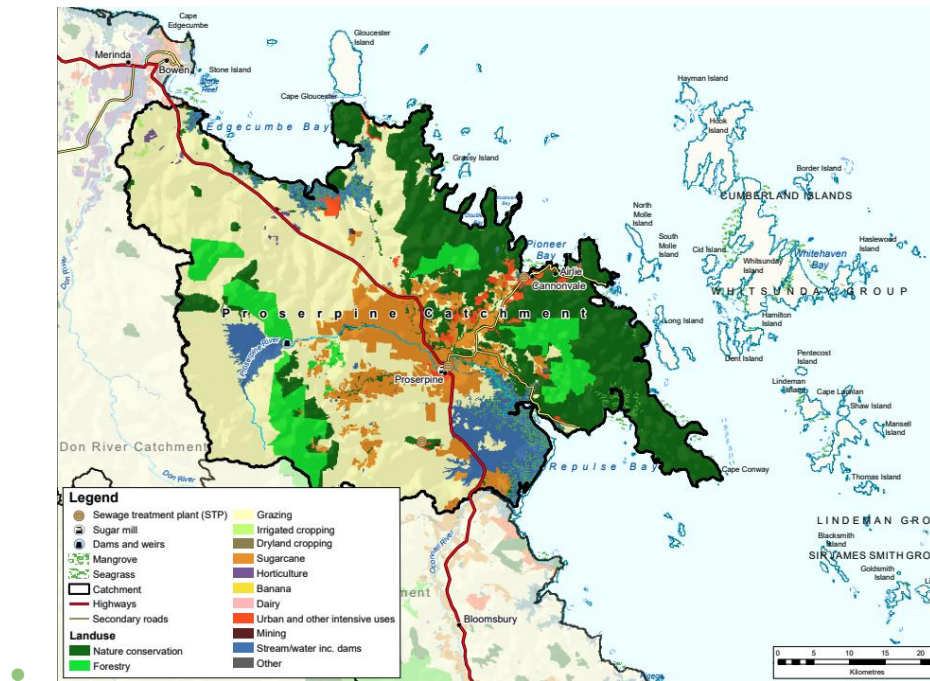
Given its scale and location within the Great Barrier Reef catchments, the sugarcane industry plays a central role in regional water quality outcomes.

Current evidence shows that sugarcane production is:

- Responsible for approximately **78% of dissolved inorganic nitrogen (DIN)**⁷

⁶ (DAFF 2025)

⁷ (Queensland Government 2025)



Dissolved inorganic nitrogen

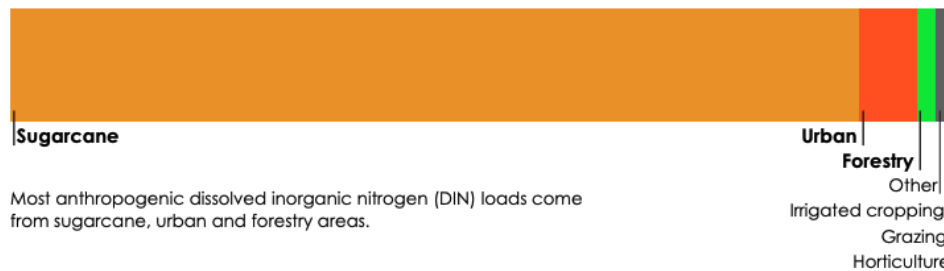


Figure 5: Proserpine catchment profile (Source: QLD Government)⁸

- And over 95% of pesticide loads entering reef catchments

This positions the sector as a central actor in water quality improvement efforts and a key focus of regulatory frameworks.

At the same time, the industry demonstrates a strong level of environmental engagement:

- Adoption of **Smartcane BMP (~50% grower participation)**
- Active nutrient and pesticide management programs
- Increasing alignment with Reef protection requirements

In parallel, the sector has been contributing positively through organically embedded circular practices:

⁸ (catchment-targets-mackay-whitsunday-proserpine 2025)

- Bagasse is used for renewable energy and cogeneration, providing substantial electricity to local communities and local transport infrastructure.
- Molasses are used for feed and ethanol production
- Mill mud and ash returned to farms as fertiliser

These flows already form part of a partially circular system, reducing waste and offsetting fossil fuel use.

The diagram below maps the sugarcane value chain as it operates in the region, from inputs and on-farm production through to milling, refining, and export. It identifies the key stages of value creation, the primary organisations involved at each stage, and the main value drivers shaping decisions, behaviours and trade-offs across the system.

These value drivers reflect the economic, operational, regulatory and environmental factors influencing how stakeholders operate at each stage of the value chain.

This mapping was developed through desktop analysis and subsequently tested and refined in a multi-stakeholder workshop, involving representatives from the sugarcane and aquaculture sectors, enabling organisations and NRM bodies.

Participants validated the key actors and value drivers, and provided additional input to ensure the representation reflects how the system operates in practice. This shared view formed the foundation for the stakeholder analysis and material and nutrient flow assessment presented in the following sections.

Sugarcane Value Chain & Sector Ecosystem

Figure 6: Sugarcane value chain & sector ecosystem

SUGARCANE VALUE CHAIN

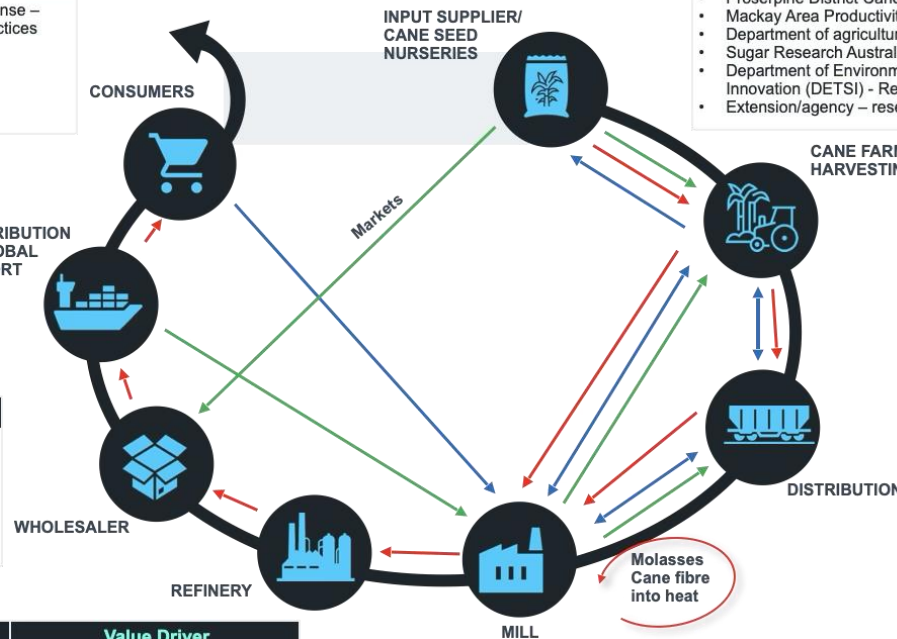
Colour Marker Index
Resource
Information
Money

Stakeholders	Value Driver
Australians	Social License – ethical practices
International	

Stakeholders	Value Driver
Sugar Terminals Limited • Mackay Port Terminal	Money

Stakeholders	Value Driver
Sugar Australia • Glebe Packing Plant	Money
Queensland Sugar Limited (QSL)	

Stakeholders	Value Driver
Sugar Australia • Racecourse Refinery (Home of CRS Sugar) • Yarraville Refinery in Melbourne	• Money • Efficiency • Quality products
Other commodity partners • Distillery (alcohol) • Pharmaceuticals • Bio dunda (Ag fertiliser from biomass) • Sugar Mulch – cane residue • Bio fuels – electricity • Concrete – trash + cellulose (seaweed) • Seaweed + cause – biochar & absorption • Mill mud	



Stakeholders	Value Driver
• Fertilisers (Wilmar, Incitec Pivot (Ridley Corporation), Nutrient Ag Solutions, Impact Fertilisers) • Soil & Plant Analysis services (SSP) • Proserpine District Cane Productivity • Mackay Area Productivity Services (MAPS) • Department of agriculture & fisheries (DAFF) • Sugar Research Australia (SRA) - cane seed varieties • Department of Environment, Tourism, Science & Innovation (DETSI) - Reef Regulations • Extension/agency – resellers	• Crop quality • Cost of ingredients/product (urea) • Sustainability of ingredients • Resilient varieties of cane seed • Storage, mixing and delivery infrastructure performance

Stakeholders	Value Driver
• Proserpine Growers / Land Managers • Contractors • Resellers • RCL (practice) • Irrigation management - Waterboards • DAFF • MAPS • DETSI Reef regulations	• Crop quality • Irrigation efficiency • Practices efficiency - Technology robotics/AI • Crop protection Chemical options/treatments • Reef regulations weather/ spray windows

Stakeholders	Value Driver
• Mackay Sugar • Cane rail network • Trucks	• Efficiency - Improving infrastructure • Money
• Wilmar International • Wilmar rail network • Haulage contractors • Warren Transport Proserpine - trucks	

Stakeholders	Value Driver
• Mackay Sugar (Farleigh, Marian, Racecourse) • Wilmar International (Plane Creek Mill, Proserpine Mill) • Tully • MSF • Isis Central • Bundaberg • Government • NC markets/consultants	• Mill efficiency/performance • Carbon market natural capital (NC) • Stronger workforce/lower turnover

B. Aquaculture - Sector Overview & Value Chain

Regional Footprint and System Presence

Aquaculture in the Greater Whitsunday region is shaped by its coastal geography, access to water resources, and proximity to established agricultural and logistics networks. The region hosts two designated Aquaculture Development Areas (ADAs), positioning it as a strategic location for industry growth, particularly for high-value species such as prawns and barramundi.

Production is spatially concentrated along coastal and low-lying areas suitable for pond-based and marine farming systems, operating in close connection with surrounding land uses and marine environments, including the Great Barrier Reef catchments.

Economic Contribution and Industry Role

Aquaculture represents a growing and increasingly significant contributor to the regional economy, complementing established agricultural industries. Regional production is forecast to increase from approximately 5,000 tonnes in 2020 to 20,000 tonnes by 2030, reaching an estimated \$116 million in annual production value.⁹

This growth aligns with broader Queensland industry trends, where aquaculture production reached 11,353 tonnes in 2022–23, reflecting a 17.1% increase year-on-year, largely driven by the prawn sector. The industry is valued at approximately \$263.3 million (2023–24), accounting for around 62.5% of Queensland's total fisheries value¹⁰, with prawns and barramundi representing the largest share of production value.

Within the regional context, aquaculture contributes to the diversification of the agriculture, forestry and fishing sector, which includes 285 businesses and supports 7.8% of employment in the Proserpine area. Compared to other agricultural activities, the sector is characterised by higher value per unit of production, with a strong focus on premium domestic and export markets, particularly for species such as prawns and barramundi¹¹.

Social Role and Regional Integration

Aquaculture contributes to regional employment, skills development and industry capability, forming part of a broader working landscape that includes agriculture, tourism and marine-based industries.

⁹ (Greater Whitsunday Alliance 2023)

¹⁰ (Department of Agriculture and Fisheries, n.d.)

¹¹ (Fisheries Research and Development Corporation, n.d.)

Across Queensland, the sector supports approximately 890 full-time equivalent jobs, with around 55% associated with prawn farming¹².

In the Greater Whitsunday region, workforce development is supported by enabling infrastructure such as the Aquaculture Centre for Excellence at Whitsunday TAFE, which provides training in fish farming, hatchery operations and pond management. The sector also contributes to regional development priorities, including opportunities linked to skills pathways and emerging participation from First Nations communities.

The sector is also connected to a broader network of suppliers and service providers, including feed production, hatcheries, logistics and processing, contributing to indirect employment and regional economic activity.

Environmental footprint and influence

Aquaculture operates within a highly regulated and environmentally sensitive context, with many farms located within or adjacent to Great Barrier Reef catchments and marine environments, where water quality and ecosystem health are closely managed.

Activities are regulated under Queensland's environmental protection framework, including classification as an Environmentally Relevant Activity (ERA), with requirements relating to discharge, biosecurity and habitat management.

The sector interacts directly with nutrient and water systems through feed inputs, effluent discharge and pond management practices. Industry practices are increasingly supported by third-party certification schemes, particularly within the prawn sector, contributing to environmental compliance, market access and social licence.

Aquaculture systems operate through controlled production environments that manage water, feed and nutrient inputs, creating defined pathways for material flows between the farm and surrounding ecosystems.

These characteristics position aquaculture as a system with clearly defined input and output streams, which can be mapped and analysed to better understand resource use and potential value recovery pathways.

The diagram below maps the aquaculture value chain as it operates in the region, from inputs and hatchery operations through to grow-out, processing, and distribution to domestic and export markets. It identifies the key stages of value creation, the primary organisations involved at each stage, and the main value drivers shaping decisions, behaviours and trade-offs across the system.

These value drivers reflect the economic, operational, regulatory and environmental factors influencing how stakeholders operate at each stage of the value chain.

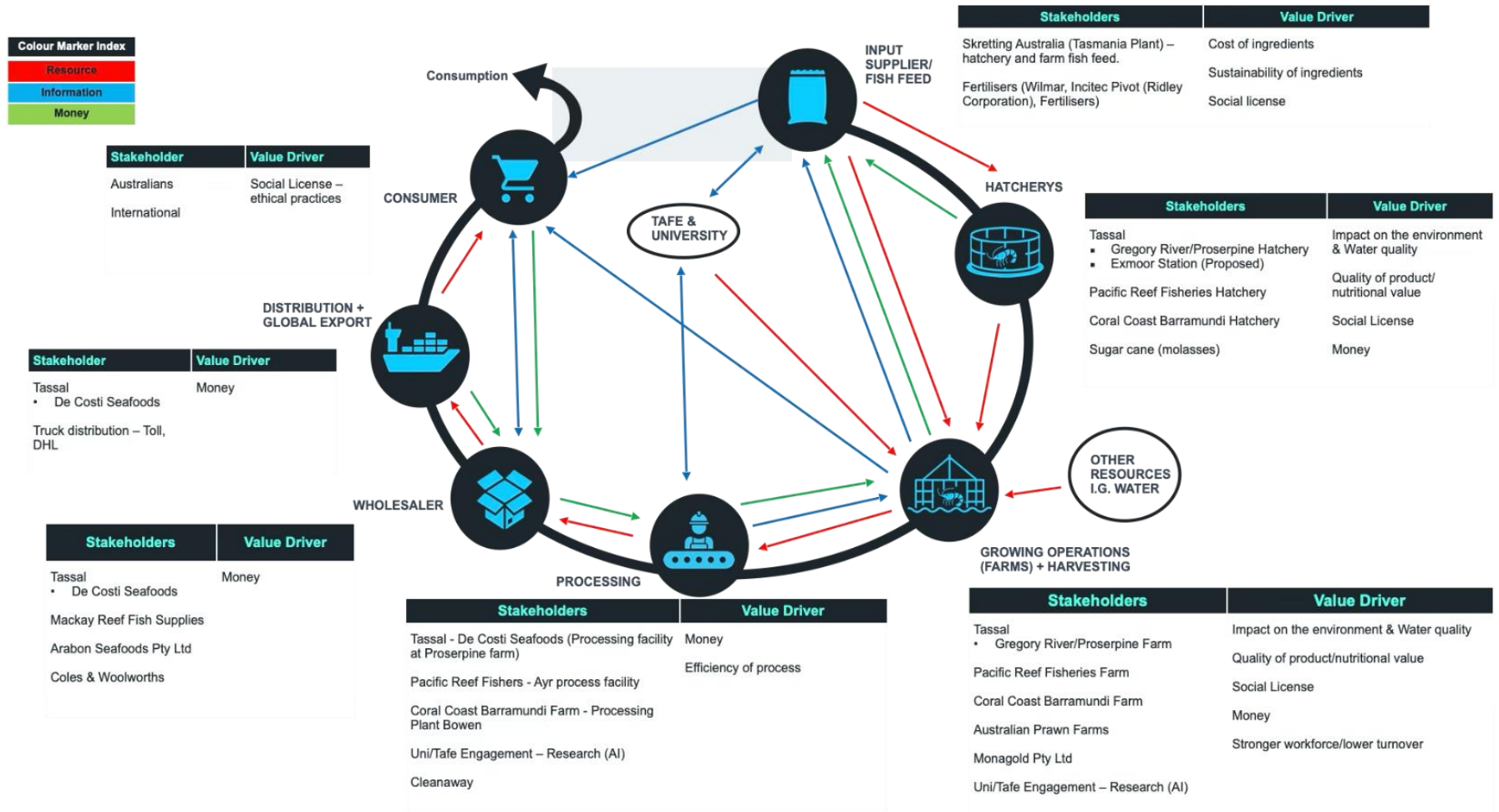
¹² (Greater Whitsunday Alliance 2023)

This mapping was developed through desktop analysis and subsequently tested and refined in a multi-stakeholder workshop, involving representatives from the aquaculture and sugarcane sectors, enabling organisations and NRM bodies.

Participants validated the key actors and value drivers, and provided additional input to ensure the representation reflects how the system operates in practice. This shared view formed the foundation for the stakeholder analysis and material and nutrient flow assessment presented in the following section.

Aquaculture value chain & sector ecosystem

Figure 7: Aquaculture value chain & sector ecosystem



In essence, the regional system examined in this study is anchored by two key primary industries: **sugarcane and aquaculture**.

Each plays a distinct but complementary role. Sugarcane underpins the region through its scale, land-use, and established infrastructure, while aquaculture contributes through high-value production and emerging growth. Both are closely linked to natural resource systems and rely on coordinated interactions across their supply chains.

Together, they shape how resources flow and how value is created across the region. This value chain perspective provides a view of the system's physical and economic footprint.

To understand how this system operates in practice, the next section shifts focus to the actors within it, examining how decisions are made, what drives them, and the conditions influencing action across the region.

2.2.2 Stakeholder Analysis – shortlisted stakeholders

An initial stakeholder identification was performed as we mapped both sectors' value chains. We asked workshop participants to identify the key regional stakeholders linked to each stage of the supply chain.

While the material flow analysis shows how resources move through the system, understanding stakeholders helps explain how decisions are made. It highlights who influences outcomes, who is affected by them, and where alignment or gaps may exist.

As the focus of this analysis is to understand the regional system around these two sectors, it is important to identify stakeholders and consider their level of influence, how their decisions and actions impact or influence the regional system but also how other's decisions and actors in the regional system influence or impact them directly.

Stakeholders were identified based on the mapped value chains (see Figures 6 & 7), and classified as **primary** (direct supply chain participants) and **secondary** (indirect influencers or affected parties). The final shortlisted stakeholders are presented below, with full details of our stakeholder analysis and multi-criteria selection process included in Appendix 1.

The **shortlisted stakeholders** (primary and secondary) formed the basis of the interviews and insights presented in the following sections.

Table 4: Shortlisted stakeholders (primary and secondary)

Shortlisted Primary Stakeholders	Shortlisted Secondary Stakeholders
Tassal	Sunwater
Australian Prawn Farms	Mackay Regional Council
Mackay Sugar	Regional Development Australia (MWI)
Wilmar International	Department of Primary Industries
Nutrients Ag - Fertiliser	Queensland University (QUT)
Incitec Pivot Fertiliser	Greater Whitsunday Alliance (GW3)

In addition to value chain stakeholders, we also engaged with a group of existing project proponents, including investors, technology providers and industry-led initiatives currently working to develop or scale circular solutions or energy projects.

While these actors do not sit directly within the mapped value chains, they provide a different perspective on how the regional system performs in practice. Their experience provided us with insights on the real challenges of moving from concept to scale, including barriers related to investment, coordination, and delivery.

Several of these proponents were identified through the initial mapping process and considered to ensure these practical insights were captured.

Table 5: Regional project proponents considered in this report

Regional Project Proponents
Townsend Industries
Wildfire Energy
Jupiter RE
QUT Biorefining Research Facility (Banyo Pilot Plant)

A. What we learned from the interviews

A total of 13 interviews were conducted. (Not all stakeholders identified for this study participated in the interview process, either due to availability or timing constraints).

The purpose of these interviews was to hear directly from organisations about how they are approaching circularity in practice, what they have tried (and why), what has worked (or not), and was currently shaping their decisions.

These insights provide a practical view of **how the system is currently performing** from an industry, project proponents, and government perspective.

The interviews focused on three areas:

- Current level of knowledge and maturity in circular initiatives
- Investment appetite, conditions required, and willingness to collaborate
- Key challenges faced, including why existing initiatives have struggled to progress or scale, and how core business priorities influence decision-making.

Across interviews, stakeholders consistently described a system where ideas, pilots and strategies are not the constraint. Most organisations have trialled initiatives or are aware of many opportunities to recover value from existing resources.

However, these efforts are not progressing beyond early stages.

The insights below synthesise perspectives gathered across industry, government, and project proponents. They reflect common patterns observed across interviews, focusing on how the current system operates in practice and where constraints to scaling circular initiatives exist.

Table 6: Insights from shortlisted stakeholder interviews

Insight area	Industry (sugarcane & aquaculture)	Government & regional bodies	Proponents & Innovators
Current position (what they are doing today)	• Circularity is largely approached through operational efficiency and cost management. • Practices such as reuse of by-products are already embedded, but primarily to support existing operations rather than create new value streams. • New opportunities (e.g. seaweed, biomaterials, nutrient recovery) are being explored but remain at pilot or concept stage	• Strong alignment with bio-economy and regional development agendas. • Focus is on enabling conditions such as planning, infrastructure, and policy alignment. • Limited direct involvement in commercial delivery of circular initiatives.	• Technologies and concepts are often developed or proven at pilot scale. • Some infrastructure or early-stage investment has already been committed. • However, most initiatives have not progressed to full commercial operation.
Investment & collaboration behaviour	• Investment decisions are driven by core business performance. • Initiatives are considered where they deliver clear operational or financial benefit. • Collaboration across sectors is limited and often not sustained beyond initial discussions. • Large capital investments are difficult to justify without proven returns	• Investment is contingent on clear business cases, defined proponents, and co-investment from industry. • Government plays a facilitation role but does not lead commercial ventures. • Funding processes are structured and criteria-driven.	• Actively seeking partnerships across industry and government. • Investment models are typically dependent on a combination of private capital and public funding. • Progress is often constrained by the need to secure multiple aligned commitments (e.g. funding, off-take agreements).
What is working vs not working in practice	• Incremental improvements within existing systems are working. • However, new initiatives struggle to move beyond pilot stage. • There is limited integration across the value chain, and benefits are not always shared in a way that encourages participation.	• Strategic intent and policy direction are clear, but translation into coordinated action is limited. • Multiple studies and initiatives exist, but there is a lack of continuity and follow-through to implementation.	• Technical feasibility is often demonstrated, but commercial viability remains a barrier. • Projects frequently stall between pilot and scale due to risk allocation, funding gaps, and lack of committed partners.
What is driving decisions right now	• Cost pressures (e.g. fertiliser, energy), operational constraints, and exposure to global market volatility are primary drivers. • Focus remains on maintaining core business performance and managing risk.	• Competing priorities across government agendas, limited funding availability, and the need to justify public investment. • Preference for initiatives that demonstrate clear economic and regional benefits.	• Immediate priorities include securing funding, establishing off take agreements, and gaining government support. • Frustration with slow processes and misalignment between funding criteria and project needs.

These insights describe how different parts of the regional system behave, how decisions are made, where efforts stall, and why many initiatives do not progress beyond early stages. They point to patterns in how work gets done across the region.

The next section looks at the same system from a different angle. Instead of focusing on people and decisions, it focuses on what is physically moving through the regional system, where nutrients are coming from, where they end up, and where they build over time. This helps identify the points in the system where there is both a problem (ie. losses to waterways) and an opportunity to capture value.

Taken together, the stakeholder insights and the material flow analysis provide a clearer picture of both how the system operates and where targeted action is most needed to support initiatives that can move beyond pilot and into delivery at scale.

2.3 What the regional system is producing today

2.3.1 Resource and nutrient flows (Material Flow Analysis)

A. Scope & purpose (what we looked at)

Material Flow Analysis (MFA) is a method to understand the movement of substances both spatially and in terms of stages in supply chains, it can reveal how substances partition between different environmental compartments, different chemical forms and where in the supply chain materials ultimately end up. When looking at the circular economy the MFA can identify current circular loops and potential opportunities to increase circularity. For our study, the key scope components considered were:

- Industries: sugarcane + aquaculture
- Focus: nitrogen + pesticides
- Geography: Proserpine catchment; Greater Whitsunday Region
- Timeframe: 1 year
- Why it matters: It helps us see where nutrients end up and where they are lost

B. Data sources & approach (how we build the picture)

Table 7: Scope and data components used in the development of the MFA

Sugarcane	
Data Sources	Approach
Sugarcane • Lifecycle inventory data from Australian Life Cycle Database • Sugarcane production in region (ABS statistics) • Pesticide degradation rates on farm and off farm (PestLCI – partitioning model) Aquaculture • Review of Nutrient Release From Aquaculture – Griffith University ◦ Pond dynamics product volumes etc • Eco-efficiency assessment of shrimp aquaculture production in Mexico (Cortez et al 2021) ◦ Feed mix • The fate of nitrogenous waste from shrimp feeding (Burford and Williams 2001) • Chemical composition of some seaweed from Mediterranean Sea coast, Egypt ◦ Seaweed characteristics • Trichlorfon use - Mann, D (2024) • Copper Sulphate use, Kubitz, F. (2023) • Formalin use Ruth Francis-Floyd (2023)	What was mapped: Farm to Mill, Mill to wastewater, Wastewater to environment Note that with sankey diagrams thicker lines means more material

C. MFA - Sugarcane Industry

Sugar Nitrogen MFA

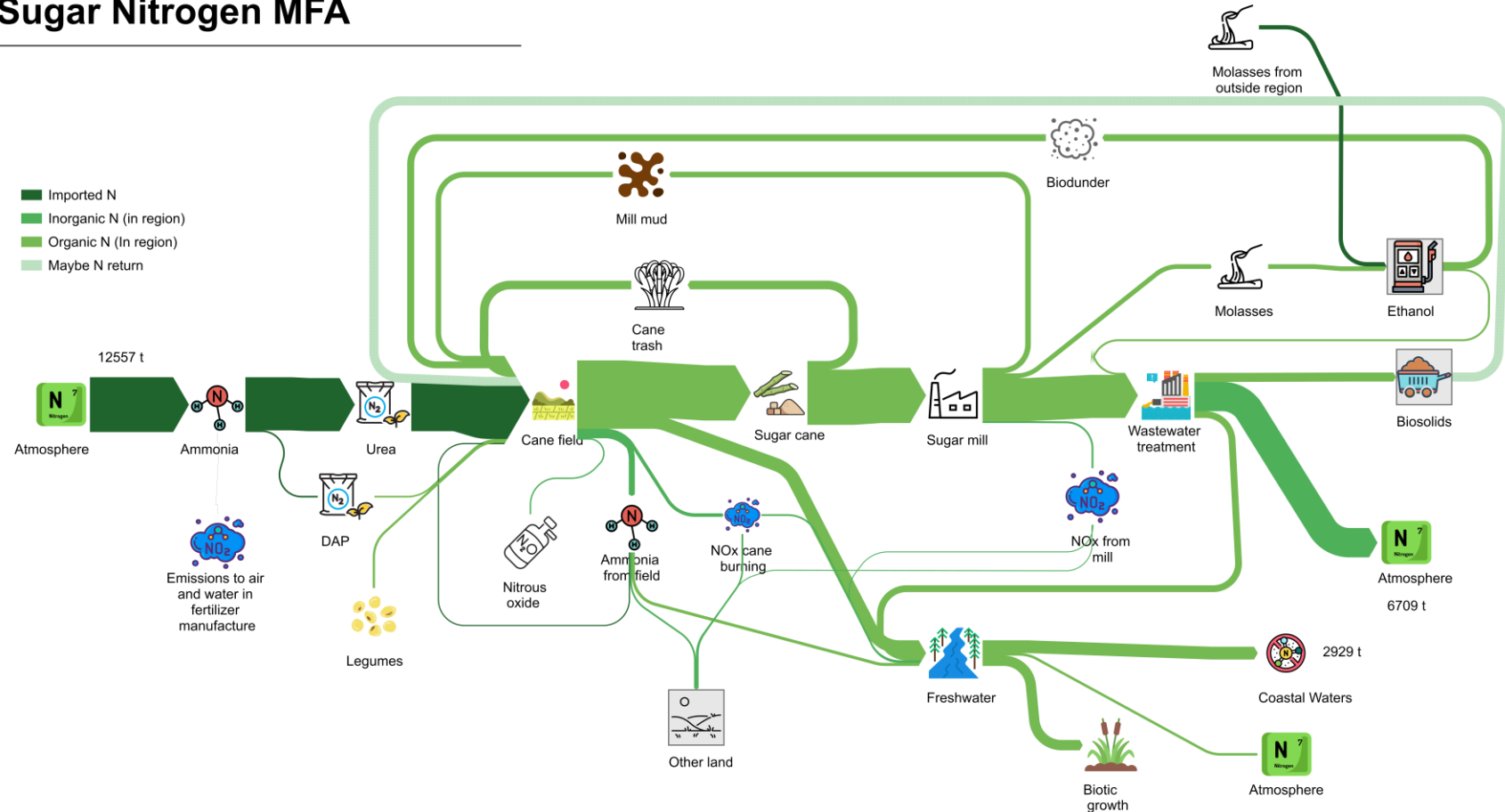


Figure 8: Material Flow Diagram - Sugar Nitrogen

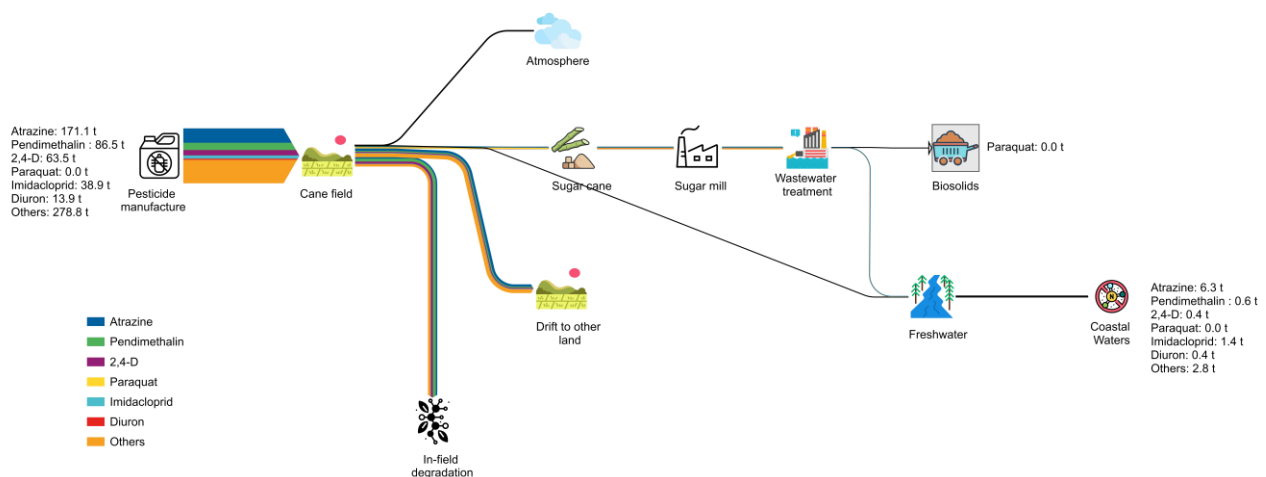
Key insights - Sugar Nitrogen MFA

- Most nitrogen comes from outside region (and country)
- Nitrogen comes in the form of Urea and DAP
- 27% of Nitrogen used in the region is from recycled or biological sources (referring to Wilmar's Dunder product and some level use of organic fertilisers)
- Sugar has no Nitrogen content, but sugarcane does! (very little to none nitrogen ends up in the product/sugar)
- Regional production of ethanol helps close the nitrogen cycle
- Nitrogen mainly ends up in air, **waterways** and waste streams

Material Flow Diagram - Pesticides

Sugarcane - Pesticides (mass)

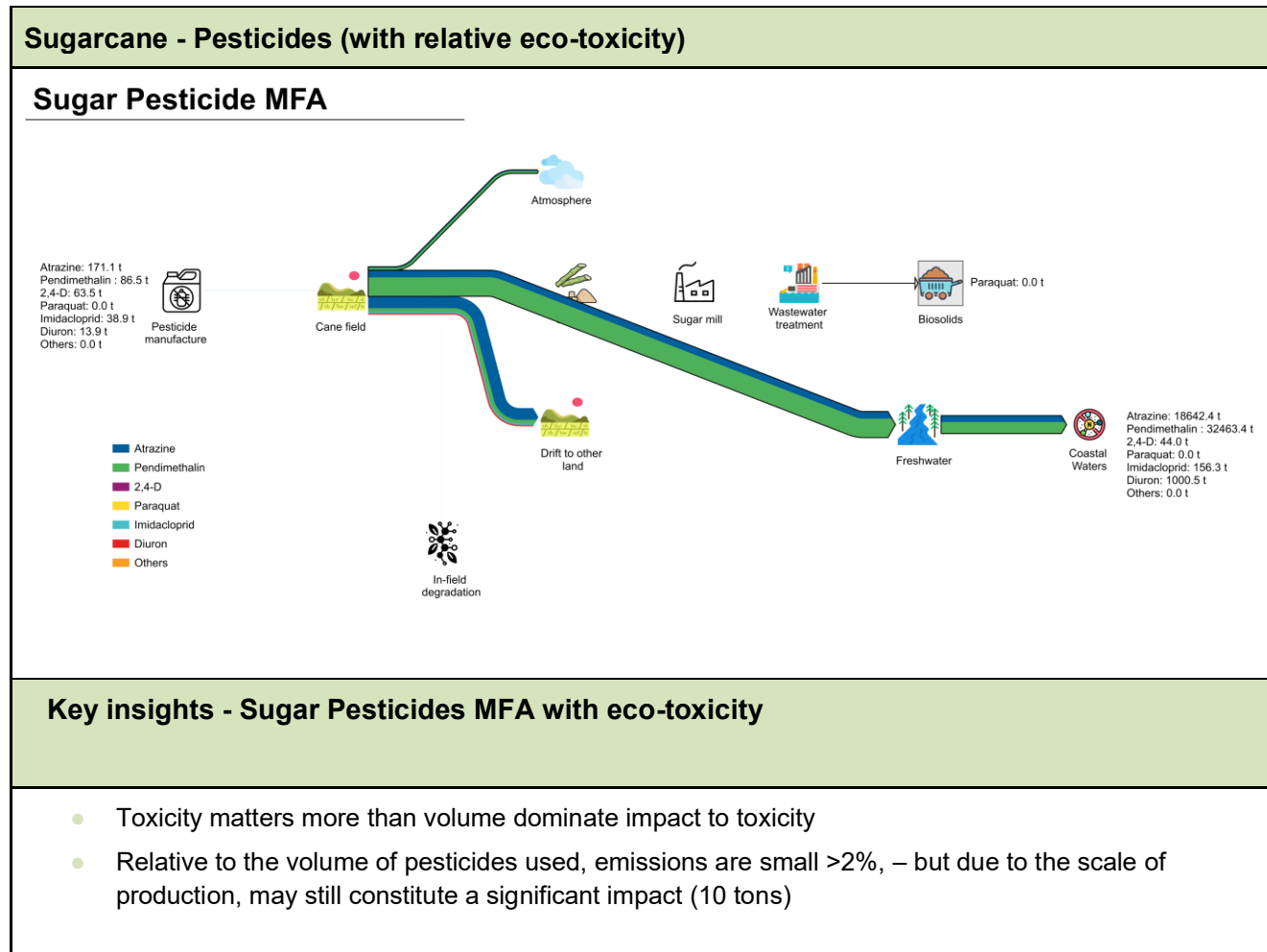
Sugar Pesticide MFA



Key insights - Sugar Pesticides MFA

- Large volumes used, most stay/degrade on farm
- Small % escapes → but still ~10 tons/year to ocean

Material Flow Diagram - Pesticides showing relative ecotoxicity



D. MFA - Aquaculture industry

Prawn Nitrogen MFA

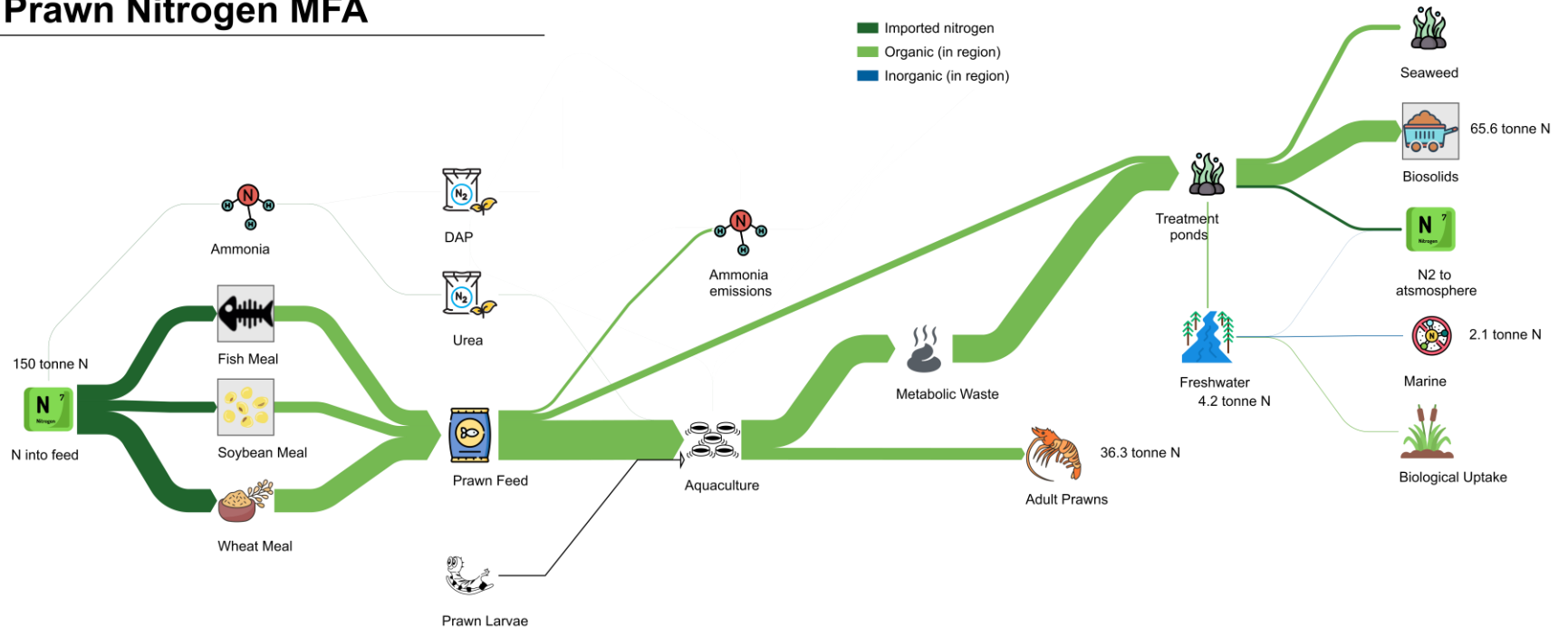


Figure 9: Material Flow Diagram – Aquaculture Nitrogen

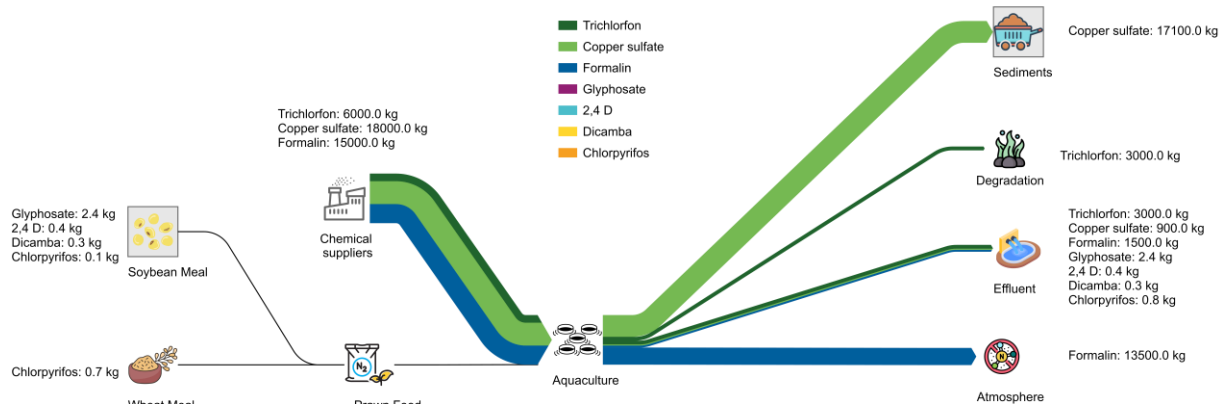
Key insights - Aquaculture Nitrogen MFA

- All nitrogen inputs come from outside the region
- Feed inputs are the main Nitrogen input contributor
- More than ⅔ of Nitrogen from the industry leaves as waste, particularly metabolic waste (including suspended solids, pond bioremediation only takes a small %)
- Treatment ponds (bioremediation) remove most of the Nitrogen with small fractions going air and to marine environment (2.1 T)

Material Flow Diagram - Pond Pesticides

Prawn Aquaculture pesticide MFA - including pond pesticide additions

Prawn Aquaculture pesticide MFA

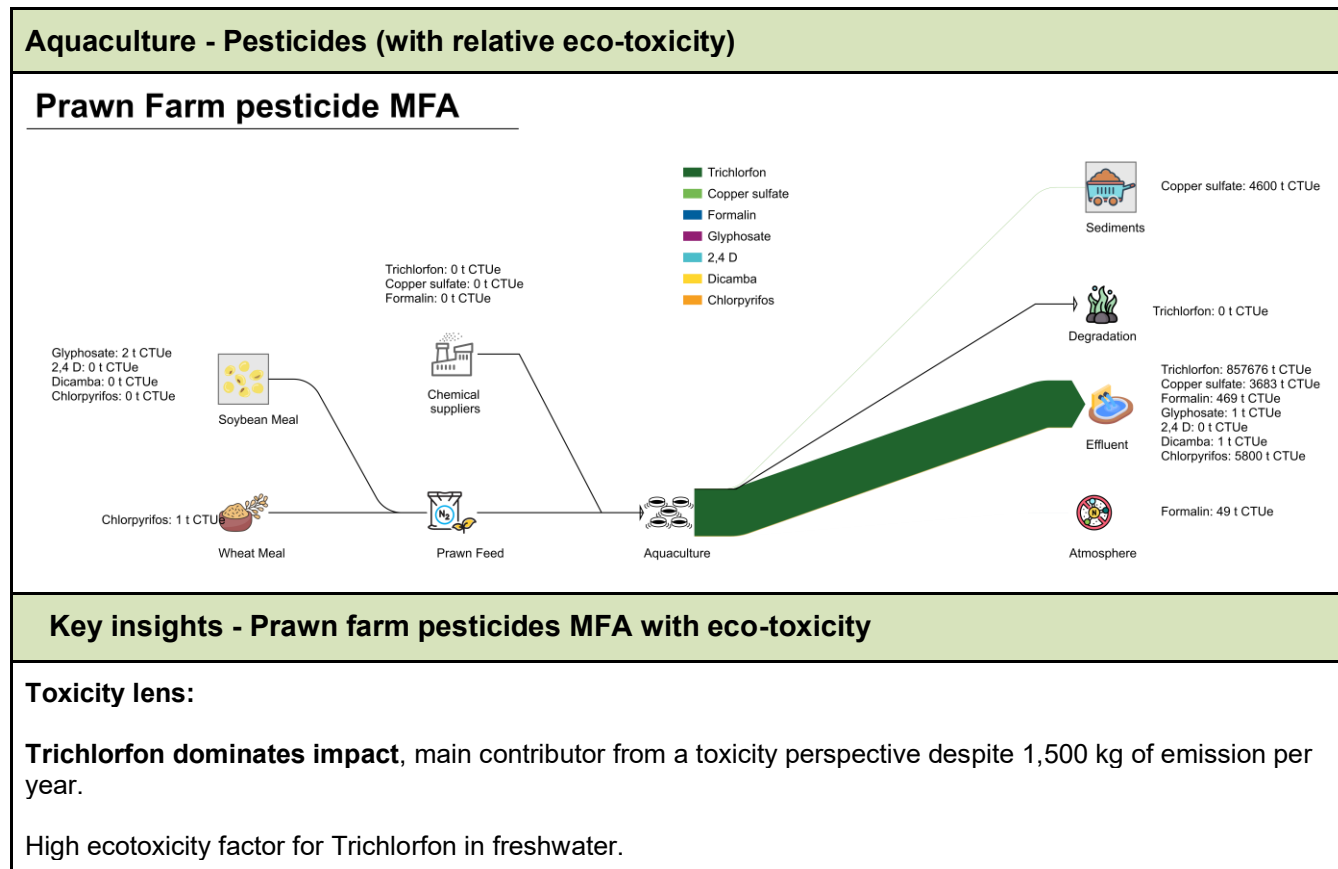


Key insights - Aquaculture Pesticides MFA

An important distinction, we mapped feed pesticides and recorded that they are 3-4 orders of magnitude smaller than pond inputs.

- Feed inputs = negligible
- Pond chemicals = dominant -> copper sulphate, formalin are the largest flows

Material Flow Diagram - Pond Pesticides showing relative ecotoxicity



E. Hotspots & MFA interpretation

As the data from both sectors was brought together, a consistent pattern emerged. The material flow analysis (MFA) highlighted a small number of points in the system where nutrients enter, accumulate, or are lost. These points represent the most relevant hotspots for circular opportunities.

Table 8: MFA's interpretation & insights captured

1	Entry points: where nutrients enter the system Across both sectors, nitrogen enters the system through a limited number of inputs: - In the sugarcane sector, fertiliser is the dominant source of nitrogen - In the aquaculture sector, aquafeed plays an equivalent role Influence is concentrated. To develop circularity at scale, it will be important (if not necessary) to involve these upstream input providers (fertiliser and aquafeed). In some cases, in Queensland, the same organisations are involved in supplying both fertiliser and aquafeed. This creates a clear hotspot for intervention, where coordinated solutions across both sectors could be explored. Implication for opportunity This creates a clear opportunity to work upstream, in partnership with input providers (fertiliser and aquafeed), to redesign how nutrients enter the system rather than only trying to recover them downstream.
2	Accumulation points: where nutrients concentrate At the other end of the system, the MFA highlighted where nitrogen and associated materials accumulate: - In aquaculture, settlement ponds act as major collection points. Despite existing efforts in bioremediation, these ponds still contain significant volumes of: - nutrients - CO₂ (linked to seaweed systems) - oils and soft shells - biosolids - Water Implication for opportunity These are not waste streams. They are concentrated resource pools with potential for further processing and value creation (as much as tailings are to mining). In this sense, settlement ponds can be understood as 'ponds of circular opportunity', with potential for: - Nutrient recovery - Bio-feedstock extraction - Further processing and value-add pathways
3	Loss points: where nitrogen leaves the system In the sugarcane sector, the MFA showed a different pattern. The final product, sugar, carries no nitrogen. This means that most of the nitrogen introduced into the system is lost along the process, primarily through: - wastewater - effluent and discharge streams

	Implication for opportunity Wastewater and discharge systems represent a key hotspot for circular intervention around: • Nutrient capture • Treatment and reuse • Integration into circular input streams
4	Existing circularity: what is already working The analysis also showed that circularity is already occurring within the sugarcane system. Approximately 27% of nitrogen flows are currently circular, driven by: • reuse of by-products back to farms • processing of molasses into liquid fertilisers for local use This shows that circular practices are viable in the region, and have been implemented successfully, but those are not yet maximised or systematised.
5	Pesticides: a different challenge The pesticide analysis took a different lens, focusing on toxicity rather than volume. Across both sectors, concentration was observed in a small number of key chemicals: • Sugarcane: Atrazine and Pendimethalin • Aquaculture: Trichlorfon Unlike nitrogen, circular solutions for pesticides are less developed and more complex. Insights from discussions with QUT researchers highlighted that the most promising pathways are not based on recovery, but on reduction at source, including: • improved soil health • increased biodiversity • more sustainable agricultural practices Implication for opportunity For pesticides, the opportunity sits upstream, not downstream: • Reduce reliance rather than recover flows • Integrate water quality objectives with sustainable agriculture programs, rather than standalone circular solutions
6	Summary: where the key hotspots sit Across both sectors, the MFA points to three priority areas for action (specifically for nitrogen flows and other biomass identified): • Upstream inputs: All concentrated upstream -> fertiliser and aquafeed supply • System accumulation points: settlement ponds and biosolid streams • System loss points: wastewater and discharge flows • Important to note that some circular practices already exist but are not yet scaled

	These hotspots provide the most practical entry points for developing circular initiatives that can both reduce nutrient loss and unlock new sources of value. Important: The opportunity is not in isolated interventions, but in coordinating action across these hotspots to retain value within the regional system.
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These material flows reveal where resource value is currently lost in the regional system, we leverage this information in sections below when we identify clusters and circular opportunities to explore.

2.3.2 Outcomes produced by today's regional system

When looking at the system today, a consistent set of outcomes starts to emerge across different parts of the region.

By outcomes, we mean what is actually happening on the ground, for example, ongoing water quality pressures where nutrient runoff continues to increase as industries grow (such as aquaculture), and nutrients are lost through mill performance in sugarcane. These are still being treated as a cost to manage, rather than something that could be recovered and turned into value within operations.

This points to missed opportunities to recover nutrients and create new value within existing business models. The following sections bring these together, highlighting what is currently happening and where pressures and gaps are becoming visible. While not exhaustive, they focus on the main outcomes consistently observed across the region.

Table 9: Outputs produced by today's regional system

Water Quality	
	Water quality targets remain difficult to achieve despite ongoing investment and action. • DIN loads remain above target levels in priority catchments (~2 to 3x above target levels) • Efforts are focused on managing impacts with lower influence at the source • Nutrient losses from main land users (industrial) continue to leave the system rather than being recovered. ~70 - 80% of nutrients not recovered. • Nutrient leakage isn't just a farming issue, it's tied to how inputs (fertiliser, feed) are sourced, priced, and used across the system. The region keeps producing runoff because upstream economics don't change. • Pesticide loads (Atrazine and Pendimethalin, trichlorfon) are high and cause acute toxicity. Addressing these is critical for water quality. • Environmental risk is acknowledged but still managed reactively, not structurally reduced. → <i>The current model is designed to manage the current system outcomes, but not yet to influence the underlying source flows that cause these outcomes.</i>
Economic Pressure & Fragility	
	Core industries are under increasing cost pressure, aging assets, uncertain supply chains, limiting their capacity to invest (including time) in any non 'core' initiative or

approach.

- Fertiliser prices have increased significantly in recent years (~80 to 120% increase since 2021)
- Current global market disruptions have disrupted supply chains adding availability risk beyond price increase alone.
- Margins in sectors like sugarcane and aquaculture remain tight
- Investment is prioritised toward core operations and risk reduction
- Core assets (mills, infrastructure) are aging and struggling to compete in today's cost environment.

→ *This is evolving from industry pressure to structural decline in risk appetite and desire or time to look to anything not perceived as 'core'.*

Supply Chain Vulnerabilities

The region remains exposed to external supply chains for critical inputs and markets.

- Heavy reliance on imported fertilisers combined with global volatility has resulted on a large system exposure.
- Limited local infrastructure to retain and process by-products
- Exposure to global shocks (energy, fertiliser, logistics)

→ *Value continues to leave the region, while risks remain externalised.*

Innovation not scaling

There is strong innovation activity, but few initiatives are reaching commercial scale.

- Multiple pilots, feasibility studies and business cases across sectors
- A consistent pattern is emerging where projects advance in parts but remain at pilot or pre-investment stages despite technical viability.
- Similar challenges emerging across circular opportunities (mature and emerging)
- Stakeholder quote:

"We've probably done 30 or 40 feasibility studies... 80% don't go ahead because they're just hard."

→ *Innovation exists, but the system is not yet set up to support scale-up.*

Capital not flowing

Capital is available in principle but not yet aligning with project needs at scale.

- Projects typically require **\$50M–\$300 million** to move beyond pilot
- Funding opportunities exist, but projects frequently remain at early stages finding difficulty to secure capital for delivery.
- Limited evidence of committed investment at commercial scale
- Stakeholder quote:

“Everyone we talk to says it’s a lighthouse project... but we just cannot get any support.”...“There’s lots of money out there... but we don’t fit the criteria.”

→ *Without clearer pathways to structure and de-risk projects, capital remains constrained.*

System Fragmentation

Fragmentation across actors increases delivery risk

- Projects depend on multiple actors across the value chain, and without a clear coordination model, delivery risk increases, *“those reliance are what kill the risk appetite.” (Stakeholder interview)*
- Stakeholder input highlights that reliance on multiple parties can increase risk
- Despite alignment with government priorities, proponents report they *“cannot get any support,”* highlighting the disconnect between policy intent and delivery. *(Stakeholder interview)*

Uncertain or underdeveloped markets for new biobased products

Emerging markets lack the maturity needed to support investment decisions:

- While interest exists, proponents still need to prove product specifications and performance before securing firm demand,
 - *“We need to produce commercial quantities... and then have a specification sheet done.” (Stakeholder interview)*
- Offtake demand is conditional and difficult to secure at early stages.

- Projects face a “*chicken and egg*” challenge where buyers require proven products before committing, making offtake agreements a key barrier to unlocking capital. (*Stakeholder interview*).

Taken together, these outcomes point to a consistent pattern. Each part of the system is being optimised in isolation.

Individual decisions make sense on their own, but when combined, they reinforce the current state and limit the system’s ability to change. This is how the status quo is sustained, and where the structural barriers begin to form.

The next section looks at how this plays out in practice, through existing initiatives developed and trying to scale across the region, and why many are not progressing beyond early stages.

2.4 Circular initiatives trying to unlock new value

Across the region, there is a large amount of circular activity.

A range of initiatives are already exploring how to recover value from existing resources whilst participating in the biomanufacturing sector, whether through nutrient reuse, energy generation, or new bio-based products. Many of these have moved beyond concept, with pilots completed, early investment secured, or partnerships formed.

However, these initiatives aren’t all at the same stage. Some have progressed to pilot or early implementation and are already working through the challenges of scaling. Others are earlier in their journey, having completed feasibility or business case development and are now moving toward delivery.

When viewed collectively, a consistent picture still emerges. Despite technical progress and strong intent, very few initiatives have progressed to commercial scale. The ones further in their journey often reach a similar point when they come across structural barriers to move beyond it; while emerging initiatives might approach similar conditions as they take their next steps. As a result, most remain in a similar position: advancing in parts, but not yet fully translating into investable, operational projects.

To better understand these initiatives, their intent and their progress, we spoke directly with a representative group of proponents. They shared what they are trying to do, where they see the opportunity for the region, and what has helped them or held them back so far.

What we heard was:

Table 9: Overall aims from existing circular initiatives in the region

Emerging circular initiatives aim to:
• Reduce reliance on imported inputs • Stabilise costs • Retain value within the region • Support industry development and diversification through the BioFutures & Bioeconomy government strategy • Build resilience, economic growth and workers attraction

The visual below brings together a selection of these initiatives and shows where they currently sit, from early concepts through to pilot activity and project development. While not exhaustive, it provides a representative view of current activity and how progress is unfolding across different stages. A more detailed summary of these initiatives is provided in Appendix 2.

Circular Initiatives in the region (non-exhaustive list)

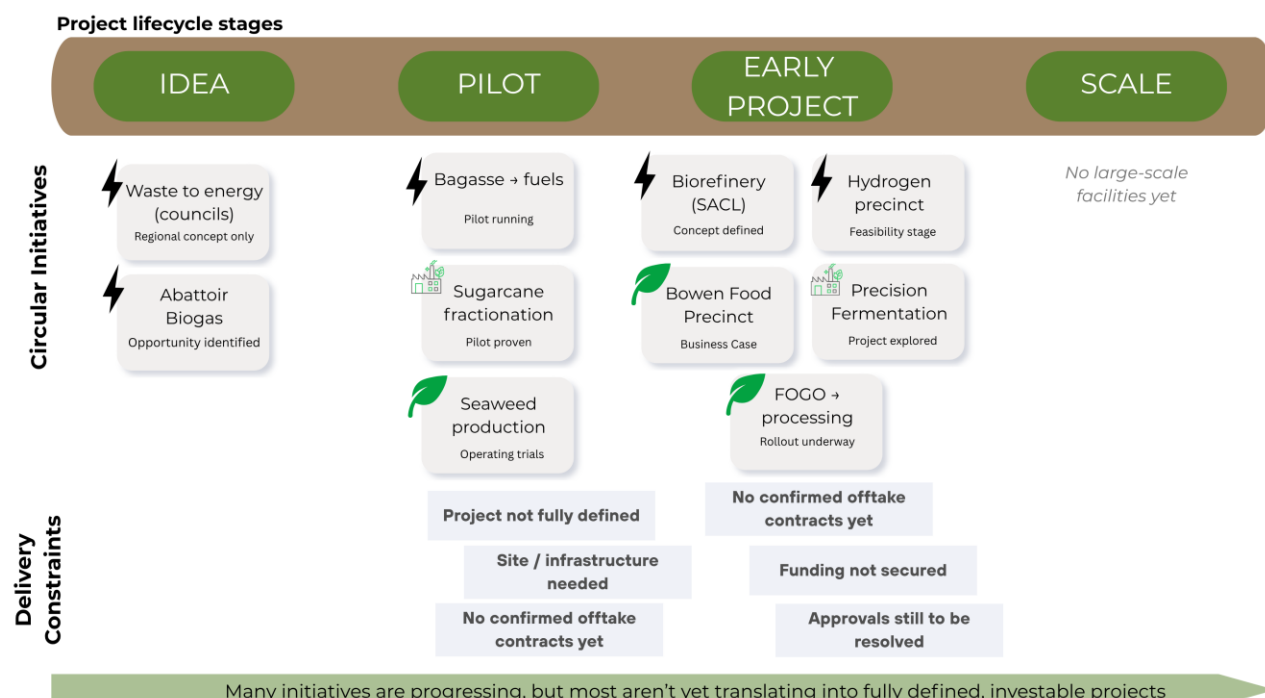


Figure 10: Circular initiatives trying to intervene the current regional system

Taken together, these initiatives point to a consistent pattern. The region understands the opportunity outlined by the State strategy and regional alliances; industries are seeking ways to diversify how they

generate value; and government is exploring how to enable them, taking important steps with the right intent.

So there is progress. Projects are being formed and explored. However, as initiatives move toward scale, **they begin to encounter a similar set of conditions that slow or prevent further advancement.** This is already visible in more mature projects, and is increasingly reflected in the next steps identified by emerging initiatives.

What this is telling us is that the challenge extends beyond individual projects and is really influenced by broader, fundamental conditions in the current regional system. It is like we are trying to play a new game but with the same rules and thinking of the preceding game.

When looking at the challenge this way, we thought it was important to examine these factors in more detail.

2.5 What is holding initiatives back and what needs to change?

Hotspots Workshop insights

The question “what is holding initiatives back and what needs to change?” was **tested directly with industry, government, and research stakeholders** through a multi-stakeholder workshop (held virtually on February 27th).

Rather than discussing theory, participants worked through real projects in the region, identifying where they stalled, who carried the risk, and what this revealed about how the system operates in practice.

The table below summarises the key project breakpoints identified and agreed by stakeholders. While it is not an exhaustive list of all initiatives, it highlights a clear and consistent pattern of structural barriers that are preventing projects from scaling:

Table 10: Hotspots workshop insights from stakeholders

Project	Where it broke	Who carried cost	Structural Barrier
Sarina Destillery (biogas)	Technical issues not solved due to lack of collaboration	Destillery	Infrastructure
Cauldron (Townsville)	Could not secure funding beyond pilot, IP issues, GMO concerns on water discharge	Proponent	Capital
Helmont (soy processing)	Input supply could not be secured	Proponent	Feedstock risk
Biosolids reuse	No end market	System-wide	Market (off-take contracts)
Protein feed (Seaweed Tassal)	Processing cost, no off-take market	Proponent	Market & infrastructure

Source: Hotspots Workshop activity

The pattern is consistent. Projects break at the same points (as listed in Table 10), and stakeholders describe the same conditions driving those outcomes, illustrated in Figure 11. This confirms the issue sits in the system, not in individual projects.

Stakeholder initiative fatigue

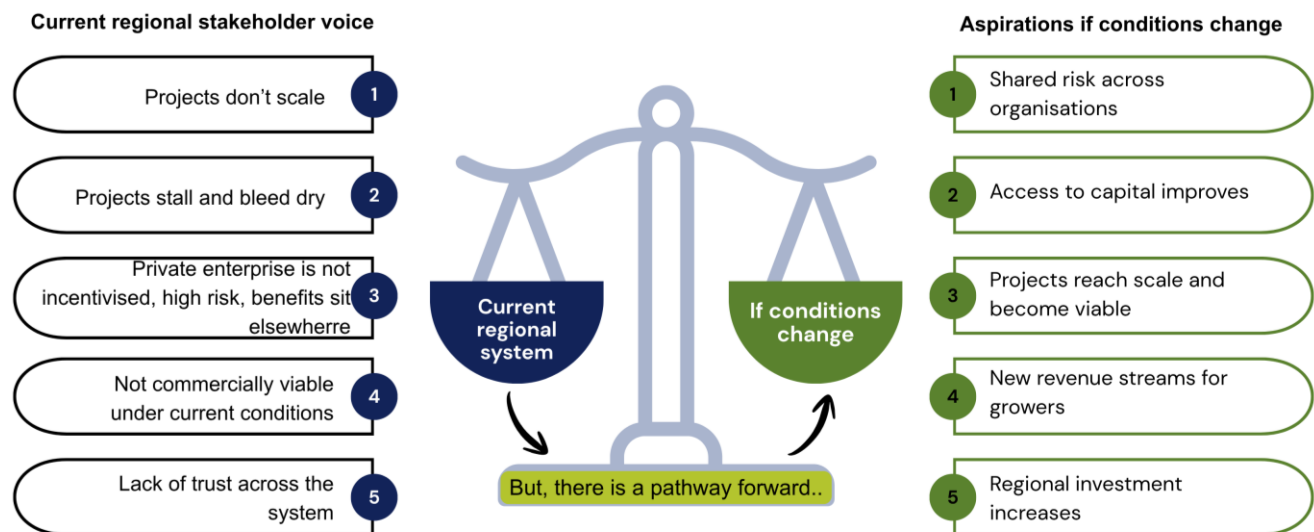


Figure 11: Stakeholder's sentiment regarding the region's ability to scale initiatives

2.5.1 Structural Barriers

Across interviews, project case reviews, and workshop validation, a consistent set of structural barriers emerged.

These are not isolated issues. They represent system conditions that shape investment decisions, risk allocation, and commercial viability of projects. Under current conditions, the lack of progress is not unexpected; it is a rational outcome.

Stakeholders consistently described that each actor in the system, across industry, project proponents, and government, is making decisions to manage their own risks, costs, and operational pressures. In isolation, these decisions are sensible and often necessary.

But when these decisions occur across the system at the same time, they begin to reinforce each other. The result is a set of conditions that limit how projects that are trying to add value to existing resources in the region can progress.

These accumulated conditions are what we refer to as **structural barriers**.

The following sections group these barriers into three system dynamics, showing how they shape outcomes across the region.

Table 11: Regional structural barriers and underlying system dynamics

 System Dynamic 1: Uncertain pathways to revenue Individual Barriers: Offtake Contracts, Markets for new products	
What is happening	• No secure, long-term buyers for new products • Markets for these products are still developing • Demand is fragmented and not aggregated
Commercial implication	• Revenue is uncertain → projects can't secure finance • Contracts can't be locked in → investment decisions stall
Regional evidence	Projects involving bio-fertilisers, protein feeds, and waste-derived products consistently stall due to lack of committed buyers and unclear market pricing

Example	Offtake and markets: “When no one wants to be first, projects sit in the middle.”
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 System Dynamic 2: Capital and risk are misaligned Individual Barriers: Capital access, Risk & Value Flows	
What is happening	• High upfront capital is needed before demand is proven • Risk sits mostly with individual proponents • There are limited ways to share or stage that risk • Supply is also fragmented, location dependent, system coordination is fragmented for feedstock logistics contracts
Commercial implication	• Exposure is too high for a single balance sheet • Returns are uncertain → capital does not flow
Regional evidence	Projects often stall between pilot and scale because capital is required before confidence is established, leaving proponents carrying disproportionate risk
Example	Access to capital “When margins are tight and demand is uncertain, capital quite reasonably waits, <u>it is not</u> ‘lack of capital’, it is a misaligned risk. Alternative: For example, comparable projects progressing to delivery have required investments in the order of ~\$80M, highlighting the gap between early-stage funding and full-scale delivery. (Source: Paddock to Power Precinct - QLD)

 System Dynamic 3: Enabling system infrastructure is missing Individual Barriers: Enabling infrastructure, Inputs Feedstocks	
What is happening	• Shared infrastructure (processing, logistics, environmental management, aggregation) is not in place

	● Feedstock supply is inconsistent (in most cases subject to seasonability) ● No clear pricing mechanism links feedstock condition to value, despite its impact on processing costs. ● Projects require multiple actors to move together, but roles, responsibilities, and incentives are not aligned.
Commercial implication	● Costs stay high and barrier complex ● Scale efficiencies are not reached ● Technical issues remain unresolved
Regional evidence	Stakeholders consistently pointed to fragmented coordination and lack of shared infrastructure as key reasons projects cannot move beyond pilot stage. Example: Townsend industries, BioMaterials project.
Example	Infrastructure gaps “When shared assets don’t exist, each project carries too much cost alone. When foundational cost are too high, there is no scale, economics don’t work.” In sugarcane for example, enabling feedstock aggregation and pre-processing requires growers, contractors, logistics investors, processors and government to align on a shared model, including roles, pricing, infrastructure and investment

These system dynamics reinforce each other.

Without clear revenue pathways, capital does not flow. Without capital, infrastructure is not developed. Without infrastructure, projects can’t reach scale.

This creates a reinforcing cycle where pressure leads to caution, caution leads to fragmentation, fragmentation pushes risk downstream (or externalises it), and the cycle resets.

Under current conditions, the system is behaving as expected. Risk remains concentrated; coordination is limited, and projects struggle to move beyond pilot stage.

If different outcomes are required, the **system must be designed differently**.

This is where this report progresses from understanding and diagnosing the current system to defining what an emerging system needs to look like, and the conditions required to support it.

DESIGNING THE EMERGING SYSTEM



3.1 Shifting conditions, new design requirements

“The best way to predict the future is to design it” - R. Buckminster Fuller

Insights from the system mapping and stakeholder discussions point to a region with strong foundations, ideas, projects, feedstocks, technologies and policy alignment are all in place, but where moving from pilot to scale remains challenging.

Many initiatives depend on multiple actors aligning across the value chain, and without clear coordination models or shared infrastructure, progress can be slower than the ambitions defined under QLD’s BioFutures and the Primary Industries Prosper 2050 roadmap require. This highlights not a lack of capability, but an opportunity to better organise how the system works to deliver industry diversification and feedstock value-adding at scale.

A core part of the challenge is that the current system was designed for conditions that no longer hold, a more stable and predictable environment. Those conditions have since shifted, with increasing volatility, fragmentation, and growing pressure across supply chains.

In this context, **continuing to optimise the current system is no longer sufficient.**

The region is now operating under a different set of conditions. The table below summarises the key changes shaping this new environment:

Table 12: External conditions shaping system design

Category	FROM (today)	TO (tomorrow)
Economy	Growth driven by global demand, scale and cost efficiency	Growth driven by resilience, diversification and regional value creation
Supply Chains	Linear, global, just-in-time supply chains optimised for cost	Distributed, regional, adaptive supply networks designed for disruption
Energy Mix	Centralised, fossil-based systems with stable input assumptions	Decentralised, renewable systems with variable supply and storage needs
Industrial Sectors	Commodity-based, export-oriented industries with low local processing	Value-adding, circular and advanced manufacturing linked to local inputs
Community Participation	Communities as workforce and impact receivers	Communities as co-investors, partners and contributors to regional value
Government leadership	Policy as enabler of market efficiency and growth	Government as active shaper of markets, resilience and industrial capability
Critical Infrastructure	Infrastructure designed for peak efficiency and predictable demand	Infrastructure designed for flexibility, redundancy and multi-use resilience
Environment & climate adaptation	Managing environmental impacts after they occur	Designing systems to reduce risk upfront and adapt to ongoing climate stress

These shifts are not abstract; they describe the conditions the regional system now needs to work within. The 'FROM – TO' view sets the design principles for what comes next.

Continuing to improve the current model will only reinforce these constraints; it will not be enough. These principles point to a different way of organising value, how infrastructure should be planned, how risk needs to be shared, and where investment should go.

For example, shifting from a centralised energy system to distributed renewables changes how projects are planned. Instead of building near major grid connections, projects can be located closer to industrial users, creating local microgrids. This expands site options and better aligns supply with demand.

The next step is to turn the guiding principles into something practical at a regional level, an emerging regional system by defining the core building blocks and how they work together to enable coordinated action.

3.2 Building blocks required in a system

Designing a new regional system does not start with isolated projects, but with putting the right building blocks, both physical and non-physical, in place and making them work together.

- **Circular clusters** - define what gets done by grouping interdependent activities that create value.
- **Precincts** - define where and how this happens at scale, enabling co-location, shared infrastructure (critical system components) and coordination.
- **Enabling conditions** make it possible, bringing the policy settings, investment models, infrastructure and governance needed for clusters and precincts to function.

Together, these elements shift the focus from individual initiatives to a system that is deliberately designed to deliver outcomes. Figure 12 presents the blocks and their key components.

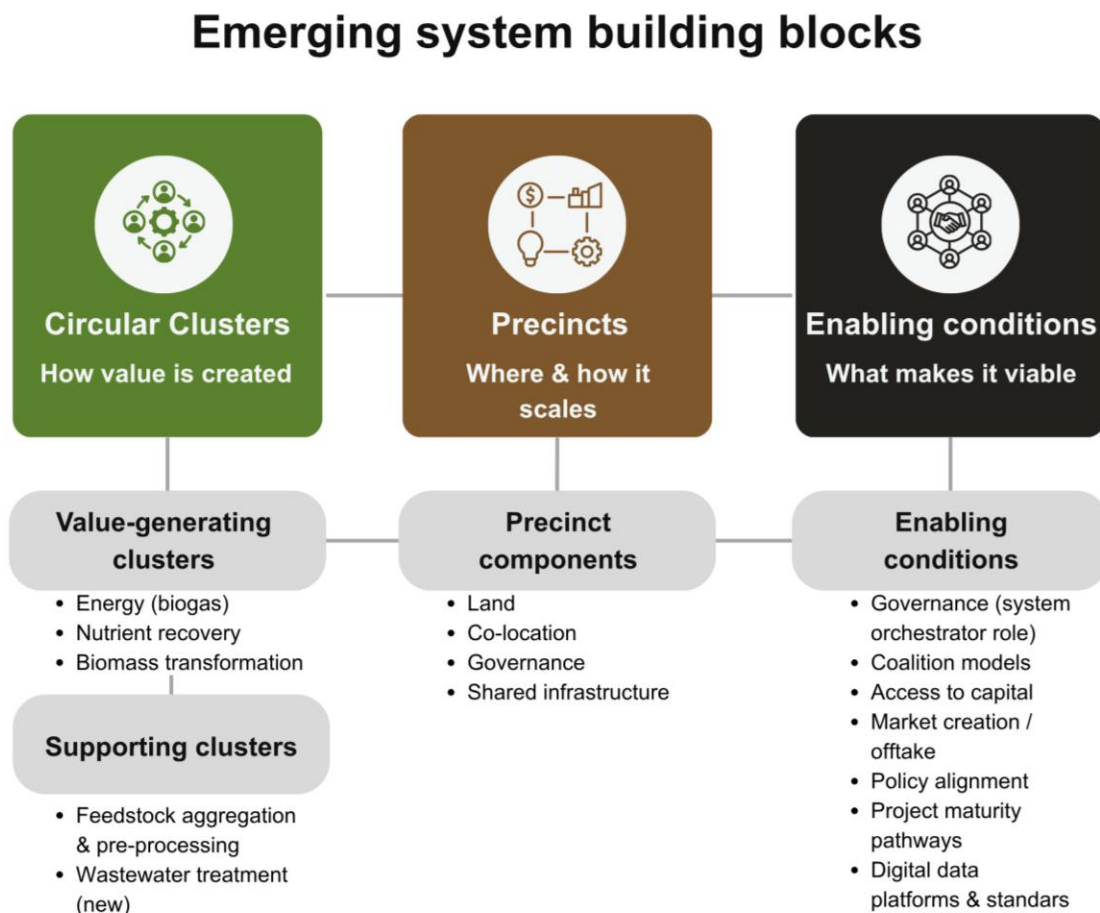


Figure 12: System blocks required in the emerging system

3.2.1 Circular clusters or pathways to value

A circular cluster, or pathway to value, is a group of connected activities that turn existing resources such as by-products, waste, energy or nutrients into useful products or services. Rather than operating as standalone projects, these activities are linked through shared infrastructure, coordinated flows and aligned markets, so value is created across the system.

Some clusters generate direct value (for example renewable energy, bio-fertilisers or new materials), while others play an enabling role, such as aggregating feedstock, providing infrastructure or coordinating supply. These enabling functions may not produce a product themselves, but without them, downstream projects struggle to operate or scale.

The key distinction is that a cluster is not just a collection of projects. It is a working system of interdependent roles, where each part supports the others to create and sustain value.

Circular Port enabling a new energy and raw materials system - Port of Rotterdam

This approach is already being applied in leading industrial regions. At the Port of Rotterdam¹³, for example, transition efforts are organised as a portfolio of interconnected clusters like:

- enabling infrastructure (such as hydrogen and CO₂ networks),
- first-wave production (biofuels, hydrogen, circular chemicals), and
- adoption projects that help establish demand.

The port acts as an orchestrator, enabling shared infrastructure and coordinating partners to scale these pathways together rather than in isolation.



The Greater Whitsunday Region is not starting from scratch. Previous work has already identified strong feedstocks, infrastructure potential, and market opportunities. The shift now is to organise these opportunities as connected pathways, rather than continuing to progress them as individual projects.

Circular clusters provide a practical way to do this. They move the focus from isolated initiatives to a coordinated system that can reduce risk, share infrastructure, and build regional value at scale.

¹³ (Port of Rotterdam 2025)

The table below presents the circular clusters identified and validated through a multi-stakeholder process. Like the approach used in the Port of Rotterdam, these clusters are designed to operate as a portfolio of mutually reinforcing pathways, rather than standalone initiatives.

Each cluster will be described across the following areas:

- What it is
- What it does
- Why it matters
- What it needs
- How it connects

We identified clusters by applying a circular economy waste-hierarchy approach (see Appendix 3 for details): prioritising opportunities that recover highest-value resources (ie. Nutrients, biomaterials, energy) before lower value uses. It is important to note that these clusters were validated through a multi-stakeholder process.

Cluster one: System enablers

Table 13: Cluster one – system enablers

Cluster One: System enablers	
What it is (definition)	System enablers are the cross-cutting fundamentals. Infrastructure, coordination, and adoption/delivery. Together, they make circular supply chains work as a system.
Non-exhaustive list of examples (mapped to circular opportunities, see appendix 4 for full list)	• Feedstock pre-processing / contamination control (OP03) • shared reverse logistics (OP09) • digital platforms, and (OP10) • trial/certification credentials for adoption (OP08)
What it does (objective & rationale)	For example, the Feedstock Pre-processing (Frontend Hub) would perform functions like: • Sorting • Dewatering • Pre-processing • Contamination control • Centralised data hub for reporting

Why it matters	A system enabler is also a 'layer' required because: • Reduces friction (also experienced as delivery constraints by existing proponents) • Enabled bankable co-location with other projects that become off-takers of processed feedstock • Improves quality control (ie. feedstocks aggregation contract management) • Supports market confidence
What it needs	• Shared logistics contracts • Economies of scale (through aggregated supply and offtake) • Economical feedstock pricing tailored to contamination levels • Standardised technologies and processes
How it connects	This cluster has a supporting role to the system. Although they don't generate direct value, they enable value to be created by making inputs available, reducing costs or coordinating adoption flows. Their role is critical for the system to work.
Comparison example	Within the example of Port of Rotterdam, one of their most important sub-clusters was the Hydrogen Backbone. The cluster builds a 'common-carrier' hydrogen pipelines and branch connections that de-risk investment for producers and consumers, enable industrial cluster switching, and unlock future imports and cross-border corridors. It was anchored by the Dutch hydrogen network build (first 32km segment in Rotterdam)¹⁴ The project is defined as a prerequisite multiplier for green hydrogen production, turning local production projects into an industrial cluster market

Cluster two: Energy conversion anchor

Table 14: Cluster two – energy conversion anchor

Cluster two: Energy conversion anchor	
What it is (definition)	This cluster plays a steady, reliable role for circular pathways by turning local

¹⁴ ("Hydrogen pipeline crucial to industrial energy transition in port of Rotterdam" 2026)

	resources into lower-carbon energy and/or energy substitutes for industry, creating a stable base of supply and demand. For the context of an industrial precinct, project proponents within this cluster could become the anchor tenants attracting investment through projects that find circular synergies with main energy products or the by-products of this cluster.
Non-exhaustive list of examples (mapped to circular opportunities, see appendix 4 for full list)	• Biomethane / biogas OP04 • Low carbon cement & industrial energy substitution OP07
What it does (objective & rationale)	What the anchor enables is energy security, emissions reduction, a stable offtake base for upstream feedstocks. • It turns feedstock into biogas • Generates green gas • Enables green urea production
Why it matters	Proponents in this cluster are essential anchors as they make the rest of the system work. • Provide a stable base, reducing risk for investors • Unlock other projects through reliable, lower carbon energy • Improve economics through shared energy infrastructure lowering cost across multiple projects • Strengthen local resilience as they reduce reliance on imports and exposure to global shocks • Cut emissions at scale as it has a system-wide impact • Attract value-adding industry
What it needs	• Infrastructure pipelines, common use infra, offtake agreements • Markets led by a market opportunity evaluation • Feedstock supply consistency & government policy support (incentive) • Clean energy supply & demand in grid • Technology providers
How it connects	This cluster could be part of a state-wide network of biomethane and biogas. Each location would serve a different role or industry. For example, in Mackay, biogas could support fertiliser supply and strengthen local nitrogen sources. In other areas, such as mine waste gas sites, energy could be used to help industries cut emissions

Cluster three: Nutrient recovery and circular inputs

Table 15: Cluster three – Nutrient recovery and circular inputs

Cluster three: Nutrient recovery and circular inputs

What it is (definition)	Nutrient recovery and circular inputs focus on capturing and upgrading nutrient and chemistry value from organic / material streams into reusable inputs for agriculture and industry.
Non-exhaustive list of examples (mapped to circular opportunities, see appendix 4 for full list)	• Biofertiliser / green ammonia or urea pathways OP05 • Industrial chemicals OP05
What it does (objective & rationale)	• Returns nutrients back to agriculture, improving soil/land productivity outcomes, and lowering cost of inputs • Keeps local economies, contributes to water quality outcomes • Reduces waste management cost and environmental impact downstream (ie. water quality)
Why it matters	• Very importantly, this cluster prioritises highest-value use of materials (rather than converting everything into energy, which is a lower-value outcome) • This will reduce fertiliser costs for farmers and cut nitrogen loads to our waterways, directly improving water quality • Improves overall system efficiency - using each feedstock stream for its highest value outcome first extracts more value from the same resources before anything is downgraded to energy. • Reduces reliance on imported inputs (local fertiliser and chemical production) • Improves farm productivity over time • Builds on existing regional investment and capacity • Creates value from what it is considered waste today • Strengthens connections across industries creating a more efficient regional system.
What it needs	• Enviro impact research & demonstrative agronomic benefit • Legislative product standards supported by R&D trials • Clear demand and offtake • Cost / benefit analysis • Coordination across the value chain
How it connects	• Relies on centralised feedstock pre-processing hub providing high value feedstocks with higher protein or chemical nutrient content. • Relies on system enablers (agronomy adoption trials, standards and certification) • Connects with production clusters, providing local fertiliser and chemical inputs that support farming and processing industries

Cluster four: High-value biomass transformation

Table 16: Cluster four – High value biomass transformation

Cluster four: High-value biomass transformation	
What it is (definition)	High-value biomass transformation is the cluster that upgrades biomass-derived resources into higher value products.
Non-exhaustive list of examples (mapped to circular opportunities, see appendix 4 for full list)	- Advanced biomaterials / bio-composites OP01 - Proteins via insect bioconversion with complementary thermal / pyrolysis pathways OP02
What it does (objective & rationale)	- It replaces key inputs used by other industries. For example, food and organic waste (FOGO) can be turned into high-protein black soldier fly larvae, which can be used in pet food and aquafeed. This reduces the need for imported fish-based ingredients currently used in feed products - Converts biomass (from crops, and other close-by agricultural outputs) into higher-value products like bio-chemicals, materials and specialty ingredients. Before lower value uses like energy. - Returning revenue back to farmers (industry diversification) - new markets - health foods and animal food markets
Why it matters	Very importantly, this cluster prioritises highest-value use of materials (rather than converting everything into energy, which is a lower-value outcome) - It creates more value per ton of biomass through high-value prioritisation, supporting new industries and reducing reliance on imported chemicals and materials
What it needs	- Reliable feedstock supply (system enabler cluster) - Funding and capital - Energy sources - Proven conversion technologies - Shared infrastructure (processing 'as a service') - Market demand for higher-value bio-based products
How it connects	- It relies on system enablers, particularly R&D, traceability services, contamination control, and certification support for market access. - Links to nutrient recovery (sharing feedstocks and by-products)

- Relies on energy clusters (using residuals for energy).

Clusters turn existing regional collaboration into **coordinated delivery**, aligning inputs, infrastructure, stakeholders and risk so projects can move together, not in isolation.

This is not about creating something new. It is about organising initiatives that already exist (and emerging ones) so they can operate at scale.

A logical transition from organising clusters is to anchor them in a physical place, sequence them and support them to reach scale. When this happens, they begin to form something more tangible: co-located circular precincts or industrial districts, where multiple circular pathways to value operate side by side.

3.2.2 Precincts - an evolved model

The circular clusters outlined in the previous section show the direction the region needs to take. They define how value can be created and how the region can position itself as a hub in the State's Biofutures roadmap and emerging ecosystem.

But clusters on their own don't deliver outcomes. They only work when there is a clear way to bring projects together, sequence them, and support them in practice. So, the question becomes:

How do we move from a set of opportunities to a system that can actually deliver them?

Precincts are the second building block. They are where projects come together and where value is delivered at scale. They reduce fragmentation by bringing infrastructure, projects, and actors into one place, enabling real connections between them. Instead of each project solving land, infrastructure and risk on its own, a precinct provides a shared foundation, making projects more viable, faster to deliver, and easier to invest in.

Important distinction: what a precinct means in this report

Precincts have evolved. Traditionally, they focused on creating a place for investment, through land planning, promotion, and streamlined approvals.

More recent examples show a different model. Precincts are now built with **clear intent** and **actively developed** to deliver specific transition outcomes. This includes:

- A defined transition focus
- Curated project selection
- Shared infrastructure
- Active coordination across projects and stakeholders

The difference is important. Traditional precincts create conditions for projects to be located. Modern precincts go further; **they build and coordinate the system that allows projects to happen and scale.**

We explored two international examples to illustrate this shift. These examples showcase a precinct operating model which was successful at transitioning their precincts from places that host investment and projects to a **deliberately designed system**. The two examples are:

- The Port of Rotterdam and
- Port of Antwerp-Bruges with its NextGen District

NextGen District¹⁵ shows a clear evolution in how precincts are run. Instead of promoting land and waiting for projects, the port authority actively curates a mix of complementary projects, sets clear entry criteria, and shapes how they come together. In short, it operates as a delivery platform, assembling and coordinating projects into a working system rather than a place where projects are simply encouraged to locate.

This model enabled them to secure €400M in investment across two anchor concessionaires. Attracted 6 large scale and diverse circular economy projects in their district (green hydrogen, water plant for wastewater reuse, biochemicals, etc)



The Port of Rotterdam¹⁶ also shows a different evolution of precinct governance. Rather than defining a fixed district, it operates the entire port as a coordinated transition platform, managing a portfolio of projects, building shared infrastructure through joint ventures, and creating delivery entities to solve common barriers. Engagement is not about attracting individual investments, but about aligning industry, government and infrastructure partners around specific system needs and moving them through to execution. In practice, the precinct functions as an active orchestrator of a project portfolio.

Secured a total combined investment €1.9B¹⁷



¹⁵ (Port of Antwerp Bruges 2026)

¹⁶ (Port of Rotterdam 2025)

¹⁷ ("First CO2 storage project in the Netherlands is launched" 2023)

Together, these examples show a clear shift in how precincts are used. The focus moves from defining what is allowed to happen, to being clear about what needs to happen, and organising delivery around it.

For the Greater Whitsunday Region, the implication is straightforward. If clusters define how value is created, precincts are how that value is delivered in practice.

Table 17 below outlines where these international approaches differ from traditional models, the results they enabled, and what this could mean for the region.

Table 17: Approach adopted by international examples and relevance to the region

Modern Precinct Category	What the two international examples did	What results they got	Insights for the Greater Whitsunday Region
Transition thesis (this filters everything)	They developed a precinct thesis & value intent. Land planning and project portfolio selection was driven by this thesis.	Built coherent ecosystems avoiding disconnected projects	Declare a transition thesis per precinct (select what clusters or circular pathways the precinct should attract & will orchestrate)
Active orchestration	Landowner (ie. Port authority) stepped into the role of system orchestrator	This role enabled them to shape portfolios of projects attracting large number of proponents	Select a portfolio, not individual projects. Defining what set need to co-exist
Pre-designed interdependencies	Understood the sequencing and dependencies between clusters, orchestrated accordingly	They reduced risk and economics	Design shared infrastructure upfront (based on the selected clusters listed in the precinct thesis). Even if staged, the system architecture must be clear early.
Shared infrastructure as a system backbone	They invested (or coordinated investment) in: - Infrastructure backbone (ie. hydrogen pipelines, CO2 networks, heat reuse) - Feedstock aggregation	Enabled scale earlier	Form coalitions to tackle shared infrastructure investment and conditions
Coalition-based governance	They brought together: - Industry - Government - Infrastructure providers - Financiers Into ongoing delivery coalitions focused on addressing system bottlenecks and aligned on co-benefits.	Action was coordinated by orchestrator (port or land owner)	Set up delivery coalitions (not just governance). Name actors, share and allocate risk / rewards, clear roles across the value chain

The Greater Whitsunday region has important work already underway through the designation and service of State Development land. This is essential to deliver a circular industrial transition, but the next step for the region is to be more intentional (and specific) about what that land is meant to do, the role it plays within the broader State (and national) network of existing and upcoming precincts, including how it connects and exchanges with others, and to build the system required to deliver on that intent.

If clusters organise value pathways for economic activity and project cooperation, and precincts provide the physical location, shared infrastructure and delivery platform; what role do **enabling conditions** play?

The following section introduces the critical role of enabling conditions in allowing the system to function and to move from concept to delivery. This has been one of the more consistent gaps in the region **identified through this work**, and a key factor in enabling projects to progress and scale.

3.2.3 Enabling conditions

Enabling conditions are what allow clusters and precincts to function as a system in practice.

They determine whether projects can move beyond concept and pilot, and whether they can be coordinated, financed and delivered at scale. Across the stakeholder interviews, a consistent pattern emerged: the region is not short of ideas or technically viable projects, but many struggle to progress due to fragmented coordination, lack of shared infrastructure, unclear delivery models and limited pathways to scale.

In contrast, our research of international successful case studies in Europe show that progress occurs when the following conditions are **deliberately designed**:

- With clear leadership
- Shared infrastructure
- Structured project pathways and
- Delivery-oriented coalitions

This section translates those insights into a set of **enabling conditions tailored to the region**, focusing on what is required to move from individual projects to a coordinated, investable regional system. Some of these enabling conditions will appear similar to elements described in the precinct evolved model section. This is intentional. In the precinct section, they were introduced as features of what a modern precinct looks like, but in essence, they are enabling conditions which must be actively put in place to enable those precincts and clusters to function in practice.

Note:

The enabling conditions outlined below have not been developed in isolation.

They are derived from the analysis of the two European case studies (Port of Rotterdam and Port of Antwerp Bruges¹⁸), where circular industrial precincts have successfully moved beyond pilot stages into delivery.

Rather than replicating those models directly, this work reverse engineered the key elements that enabled their success, how projects were coordinated, how infrastructure was planned and delivered, and how risk was managed across multiple actors. We translated these elements into a set of conditions relevant to the Greater Whitsunday region.

These conditions reflect both what has worked elsewhere, and the **gaps consistently identified through stakeholder engagement** in this region.

¹⁸ (Port of Rotterdam 2025) (Port of Antwerp Bruges 2026)

Table 18: Detailed review of enabling conditions for the emerging regional system design

Enabling Condition	What it means	Type	What leading precincts did	Who led / who was involved	What this enabled (system impact)	What this means for the region (next steps)
		• (Governance • Infrastructure / Delivery • Market / Finance)				
Clear transition focus (precinct thesis)	Define what each precinct is designed to do (role to play) and which clusters it will support	Governance	Antwerp-Bruges defined NextGen District (88 hectares) as a circular manufacturing hub focused on circular feedstocks, renewable energy and recycling. Rotterdam's Port Vision set a system-wide transition around hydrogen, CO2 networks and circular raw materials	Port authority + government	Built coherent ecosystems instead of disconnected projects	Build on existing SDA planning by defining a clear transition focus for each precinct (which clusters it will host and why)
System orchestrator (active coordination role)	A single entity responsible for coordinating projects, infrastructure and partners	Governance	Port authorities took an active role in assembling portfolios of 10+ interdependent transition projects , coordinating infrastructure, partners and sequencing across the port system	Port authority + industry + government	Reduced fragmentation and accelerated delivery	Strengthen the role of a regional or precinct-level coordinator to actively align projects, partners and infrastructure over time
Curated project portfolio	Select projects that work	Governance		Orchestrator + proponents	Created interdepend	Evolve from assessing individual projects to curating

	together, not just individual proposals		Rotterdam grouped projects into coordinated transition portfolios (e.g. hydrogen, circular chemicals, CO2 storage), selecting projects based on system fit rather than individual merit		ent, lower-risk systems	portfolios of complementary projects aligned to precinct intent
Pre-designed interdependencies and sequencing	Plan how projects connect and in what order they develop	Delivery	Projects such as hydrogen production, CO2 transport (Porthos), and industrial users were sequenced together , with infrastructure developed in parallel to demand	Orchestrator + technical partners	Reduced risk and improved economics	Incorporate system-level planning early (how projects connect, what comes first, what depends on what)
Shared infrastructure backbone	Common infrastructure used by multiple projects	Infrastructure / Delivery	Rotterdam developed CO2 transport and storage infrastructure (Porthos), hydrogen backbone planning, and heat networks, designed for multiple users across the port	Public + private + infrastructure providers	Enabled scale and reduced duplication	Continue current infrastructure planning, with increased focus on shared, multi-user infrastructure aligned to priority clusters
Feedstock aggregation & preprocessing (OP03)	Centralise collection and preparation of inputs for	Infrastructure / Delivery	European precincts established centralised material handling, waste sorting and preprocessing systems to supply multiple downstream industries at consistent quality and scale	Waste operators + industry	Enabled downstream industries to operate reliably	Progress existing thinking on resource hubs into shared feedstock infrastructure that supports multiple

	multiple industries					projects and industries
Shared logistics & reverse supply chains (OP09)	Efficient movement of materials across the system	Infrastructure / Delivery	Ports leveraged existing logistics networks (shipping, rail, pipelines) to move waste streams, feedstocks and products across industrial users	Industry + logistics providers	Reduced cost and friction across projects	Expand existing regional logistics capabilities to support reverse flows and circular product distribution
Structured project maturation pathway	Clear pathway from pilot to commercial scale	Delivery	Both ports supported projects through pilot -> demonstration -> commercial scale, often co-located within precincts to enable faster scale-up and integration	Government + investors + operators	Increased success rate of projects scaling	Strengthen support pathways (QUT Mackay Pilot Plant) that help projects move from feasibility to demonstration and into commercial deployment
Blended capital and early de-risking	Combine public and private capital to unlock projects	Market / Finance	Major infrastructure (e.g. CO2 storage, hydrogen systems) was supported by public funding and risk-sharing mechanisms to unlock private investment	Government + investors	Enabled investment in emerging industries	Continue leveraging existing funding programs, with more coordinated use to support portfolios and shared infrastructure
Market formation and offtake alignment	Secure demand early for new products	Market / Finance	Ports worked with industry to develop early offtake agreements for hydrogen, CO2 services and circular products, aligning supply and demand	Industry + buyers + government	Improved revenue certainty	Support early engagement with buyers and industry to build demand signals for emerging products

Certification, trials & adoption support (OP08)	Build trust and uptake for new products	Market / Finance	European models linked projects to certification systems, standards and validation pathways to enable market acceptance of new products	Government + R&D + industry	Enabled market entry and adoption	Build on existing R&D and extension efforts to establish consistent trial, certification and adoption pathways for new products
Digital traceability & data platforms (OP10)	Track materials, carbon and value across the system	Market / Governance	Ports developed data platforms to track emissions, material flows and industrial performance, supporting compliance and market access	Government + industry	Enabled transparency and access to premium markets	Progress regional data initiatives into shared platforms that support traceability, certification and investment decisions
Coalition-based delivery models	Formal partnerships to deliver shared assets and projects	Governance	Established multi-party delivery coalitions (industry, government, infrastructure providers, financiers) to deliver infrastructure and projects, not just plan them	Industry + government + investors	Turned coordination into execution	Build on existing partnerships by forming delivery-focused coalitions with clear roles, shared risk and defined outcomes

Together, these enabling conditions shift the emerging system from a collection of individual initiatives to a coordinated, investable portfolio of projects, supported by shared infrastructure, aligned actors and clear pathways to scale.

Below we present an example showing how coordinated delivery, shared infrastructure and early alignment of partners can help projects move forward together rather than in isolation:

Example: Porthos CO2 Transport & Storage (Port of Rotterdam)¹⁹

Porthos is a large-scale CO2 transport and storage system in the Port of Rotterdam, designed to capture emissions from industry and store them in depleted gas fields under the North Sea. It is one of the first open-access CO2 backbone systems in Europe.

Key project highlights

- Joint venture: **EBN, Gasunie, Port of Rotterdam Authority**
- Industrial users: **Shell, ExxonMobil, Air Liquide, Air Products**
- Scale: **~2.5 Mt CO2 per year for 15 years (~37 Mt total)**
- Infrastructure: **~20 km offshore pipeline to depleted gas fields (3–4 km below seabed)**
- Investment: **~€1.3 billion** (supported by public funding, incl. CEF Energy)
- Milestones: **Final Investment Decision (2023) -> Pipeline installed (2025)**

Collaboration as the success backbone

- A **delivery coalition** with clear roles across infrastructure owners and industrial users
- **Shared CO2 transport and storage infrastructure** designed for multiple emitters
- **Long-term contracts secured early** to provide demand certainty
- **Public funding used to de-risk** the backbone infrastructure
- A **clear delivery pathway**, with infrastructure and users progressing in parallel

What this enabled

- Multiple industrial projects progressed together rather than individually
- Investment decisions supported by shared infrastructure and committed demand
- A scalable platform that can expand to additional users over time

Furthermore, this is now translating into delivery on the ground, in March 2026, Shell connected its CO2 capture plant to the Porthos system (“golden weld”), showing how industry progresses once the shared backbone infrastructure is established²⁰.

¹⁹ (“Porthos”, n.d.) (porthos co2 transport and storage 2022)

²⁰ (Porthos CO2 Transport and Storage 2026)

3.3 The emerging regional system - conceptual design

Bringing these three elements together: clusters, precincts and enabling conditions creates a more complete **model for delivery**. It turns a set of opportunities into an **emerging regional system** that can be implemented.

The conceptual design below shows how these elements work together. It draws on the project and insights identified through stakeholder engagement to ground the model in the region's reality.

Emerging Regional System

Conceptual design

Clusters

Cluster 1	System enablers
Cluster 2	Energy conversion anchor
Cluster 3	Nutrient recovery & circular inputs
Cluster 4	High-value biomass transformation

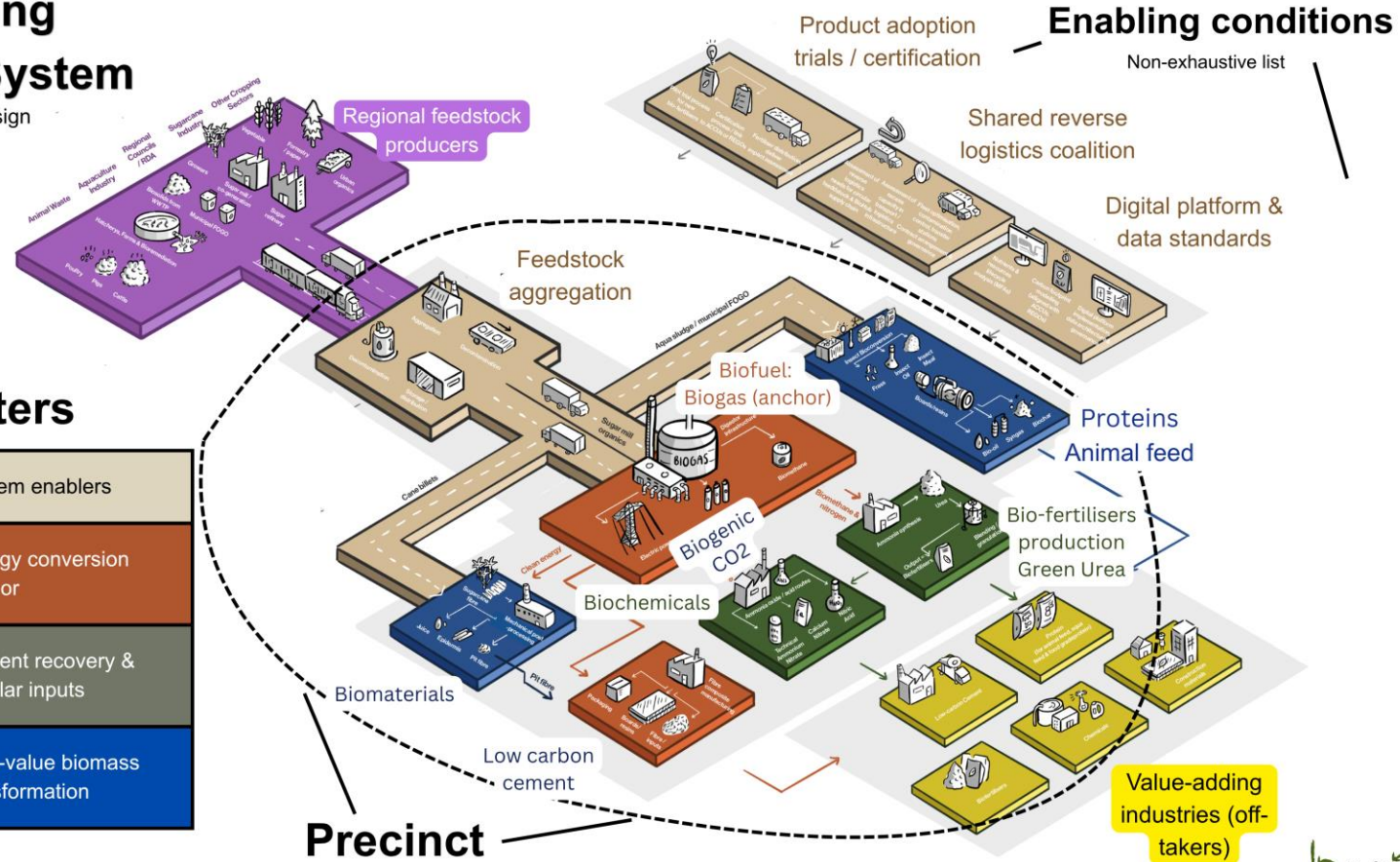


Figure 13: Illustrative test case of the emerging regional system (precinct model). Design delivered by Elise Motalli.

ACTION



BRIVIO

This section answers the straightforward question:

where do we start, and what do we do next?

The shift outlined in this report is clear but turning it into action could feel complex.

This section focuses on making those first steps practical. It sets out where to begin, who needs to be involved, and how to move from a set of ideas to coordinated action on the ground.

To maintain consistency, the coalition-building recommendations in this section continue to draw on the same two reference cases used in the previous section, the NextGen District in Antwerp and the Port of Rotterdam²¹ transition programme, using them as practical benchmarks for how stakeholder engagement is structured and successfully translated into delivery.

4.1 Step zero: Industrial transition developer

The first step is to move from coordination to delivery by establishing a clear **‘industrial transition developer’ role**. This becomes the accountable ‘engine’; without this, engagement stays fragmented.

This is an evolution of the current regional approach to facilitation, advocacy and project support. This role **does not replace what already exists; it builds on it** by adding a single, accountable function with a clear and real mandate to:

Table 19: Top priorities for the industrial transition developer role

1	Develop transition thesis for the region Define a clear transition thesis - framing the ‘role to play’ by the region in the State’s Biofutures ecosystem, through a specific precinct(s) or project portfolio (feedstock aggregator, energy anchor, biofertilisers, biomaterials, biochemicals, etc).
2	Select circular clusters & act as portfolio curator Select placed-based clusters that bring to life the transition intent and form coalitions to deliver them (select participants based on complementarity & dependency). Use formal evaluation tools to screen and prioritise projects that can participate in the portfolio.
	Form early cross-system coalitions

²¹ (Port of Antwerp Bruges 2026) (Port of Rotterdam 2025)

3

Align the right partners around specific opportunities or challenges. First round of coalitions need to be created to de-risk investment and deliver shared infrastructure (a core system enabler).

For example, Port of Antwerp-Burges formed a coalition that delivered treated wastewater (effluent) from residential source into high-quality process water (cooling water) for industrial companies in the precinct. Parties involved were local government, industry and land owner (port). This initiative received mixed funding (public + private + JV structures).²²

Coalitions becoming investable entities

4

This part will be a critical shift in the journey. The point when the coalition then becomes an investable entity that delivers shared infrastructure.

In the example above, a company named Waterkracht was formed as a partnership initiative between Ekopak (technology providers & will be plant operator); EPICo2 (infrastructure fund / financier); Water-link (new water pipe distribution network at the port (precinct) for all industrial customers to use circular water), and Aquafin (local government responsible to treat residential wastewater, they will transport the effluent to the new cooling water plant).

5

Use public funding to de-risk early stages

This role is responsible for funding or seeking funding linked to site readiness, permitting, demo zones. Not full projects. Public funds are for early stages and to reduce early friction (not replacing it).

Embed regulators into the coalition early

6

This role needs to engage and work with regulators, industry bodies, and governments on permits and frameworks. Aim is to remove an important bottleneck (approval and compliance delays). Note this role is currently delivered by State Office of Coordinated General in the region.

Important consideration

The **National Environmental Protection Agency** (National EPA) in Australia will officially commence on 1 July 2026, following the passage of Environment Protection Reform Bills on 28 November 2025. As an independent federal regulator, it will focus on enforcing environmental laws, conducting audits, and issuing Environment Protection Orders.

7

Create ongoing coalition platforms

Establish enduring coalitions that bring together multi-level government, natural resource management agencies, industry, industry bodies, economic development and academia.

²² (Water Kracht 2022)

Their purpose is to build a lasting layer of social infrastructure that enables delivery entities to operate effectively. This means moving beyond ad hoc collaboration to a model grounded in **trust, routine engagement, and active coordination**.

8

Maintain a managed project portfolio

Actively manage the total number of projects across the structured program as the program owner. This with the intent to keep the coalition dynamic and a continuous pipeline (no one-off wins).

In this region, those capabilities are present, but spread across multiple organisations, leading to fragmentation when action is required. Bringing them together into a coordinated, action-driven coalition model, led by an entity (or group of entities) stepping into this industrial developer role, is the **critical starting point to move from intent to execution**.

Does it have to be a single entity, or can it be a coalition?

The role can be held by a single entity or a coalition, but it must operate with the **clarity, authority and integration of one**. If coalition is the preferred way, it needs to be ideally structured with:

- A defined lead (or backbone organisation)
- Formal governance and decision-making authority
- Shared mandate across partners
- Ideally pooled resources or delegated powers, not just coordination

This is the first move, this is how execution begins.

Our recommendation is not to add yet 'another body' but to explore the viability of developing a set of **execution instruments** that turn **engagement into delivery** owned by carefully pre-selected coalitions based on the goal.

4.2 Step one: Action-driven coalitions

As outlined in section 4.1, one of the important roles the **industrial transition developer** will play is of a **coalition builder**; establishing three types of coalitions, each playing different but complementary roles. We thought important to make the distinction between the three listing the important role each plays:

4.2.1 Coalition for shared physical infrastructure or flows

- A coalition playing an instrumental role in starting the emerging system, the role of an **enabling layer** which makes projects possible and **builds the platform**.

- Brings together asset owners and users to design, fund and deliver **common-use infrastructure** (ie. energy, water, feedstock logistics) that no single project can justify alone.
- Focuses on **capital alignment and risk-sharing**, typically formalised through Joint Ventures (JVs), Special Purpose Vehicles (SPVs) or long-term service agreements.
- Example of organisations in the region which could be part of these coalitions: utilities (power, water), port/transport operators, local government, infrastructure investors, major industrial users (mining, agriculture, processing), and potentially state funding bodies.

4.2.2 Circular cluster value delivery coalitions

- A coalition playing in the **value layer**. Generating the economic outcomes & value
- Brings together complementary industries across a value chain to **turn feedstocks into higher-value products**, aligned to the circular hierarchy (highest value first). See report section 3.2.1 Clusters for cluster details.
- Focuses on **commercial coordination and interdependency** (who supplies what, who takes outputs, how value flows between participants).
- Example of organisations in the region which could be part of these coalitions: feedstock producers (agriculture, sugarcane, aquaculture, others), processors (cane separation technologies, biomanufacturing, biorefining, precision fermentation, insect bio-conversion, etc), technology providers, offtakers (export markets, input material providers (fertiliser distributors), industrial buyers), and logistics providers.

4.2.3 Social infrastructure coalition

- A coalition playing in the **coordination layer**. The one that keeps the system working and sustain the coordination.
- Establishes an ongoing platform for **trust, alignment and decision-making**, ensuring actors coordinate beyond individual projects or funding cycles.
- Focuses on **relationships, shared direction and removing systemic barriers** (value and risk-sharing mechanisms, policy incentives required, approvals & regulation changes advocacy, skills, sequencing & dependencies).
- Example of organisations in the region which could be part of these coalitions: regional development bodies, government agencies (state and local), industry associations, natural resource management agencies, research institutions (e.g. universities, CSIRO), and key private sector leaders.

4.3 Step two: Turn circular clusters into a sequenced project portfolio

We defined and introduced circular clusters in section 3.2.1 of this report. With clusters defined, the next step is to translate them into a coordinated set of projects that can be delivered in practice. The recommended intent is to take an active role in deciding what gets built, in what order, and how projects

connect with each other. Furthermore, to take an active role in positioning the region's role in the State's Energy transition and BioFutures Strategy connected to an ecosystem of other precincts playing similar roles as a distributed network.

This is not about listing projects. It is about building a portfolio where each project has a role, and where sequencing reflects real dependencies across feedstocks, infrastructure and markets.

The following table presents a practical way to do this. It also provides the link to what coalition(s) will be playing the active role in the step:

Table 20: From clusters to project portfolio: key steps

#	Step	What needs to be done	Led by	Who needs to be involved	Active coalition
1	Confirm priority clusters	Shortlist the circular clusters the region will actively progress, based on State's Place-based approach, regional strengths and available feedstocks, existing activity and stakeholder alignment	Industrial transition developer	Key industry players, regional bodies, multi-layer government	Social infrastructure coalition
2	Sequence clusters	Identify dependencies between clusters and determine what needs to happen first to unlock others (ie. enabling systems like feedstock aggregation before higher-value processing)	Industrial transition developer	Industry, infrastructure providers, technical experts	Social and infrastructure coalitions
3	Identify co-location and select precincts	Determine where activities should be physically grouped to share infrastructure and enable material and energy flows	Industrial transition developer	State Development Areas operators, utilities, major industry (sugarcane)	Infrastructure coalition
4	Declare precinct value intent	Define the role of each precinct based on the clusters it will	Industrial transition developer	Government, industry	Social infrastructure coalition

		support, and the types of projects it will prioritise	(with government alignment)	leaders, investors	
5	Translate clusters into interdependent projects	Group projects into connected sets based on feedstock, infrastructure and market linkages, not as standalone initiatives	Industrial transition developer	Project proponents, industry partners, technology providers	Cluster value delivery coalition
6	Build and sequence the portfolio	Develop a clear pipeline showing which projects come first, what enables others, and what can progress in parallel	Industrial developer	All coalition members (industry, infrastructure, government, finance)	All three coalitions working together

The clusters and initiatives identified and explored through the project's stakeholder engagement processes, provide a practical starting point for this portfolio approach. As illustrated in previous sections of this report, the region already has a mix of operating projects and emerging opportunities across energy, nutrient recovery and high-value biomass transformation. The task now might not just be about identifying more projects or qualifying existing ones, but to **group and sequence these into a coherent portfolio within defined precincts**, where shared infrastructure, feedstock flows and industry partnerships can be aligned to move from individual initiatives to a functioning system.

4.4 Step three: Precinct activation and enabling conditions roadmap

With the coalitions in place and the project portfolio defined, the next step is to activate the precinct and put the enabling conditions into practice. This requires a staged approach, moving from **organising** and aligning actors, to **building** projects and infrastructure, and ultimately to operating as a **connected system**.

Table 21 below presents a roadmap that sets out a practical sequence of actions over time, showing how the region can move from early coordination to visible delivery and long-term scale:

Table 21: Precinct activation action roadmap

Short term (0 to 2 years)	Organise and commit
	Industrial transition developer role established and leading coordination

	● Coalitions formed and working on defined opportunities / challenges ● Priority circular clusters confirmed and translated into a first project portfolio (linked to a selected precinct) ● Early-stage projects (shared infrastructure) bundled and prepared for investment (pre-FID) ● Key enabling gaps identified and addressed (planning, approvals, data, coordination)
Medium term (3 to 7 years)	Build and scale
	● Precinct value intent formalised and visibly taking shape on the ground ● Shared infrastructure investment decisions made (energy, water, logistics, etc.) ● Anchor projects reaching final investment decision (FID) and construction underway ● Circular cluster-based project portfolio expanding with new entrants ● Market signals strengthening (offtake agreements, supply chain integration, investor confidence)
Long term (8+ years)	Integrate and replicate
	● Precinct operating as a connected system (not individual projects) ● Strong interconnections across clusters (materials, energy, by-products flowing) ● Integration with other precincts across the State and nationally (distributed network) ● Continued scaling of existing industries and attraction of new value-adding activities ● Model replicated in other regions, building a broader circular regional economy

Figure 14 shows the Precinct activation roadmap, illustrating the key stages in the design and delivery of the region's emerging system:

Precinct activation roadmap

Key stages in the journey to activate precincts and enabling conditions

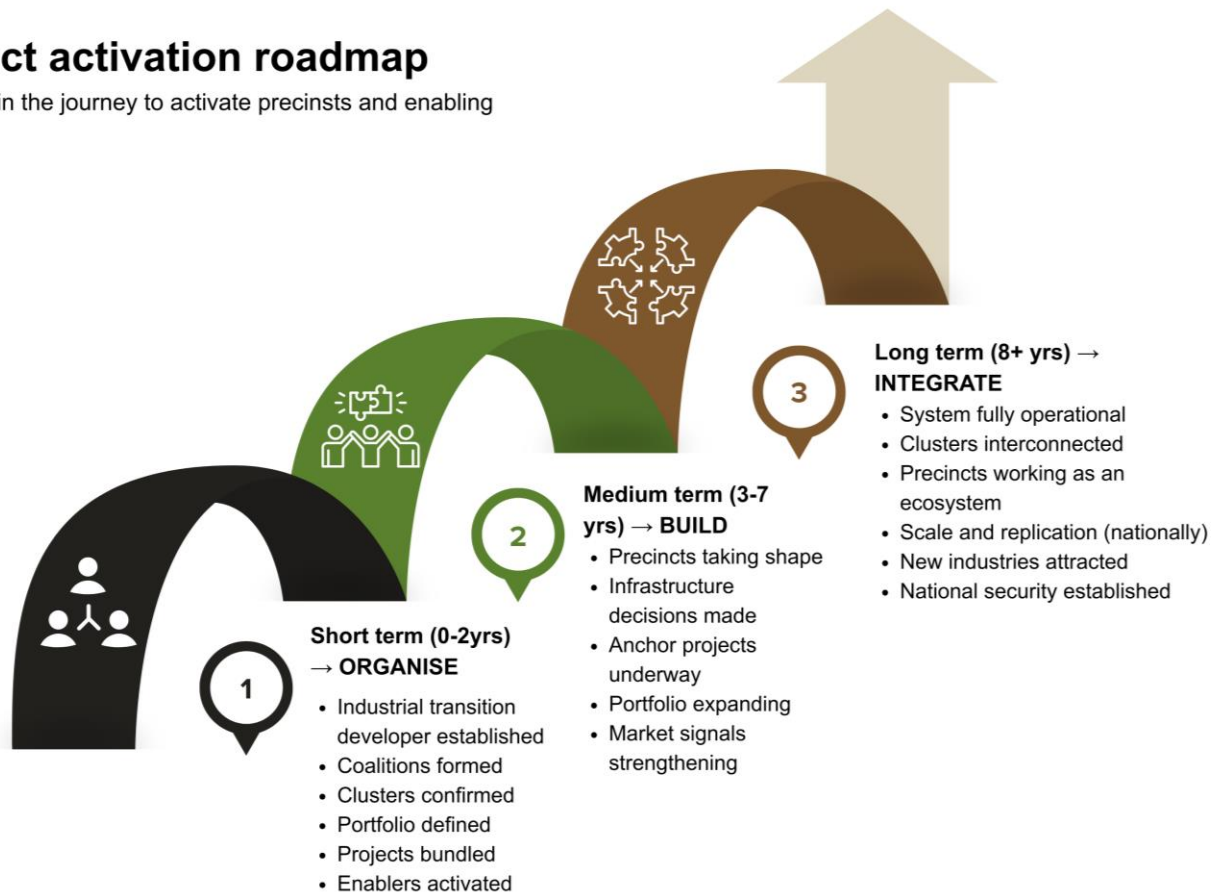


Figure 14: Precinct activation roadmap

4.5 The role of NRM in enabling the transition

NRM organisations play a critical supporting role in enabling the transition outlined above. While they are not the industrial transition developer (role defined in section 4.1), they provide key system functions that allow coalitions, project portfolios and precincts to emerge and operate effectively.

A unique position in the system

NRMs play a unique position within the regional system. They are neither regulators nor commercial actors, yet maintain enduring relationships across landholders, industry, government and community.

This positioning enables them to act as trusted, place-based organisations, grounded in both science and on-ground reality. For example, within the Mackay Whitsunday Issac region, this positioning is particularly relevant given the strong interface between agriculture, aquaculture, and water quality outcomes.

As the system shifts from coordination to delivery, this role becomes increasingly important. The structural barriers identified in this report (see section 2.5.1) are not solely technical or financial challenges. They are also coordination challenges, requiring alignment across multiple actors,

confidence in new models, and credible pathways from concept to adoption. NRMs are well positioned to support these conditions.

Their role across the system

NRMs play a critical role across all elements of the system:

- **Coalitions** - > Through their networks and mandate, NRMs act as a neutral convening force, supporting the formation of action-driven coalitions by bringing together producers, processors, researchers, technology providers, and government agencies. In doing so, they help establish the trust required for shared decision-making and early-stage coordination.
 - This can be observed through the formation of active coalitions, regular cross-sector engagement, and shared initiatives progressing beyond individual organisations.
- **Clusters** - > NRMs also contribute to the development of circular clusters by providing a systems-level understanding of resource flows across catchments. This perspective supports the identification of opportunities where value can be retained and recirculated within the region, and where environmental outcomes align with industry development.
- **Project portfolio** -> A critical function of NRM within this model is the provision of place-based data and validation. Through monitoring, trial work and on-ground insights, NRMs support the progression of projects from concept through to adoption. This helps de-risk investment decisions, inform certification and market access, and provide confidence to both proponents and capital.
 - This is reflected in the number of trials progressing to on-ground adoption, and projects moving from pilot stages into commercially viable pathways.
- **Enabling conditions** -> NRMs play an important role in enabling adoption. Through extension, demonstration and direct engagement with landholders, they support the uptake of new practices and products, helping to establish the demand conditions required for circular value chains to function. This is visible through increased uptake by growers and early market signals for new products.
- **Precincts and regional outcomes** -> Across the project portfolio and precinct scale, NRMs contribute to system alignment. By working alongside the industrial transition developer and other regional actors, they help ensure that initiatives are coordinated, grounded in local conditions, and connected to long-term environmental outcomes.

Stewardship and long-term role

Importantly, NRMs provide continuity as the system evolves. As projects scale and new value chains emerge, they help maintain a focus on water quality, soil health and ecosystem resilience, ensuring that economic development remains linked to the region's natural capital base.

In this way, NRMs act as connectors and stewards within the system. Their role is structural in the system. They enable the conditions required for coordinated action, supporting the transition from pilot to scale, and ensuring that circular economy development delivers lasting regional value, including new industry activity, investment flows, and employment opportunities.

Delivering circular value through coordinated action

5.1 A regional system at a crossroads

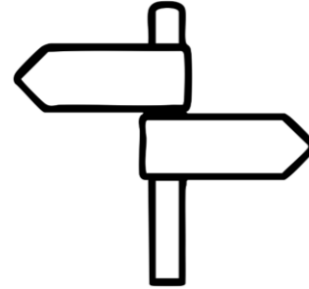
The region is at a clear **crossroads**.

Over the past decade, multiple strategies have identified the same **opportunity**:

-> abundant feedstock, strong industry foundations, and the potential to build a globally competitive bio-economy.

They have also pointed to the same **constraints**:

-> fragmented effort, lack of coordination, and the absence of an effective system that can bring projects together and support them at scale.



The question is no longer what needs to be done.

It is whether the region continues to work within the current model or **chooses** to design a system capable of delivering on what has already been identified.

This requires a shift: **starting with trust, aligning around shared challenges, and coordinating action with intent.**

Action-driven collaboration focused on removing the barriers that have consistently held initiatives back.

5.2 What this unlocks - system level benefits

What follows is not a new set of opportunities.

It is what changes when the region addresses the barriers consistently identified across previous strategies and categorised as system's dynamics in our report (see section 2.5.4 for details):

- Uncertain pathways to revenue
- Capital and risk are misaligned
- Enabling system infrastructure is missing

By working in a more coordinated and intentional way, the region moves from knowing what to do, to being able to deliver it. The shifts below describe how that shows up in practice across industry, investment and regional resilience.

Table 21 below outlines the shifts our region could unlock if choose to:

Table 21: Emerging system benefits

#	System level benefit	Existing signals of change
1	From fragmented effort → to coordinated delivery at scale - Projects are developed as part of shared portfolios, linked to clear regional priorities - Infrastructure, planning and investment are aligned early across stakeholders, not solved project by project - Industry, government and research work to a common delivery sequence -> Responds to repeated calls for stronger coordination and delivery mechanisms	- BioHub already aligning government, industry and R&D into a \$1B+ platform.²³ - QUT pilot at Racecourse Mill shows shared infrastructure in action²⁴ - GW3 and partners acting as regional coordination layer
2	From strong fundamentals → to projects that actually scale - Precincts and co-location bring together feedstock, infrastructure and end markets - Shared services and infrastructure reduce duplication and cost - Projects are designed to fit within a broader system, not operate in isolation -> Responds directly to the gap between pilots and industrial-scale delivery	- Region has ~3Mt/year of biomass feedstock ready for industrial use.²⁵ - Bowen model shows clear pilot → commercial scale pathway²⁶ - Co-location with mills/ports reduces cost and accelerate scale
3	From feedstock advantage → to value realised in-region - Processing and manufacturing are co-located with feedstock - Industrial-scale facilities (emerging industry) capture value before export - Existing industries (ie. sugar) expand into new revenue	- Region produces ~28% of Australia's sugar but exports most value value²⁷ - Biorefineries convert waste into higher-value fuels, chemicals, materials - Bowen precinct captures value from low-grade and surplus produce

²³ (Greater Whitsunday Region Alliance 2024)

²⁴ (Greater Whitsunday Alliance, n.d.)

²⁵ (Greater Whitsunday Alliance, n.d.)

²⁶ (Bowen Food Futures 2025)

²⁷ ("Sugar-Plus-Industry-Roadmap-document", n.d.)

	streams & develop multi-product revenue structures with growers Less raw material leaves the region without value being captured -> Responds to the consistent focus on value-adding locally	
4	From investment hesitation -> to an investable regional proposition - Projects are presented as part of a coordinated system with shared infrastructure and demand - Alignment in coalitions for shared infrastructure, demand, and clearer development pathways reduce investment risk - The region presents a more coherent and credible proposition to investors -> Responds to the need for scale, capital attraction and de-risking	- BioHub positioned to attract \$1B+ global biofutures investment - Strong global demand tailwinds (ie. +40% global protein demand)²⁸ aligned with regional strengths - Early public funding already de-risking first projects
5	From volatility & exposure → to regional resilience - Industry base becomes more diversified and interconnected across value chains - Revenue is less dependent on single commodities and global price cycles - Local supply chains strengthen through the use of by-products and circular inputs -> Responds to increasing exposure to global market shifts and the need for economic resilience	- Bio-economy modelling shows ~6,640+ FTEs by 2035²⁹ - Government increasingly recognising the risk of commodity dependence³⁰ - National focus shifting toward sovereign capability and local value-adding for regional resilience³¹
6	From environmental obligation → to economic driver Water quality, emissions and waste are treated as inputs to industry, not externalities	- Emerging push to integrate natural capital into financial performance - New markets rewarding low-carbon, bio-based

²⁸ ("FAO.org Publications FAO flagship publications The State of Food Security and Nutrition in the World", n.d.)

²⁹ (QUT 2014)

³⁰ ("Hansard - House of Representatives 25/03/2026 Parliament of Australia" 2026)

³¹ ("Hansard - House of Representatives 25/03/2026 Parliament of Australia" 2026)

	- Environmental outcomes are designed into production systems from the start - Natural capital becomes part of how the region measures and creates value -> <i>Responds to the shift from environmental compliance to a driver of economic activity</i>	- products³² - Waste streams increasingly treated as inputs to production systems (right demand signals)
7	From activity → to aligned execution - Existing initiatives, funding and capabilities are connected rather than duplicated - Effort is directed towards shared challenges, enhancing individual agendas - Decisions are made with visibility of the whole system, not in isolation -> <i>Responds to the gap between high activity and effort and limited outcomes identified across all reports</i>	- Multiple initiatives exist but remain fragmented today ³³ - Regional bodies already forming a coordination backbone - Precinct + portfolio approach enables sequenced delivery at scale.

These shifts do not require more activity. They require working differently, with trust, shared intent and coordinated action across the system.

³² (“Global Energy Perspective 2025” 2025)

³³ (“Current State development areas”, n.d.)

Final recommendations

The region does not lack ideas, strategies or opportunity. Multiple reports have already made the case for circular industries and regional value-adding. Yet progress at scale has not followed.

The issue is no longer what to do. It is how the region comes together to get it done.

This report focuses on what needs to change for delivery to happen.

At the centre of this is a **reset in how value and risk are shared**, and how the system works together under pressure. By addressing these system conditions first, the region can create a **platform that enables circular initiatives to scale**, including those that close nutrient and pesticide loops and, in doing so, we increase the likelihood that Reef-targeted water quality programs will succeed in support of the Reef 2050 targets.

The table below summarises our core report recommendations:

Table 22: Final report recommendations

1	Start with coalitions (step zero) The first step is not another study or plan. It is to start working differently, together. This means forming a small number of action-driven coalitions focused on real, shared challenges. ● Establish coalitions around problems that no single organisation can solve alone ● Be clear from the start on how value and risk are shared across the system ● Bring together the right mix of actors needed to act, not just to discuss ● Define a clear role to drive progress, with the ability to anchor investment or assets ● Use common language, data and measures so decisions stay aligned ● Deliver early, practical actions that build trust and momentum Natural Resource Management (NRM) organisations can play a key enabling role in this. They are trusted across the region, understand how the system works on the ground, and hold data that can guide decisions. They can help bring the right people together, keep efforts aligned, and support coalitions as they move into action.
2	Build clusters as connected pathways (what gets done) Moving forward requires a shift from individual projects to connected pathways that create value across the system. ● Group related initiatives into clusters that share inputs, infrastructure and markets ● Focus on pathways where the region has clear strengths and can scale ● Recognise that some clusters enable others and are critical to making the system work ● Align actors around shared value chains, not isolated opportunities

- Select project based on suitability with the cluster in design

3

Activate precincts as delivery platforms (where it happens)

Clusters will not scale without a clear way to bring projects together, reduce risk and coordinate delivery.

- Use precincts to co-locate projects and enable shared infrastructure
- Sequence investment so early projects unlock the next wave
- Align planning, infrastructure and approvals to support priority pathways
- Focus on enabling real projects, not promoting generic development

4

Put enabling conditions in place (what makes it possible)

For this system to work, the right conditions need to be in place to support coordinated delivery.

- Align funding, policy and approvals to support shared outcomes, not individual projects
- Build shared data, measurement and reporting systems to guide decisions
- Support new commercial models that reflect shared value and risk
- Strengthen coordination roles that help maintain alignment across the system

This is a shift from working in parts to working as a system. **From individual optimisation to shared resilience.**

These elements are interdependent. Progress in one area depends on movement in the others.

This is where the transition to regional resilience and economic transformation begins.

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Appendices

Appendix 1 – Stakeholder analysis (identification and shortlisting process)

Who are the stakeholders influencing the regional system

The inclusion of stakeholders followed the boundaries of the value chains mapped.

This step provides a clearer view of how the system functions in practice, not just through flows of materials, but through the relationships, decisions, and priorities that shape them.

There are two types of stakeholders performing functions in the regional system:

- **Primary Stakeholders** - Organisations that are part of each of the sector's supply chain are called primary stakeholders. These are the most obvious stakeholders to include.
- **Secondary Stakeholders** - Organisations who are not directly embedded in the value chain, but who are able to affect it indirectly or are themselves indirectly affected by the value chain (NRMs are a secondary stakeholder in this system)

Sugarcane		
Value chain category	Primary Stakeholder	Secondary Stakeholder
Input supplier / cane seed nurseries	Fertilisers (Wilmar, Incitec Pivot (Ridley Corporation), Nutrient Ag Solutions, Impact Fertilisers) Extension/agency – resellers	Soil & Plant Analysis services (SSP) Proserpine District Cane Productivity Mackay Area Productivity Services (MAPS) Department of agriculture & fisheries (DAF) Sugar Research Australia (SRA) - cane reed varieties Department of Environment, Tourism, Science & Innovation (DETSI) - Reef Regulations Mackay Regional Council Department of Primary Industries Queensland University (QUT) Regional Development Australia - Mackay Whitsunday & Issac

Cane farming & harvesting	Proserpine Growers / Land Managers Contractors Resellers Irrigation management - Waterboards	RCL (practice) DAFF MAPS DETSI Reef regulations Mackay Regional Council Department of Primary Industries Queensland University (QUT) SunWater Regional Development Australia - Mackay Whitsunday & Issac
Distribution	Mackay Sugar - Cane rail network Trucks Wilmar rail network Haulage contractors Warren Transport Proserpine - trucks	Mackay Regional Council Department of Primary Industries Queensland University (QUT) Regional Development Australia - Mackay Whitsunday & Issac
Mill	Mackay Sugar (Farleigh, Marian, Racecourse) Wilmar International (Plane Creek Mill, Proserpine Mill)	Tully MSF Isis Central Bundaberg Government NC markets/consultants Ergon Energy SunWater Mackay Regional Council Department of Primary Industries Queensland University (QUT) Regional Development Australia - Mackay Whitsunday & Issac Greater Whitsunday Alliance (GW3)
Refinery	Sugar Australia Wilmar Australia Mackay Sugar Racecourse Refinery (Home of CRS Sugar) Yarraville Refinery (Melb)	Department of Primary Industries Queensland University (QUT) Other commodity partners Distillery (alcohol) Pharmaceuticals Bio dunda (Ag fertiliser from biomass) Sugar Mulch – cane residue Bio fules - electricity Concrete – trash + cellulose (seaweed) Seaweed + cause – biochar & absorption

		Mill mud
Wholesaler	Sugar Australia - Glebe Packing Plant	Queensland Sugar Limited (QSL)
Distribution plus Global export	Wilmar International Sugar Terminals Limited Mackay Port Terminal	
Aquaculture		
Value chain category	Primary Stakeholder	Secondary Stakeholder
Input supplier / fish feed	Skretting Australia (Tasmania Plant) – hatchery and farm fish feed. Fertilisers (Wilmar, Incitec Pivot (Ridley Corporation), Fertilisers)	Mackay Regional Council Department of Primary Industries Queensland University (QUT) Regional Development Australia - Mackay Whitsunday & Issac
Hatcheries	Tassal - Gregory River/Proserpine Hatchery Tassal - Exmoor Station (Proposed) Pacific Reef Fisheries Hatchery Coral Coast Barramundi Hatchery	Mackay Regional Council Department of Primary Industries Queensland University (QUT) Regional Development Australia - Mackay Whitsunday & Issac Greater Whitsunday Alliance (GW3)
Growing operations (farms)	Tassal - Gregory River/Proserpine Farm Pacific Reef Fisheries Farm Coral Coast Barramundi Farm Australian Prawn Farms	Monagold Pty Ltd Uni/Tafe Engagement – Research Greater Whitsunday Alliance (GW3)
Processing	Tassal - De Costi Seafoods (Processing facility at Proserpine farm) Pacific Reef Fishers - Ayr process facility Coral Coast Barramundi Farm - Processing Plant Bowen Cleanaway	Uni/Tafe Engagement – Research (AI) Mackay Regional Council Department of Primary Industries Queensland University (QUT) Regional Development Australia - Mackay Whitsunday & Issac

Wholesaler	Tassal - De Costi Seafoods Mackay Reef Fish Supplies Arabon Seafoods Pty Ltd Coles & Woolworths	
Distributor & global exporter	Tassal - De Costi Seafoods Truck distribution – Toll, DHL	

How stakeholders were prioritised

To focus our engagement, we developed a shortlist of primary and secondary stakeholders. This was done using a Multi-Criteria Analysis (MCA) to prioritise stakeholders based on their relevance to the system and process we were trying to do. A detailed view on the MCA process is shown below.

The MCA approach allowed us to prioritise those stakeholders most critical to understanding how the system operates in practice and where change can be enabled.

Multicriteria Assessment (MCA) for stakeholder analysis and shortlisting

Stakeholders were assessed across the criteria listed below, a weighted scoring approach was applied to ensure consistency across stakeholders. Then they were prioritised based on their combined influence, relevance and ability to support system change.

Category	Criteria	Key questions
Strategic Relevance	Alignment with initiative goals	Does the stakeholder's strategy/mandate explicitly support circular economy, water stewardship, or sustainability?
	Value chain relevancy	Do they have large influence upstream and downstream across their value chain?
Financial & Investment Capacity	Capital availability	Could they commit financial resources to the initiative?
	Investment appetite	Do they have a track record or previous investment in circular economy, resource efficiency, biomanufacturing initiatives?
	Risk tolerance	How open are they to innovation, new models and revenue diversification?

Influence & Leverage	Policy/regulatory influence	How large or small is their ability to shape or influence policy, rules around resource recovery and water quality?
	Market influence	Is their scale of operations or supply chain large? (vertically integrated); are they market leaders in the region?
	Social license	How visible is their reputation in the region, is there potential to influence others by example?
Operational Contribution	Resource match	Do they have by-products or resources they could exchange? - As important, do they need or buy (import) large amount of resources relevant for replacement or exchange?
	Technical capability / talent / workforce	Do they have access to internal or external expertise or technology to enable circular exchange/replacement? (ie. Partnerships with R&D, QUT)
	Infrastructure control	Do they have access to physical infrastructure that can facilitate exchange? (ie. Land, facilities, logistic, storage, distribution networks?)
Motivation & Willingness	Past engagement	Is there history of collaborative approach and engaging in other water quality or sustainability programs (several examples of initiatives they have promoted or engaged with)
	Readiness to engage	Are they signals of willingness to co-invest or co-design initiatives
	Shared value potential	How large is their degree of mutual benefit across one or more areas (cost savings, compliance, revenue diversification, workforce, brand enhancement, innovation opportunities)
Sustainability & Impact Potential	Water quality risk exposure	Are they directly at risk from poor water quality downstream?
	Revenue diversification strategy? / Carbon/climate commitments	Are they involved in a revenue diversification strategy?, Are they part of accelerated decarbonisation initiative?, do they have to report emissions publicly?
Practical Engagement Factors	Decision-making accessibility	Can we secure interviews with key decision makers?
	Partnership maturity	Do they have governance structures to support multi-stakeholders initiatives?

Timing & urgency

Is there capacity and priority in this area?, is our engagement in their right planning cycle or investment window? (ie. Is this right enough timing?)

Appendix 2 – Detailed list of existing circular initiatives in the region

Number	Initiative	Description	Cluster	Status / Stage
1	Seaweed production – soil improvement / animal feed	Growing seaweed in settlement ponds as part of a bioremediation program and testing higher-value uses including fertiliser, compost, cattle feed and biochar.	Nutrient recovery / aquaculture by-products	Product/offtake market feasibility and partnership exploration
2	Sugarcane biomaterials / fractionation	Proponent has developed a process to separate harvested sugarcane into juice, fibre and other fractions for downstream manufacturing and biomaterials applications.	High-value biomass / bio-manufacturing	Pilot completed; moving toward commercial scale
3	Precision fermentation / biomanufacturing at Racecourse	Proponent explored a Racecourse-based precision fermentation facility using sugar inputs to manufacture high-value bio-based products through contract manufacturing.	Bio-manufacturing / precision fermentation	Business case / pre-commercial; Mackay project not progressed to build
4	Bagasse to renewable fuels pilot	A Mackay pilot biorefinery capability has been established to convert sugarcane bagasse into renewable diesel and sustainable aviation fuel.	High-value biomass / renewable fuels	Pilot operations / commissioning-scale capability
5	Mackay lignocellulosic biorefinery concept	Proponent published a Mackay biorefinery concept using lignocellulosic feedstocks such as bagasse and woodchip to produce ethanol and biocrude intermediates for renewable diesel and SAF.	High-value biomass / renewable fuels	Pre-FEED / FEED-seeking
6	Bowen Food Futures Precinct – reject tomatoes/capsicums to powders/extracts	Proponent is developing a precinct concept to turn reject tomatoes and capsicums into powders, extracts and nutraceutical ingredients.	Food waste valorisation / bio-manufacturing	Business case / pre-FEED
7	Shared LGA waste-to-energy facility (Mackay–Isaac–Whitsunday corridor)	A tri-council concept has explored a shared regional waste-to-energy / advanced waste treatment facility across the Greater Whitsunday corridor.	Waste-to-energy / municipal resource recovery	Concept → feasibility
8	FOGO rollout and organics processing	Kerbside food organics and garden organics collection is being rolled out in Queensland, creating a future feedstock base for composting, anaerobic digestion or other organics processing.	Organics recovery / municipal feedstock	Programme rollout + local processing feasibility

9	Abattoir waste to biogas / by-products	Waste streams from meat processing facilities such as Bakers Creek and Signature Onfarm have been identified as potential feedstocks for biogas and by-product recovery.	Organic waste / biogas	Underlying facilities operational; biogas concept remains early / unconfirmed
10	Mine gas capture and power generation (Isaac Energy Hub / Isaac Power Station)	Proponent is using existing gas infrastructure in the Bowen Basin and developing the Isaac Power Station to convert captured gas into electricity.	Waste gas recovery / clean energy	Existing gas operations + FEED / pre-FID moving toward construction for power station
11	Abbot Point hydrogen precinct (HyNQ)	A hydrogen and ammonia precinct is being developed within the Abbot Point SDA, with surrounding renewables intended to support domestic liquid hydrogen supply.	Clean fuels / hydrogen precinct	Feasibility / pre-FEED

Appendix 3 – Circular Waste Hierarchy (tool)

Australia's Department of Climate Change, Energy, the Environment, and Water (DCCEEW) released in 2017, their National Food Waste Strategy³⁴ where they recognised circular economy as the relevant approach to achieve their food waste reduction ambition. As stated by them:

The waste hierarchy prioritises waste management practices in favouring food waste avoidance over resource reuse, recycling, reprocessing, and energy recovery, followed by waste disposal. The hierarchy recognises the inherent value of food waste in providing guidance on the most resource efficient and environmentally sound approaches to dealing with waste.

³⁴ <https://www.dcceew.gov.au/sites/default/files/documents/national-food-waste-strategy.pdf>

Examples

- Education campaigns
- Research and development to support more efficient production methods
- Packaging initiatives to improve shelf life

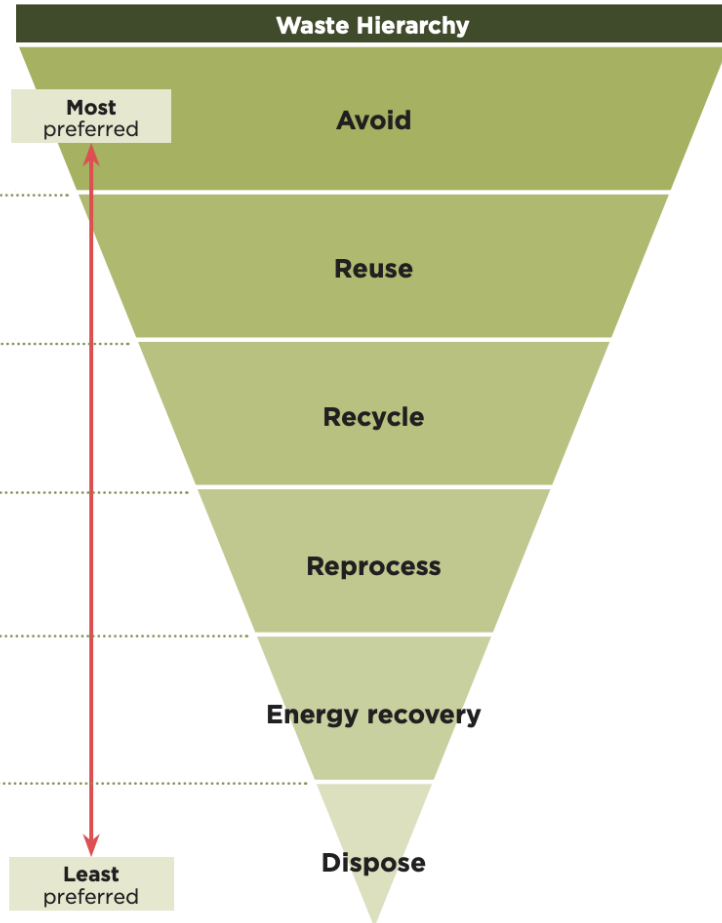
- Food rescue donations
- Repurposing aesthetically imperfect food (e.g. packaged carrot sticks)
- Repurposing without processing for animal feed

- Composting (windrows and anaerobic digestion)
- Soil conditioners
- Worm farms
- Biotechnology solutions for animal feed

- Conversion to pharmaceutical and nutraceuticals
- Conversion to cosmetic products

- Incineration and anaerobic digestion for energy recovery

- Landfill
- Incineration for non-energy recovery
- Food waste going to sewer



Appendix 4 – Preliminary list of Circular Opportunities list (GWR)

Opp. Number	Name of Cluster	Description	Key stakeholders / partners	Value Tier	Feed stock Resource (potential input)	Conversion Output	Value-added products	Indicative Development Cost (H/M/L)	Target Markets / Sectors	By-products
OP01	Advanced biomaterials / biocomposites	Townsend Industries proposes a separation system yielding multiple cane fractions (inner core, outer rind, outer skin/wax, microfiltered juice) with downstream products including fibre particulate composite pellets (packaging/plastic replacement), activated carbon (with biochar by-product), fibre flour, nutraceuticals/cane wax, and engineered timber products.	Sugarcane growers Sugar Mills Precision Fermentation or Fermentation Tech	A/B	Sugarcane billets Standover cane	Four cane fibres: * Inner Core Fibre * Outer Rind * Outer Skin & Wax * Microfiltered Sugarcane Juice	In correlated order to output: * <u>Fibre Particulate Composite Pellets (FPC)</u> for packaging or as plastic replacement input materials. * <u>Activated Carbon</u> - generating biochar as a by-product of making AC. * <u>Concentrated juice beverages</u> 95% purity level, high protein content & low ash. * Nutraceuticals & cane wax * <u>Fibre flour</u> - requiring post-separation processing. * <u>Engineered Timber Products</u> - Natural fibre composite engineered timber products.	High	Packaging converters Food & Beverage Industrial clean-up (water treatment, soil remediation, air filtration) Cosmetic, Nutraceuticals, Medical. Concentrated juice can undergo further fermentation post-processing for F&B industry offtake.	Biomass
OP02	Proteins / Animal Feed	A BSF facility converts mixed organic side streams into insect meal (protein), insect oil, and frass, with frass/residuals bridging into pyrolysis to produce biochar,	GoTerra (or similar)	B	Soft Shells, Prawn processing by-products (incl. sludge, e,	* Insect meal (protein from larvae) * Insect oil (lipids) * Frass/residual (bridge materials to pyrolysis) *	Aquafeed (novel ingredients locally sourced) High quality, insect-based protein isolates Biochar-frass blends (potentially to be tailored to cane soils)	Medium	Animal nutrition markets (livestock, aquaculture) Protein & oil co-products Fertiliser / soil conditioners	Heat/power Biosoil

		syngas and bio-oil; syngas may supply process energy.			pond residues). Municipal FOGO, soft green waste Break crops (cane rotation), cane trash, lignocellulose	Biochar (solid carbon) * Syngas (could be used to run the pyrolysis process itself, including dewatering aquaculture inputs) * Bio-oil / condensates				
OP03	Frontend Infrastructure - Organics Hub	A central "resource management infrastructure" opportunity: mechanical processing, central dewatering, storage and decontamination to create a cleaner, drier feedstock stream for later conversion (AD, pyrolysis, materials manufacturing).	* Sugarmills (Mackay Sugar, Wilmar) * Tassal, Australian Prawn Farms+ * Mackay Regional Council (Biosolids) * Cropping/ Forestry/ Cattle farming (ie. Mort & Co Fertilisers)	C	Sugarcane (trash, bagasse, other organics) Aquaculture (mortalities, pond sludge, other organics) Regional Council (WWTP - Biosolids) Cropping industries (regional) Forestry Waste (incl. solid	Pre-processed & decontaminated feedstock for subsequent industrial processing	Decontaminated, clean, dry feedstock for bio-conversion sub-sequence processes	Medium	Bio-manufacturing emerging sectors Bioenergy sectors Bio-fertiliser sectors	TBD

					waste paper and/or timber, etc) Manure (poultry, feedlot cattle)					
OP04	Biofuels - Biomethane (anchor)	A central anaerobic digestion and gas purification facility producing biomethane, biogenic CO ₂ , and/or electric power, with downstream pathways to industrial green gas, green ammonia/urea and fertiliser products.	<u>Partnering with:</u> Bioenergy Company - ie. NQBE, Licella Holdings, or international (Brasil)Geo BioGas& Carbon Gas Network Distributor in the region (pipeline)	C	Aqua culture (seaweed) Sugar mills (Vina sse & Filter Cake) Other relevant organic feeds tocks (if applicable)	Biomethane Biogenic CO ₂ Electric Power	Further processing to produce/distribute * Industrial-use biogas/green gas * Green Ammonia (including chemical industrial applications) * Green Urea (premium product) * Solid Fertiliser (plant growth substrate)	High	Industrial green gas users (explore METS industry nearby - industry fuel switching) Symbiotic relation with Mill for heat and steam use Fertiliser Sector (Nutrient Ag Solutions, Impact Fertilisers, Ridley Corporation) Potential partnership with Cement Production companies (co-location is key) using Biogas to lower carbon content in cement (Brisbane Olympics upcoming demand)	Potential Sulphur recovery
OP05	Biofertilisers	A downstream integration	Bioenergy Develop	C	Excess	Green Ammonia	As described	Medium	Primary Industries	

		opportunity: convert biomethane into ammonia products (green ammonia, green urea/biofertilisers) focused on primary industries and possible export-grade premium product.	r (int or ext) Mackay Sugar/Wilmar Tassal		energy from Mackay Sugar co-generation Biomethane	Green Gas Green Urea / Biofertilisers			- Sugarcane, Other cropping largely present in the region / State Potentially scaling to international markets (premium green product)	
OP06	Industrial Chemicals	A chemical industry expansion using biomethane and ammonia/nitrogen infrastructure: product slate includes nitric acid, calcium nitrate, technical ammonium nitrate, diesel exhaust fluid, odour management, base chemicals and concrete additives.	Biomethane producer (OP05)	C	Biomethane Biogas	Ammonia Nitric Acid Calcium Nitrate Technical Ammonium Nitrate	Animal nutrition Diesel Exhaust Fluid Bio Nutrients (WWTP) Odor Management Base chemicals Concrete Additives	High	Mining & Metals METS Industrial Water Treatment Defence	
OP07	Low-carbon cement & construction materials symbiosis	Use biogas/biomethane to lower fossil fuel use in cement and construction sectors, and potentially integrate fibre-derived boards/resins into construction materials	Cement Australia / Boral	C	Biogas	Low carbon cement	Additional construction materials (resins, boards from fibres and other organic sources)	High	Construction and Infrastructure Sectors	
OP08	Biofertiliser trial process & (voluntary) certification platform	Build a standard pilot/trial process for new bio-fertilisers,	Nutrien Ag Solutions Ridley Corporation Sugar Australia	C	Portfolio of new fertiliser products in	NA	Develop a standard pilot/trial process for new bio-fertilisers leading to a	Medium	Government NRM Growers / Farmers Product Developers	

		potentially moving to voluntary certification, consider farmer training, and map requirements for storage, blending and distribution/delivery.	(TBC) QUT NRMs		the region		(voluntary) certification Link to Australian Government Renewable Guarantee of Origin (REGOs) schema for credits/certification Understand the requirements in asset/infrastructure to deliver new organic fertilisers (storage, blending, distribution)		(fertiliser, soil conditions, etc)	
OP09	Shared reverse logistics and waste-to-value transport	Use existing logistics capabilities around sugar operations to expand into resource recovery and reverse logistics for BioHub precincts, reducing friction for organics collection and product distribution.	Cleanaway, Veolia, other relevant in region	C	Excess capacity in transport/logistics infrastructure for resource recovery, value add transport		Shared logistics infrastructure	Medium	Enterprises operating in BioHub precinct (Racecourse) - expanding existing contracts for waste management/disposal into resource recovery / reverse logistics	
OP10	Digital Platforms	Data traceability to track side streams (by-products) into final products. Supported by LCA's, carbon footprint modelling in alignment with Australian ACCUs and REGOs	All precinct level proponents including Gov.	C	Data traceability to track side streams (by-products) into final products. Supported by LCA's, carbon	Digital traceability, environmental management systems, data frameworks.	Assessment and assurance and Market acceptance.	Medium	Green premium product markets International sustainable products premium	

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