GETTING TO CIRCULAR

a Summary of Āmiomio Aotearoa, a Circular Economy for the Wellbeing of New Zealand

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Āmiomio Aotearoa

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"Room for improvement." That was the World Bank's verdict on New Zealand when it identified us as among the highest waste generators per capita in the developed world.[1] The upside to that verdict is that many citizens want that improvement. We also want healthier ecosystems, less chemical contamination, and less of the other costs of our current 'take-make-dispose' economic system.

A circular economy answers that call. It's an international concept of an economy that keeps resources circulating to limit the inflow and outflow of materials, reduce waste and pollution, and regenerate systems to protect natural resources. Āmiomio is te reo Māori for "around and around", and *Āmiomio Aotearoa: A circular economy for the wellbeing of New Zealand* was a project that aimed to help New Zealand transition to a circular economy. It was funded by the Ministry for Business, Innovation and Employment's Endeavour Fund (#UOWX2004), was hosted by the University of Waikato and involved researchers from multiple institutions nationwide.[1]

The nature, scale and scope of the changes needed to achieve a circular economy are immense. Āmiomio researchers examined it via three themes in particular. One team created an Aotearoa-appropriate vision of the circular economy informed by tikanga and mātauranga Māori. Another examined the needed upgrades to regulatory frameworks, business practice, economic theory and consumer behaviour. A third focussed on materials and designs to move away from fossil fuel-based products and waste. Their work spanned five years, from 2020 to 2025. This document synthesises it and points readers to detailed outputs at the University of Waikato's Āmiomio Aotearoa research outputs page.[2]

HOW STRONG IS YOUR CIRCULARITY?

A holistic approach that includes wellbeing in a circular economy aligns with strong circularity. Weak circularity has a narrower focus on market-led approaches, entrepreneurism and changes in consumer behaviour, and involves an expectation that economic growth will be maintained or accelerated. It places more emphasis on recycling and technological innovation without addressing the extraction of primary resources.

Strong circularity has a broad focus on the economy's entire flow of materials, and promotes change to lessen the full spectrum of impacts at extraction, production, transportation, consumption and disposal. This approach emphasises active leadership by governments in terms of regulation, incentives and education to promote cultural change that supports circularity. Unlike weak circularity, the strong version also seeks to balance environmental, economic, social and cultural sustainability.[3]

[1]Hodge, S., Barrett, P., & Kurian, P. (2025). The circular economy in Aotearoa New Zealand: a critical evaluation of policy and its current prospects. Kōtuitui: New Zealand Journal of Social Sciences Online, 1–20.

[2]https://www.waikato.ac.nz/research/projects/Āmiomio-aotearoa/research/

[3]Hodge, S., Barrett, P., & Kurian, P. (2025). The circular economy in Aotearoa New Zealand: a critical evaluation of policy and its current prospects. Kōtuitui: New Zealand Journal of Social Sciences Online, 1–20.

THE AOTEAROA FRAMEWORK

Āmiomio Aotearoa sought to integrate Māori and European ideas on circularity, sustainability and wellbeing.[4] These concepts are already central to Māori and other Indigenous cultures, who believe that people are born of nature and carry great responsibility for her care. Te ao Māori prioritises wellbeing for all, including future generations; sustainable ways of living; and protection and regeneration of the natural world – all concepts that the circular economy in its strongest form aims to achieve.

Te ao Māori weaves sustainability and wellbeing particularly deeply into its core. In this view, people are connected through whakapapa (genealogy) to a river, a species, a natural resource. This relationship means such entities cannot be harmed without harming people. In addition, the health of natural entities is recognised as essential to people's continued existence. So, too, are relationality, interdependence and reciprocity – that is, a holistic balance between people, and between people and the natural world. Such beliefs are reflected in protocols (tikanga) and stewardship (kaitiakitanga) that protect the natural and human worlds, and can help shine a light on a way forward from the decline in many measures of the natural world's health.

… the health of natural entities is recognised as essential to people's continued existence.

Elevating consideration of te ao Māori in research about circularity and sustainable wellbeing requires some awareness of Aotearoa's colonial history, which effectively undermined the Māori world view.[5] Te Tiriti o Waitangi (the Treaty of Waitangi) sets out a protective system for Māori rights and interests as tangata whenua (people of the land), including tino rangatiratanga (self-determination), but it has been frequently breached by the Crown in ways that severely disrupted Māori systems of land stewardship, culture, language and way of life. The shifting balance of power meant a European world view prevailed, one that lent itself to a linear economy where resource exploitation, use and disposal became the norm.

However, the pre-existing values, beliefs and world view are still deeply important to tangata whenua, and also resonate with many tangata tiriti (people of the treaty). Treaty settlements are increasingly making way for the Māori world view to inform economic policy (McMeeking et al., 2019), ecological systems (Joseph et al., 2019), Māori economies (Rout et al., 2024; Schulze et al., 2024), and mātauranga Māori infused innovation (Jefferies, 2024; Mika et al., 2024). Such developments are congruent with a circular economy.

The question, then, is how to integrate Māori and European ideas on circularity, sustainability and wellbeing so that they have standing in our present economic, political and legal system. This is a long-term matter, and entrusting governments with such a commitment is fraught because short-term electoral cycles incentivise short-term decision-making. Appointing guardianship that places greater relative weight on nature could help overcome this time inconsistency problem.

[4]Mika, J., Oxley, L., Claus, I., Roa, T., Morrison, S., & Peryman, M. (2024, May 13). Āmiomio: Toward a framework for sustainable wellbeing—A New Zealand perspective (Version 2). University of Waikato. Unpublished manuscript.

[5]Ibid.

HOW TO STRIKE THE BALANCE: RECIPROCITY BETWEEN HUMAN AND NONHUMAN ENTITIES

The Āmiomio team presented several approaches to achieving this integration.[6] One is pricing systems that define and enforce obligations that arise from the use of natural capital. For example, plastic is made from mined oil and gas. It has negative externalities: its production emits greenhouse gases and it causes microplastic and chemical pollution. Putting a levy on plastic containers, for example, would incentivise people and companies to reduce pollution. Such pricing systems can reduce environmental harm at a lower cost than does regulation. Greenhouse gas levies and biodiversity credits would also be examples of pricing systems.

Another way to protect nature from being undermined is by giving legal personhood to natural entities. In 2014, the forest Te Urewera became the first ecosystem in the world recognised by a legislature as having legal personhood. In 2017, the Whanganui River became the first river. In 2018, Mount Taranaki attained the same status. The advantage of this legal standing is that these entities can litigate (or their caretakers can do so on their behalf) when people or companies shirk their responsibilities and, as a result, harm the entity.

A third way to encompass sustainable wellbeing into the system is to include nature in economic models. Nature has traditionally been left out, but the Āmiomio team created an economic approach and model (beyond the pricing systems described above) that includes it. To do this, it's necessary to recognise that by protecting and regenerating nature, we steward the renewable natural capital on which our existence depends. Furthermore, this 'natural capital' should be passed intact to future generations. Sustainability in this view can be defined as non-declining capital (natural capital plus other types of capital, such as human capital, social capital and physical infrastructure).

This economic approach considers long term sustainability in the context of a household budget: when something depletes faster than it regenerates, debt is incurred – or natural capital is depleted. Natural capital increases when the environment is protected and regenerated, and it is drawn down when resource use exceeds the environment's ability to renew itself. When nature does not renew itself, intervention strategies, incentives and government protection are needed to maintain natural capital. Economic models that span current and future time periods and integrate nature could be adopted worldwide.

A fourth way is to leverage different types of economic activity (so-called 'diverse economies') that sit alongside the dominant economy. Āmiomio researchers examined a rural Māori community involved in restoring a river catchment with an aim to regenerate mahika kai (a traditional food-gathering place), and noted that a circular economy also has to be regenerative across all the dimensions as mentioned above.[7]

Culturally significant food species such as tuna (eels) rely on healthy river ecosystems. That is undermined by various 'waste' outputs from other economic activities such as excess nutrients from farms or slash from plantation forestry. Regenerating mahika kai involves aligning cultural, social, scientific, economic and spiritual interdependencies – complex interrelationships that could be modelled using Māori first principles.

LEGISLATION FOR CIRCULARITY

The narrowest view of circularity and sustainability focusses on managing waste. Āmiomio researchers analysed the history of waste-related legislation in New Zealand, documented the emergence of circular economy policies, and scoped overseas legislation for examples that could advance circularity here. They identified promising legislative amendments and key next steps. They concluded that any scaled-up shift to circularity will only happen with incentives and support from revamped policy, legal and institutional frameworks.

[6] Ibid.

[7] Ruwhiu, D., Amoamo, M., Carter, L., Bargh, M., Ruckstuhl, K., Carr, A., & Awatere, S. (2023). Ngā Whai Take. Reframing Indigenous Development. In Ruckstuhl, K., Velasquez Nimatuj, I.A., McNeish, J., Postero, N. The Routledge Handbook of Indigenous Development. Abingdon, Oxon; New York: Routledge. pp.297-308.

Concerns about waste unfolded slowly from the late 1980s and resulted in the 2008 Waste Minimisation Act (WMA), which remains the key legislative framework for managing and minimising waste, and for enlisting the involvement of waste generators through mechanisms like 'product stewardship'.[8] The Act also introduced the waste disposal levy to disincentivise waste disposal and to fund waste minimisation and related activities. The levy has increased several times, and half of it goes to territorial authorities for waste minimisation. The other half is contestable, and has consistently funded activities near the bottom of the waste hierarchy (see Figure 1).[9] An amendment to the WMA in 2024 allowed the fund to be allocated to a wider range of environmental activities beyond waste-related initiatives.

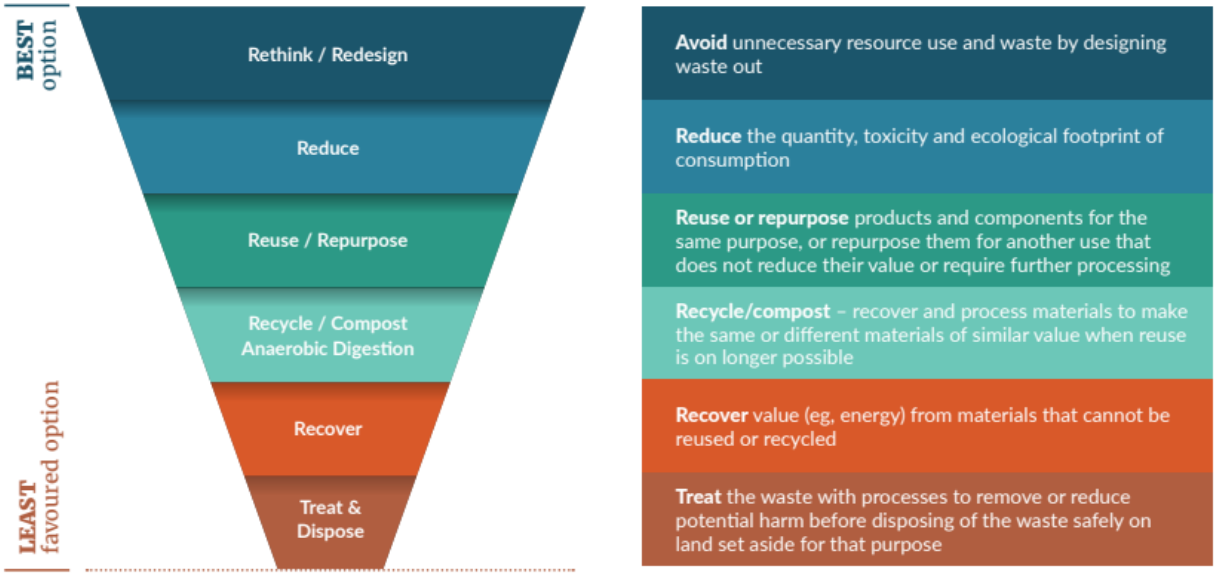

Figure 1. Waste hierarchy.
From Ministry for the Environment (2021) Waste reduction work programme.

Despite the WMA, New Zealand's total waste sent to landfill increased 39 percent between 2009 and 2021.[10] Commitment to it by successive governments has fluctuated, particularly faltering under those oriented towards free-market approaches, which tend to view waste minimisation and management as costs that hinder businesses.[11]

Circularity, as opposed to waste minimisation, became a policy goal in New Zealand only after 2017. It was part of the 2023 Waste Strategy and also the first Emissions Reduction Plan, reflecting that the way we make and use products contributes greatly to climate change. The focus, however, was only on the 'weak' end of the circularity spectrum (see sidebar).[12] Concepts of wellbeing and sustainability were mentioned, but these – and indeed any mention of the circular economy – dropped away with the next Government in 2023. While the new Government increased the waste levy, it shifted the focus to market leadership, and accordingly reduced regulatory burden on the business sector. This shift happened in spite of international market incentives for sustainable practices, such as international agri-food buyers seeking low-carbon supply chains.[13]

The new Government also discontinued work that had been underway. Proposed kerbside recycling and food waste collection initiatives were cancelled. The May 2024 Budget cancelled the development of the Circular Economy and Bioeconomy Strategy, which had been one of the actions in the first Emissions Reduction Plan. In 2025, it issued a 'Waste and Resource Efficiency' strategy, which replaced the 2023 Waste Strategy, and produced the second Emissions Reduction Plan without reference to circularity.[14]

[8] Barton et al. (forthcoming). Āmiomio Aotearoa Circular Economy Policy Synthesis.

[9] Blumhardt, H. & Prince, L. From lines to circles: Reshaping waste policy. Policy Quarterly, 18(2), 71-80.

[10] Ibid.

[11] Barton et al. (forthcoming). Āmiomio Aotearoa Circular Economy Policy Synthesis.

[12] Hodge, S., Barrett, P., & Kurian, P. (2025). The circular economy in Aotearoa New Zealand: a critical evaluation of policy and its current prospects. Kōtuitui: New Zealand Journal of Social Sciences Online, 1–20. https://doi.org/10.1080/1177083X.2025.2504489

[13] Ibid.

[14] Barton et al. (forthcoming). Āmiomio Aotearoa Circular Economy Policy Synthesis.

INITIATIVES WITH HEADWAY

The WMA created a legislative framework allowing governments of the day to initiate activities like establishing product stewardship schemes. This was underutilised for the first decade of the Act's existence, but the Labour-led governments between 2017 and 2023 instigated some initiatives, not all of which have been fully implemented. One is Regulated Product Stewardship Schemes for a range of products declared as 'Priority Products' in 2020. Only one such scheme, for tyres, has been fully designed, backed by regulation, and is now fully operational. However, others wait in the wings.

The WMA includes a provision that allows for bans on some items. This has been applied to a range of plastic items, from microbeads to single-use plastic shopping bags, produce bags, certain takeaway containers, and straws. Further planned phase-outs of PVC and polystyrene food packaging have been put on hold.

Other initiatives are in various stages of development: tackling building and construction waste, a beverage container return scheme that was fully designed but was deferred, and a recent Green Party Member's Bill that would amend the Consumer Guarantees Act (CGA) to include 'right to repair' provisions.[15,16] The Bill was introduced to the House of Representatives in 2024 and passed its first reading. The select committee's report is currently pending.

'Right to repair' movements aim to enable people to extend product lifespans and keep goods in circulation, reducing the volume and pace of materials and products moving through the economy.

'Right to repair' movements aim to enable people to extend product lifespans and keep goods in circulation, reducing the volume and pace of materials and products moving through the economy (see the right-hand section of the circular economy butterfly diagram at Figure 2). They target business practices that make it difficult or impossible to repair items, such as not making spare parts, diagnostic information or local maintenance services available, or planned obsolescence strategies (for example, gluing batteries in place or updates that won't work for older products). Early Āmiomio Aotearoa research examined areas of law for which updates would strengthen the right to repair in New Zealand. This included the WMA, intellectual property laws and the CGA.[17]

[15] Zaw, W. T. (2022). Right to Repair: The Obstacles in the Current Law. The New Zealand Law Journal.

[16] Barton et al. (forthcoming). Āmiomio Aotearoa Circular Economy Policy Synthesis.

[17] Blumhardt, H. (2022). My Product, My Right to Repair it. In A. Pendergrast & K. Pendergrast (Eds.), More Zeros and Ones: Digital Technology, Maintenance and Equity in Aotearoa New Zealand. Bridget Williams Books.

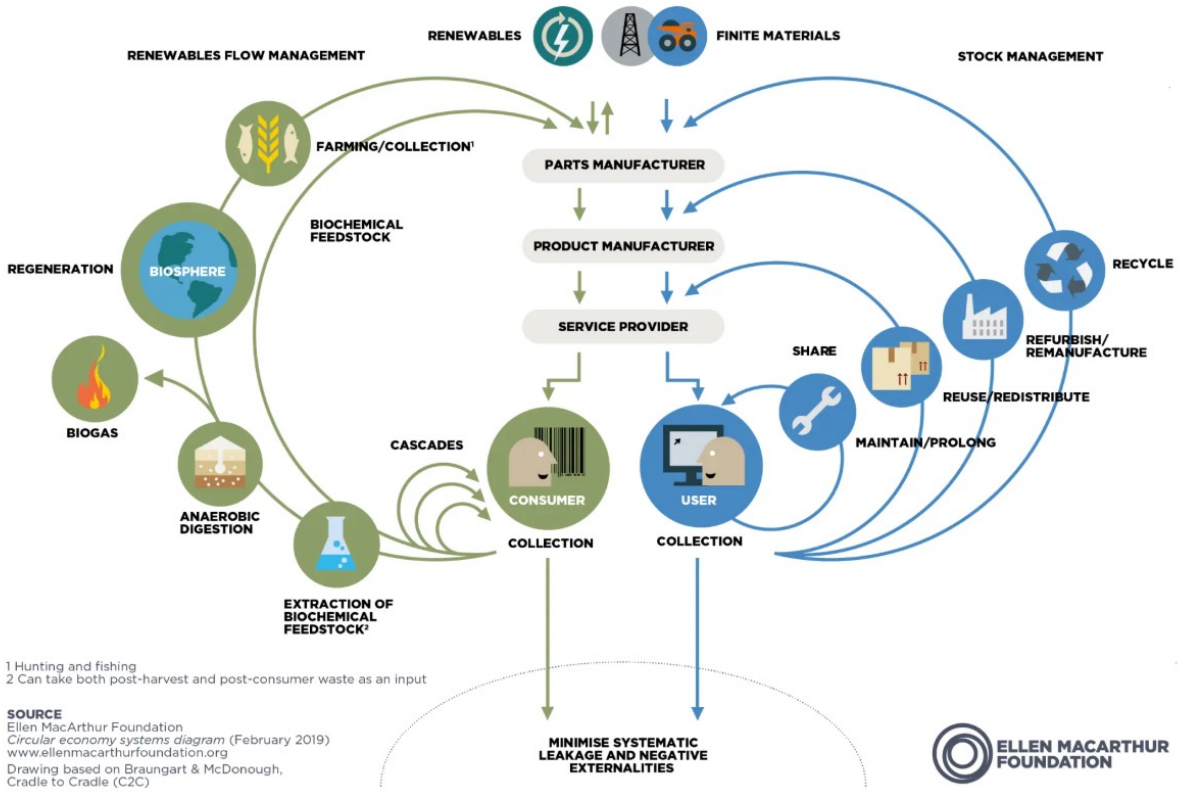

Figure 2. The circular economy butterfly diagram.
Source: Ellen MacArthur Foundation.

An update of the WMA is currently proposed. It includes Extended Producer Responsibility (EPR), which makes it mandatory for importers and producers to be responsible for sustainable disposal of end-of-life products, based on the 'polluter pays' principle. The proposed update also includes changes in the use of the waste levy, and improved compliance, monitoring and enforcement. It is less ambitious than previous proposals that would have included full implementation of the beverage container return scheme and new provisions to regulate products (including to facilitate repair), set environmental performance standards, grant broader powers to ban specific products and materials, and to regulate systems such as introducing duties of care and licensing for waste service providers. There were proposals for strategy, planning and reporting.[18]

The WMA obliges local governments to develop and implement plans for waste management and minimisation. Āmiomio researchers surveyed the state of circular economy initiatives in the Waikato region, finding uneven progress and a focus primarily on recycling and recovery rather than prevention, repair and reuse.[19]

[18] Barton et al. (forthcoming). Āmiomio Aotearoa Circular Economy Policy Synthesis.

[19] Barrett, P. (2024). Territorial local authority governance of the circular economy in the Waikato: an environmental scan. Paper presented at the New Zealand Political Studies Association Conference, University of Auckland, 17 February.

WHERE WE COULD GET TO

Āmiomio researchers looked overseas, noting that trade agreements could help or hinder circularity. They also examined four comparable countries to gather examples of waste-minimising and circularity policies that could serve as a basis for local versions.

Of particular note is Taiwan, which has actively implemented circular economy policies since 2016. Āmiomio researchers visited Taiwan, gaining insight into its relevant policies and practices, particularly in areas such as waste disposal and recycling, the right to repair, reuse strategies, and designing out waste. The country also has bans, incentives, EPR programmes, and fines if people don't sort waste into streams. It has remarkably low waste generation per capita.

How then, can New Zealand move ahead? A new or updated WMA could, for a start, define a circular economy and include a zero-waste hierarchy. It could facilitate actions that fall into seven key strategies, all of which have multiple precedents internationally, and some of which are partly underway here.

How then, can New Zealand move ahead with legislation to support a circular economy? A new or updated WMA could, for a start, define a circular economy and include a zero-waste hierarchy. It could facilitate actions that shift policy, practice and investment decisions towards the top of that hierarchy. These fall into seven key strategies, all of which have multiple precedents internationally, and some of which are partly underway here: (i) bans and restrictions, (ii) mandates and obligations, (iii) targets and target-setting powers, (iv) economic instruments, such as levies and rebates, (v) circular design specifications and standards for products and services, (vi) resource recovery standards that support the reuse of captured materials, and (vii) transparency requirements, such as labelling, for products and materials.[20] In addition, greater data collection powers would enable a broader assessment and measurement of circularity.

Amending other Acts, too, would assist. Updates to the Hazardous Substances and New Organisms Act could address the widespread use of hazardous chemicals in packaging, electronics and other everyday objects. A true circular economy, after all, regenerates nature – whereas recirculating products and materials that contain hazardous chemicals can disperse them and cause broader contamination. Building Code updates could mandate a longer building lifespan and the sorting of construction and demolition waste into different materials. Tax reforms could help incentivise businesses to transition toward circular practices and wider behavioural shifts.

This diverse suite of changes outlined by Āmiomio researchers – a mere summary of which is included here – would help to shift the economy towards circularity.

Other initiatives could help citizens make choices. Digital product passports, for example, can be applied to many products and reveal any substances of concern throughout a product's life.[21] Such information is currently mostly hidden, but transparency lets people make informed purchasing decisions and encourages producers toward circular practices.

[20] Blumhardt, H. (2023). Working Paper: Regulating products, production, and consumption for a Circular Economy in Aotearoa New Zealand.

[21] Dorner, Z., Tucker, S., Zhang, A., & Heuber, A. (2025). From willingness to engage to willingness to pay: A behavioral experiment on green consumer information in a digital product passport (Working Paper No. 25/03).

GRASSROOTS, RESEARCHERS AND BUSINESSES

There are more than just regulatory actors in the system. Taking a multi-level perspective, Āmiomio researchers took a broad view of system actors to assess where Aotearoa is heading in the circular economy transition. A scan of circular activity throughout the country found that in 2022, businesses, researchers, social enterprises and non-governmental organisations were the three largest groups using circular economy language.[22] These system actors focussed mostly on reducing and minimising waste, recycling, plastic and packaging, reducing carbon emissions and responding to climate change. The focuses of local government were similar. Regenerating natural systems – a key circular economy aim – received scant focus.

There are multiple community-led circular ventures in Aotearoa that operate high on the waste hierarchy. They are usually low-tech and serve the needs of their local people. Op-shops are possibly the oldest example, but there are food rescue and composting activities; re-use initiatives; zero-waste sorting, redistribution and repair hubs; and even hospitals actively reducing their waste. Many rely on funding from local councils' waste minimisation grants, which are funded by the waste levy.[23]

Cultural shifts that further progress circularity could be brought about by raising awareness and knowledge of it, and by ensuring that circular practises provide real benefits for customers and communities. For example, Āmiomio researchers explored how existing enterprises like food cooperatives, car-sharing businesses and social energy retailers can help meet people's everyday needs and reduce living costs while also having environmental benefits.[24] Their research showed that social licence for greater circularity is fostered when businesses, policies and enterprises consider more than just profit and efficiency, and instead also focus on redistributing surplus to reduce inequalities and meet people's material needs.

THE WASTE PROBLEM

Āmiomio Aotearoa focussed on how to transition to a circular economy, but it also identified the scale of the problem that needs fixing in New Zealand.[25] Landfills keep filling up; even those with the most sophisticated technology emit methane, and the liners that contain leachate have a finite life. Old landfills have ruptured due to extreme weather events, and rising sea levels threaten coastal landfills. Many consumables can't or won't be recycled, and large quantities of plastic are exported to South East Asia, promulgating what has been called 'waste colonialism'.

Plastics can contain and can leach harmful chemicals and are shed from tyres, clothes, carpets and upholstery. While in use and as waste, these products degrade into microplastics, which are now prevalent in air, water, food and living organisms, including humans.

Making, transporting and consuming goods creates nearly half of global greenhouse gas emissions. Most products are short-lived and/or disposable, made from virgin materials, not designed for reuse, repair or recycling, and over-duplicated. When they are wasted and not kept in circulation, so too are their embodied emissions, and more energy and raw materials must be extracted to manufacture and transport their replacements.

[22] Diprose, G., Walton, S., Greenaway, A., and Collins, E. (2022). How is the circular economy emerging in Aotearoa New Zealand? Research Brief.

[23] Stupples, P., and Diprose, G. (2024). From micro to meso: making visible communities of circular practice. Presentation at the New Zealand Geographical Society Conference, November 2024.

[24] Diprose, G., Dombroski, K., Strong, D., & Greenaway, A. (Forthcoming). Expanding circular economies through transformative reinvestments. Local Environment, doi.org/10.1080/13549839.2025.2533143.

[25] Blumhardt, H. & Prince, L. From lines to circles: Reshaping waste policy. Policy Quarterly, 18(2), 71-80.

GOING FOR ZERO WASTE

The zero waste movement overlaps with a 'strong' circular economy, with the circular economy approach having a more corporate and technological flavour and following.[26] Zero waste is guided by values of fairness, redistribution and community resilience, and follows principles to eliminate waste at its source via:

- product redesign
- reuse
- recycling
- composting organic materials

The zero waste movement supports regulatory mechanisms to require producers to be responsible for their products and take responsibility for costs such as waste management and pollution. It champions public investment and procurement being directed high in the waste hierarchy, especially to localised resource recovery and zero-waste business models, including infrastructure and reverse logistics for circular practices.

Zero-waste business models would favour:

- sharing over individual ownership
- reuse over single-use
- upgradeability over replacement

Examples of these models include public transport, library/loan systems (extending beyond books to tools, toys, etc.), laundrettes, clothing rental, app-based peer-to-peer sharing services, reusable packaging systems, whole-house deconstruction to salvage and reuse building materials, and easy and affordable repair of consumables, appliances and equipment.

These kinds of enterprises can help build social licence for greater circularity because they tend to focus on local communities' needs, can reduce living costs, create jobs, and provide the social and physical infrastructure that enables people to act, rather than relying on high-level policy or discourse.[27]

WHAT IS IT AGAIN? PROVIDING DEFINITIONS AND STANDARDS

There would be great benefit to a lead Government agency providing reputable, consistent and evidence-based information on the circular economy that can be referred to by all Government agencies and the private sector.[28] This could include definitions, measurements and targets. Such whole-of-government understanding would reduce misinterpretation and siloed thinking that misses the big picture.

An example of silo-based thinking is the circularity dimensions of climate change. The generally accepted practice is for emissions to be recorded as and where products are produced, but that diverts attention from their embodied emissions when they become waste. Awareness of those emissions where products are consumed would help achieve a circular economy.

Without being clearly defined, the circular economy concept is easily diluted by apparent solutions that do not reduce the amount of material entering the economy and the emissions associated with continued overconsumption.

[26] Ibid.

[27] Diprose, G., Dombroski, K., Stronge, D., Greenaway, A. 2025. Expanding circular economies through transformative re-investments. Local Environment 1–19.

[28] Blumhardt, H. Regulating Products, Production, and Consumption for a Circular Economy in New Aotearoa (Āmiomio Aotearoa, March 2023).

Without being clearly defined, the circular economy concept is easily diluted by apparent solutions that do not reduce the amount of material entering the economy and the emissions associated with continued overconsumption. They do not 'close loops' by putting materials back to their original use. They can disperse hazardous chemicals or generate new ones, and they can entrench market demand for waste generation.

Imperfect solutions are often expensive.[29] One example of this is waste-to-energy processes, for which New Zealand has no position or specific legislation. An in-depth analysis of incineration concluded that it is not compatible with a circular economy because of hazardous discharges, the risk of operational failures, the difficulty of enforcing consent conditions, its long-term need for waste as fuel, high greenhouse gas emissions and low electricity generation.[30]

PACKAGING AND CIRCULARITY

Single-use plastics have come to signify the 'throwaway culture' of the linear economy. Plastic packaging accounts for just over a third of the plastics that are produced globally, and most of it is single use. It's highly functional – but depending on its precise contents and how it is dealt with, can also pose environmental and human health risks.[31]

An alternative is reusable packaging, which could replace 20–30 percent of single-use plastic packaging. There are four types: returnable packaging (usually secured by a deposit system), refill systems in which customers refill their own packaging, transport packaging such as crates and satchels, and refill-by-parent packaging in which lightweight refills repeatedly fill a sturdier 'parent' container.

Single-use plastic packaging is so ingrained in trade and exchange that it is difficult for businesses and individuals to reduce it. Businesses wanting to implement reusable packaging face multiple barriers, especially cost; they must internalise all the extra costs, whereas the environmental and social costs of single-use packaging systems are subsidised by publicly funded disposal services. The playing field is uneven.

But are reusable systems really 'better'? Another Āmiomio project focussed on that question, particularly the environmental, health and socio-economic impacts of reusable packaging in the grocery sector compared to single-use systems.[32] The results showed that reusable packaging avoided waste, enabled safer packaging materials to be used, and that retailers dedicated to using reusable packaging systems often had spillover benefits in terms of providing a retail venue for local food producers and supporting customers to live their sustainable values. But products in reusable packaging were often more expensive and much less available than their single-use packaged counterparts.

Regardless, New Zealand has a number of reusable packaging initiatives, including zero-waste grocers and 'nude food' supermarket produce departments. Āmiomio researchers documented the substantial infrastructure, systems, expense, skills, marketing and behaviour changes needed for these two approaches to work. They suggested policies and regulation to incentivise reuse and disincentivise single-use packaging, and to help shift social acceptance and norms towards reusable packaging systems.[33]

GETTING BUSINESSES TO CIRCULAR

If countries are to transition to a circular economy, their businesses must do so. Āmiomio researchers examined fundamental aspects of circular businesses, including the precursors to circular manufacturing and the types, benefits and challenges of circular supply chains.

Using surveys and case studies of Chinese manufacturers, they concluded that a strong organisational culture focusing on the circular economy along with integrated management systems improves the ability of firms to implement circular manufacturing. This improves their environmental performance and financial performance.[34]

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[29] Blumhardt, H. & Prince, L. From lines to circles: Reshaping waste policy. Policy Quarterly, 18(2), 71-80.

[30] Barton B, Wee R. (2024) Waste to Energy Projects, the Circular Economy, and the Law New Zealand Law Journal, July, 222-227.

[31] Blumhardt, H. (2023). Current and future approaches to shifting businesses towards plastic-free packaging systems based on reduction and reuse Cambridge Prisms: Plastics, 1, E18.

[32] Blumhardt et al Reusable Packaging in the Grocery Sector: Understanding Impacts and Outcomes.

[33] Diprose, G., Lee, L., Blumhardt, H., Walton, S., & Greenaway, A. (2023). Reducing single-use packaging and moving up the waste hierarchy. Kōtuitui: New Zealand Journal of Social Sciences Online, 18(3), 268-289.

[34] Liu, Y., Farooque, M., Lee, C. H., Gong, Y., & Zhang, A. (2023). Antecedents of circular manufacturing and its effect on environmental and financial performance: A practice-based view. International Journal of Production Economics.

A fundamental aspect of transitioning to a circular economy is a transformed approach to supply chain management. Whereas traditional supply chains move raw materials through the economy to end up as waste, circular supply chain management (CSCM) often connects an ecosystem of different supply chains to recover value. CSCM was examined by Āmiomio researchers using case studies and literature reviews, providing in-depth overviews and further reading.[35, 36, 37, 38, 39]

They identified different types of supply chains – restorative ones for technical materials (e.g., metal and plastics) and regenerative cycles for biological materials (e.g., food waste). Chains can be closed-loop if they stay within the original supply chain, or open-loop if they connect and co-operate with other firms and sectors. Similarly, industrial symbiosis involves traditionally separate entities working collaboratively to exchange wastes and share resources. The research also showed that some manufacturers stopped delivering physical products and shifted to providing 'product-as-a-service' offerings that they lease or rent out.

The research found that there are cost efficiencies and competitive advantages for first-movers or early adopters, who design their supply chains and products from the outset for circularity. Shifting a linear supply chain to enable circularity is more challenging, particularly because the financial rewards are delayed; government mandates such as take-back schemes or Extended Producer Responsibility have assisted with this and been key drivers in some countries. Some governments have assisted with creating industry clusters that connect to make circular supply chain ecosystems.

Circular supply chains tend to be more resilient because their resource flows are protected from price fluctuation, seasonality and supply disruptions.

Circular supply chains tend to be more resilient because their resource flows are protected from price fluctuation, seasonality and supply disruptions. Costs are reduced, not least due to the use of recycled, remanufactured or refurbished products. Relationships are better because chains must work together, for example to organise reverse logistics (the return of used products and materials from customers back to manufacturers for reuse) or reverse engineering (in which components are removed from used products and reused in new products). Reverse supply chains recover used products via take-back schemes, sort them for reusability, and route them for reuse, refurbishment, remanufacture, recycling or sustainable disposal.[40]

[35] Zhang, A., Wang, J. X., Farooque, M., Wang, Y., & Choi, T. M. (2021). Multi-dimensional circular supply chain management: A comparative review of the state-of-the-art practices and research. Transportation Research Part E: Logistics and Transportation Review, 155, 102509.

[36] Farooque, M., Zhang, A., Liu, Y., & Hartley, J. L. (2022). Circular supply chain management: Performance outcomes and the role of eco-industrial parks in China. Transportation Research Part E: Logistics and Transportation Review, 157, 102596.

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[40] Gunasekara, L. A., Robb, D. J., & Zhang, A. (2023). Used product acquisition, sorting, and disposition for circular supply chains: Literature review and research directions. International Journal of Production Economics.

CIRCULARITY AND RESILIENCE

A linear system that continually imports new materials and products to replace those that are lost as waste is vulnerable to disruption in global transport chains. Resilience to such disruption can be increased by circular practices because they are a form of local provision enabling many needs to be filled from products and materials already in circulation. Circularity can also reduce our exposure to currency fluctuations.[41]

Even in firms finding it difficult to move to circular supply chains, there was broad recognition that not doing so causes environmental harm. Remanufacturing is highly regarded in the literature as an important way to reduce carbon emissions from the production process.

Firms are wary of their customers' willingness to participate in circular practices such as take-back schemes and buying refurbished rather than new products. In China, where there are many eco-industrial parks that facilitate circular supply chain management, a subsidy scheme incentivises customers to replace home appliances with remanufactured ones instead of new.

Circular supply chains start with product design. Remanufacturing, for example, relies on products being designed for disassembly. Based on interviews with New Zealand businesses, Āmiomio researchers developed a practical roadmap to guide businesses and policymakers in circular product design. They outlined the barriers to doing so and identified consumers, industry leaders and governments as having the most influence in overcoming the barriers.[42]

CIRCULAR ECONOMY DIRECTORY

Āmiomio Aotearoa contributed to the governance and review of applications for the Circular Economy Directory for the Sustainable Business Network, which brings together New Zealand businesses wanting to minimise their environmental impact.[43] The directory is an online catalogue of businesses offering circular solutions for other businesses, whether they want to redesign systems or products, reduce carbon emissions, regenerate nature, share and trade existing resources, extend product lifespans, recycle or compost. It lets businesses search for products and supplies with circular features, for raw materials and components, for goods with a product stewardship scheme, and for 'product-as-a-service'.

MATERIALS AND DESIGN FOR A CIRCULAR ECONOMY

Redesigned products and systems are needed to escape the linear economy in which products are used once and either sent to landfill or recycled into lower-value products. Products for a circular economy are designed to be adaptable and eventually disassembled. Their materials can be re-used, hold their value if recycled, and be regenerative if composted – which means avoiding the use of toxic substances. Packaging, construction and demolition are major contributors to waste, and these were the focus of Āmiomio Aotearoa's product designers, material scientists and engineers.

[41] Barton, B. (2022). Building Resilience from the Ground Up: Local Supply and Demand Management with Renewables, Prosumers, Energy Efficiency, Critical Minerals, and the Circular Economy. In C. Banet, H. Mostert, L. Paddock, M. F. Montoya, and I. del Guayo (Eds.), Resilience in Energy, Infrastructure, and Natural Resources Law: Examining Legal Pathways for Sustainability in Times of Disruption (pp. 327-341). Oxford University Press, doi:10.1093/oso/9780192864574.003.0020.

[42] Wang, J. X., Burke, H., & Zhang, A. (2022). Overcoming barriers to circular product design. International Journal of Production Economics, 243, 108346.

[43] https://sustainable.org.nz/circular-economy-directory/

Most building waste goes to landfill, including readily recyclable materials, but it could be recycled if it was segregated at building sites.

Researchers evaluated the large amount of material flowing into, through and out of the construction sector in Aotearoa New Zealand (Figure 3 and Figure 4).[44] They used data from multiple sources and estimated where necessary. They found that on average, three tonnes of waste is produced to construct a dwelling's envelope, and demolishing a dwelling typically produces 20–26 tonnes of waste. Most building waste goes to landfill, including readily recyclable materials, but it could be recycled if it was segregated at building sites. Plastic packaging of building materials is common but often not considered necessary by builders. Plastic is also used in construction components and to protect buildings.

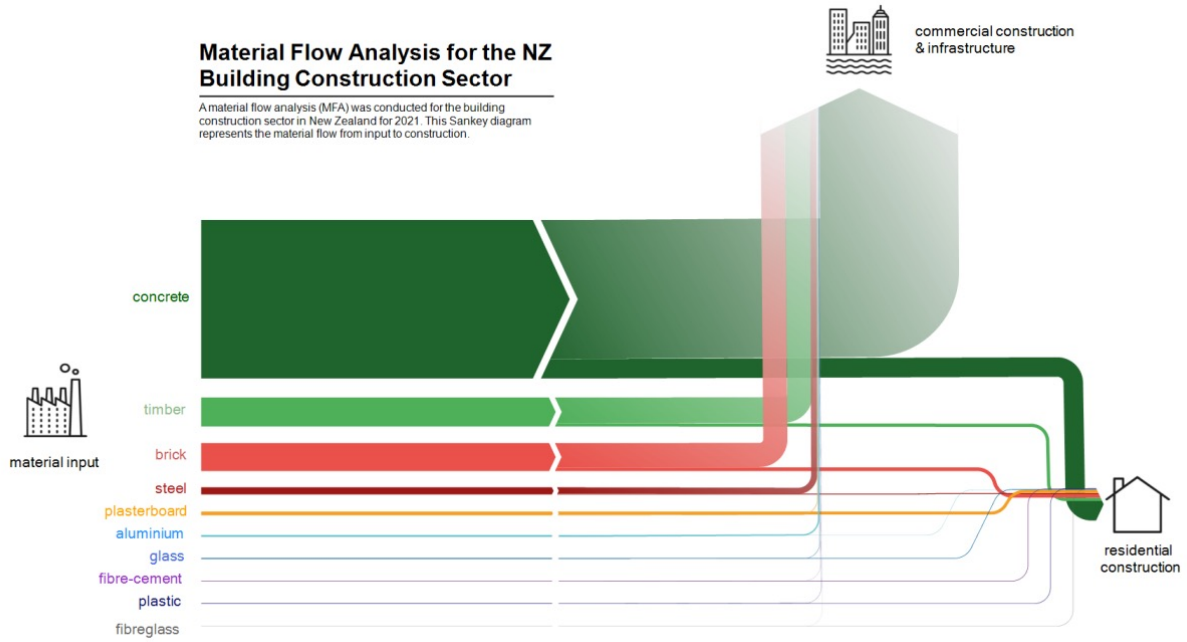

Figure 3. Sankey diagram showing material flow into the building construction sector in 2021. (The size of the arrows represents the mass of the material.)

From Nelson, J. M. B., et al. (2022). Preliminary materials flow analysis for Aotearoa New Zealand's building construction sector. University of Waikato.

[44] Nelson, J. M. B., Elliot, G., Pickering, K. L., & Beg, M. D. H. (2022). Preliminary materials flow analysis for Aotearoa New Zealand's building construction sector. University of Waikato.

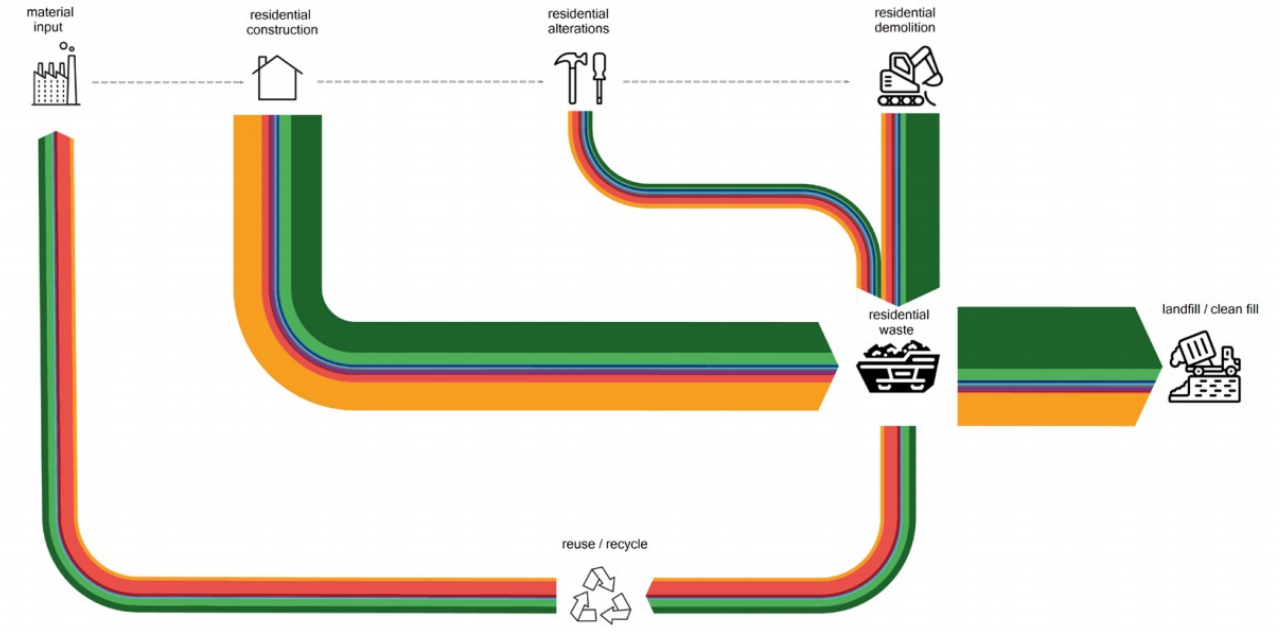

Figure 4. Sankey diagram showing waste from the residential construction and demolition sector in 2021. (The size of the arrows represents the mass of the material.)

From Nelson, J. M. B., et al. (2022). Preliminary materials flow analysis for Aotearoa New Zealand's building construction sector. University of Waikato.

BREAKING DOWN BIOPLASTICS

There's a trend towards bioplastics for packaging and takeaway cups. But most so-called compostable plastics are landfilled due to the conditions they need to degrade or because they get mixed with other waste.

One Āmiomio group focussed on using enzymes to assist with degrading bioplastics to either recycle or compost them safely. Compared to traditional mechanical recycling, enzymes use less energy, water and harsh chemicals, and the process can tolerate more contamination. The protein-degrading enzymes are produced by engineered microbes and break apart bioplastic bonds under mildly warm temperatures. This work focused mostly on polylactic acid (PLA), a bioplastic made from fermented plant starches. To make the breakdown process work at scale, biocatalysts were used, and an effective novel one was synthesised. Enzymatically degraded PLA can be used again to make virgin PLA products.[45]

Another bioplastic, polycaprolactone (PCL), was used to create a composite that successfully conducts electricity and can be used as a thermal sensor. It was combined with carbon nanofibers and enzymes. When added to warm water to activate the enzymes, it biodegraded completely.[46]

Combining readily biodegraded bioplastics with waste streams of natural fibres could extend their applications to demanding ones such as housing. Bioplastics have poorer physical performance than petroleum-based plastics, but reinforcing them with treated plant fibres can make them stronger than petroleum-based plastics and also reduce the product cost.

Combining readily biodegraded bioplastics with waste streams of natural fibres could extend their applications to demanding ones such as housing.

[45] Greene, A. F. (In progress).

[46] Greene, A. F., Abbel, R., Vaidya, A. A., Tanjay, Q., Chen, Y., Risani, R., Saggese, T., Barbier, M., Petcu, M., West, M., Theobald, B., Gaugler, E., & Parker, K. (2023). Environmentally Benign Fast-Degrading Conductive Composites. Biomacromolecules.

Āmiomio researchers successfully combined PLA with harakeke (flax), lyocell (from wood pulp) and hemp hurd (the woody inner portion of the hemp stalk). In each case the fibres' performance in the biocomposite was improved by pretreatments such as mechanical processing, enzymatic treatment and surface engineering. The optimum percentage of fibres and the resulting changes in performance were assessed, and all the fibre types were able to improve PLA's performance. The biocomposites were successfully used for 3D-printing, and could be reshaped and re-used.

Harakeke was also used in a biocomposite with PLA and the biodegradable polyester polybutylene succinate, which has properties comparable to polypropylene. In this composite, harakeke alone wasn't sufficient to improve the properties, but with a compatibiliser it was.[47]

Another waste product – milled mussel shells – was also explored as a plastic additive, this time in a matrix with recycled polypropylene from ice cream containers. The shells were coated to help them disperse and bond with the plastic, and the most successful coating was inspired by the adhesive properties of mussel foot protein.[48] The resulting composite, which also included treated flax fibres, was stronger than polypropylene alone. It was also more dimensionally stable, which is useful for 3D printing and structural applications, as well as more UV (sun) resistant. The mussel-polypropylene biocomposite could be used as a building material.

SMART DESIGN

Strengthened bioplastics combined with the world of 3D printing could open a new world of constructing buildings with components that are reusable, recyclable and do not generate waste. Currently about 40 percent of New Zealand's waste comes from the construction and demolition of buildings.

Āmiomio research investigated a new construction method using 3D printing to create bespoke structural modules from biocomposites such as those described above (Figure 5). Design optimisation software generates the design of modules, which are frames to which cladding is added, and ensures they meet the building's load, bracing and building code requirements. The modules are bolted together and can be unbolted for rearrangement or deconstruction. Modules can be reused or recycled into new modules if reuse isn't possible.[49]

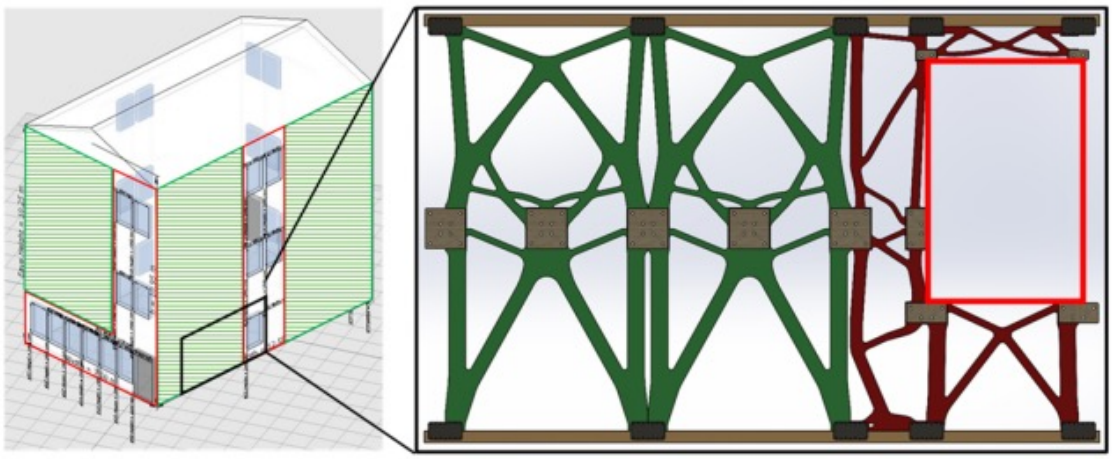

Figure 5. Theoretical assembly of a 3-storey building wall section comprised of modules designed using design optimisation software, made of biocomposites and manufactured using 3D printing. Structural modules are green and non-structural modules supporting a window are brown. The wall can be disassembled and the modules reused or recycled.

From Allouche, W., et al (2025). Thermoplastic composites in sustainable construction: Topology optimisation and additive manufacturing for a recyclable and modular building system. Proceedings of the 30th International Conference of the Association for Computer-Aided Architectural Design Research in Asia, 3, 417-426.

[47] Akindoyo, J. O., Pickering, K. L., Beg, M. D. H., & Li, Y. (2024). Reactive compatibilization of harakeke fiber-reinforced poly(lactic acid)/polybutylene succinate blend. Journal of Applied Polymer Science, 141(40), e56030.

[48] Xu, J., Mucalo, M. R., & Pickering, K. L. (2024). Bioinspired surface modification of mussel shells and their application as a biogenic filler in polypropylene composites. Composites Part C: Open Access, 15, 100520.

[49] Allouche, W., Pickering, K. L., Gauss, C., Beg, M. D. H. (2025). Thermoplastic composites in sustainable construction: Topology optimisation and additive manufacturing for a recyclable and modular building system. Proceedings of the 30th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA), 3, 417-426.

Using current construction waste streams for further construction is another way to reduce building waste. Many New Zealand built structures use timber treated with copper, chromium and arsenic, so the timber cannot be recycled, composted or burnt at the end of its life and must be sent to landfill. Āmiomio researchers developed a method to grind this treated timber into a flour, treat it with bleach and alkalinity, and combine it with polypropylene. This formed a building material that virtually eliminated arsenic in leachate (to below drinking water standards) and is suitable for semi-structural applications.[50]

Another abundant end-of-life product is sheepskins, most of which are disposed of as waste. They are rich sources of the proteins collagen, gelatin and keratin. Āmiomio researchers developed three processes to extract these compounds, leading to different protein structures and molecular weights. All three approaches give distinct products with the potential to be commercially relevant.[51]

BUT IS IT LOVELY?

Bio-based composites look and feel different to petroleum-based plastic, and even environmentally minded people have been reluctant to purchase them. An Āmiomio team explored this conundrum, finding that purchasers tend to find bio-based composites undesirable and also hard to distinguish due to disparate and confusing use of labels or standards such as 'eco' and 'biodegradable'. Plus their technical performance can be variable.

An ideal biocomposite would rate highly for naturality, beauty and value. A series of trials with several biocomposites showed they were more likely to be rated highly if they had perceptible fibres, visual consistency and smoothness (Figure 6). Being able to feel the products as well as see them altered perceptions. To increase the popularity of bio-based composites, the researchers called for innovative product designs, particularly focussed on tactile and visual signals that distinguish the product as natural.[52, 53, 54, 55]

[50] Nelson, J., Pickering, K. L., & Beg, M.D.H. (2023). Assessment of the potential of waste Copper Chromium and Arsenic (CCA)-treated timber fibre reinforced polypropylene composites for construction. Journal of Composites Science.

[51] Matinong, A.M.E., Pickering, K.L., Waterland, M.R., Chisti, Y., Haverkamp, R.G. (2024). Gelatin and Collagen from Sheepskin. Polymers, 16, 1563.

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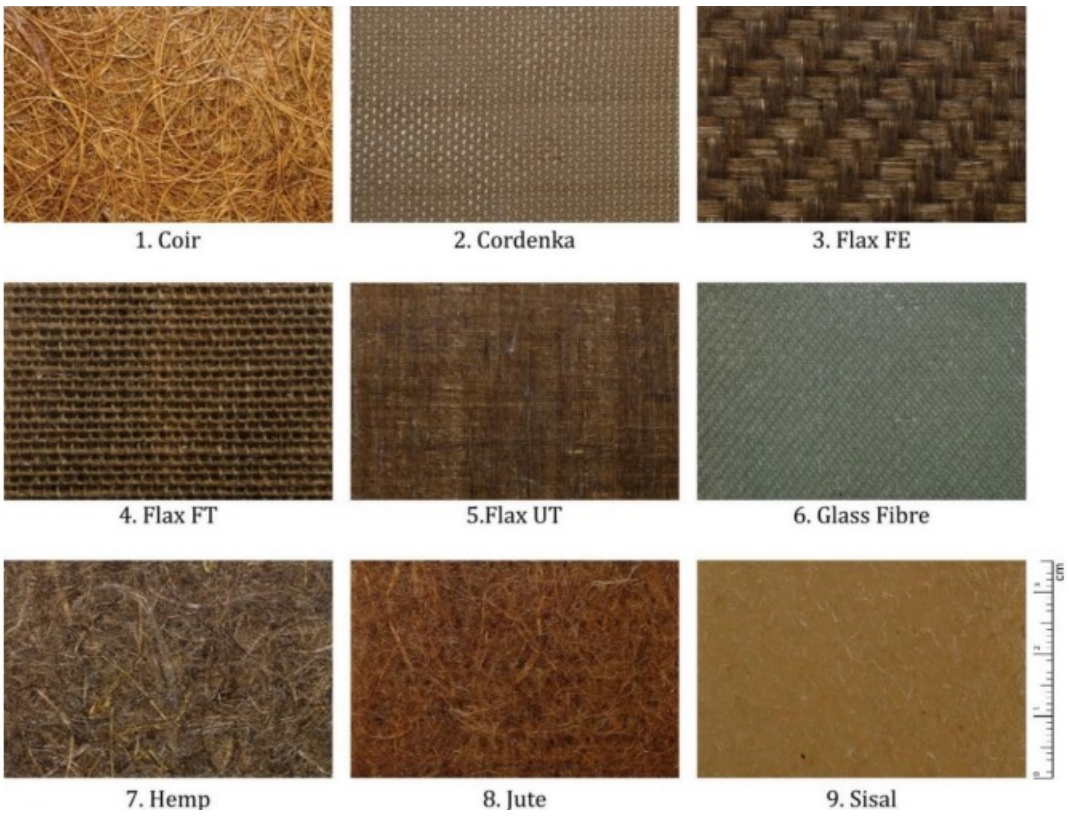

Figure 6. Images of samples used to assess the role of perception in consumer acceptance. All are bio-based composites apart from the glass fibre.

From Thundathil M., et al (2025). Designing Sustainable Materials: The Role of Material Perception in Consumer Acceptance. New Design Ideas, 9(1), 30-59.

MOVING FORWARD

Aotearoa New Zealand has yet to undergo deep systemic change to achieve a circular economy (see Figure 7. How the circular economy transition progresses), so it remains largely linear. There are broad drivers for transformation, such as climate change and cultural values, but national policy is only moderately supportive and is fragmented. There is no coherent circular roadmap.

But there is interest from businesses and society. This country has a longstanding waste minimisation movement, and there are many other community initiatives. Scientists, engineers, business leaders and entrepreneurs are innovating in ways that could shift the economy. Māori are steadfast in their traditional culture and values, illuminating a path forward that involves wellbeing for all, including future generations and the natural world.

Importantly, many of these early steps demonstrate circularity's benefits because they meet people's needs and reduce their costs, while also having environmental benefits. This develops social licence for circularity and to encourage behaviour change. It also meets the wellbeing imperitive – or social and cultural sustainability – of so-called 'strong' circularity. New Zealand's small steps towards a circular economy have to date mostly epitomised 'weak' circularity, focussing on economic growth rather than human and environmental wellbeing, and on waste management rather than reducing the amount of waste that needs disposing of.

There is enormous potential for change at the highest level, with Taiwan being an example of a country that has embedded circular economy policies and practices, and is seeing the fruits of that in terms of changed behaviour and low waste generation. Āmiomio researchers have identified similar policies and practices that could be implemented in Aotearoa New Zealand.

Many of the policies are to account for negative side effects that businesses typically externalise because they're allowed to. Regulatory levers that require businesses to internalise these costs are well-described by Āmiomio Aotearoa research and would make circular models economically viable by letting them operate on a fairer playing field. Multiple potential reforms are outlined – some as simple as definitions and transparency requirements, and as old-fashioned as making items repairable – to penetrate the web of barriers that maintains the linear, polluting economy because it is cheapest and most profitable.

Putting these levers in place would facilitate much-needed change in other areas that Āmiomio Aotearoa has tackled. These involve the design, materials and supply chain foundations of a circular economy. Circularity needs non-toxic materials created from nature that go back to nature; products that are designed for disassembly and remanufacture; supply chain approaches that enable products to be taken back and reused.

This document merely skims years of work and contributions by 49 Āmiomio researchers, but readers are encouraged to delve further into the references provided for substantive detail. Āmiomio Aotearoa: A circular economy for the wellbeing of New Zealand received Government funding and launched in 2020, when the circular economy was a policy goal. It ended in 2025, a time when the term 'circular economy' had ceased to be used by the Government. Its researchers hope that in future, their work will provide useful inspiration, guidance and actionable paths forward for people stewarding a liveable, healthy planet for future generations.

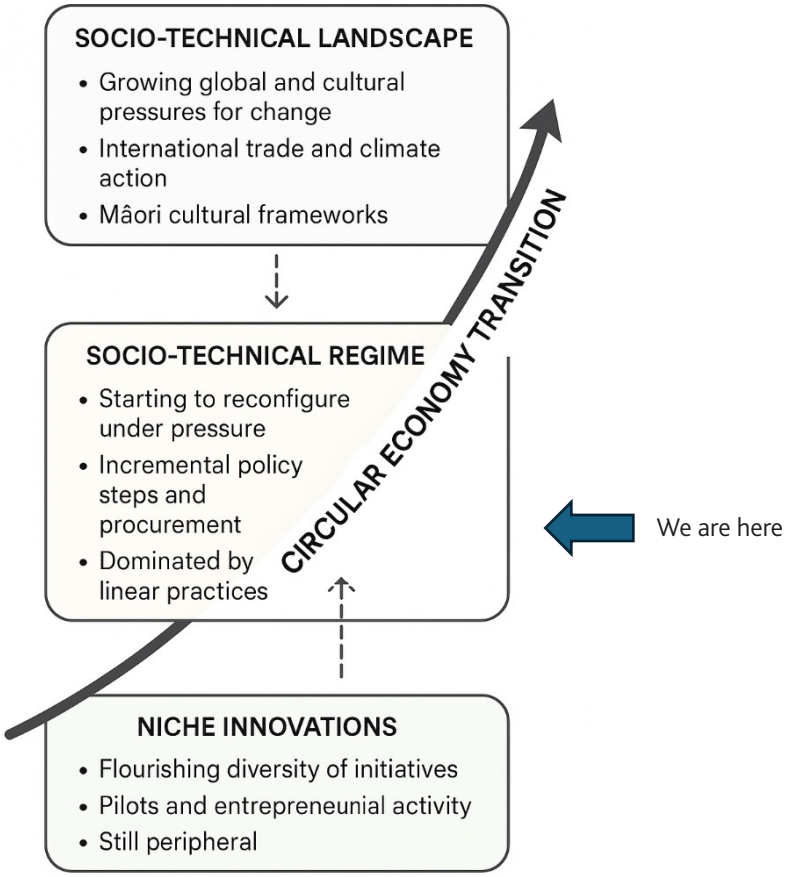

Figure 7. How the circular economy transition progresses
(from Walton et al, 2025, Forthcoming)

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