Securing Costa Rica's Sustainable Future:

A multi-level perspective analysis of the sustainability transition to operationalise the 3Rs in the plastic waste management system in Costa Rica.

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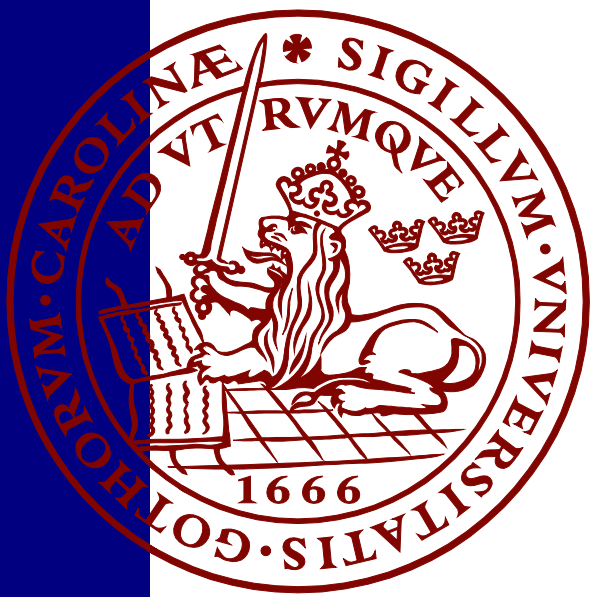

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Abstract

Plastic waste and pollution have proliferated globally causing environmental degradation and biodiversity loss. Costa Rica hosts 5-6% of global biodiversity and struggles to balance socio-economic development with environmental protection in the context of plastic waste management. This system is analysed through the multi-level perspective using primary data collected from semi-structured stakeholder interviews and secondary data from policy documents, reports and articles. It aims to understand how the transition to a 3R (Reduce, Reuse, Recover) compliant plastic waste management system is progressing and identify how it could be supported. Findings show windows of opportunity emerging as societal landscape changes pressures the political and market regime to adopt progressive plastic waste management policies. Momentum is building with niche-innovations aligning through learning, network expansion and articulating needs to promote increased recovery. However, reduce and reuse strategies are less developed. National and local governments are essential in enabling niche-innovation, opening key markets and achieving co-benefits.

Keywords: Circular economy, integrated sustainable waste management, plastic pollution, waste-pickers, recycling, recovery

Word count: 11,045

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1. Introduction

1.1 The problem of plastic pollution

In March 2022, a landmark international agreement was made at the United Nations Environmental Assembly aiming to *"end plastic pollution and forge an international legally binding agreement by 2024"* by addressing the full life-cycle of plastic (United Nations Environment Programme [UNEP], 2022). This action came after increasing concern about the world's ability to safely manage plastic waste in-line with its projected growth. Borrelle et al. (2020) estimated that 11% of globally generated plastic waste, 19-23 million tonnes, entered aquatic ecosystems in 2016. The pace at which plastic is accumulating in rivers and oceans is rapid and there is increasingly robust evidence that it adversely affects coastal ecosystems and ecosystem functioning (Villarrubia-Gómez et al., 2018). This pollution causes biodiversity loss as millions of animals die due to entanglement or starvation(International Union for Conservation of Nature [IUCN], 2021; Parker, 2019). UNEP (2017) found *good knowledge and evidence*[1] to suggest that marine megafauna such as sea turtles, sea birds, dolphins and whales are adversely impacted by entanglement and ingestion of plastics and *fair knowledge and evidence* to suggest that fish, corals, and phytoplankton are impacted by the absorption and ingestion of micro and nano-plastics.[2] As land-based sources of plastic waste account for 80% of plastic which enters the oceans (Alpizar et al., 2020), it is critical to address the generation and flow of plastic towards the oceans. Despite ambitious government commitments (as of 2020), Borrelle et al., (2020) projected annual leakage of plastic waste into aquatic ecosystems could rise to 53 million tonnes each year by 2030, highlighting the extraordinary scale and speed at which the world must transform its management of plastic waste.

Plastic is an abundant material that is used extensively worldwide, largely as low-cost single-use products. This type of use exemplifies modern consumer culture built on convenience and the ultimate luxury - disposability. It is symptomatic of an inherently wasteful linear economy that is predicated on extraction, overconsumption and pollution. In Costa Rica, plastic has become a major problem due to the high consumption of single-use plastic and an inadequate waste management system. Recycling rates are very low with just 3.7% of total waste recycled in 2018 (54 thousand

[1] Based on the weight of scientific evidence as assessed by UNEP (2017).

[2] Plastic particle size as measured by the diameter: mega (>1m), macro (<1m), meso (<2.5cm), micro (<5mm) and nano (<1 µm).

tonnes) with the rate for plastic far lower (Government of Costa Rica, 2021). Due to poor containment, an estimated 110 tonnes of plastic accumulates in the environment each day (Government of Costa Rica, 2021). The Inter-American Development Bank [IADB] (2020) reported an estimated 11% (176,028 tonnes) of total waste generated in Costa Rica in 2020 was plastic. Single-use products such as bottles and packaging account for such a large proportion of the country's plastic waste that the government has developed a dedicated regulatory framework (Table 6 Appendix 1). The Ministry of the Treasury reports annual production of 600 million single-use plastic bottles, of which almost 90% end up in rivers, coasts, and marine environments due to inadequate disposal (Ministry of Health, 2017). These figures are expected to increase year-on-year as global plastic production capacity increases (see Section 2.1) and incomes rise, which is correlated with higher plastic consumption (Ministry of Health, 2017). Costa Rica, similar to many upper-middle-income countries, faces an urgent challenge to balance socio-economic development with environmental protections.

Costa Rica is experiencing a litany of related social and economic impacts due to environmental degradation caused by plastic pollution. These include costs of environmental clean-up and losses for livelihoods and tourism. For example, the National Power and Light Company reported economic losses of CRC 64 million (USD 98,000) over a four-year period for clean-up of approximately 5,000 tonnes of plastic from four hydro-electric power plants (Ministry of Health, 2017). Tourism is a significant economic sector accounting for 6.3% of GDP in 2016 and employing approximately 12% of the workforce (160,000 directly and 450,000 indirectly) (Instituto Costarricense de Turismo [ICT], 2016). The sector is built upon the country's natural attractions and sustainable credentials which are threatened by plastic pollution (McGovern et al., 2020). Another affected sector is fishing as pollution causes fish stocks to fall making it difficult for coastal communities' dependant on fisheries (UNEP, 2021). Although the sector contributes a small portion of Costa Rica's GDP (0.19%)[3] it employed 9,522 people in 2018 largely in low-income coastal communities (Organisation for Economic Co-operation and Development [OECD], 2021).

[3] Costa Rica's GDP in 2020 was equal to USD 62 thousand million (World Bank, 2020).

1.2 The need for a global sustainability transition

Plastic pollution is part of global interconnected crises of climate change, environmental degradation and unsustainable development. In 2022, the IPCC asserted with *very high confidence*[4] that global warming of 1.5℃ above pre-industrial levels in the near term (2021-2040) would cause unavoidable increases in climate hazards, threatening ecosystems and humanity. It is anticipated that every additional 0.1℃ beyond 1.5℃ warming will intensify environmental harms, human suffering and severely constrain opportunities to adapt or build resilience to the changing climate (IPCC, 2022). Thus reducing global greenhouse gas (GHG) emissions to net-zero has become a prescient goal to achieve the Paris Agreement target of limiting global warming to under 1.5℃ to mitigate the most extreme effects of climate change (UNFCCC, 2015). This requires a global sustainability transition at an unprecedented scale and rate. The plastic sector is relevant for decarbonisation efforts as it accounts for approximately 8-9% of global oil and gas consumption (3-4% as energy and 4-5% as feedstock) (Nielsen et al., 2019). Plastic production and incineration globally emit approximately 400 million tonnes of CO_2 (Nielsen et al., 2019). Therefore, a full life-cycle approach is needed to reduce fossil-fuel use and improve plastic waste management.

In addition, the global community committed to achieving the United Nations Sustainable Development Goals (UN-SDGs) by 2030 (UN DESA, 2016). These goals set out a sustainable development agenda to address urgent global challenges, eradicating poverty whilst balancing the social, environment and economic dimensions of sustainability. In order to balance these dimensions, the concept of planetary boundaries was developed, quantifying thresholds for nine areas[5] within the earth system that are affected by humans (Rockström et al., 2009). If transgressed, the Holocene state which has enabled human development will be endangered. Recent research suggests that the boundary for novel entities (formerly chemical pollution) has now been exceeded (Persson et al., 2022). This is the result of rapidly increasing global plastic production, 79% between 2000 and 2015, and the presence of plastic in the most remote places on Earth. This suggests an impact pathway connecting production and unwanted effects on the earth system (Persson et al, 2022). Although the UN-SDGs contain only one explicit target for reducing marine plastic

[4] Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgement) and the degree of agreement. Confidence indicators: Very low, low, medium, high and very high (Mastrandrea et al., 2010).

[5] Rockström et al., 2009 defined nine planetary boundaries: climate change; biodiversity loss; biogeochemical; ocean acidification; land use; freshwater; ozone depletion; atmospheric aerosols; and chemical pollution, now novel entities.

environmental impacts (SDG-14.1.1b), 12 of the 17 goals have been identified as directly or indirectly impacted by (micro)plastic pollution (Table 1) (Walker, 2021). Drawing on the idea of sustainability as multi-generational equity (Brundtland, 1987), we view it as achieving UN-SDGs within the planetary boundaries.

Table 1. Summary of UN-SDGs directly impacted by (micro)plastics

UN-SDG related to (micro)plastics	**Related barrier to achieve SDG**
1 No poverty	Negative impacts on ecosystem services and economic impacts on communities
2 No hunger	Presence of (micro)plastics in food packaging, agricultural soils, fruits and vegetables, fish and shellfish posing potential risks to human health through ingestion
3 Good health and well-being	Presence of (micro)plastics in humans and foetus via ingestion, inhalation, and dermal exposure of microplastics in packed food products, foodstuff, and air
6 Clean water and sanitation	Presence of (micro)plastics in drinking water and treated wastewater effluent
7 Affordable and clean energy	Incineration of (micro)plastic waste used in waste-to-energy systems contributes to GHG emissions, release of atmospheric pollution
9 Industry, innovation and infrastructure	Innovation is required for sustainable bio-based alternatives to fossil fuel–based plastics to help contribute to a circular economy
10 Reduced inequalities	Exports of plastic waste from developed to developing countries have been considered waste pollution transfer
11 Sustainable cities and communities	Indiscriminate disposal of plastics in countries with inadequate waste management systems is choking critical urban infrastructure
12 Responsible consumption and production	Unsustainable global plastic production, consumption and plastic waste mismanagement
13 Climate action	GHGs are emitted at every step of the plastic life cycle, from production to transportation to waste disposal
14 Life below water	Extraordinary efforts are required to reduce leakage of (micro)plastics to marine and freshwater ecosystems
15 Life on land	Mismanagement of (micro)plastic waste causing widespread terrestrial pollution of (micro)plastics in landfills, urban and rural areas, protected areas, and agricultural soils

Note. Reproduced and adapted from Walker, 2021

1.3 Exploring a sustainability transition in Costa Rica

The circular economy (CE) offers a framework to achieve sustainable development within the planetary boundaries (Section 3.1.1). While there has been increasing interest in how the theoretical

goals of a CE can be implemented in a real-world context, most attention is focused on technological developments, overlooking the role of consumption patterns. In Costa Rica, the linear economic system with increasing waste generation puts pressure on waste management infrastructure already operating beyond capacity (six out of seven landfills in *"technical closure"* since 2016) (Lara, 2021). The management of plastic waste in Costa Rica offers an opportunity to explore how CE principles could be applied at a national level. The sustainability transition being analysed is conceptualised as a shift in the existing plastic waste management system (PWMS) to a new system where the 3Rs waste hierarchy ('Reduce', 'Reuse', 'Recover')[6] is operationalised through an Integrated Sustainable Waste Management (ISWM) system (Section 3.1.2).

Costa Rica was selected as the study focus for three primary reasons. Firstly, its natural environment hosts important ecosystems comprising tropical rainforests, wetlands and mangroves covering approximately 56% of the country (Convention on Biological Diversity, n.d.). These ecosystems provide habitat for 5-6% of global biodiversity in just 51,079.25 km^2, making it one of the most species-dense countries in the world (Butler, 2016). Costa Rica also hosts the most polluted river in Central America, the Tárcoles, which crosses through 36 of the 82 municipalities spanning the Greater Metropolitan Area out to the Pacific Ocean (Alfaro, 2014; National Meteorological Institute, n.d.). It is home to over 50% of the population which, coupled with an inadequate waste management system, contributes to the flow of plastic pollution from the tributaries and rivers in the cities downstream to the ocean (Alfaro, 2014). As Costa Rica has coastline on the Caribbean Sea and Pacific Ocean, it is an important location to address plastic leakage.

Secondly, it appears well-positioned to make a transition to a 3R compliant plastic waste management system as it has nationally committed to align industry and business culture with CE principles which include reduced waste generation and proper waste management by 2030. By 2050 it aims to have solutions for collection, separation, reuse, and disposal of waste for 100% of the territory (Table 6 Appendix 1). It is an upper-middle income country with a stable democracy which has shown steady economic growth over the past 25 years (World Bank, n.d.). It has positioned itself as an environmental leader and is the only tropical country to have reversed deforestation (UNEP, 2019). To conserve and protect the environment, Costa Rica has created extensive national parks,

[6] We define 'Recover' as encompassing 'Recycle', 'Refurbish/Remanufacture', 'Redistribute', and 'Maintain/Prolong' operations or practices according to the Ellen Macarthur Foundation (n.d.-b) conceptualisation diagram of a circular economy.

protected marine areas (Alvarado Salas, 2003) and developed fiscal incentives such as tax credits and payments-for-ecosystem-services (Government of Costa Rica, n.d.-a; UNEP, 2019; World Bank, n.d.).

Thirdly, it is experiencing a demographic shift marked by population growth, rapid urbanisation, and rising income levels (Oviedo et al., 2015). While this development has improved many lives, it is driving plastic waste generation and pollution, and has highlighted major gaps in waste management infrastructure which has failed to keep up with socio-economic development. The exponential growth of plastic waste generation and the complexity and costs of recycling processes make plastic, a subcategory of municipal solid waste (MSW), particularly difficult to manage (Section 2.1). These challenges increase the risk of plastic leakage.

1.4 Research aim and questions

Plastic waste and pollution have proliferated in Costa Rica necessitating a transition to a new plastic waste management system. This thesis aims to analyse the sustainability transition to a 3R compliant plastic waste management system by answering the following research questions:

RQ1: How is plastic waste managed and governed in Costa Rica, considering elements of the waste value chain, regulatory frameworks and operating context for two municipalities (Garabito and Goicoechea)?

RQ2: How do stakeholders within the plastic waste value chain characterise interactions and processes for the transition to a 3R compliant plastic waste management system?

RQ3: How is the sustainability transition to a 3R compliant plastic waste management system in Costa Rica progressing?

RQ4: How could this sustainability transition be supported at the national and municipal levels?

1.5 Outline

Following on from this introduction, the thesis is structured as follows: chapter 2 provides background to managing plastic waste; chapter 3 introduces the concepts of sustainability in relation to plastic waste, and theories to analyse the transition of the plastic waste management system; chapter 4 outlines the research design and methods employed to answer the research questions; chapter 5 presents and analyses the results; and chapter 6 concludes.

2. Background

2.1 Considerations for managing plastic waste

Plastic is a complex material to manage because many of the desired material characteristics of plastics also make them virtually impossible for nature to degrade or assimilate (Geyer et al., 2017). It is also extremely challenging to recycle plastics in a cost-effective manner (Allwood & Cullen, 2012). Plastics describe a broad range of materials that are predominantly made of hydrocarbon monomers, ethylene and propylene, that link together in chains creating larger polymer molecules (Center for International Environmental Law [CIEL], 2017); Geyer et al., 2017), which are sourced almost exclusively from fossil-fuels. The properties of plastics are mainly influenced by the chemical and physical structure of the base monomers, but the use of additives, fillers and different heat treatment processes also influences making them extremely versatile and convenient.[7] Additionally, plastic manufacturing has optimised the process to use as little material as possible, making them more cost-efficient to produce than other materials (Allwood & Cullen, 2012). By weight only five of many types of plastics dominate global production: high and low-density polyethylene (HDPE, LDPE) (34.4%); polypropylene (PP) (24.2%); polyvinyl chloride (PVC) (16.5%); polyethylene terephthalate (PET) (7.7%); and polystyrene (PS) (7.3%) (CIEL, 2017). Four of these are used for packaging, the largest market in the industry (HDPE, LDPE, PP, PS) (Geyer et al., 2017; Meys et al., 2020).

Recovery processes for plastic waste includes mechanical and chemical recycling, and co-processing in cement kilns. *Mechanical recycling* maintains the molecular structure while changing the physical properties of the material. This process entails the collection, sorting, washing, grinding, compounding and pelletizing to then be used as secondary material for other products (Ragaert et al., 2017). Mechanical recycling, which includes downcycling and upcycling activities[8] creates new products from the material. However, there is a limit to the number of transformations it can undergo, and the material will ultimately end up in landfills, incinerated, or co-processed (Meys et al., 2020). *Chemical recycling,* which needs scaling up*,* converts the polymer molecular structure into smaller molecules creating chemical products that can be used as feedstocks for refinery, fuel, monomer, and value-added chemicals (Meys et al., 2020). *Co-processing in cement kilns* consists of using MSW including plastic waste in clinker production to reduce or substitute lignite or coal fuel

[7] For non-fibre plastics, it is reported that they contain by mass around 93% of polymer resins and the remaining 7% is additives (Geyer et al., 2017).

[8] Down-cycling transforms the plastic waste into a lower quality product while up-cycling transforms it to a product of equal or higher quality.

input. During the co-combustion, the mineral part of the waste can also be used to substitute primary mineral materials (e.g. limestone) in the cement production (Geocycle, n.d.; Meys et al., 2020).

Assessing the environmental impact of these treatment processes for plastic waste is complex and includes trade-offs between GHG emissions, fossil reserve depletion, terrestrial acidification and eutrophication. Both recycling options have the potential to reduce or avoid fossil-fuel based plastic production by using either recycled pellets or chemical products as a feedstock, decreasing the fossil-fuel demand and associated GHG emissions (Meys et al., 2020; Ragaert et al., 2017). Meys et al., (2020) assessment concluded that mechanical recycling and energy recovery in cement kilns (versus in municipal incinerators[9]) of PET, HDPE, LDPE, PP, and PS is preferable for GHG emissions over chemical recycling to produce refinery feedstock of fuel products. In contrast, chemical recycling to produce monomers and value-added chemicals is preferable over mechanical recycling, energy recovery, and landfilling, especially if separation of plastic is not feasible.

Lock-ins develop when dominant practices in society become interwoven with other elements such as policies, norms, preferences and infrastructure. With plastics, production and consumption patterns signal a high societal reliance which creates a path dependency (Geels, 2011; Loorbach et al., 2017). Despite large-scale production only in practice since the 1950s, an estimated 7,800 million tonnes of virgin plastic had been produced up to 2015 (Geyer et al., 2017; Jones, 2021). This is testament to the rate and scale at which plastic has become part of everyday life and created infrastructural, institutional, and behavioural lock-ins (Bauer & Fontenit, 2021). The petrochemical industry has had access to abundant cheap natural gas liquids for the last decade (Bauer & Fontenit, 2021) which has attracted significant new investment with new facilities expected to come online by 2030 (CIEL, 2017).[10] Estimates suggest plastic production will double by 2050, making the industry one of the largest drivers of oil and gas consumption (International Energy Agency [IEA], 2018). There are significant infrastructural and technological lock-ins arising from sunk investments in building the physical infrastructure and production facilities. These are at risk of becoming

[9] Differences between co-processing and incineration include co-processing facilities that require less sophisticated infrastructure, destroys waste materials and gases through higher temperatures, excess of oxygen and longer residence times. It leaves no material residue behind as the ashes created in the chemical reactions are used as substitutes of primary mineral materials.

[10] Plastic production is intrinsically integrated with the fossil-fuel supply chain with many fossil-fuel companies producing plastics directly or through subsidiaries, such as ExxonMobil, Chevron Phillips and Sinopec (CIEL, 2017).

stranded assets in a sustainable transition away from fossil-based plastics (Jambeck et al., 2015; Bauer & Fontenit, 2021). The IEA (2018) projected that the petrochemical industry would account for over a third of growth in oil demand between 2017 and 2030 and would consume an additional 56 million cubic metres of natural gas. Other lock-ins affecting the transition include an institutional lock-in due to the vested interests of powerful actors and a behavioural lock-in as the result of the insidious and convenient nature of plastic products, so much of which is used for mundane single-use packaging.

3. Theory and concepts

3.1 Sustainability concepts

3.1.1 Circular economy

The concept of a CE has become a key approach for sustainable development. The origins of the concept can be traced back to several schools of thought including ecological economics, environmental economics, and industrial ecology. Ecological economists conceived the idea of a closed economic system as necessary for sustaining human life on earth (Ghisellini et al., 2016). Environmental economists introduced the concept of a CE as a necessary shift due to natural limitations of energy and matter degradation (Ghisellini et al., 2016); and industrial ecology emerged to counter the idea that environmental impacts are externalities of industrial systems that should be studied separately. Instead both aspects should be studied together as one system (Ghisellini et al., 2016).

Conceptually, there are over 100 different definitions of CE due to its interdisciplinary influence (Kirchherr et al., 2017). For this study, we took one of the most used definitions of a CE by the Ellen Macarthur Foundation (n.d.) which is an economy that is regenerative and redistributive by design and based on three main principles: 1) eliminate waste and pollution; 2) circulate products and materials at their highest value; 3) regenerate nature. This can be achieved by operationalising the 3R waste hierarchy shown in Figure 1 (Ghisellini et al., 2016). Operationalising the 3Rs to address plastic waste requires an overall reduction in plastic consumption and a systematic redesign of plastic products that reduces virgin material input, facilitates the reuse of the product, extends the product life-cycle, and facilitates recycling processes. 'Reducing' the overall consumption of plastic products has the largest potential to transform the plastic waste management system and should take precedence over 'reusing' and 'recovery' given the complexity, and energy-intensity of the 'recovery' options (Jones, 2021).

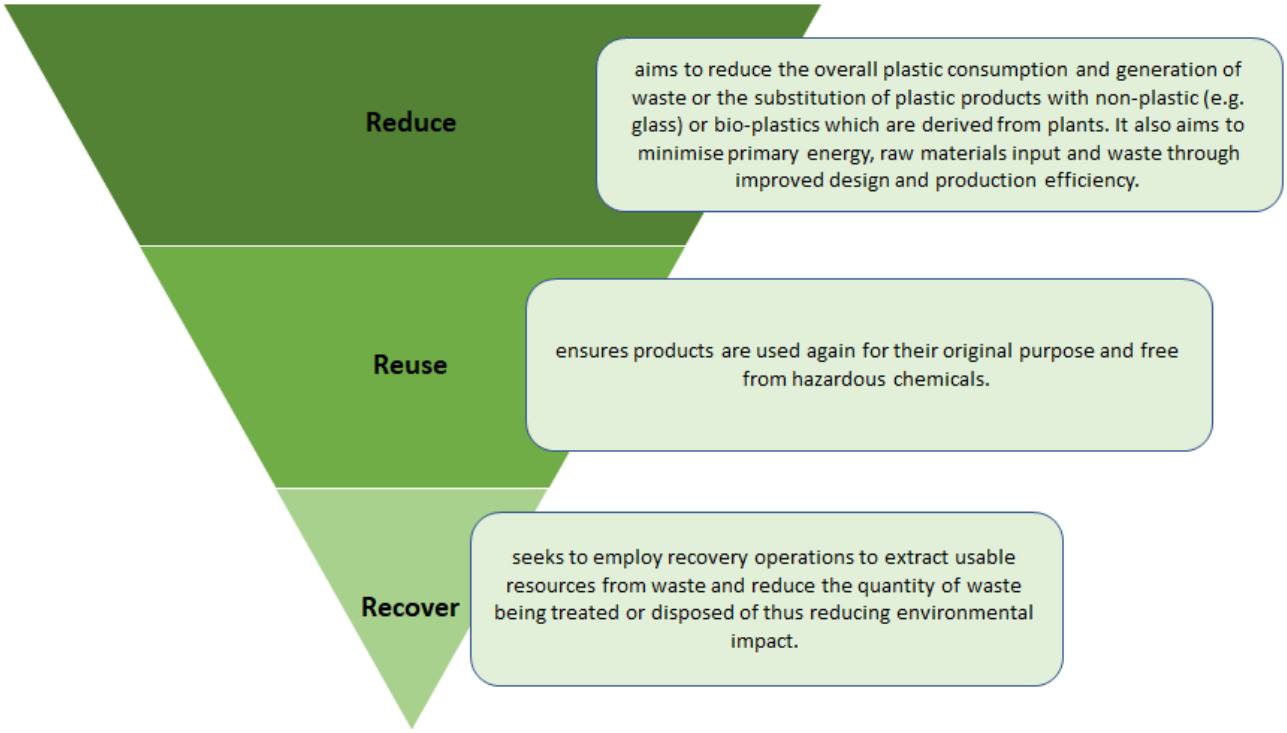

Figure 1. The 3R hierarchy for waste management

*Note***.** Own creation based on the 3R waste hierarchy presented in Ghisellini et al., 2016.

3.1.2 Integrated sustainable waste management

Waste is a major component of a CE and the ISWM framework offers a holistic and strategic approach to operationalise the CE goals. Figure 2 shows the ISWM which is defined by Wilson et al. (2013, p.55) as *"Integrating across three dimensions – all the elements of the waste hierarchy, all the stakeholders involved and all the 'aspects' of the 'enabling environment' (political, institutional, social, financial, economic and technical)".*[11] This approach shifts from the conventional approach to solid waste management primarily focused on the technical or financial-economic dimensions to encompass everything needed to secure the sustainability of a waste management system (van de Klundert & Anschütz, 2001; Wilson et al., 2013). The approach involves participation of all stakeholders in the waste management chain and consideration of the local context to assess, plan, manage, and evaluate a waste management system.

[11] The name is an evolution from Integrated Waste Management and Integrated Solid Waste Management, which have been mostly used in the context of technological integration with waste management in developed countries.

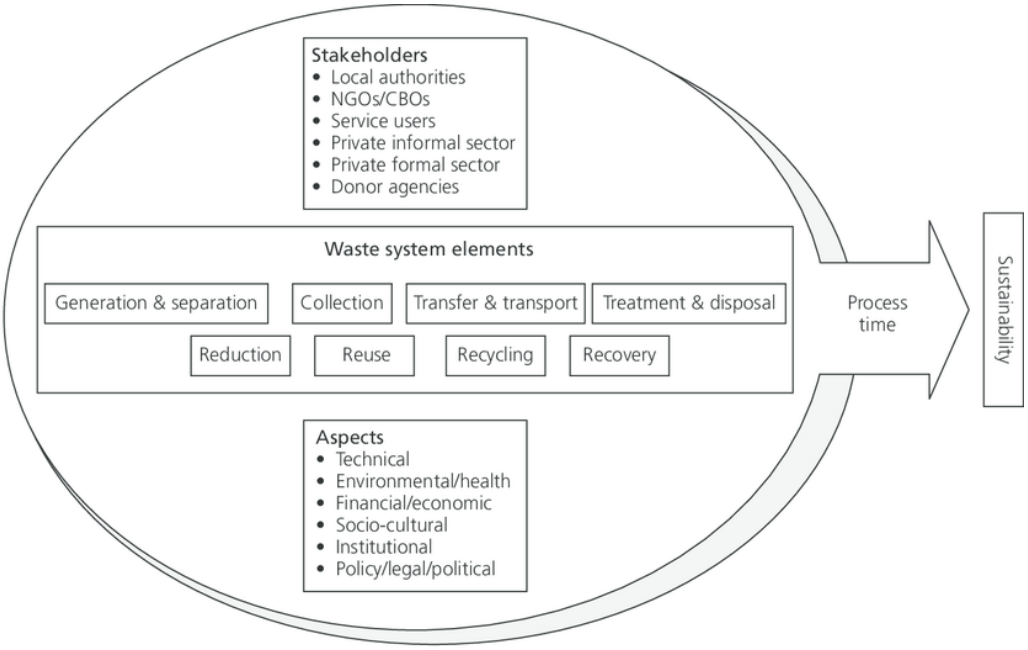

Figure 2. Integrated Sustainable Waste Management Framework

Note. ISWM visualisation by showing the three dimensions that should be integrated. Reproduced from Wilson et al., 2013.

3.2 Transitions theories

3.2.1 Sustainability transitions

Sustainability transitions research has received increasing attention over the past decade as the world faces fundamental sustainability challenges requiring rapid system changes in several domains (Markard et al., 2012). Sustainability transitions are defined as *"long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption"* (Markard et al., 2012, p.956). Sectors like waste management can be conceptualised as socio-technical systems consisting of multiple elements including infrastructure, user practices, policies, value chains and markets (Markard et al, 2012; Geels, 2012). A socio-technical transition differs from a purely technological transition because they involve regulatory and cultural changes which could happen in institutional structures or user preferences. They also tend to include non-technical innovations which may complement technological innovations and often affect the related societal domains.

Transitions occur when system elements interact and are involved in a set of processes that lead to transformational changes. Friction between actors with different values, resources, priorities and practices can hinder transition progress. As these elements are tightly coupled and varied, it is

important to understand the dynamics of the system. Nevertheless, transitions are inherently uncertain as many processes occur simultaneously making it virtually impossible to predict what transition will prevail.

3.2.2 The multi-level perspective

The multi-level perspective (MLP) emerged as a framework for analysing socio-technical sustainability transitions, aiming to understand how and why they occur. Transitions toward sustainability are typically goal-oriented, seeking to address major environmental problems which require systemic structural reconfiguration (Geels, 2011). A sustainability transition to operationalise the 3Rs for plastic waste management has the goal of providing a service for the common good in Costa Rica. Therefore, public policy is a key enabler for a transition to occur (Geels, 2011). Another characteristic in transition domains is the dominance of large companies which have complementary assets, such as virgin plastic production facilities which keeps costs low and provide stability and lock-ins to the current regime (Section 2).

The MLP views transitions as nonlinear processes that typically unfold over decades, involve many actors and have no single cause or driver. This is the case for Costa Rica which ISWM regulations 12 years ago (Section 5.1). To investigate how dynamics and interactions between various actors within a system manifest across multiple dimensions (Loorbach et al., 2017), the MLP proposes three analytical levels where the elements in the system are maintained, reproduced and transformed. These levels, presented in Figure 3, are: *niche* (radical innovations); *regime* (established practices and rules); and *landscape* (wider context) (Geels, 2011). This study reflects Geels' (2011) adaptation to the MLP which dropped the notion of 'nested hierarchy' as niches often emerge from outside rather than within regimes. Therefore, the levels are differentiated by the degrees of stability, structuration of local practices and the number of actors involved in reproducing regimes.

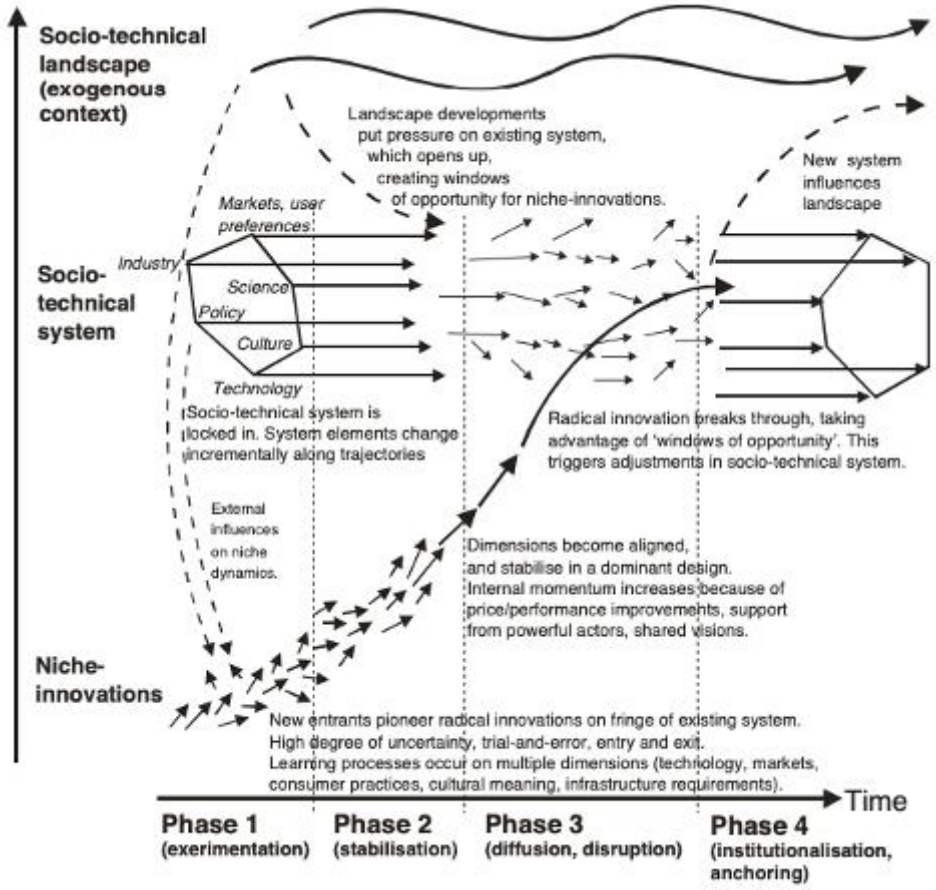

Figure 3. Multi-level perspective on socio-technical transitions.
Note. Geels (2019) which presents this substantially adapted diagram of the MLP.

Geels (2011, p.26) defines transitions as *"shifts from one regime to another''* highlighting this level as the locus. Therefore, the *niche* and *landscape* levels are derived from the *regime*: the *niche* as a substantial deviation of practices or technologies from the *regime*; and *landscape* as an external influence on interactions between the *niche* and *regime*. This study is concerned with the shift from the existing plastic waste management system to one which is compliant with the 3Rs.

The regime level refers to *"the deep structural rules that coordinate and guide actor's perceptions and actions"* (Giddens, 1984 as cited in Geels, 2012, p.3) which cause stable configurations and trajectories. In this level, change is discrete following a predetermined set of guidelines and expectations. This is due to lock-in mechanisms including: techno-economic (e.g. sunk investments, economies of scale and experience); social and cognitive (e.g. routines and shared mindsets and 'social capital' from aligned actors); and institutional and political (e.g. uneven playing field as existing regulations favour incumbents and vested interests hinder radical innovation) (Geels, 2019). Existing systems tend to be resistant to change because they are stabilised by the alignments between elements.

The landscape level is the wider context influencing the dynamics, interactions, and developments within the regime and *niche* levels beyond the control of individual actors in each of the levels (Geels, 2011, 2012, 2019; Köhler et al., 2019). This level can include slow-changing factors (e.g. demographic patterns, geo-politics, societal concerns, macro-economic trends) and external shocks (e.g. wars, financial crises, global pandemics).

In contrast, the *niche*-level is characterised by innovative social or technological actors that deviate from the regime (Köhler et al., 2019; Geels, 2011). Innovations tend to emerge through actors operating on the periphery of existing systems such as entrepreneurs, activists or start-ups. Though each transition is unique, the MLP proposes a general process which involves niche-innovations building internal momentum, creating pressure on the regime, resulting in the regime destabilisation creating windows of opportunity for the diffusion of disruptive innovations. For niche-innovations to gain momentum three processes need to occur: 1) alignment between multiple "learning processes"; 2) clear articulation of expectations of the niche-innovation to provide guidance and acceptance; and 3) an expansion of social networks by enrolling new actors to increase the resource base and add legitimacy. Seeds for systemic change can be found where these processes happen simultaneously enabling innovations to gain enough momentum to (partially) replace, reconfigure or transform the regime.

Niche-innovations face challenges to their development in the first phase (experimentation) characterised by trial-and-error, uncertainty and high failure rates. These challenges include: the relative high-cost of innovations compared to existing technologies as they do not benefit from decades of experience or economics of scale; the lack of market demand for new products and uncertainty about user preferences which hinder social acceptance, cultural legitimacy and access to investment (Geels, 2019). In the second phase (stabilisation), innovations stabilise into the dominant system after establishing a foothold. In the third phase (diffusion, disruption) the innovation diffuses into the mainstream and is characterised by struggles between niches and regimes on economic, business, political and cultural grounds. In the fourth phase (institutionalisation, anchoring) the old socio-technical system is (partially) replaced by the new system and becomes institutionalised by new regulatory frameworks, user patterns, norms and standards and technical capabilities.

This study applies the MLP framework to analyse the transition to a 3R compliant plastic waste management system in Costa Rica. The system boundaries are set using the ISWM approach (Section 3.1.2) and focuses on plastic waste from consumption to final disposal within the geographical boundaries of Costa Rica. The MLP is applied at the national level and includes *niche* and *regime*

actors operating in the country, while acknowledging the influence of global factors at the landscape level.

4. Methodology

To answer the research questions, fieldwork in Costa Rica was undertaken between January and March 2022 primarily in San José and Garabito. Primary and secondary data was collected and analysed as presented in Table 2.

Table 2. Research design.

Research question	Data	Method
RQ1: How is plastic waste managed and governed in Costa Rica?	Documents & preliminary interviews	Document review & synthesis
RQ2: How do stakeholders characterise interactions and processes for the transition?	Semi-structured interviews	Thematic analysis
RQ3: How is the sustainability transition in Costa Rica progressing?	Findings from RQ1 & RQ2	Critical discussion
RQ4: How could this sustainability transition be supported at the national and municipal levels?	Findings from RQ1, RQ2 & RQ3	Critical discussion

Note. Own creation

4.1 Data collection

4.1.1 Document review and preliminary interviews

To answer RQ1, a document review was carried out to identify relevant policies for plastic waste management and plastic pollution prevention to understand the national policy context. First, a preliminary review was undertaken using the search-engine 'Google' to scout the policy landscape of Costa Rica by using the following search terms in English and Spanish: "waste management"; "integrated waste management"; "plastic waste"; "plastic contamination"; "plastic pollution"; "circular economy"; and "sustainable waste management". Then a process of cross-referencing was carried out to locate specific policies or plans in the national legislative database which includes laws, executive decrees, international agreements, regulations and other rules of general application. Actors identified as being within the waste management value chain were further researched using Google and grey literature such as newspaper articles and NGO reports to understand their roles, responsibilities and operating context. In parallel, preliminary interviews were conducted in-person and by telephone with condominium staff, several municipalities, a sorting company and assorted

citizens. The objective was to understand how they managed plastic waste and their interactions with municipalities (Table 1 in Appendix 1).

In addition, two municipalities were investigated to understand how different geographical and demographic contexts might affect the implementation of a 3R ISWM approach to plastic waste management. The municipalities were selected based on their different operational realities and accessibility to relevant and willing staff. The municipalities investigated were: Garabito which is coastal, downstream of the Tárcoles river and a busy tourist destination; and Goicoechea which is urban and densely populated, located within the capital city upstream of the Tárcoles river. The combination of document review and preliminary interviews enabled us to conceptualise the existing plastic waste management system, analyse the policies governing the system and identify stakeholders.

4.1.2 Semi-structured interviews

To answer RQ2, semi-structured interviews were conducted with stakeholders within the plastic waste value chain. These stakeholders were identified through the document review and preliminary interviews. Based on the MLP, stakeholders were categorised by analytical level (*niche* or *regime*) and the type of activities they may engage in to operationalise a 3R-compliant PWMS (Table 3). This was then used to tailor the interview protocol (Table 2 in Appendix 1) guiding the discussion to find out how they characterised enabling and hindering interactions and processes for the transition to a 3R-compliant PWMS. The interview was semi-structured to allow flexibility to pose follow-up questions to further substantiate answers (Roulston & Choi, 2018). The questions were developed based on the answers to RQ1.

Table 3. Stakeholder selection for interviews and categorisation

Identifier	Stakeholder name	Stakeholder Profile
E1	ACEPESA	Niche-innovator acting on the periphery. NGO working on waste management, social and environmental issues. Supports informal waste collectors.
E2	Eco-Tárcoles	Niche-innovator acting on the periphery. Private company working on beach clean-up and establishing a down-cycling facility.
E3	Fast Moving Consumer Goods (FMCG) company (unnamed)	Regime-level actor with a niche-innovation to use recycled plastic from beach and ocean clean-ups. International FMCG company.
E4	Garabito Municipality	Regime-level actor responsible for translating into action national waste management plans.
E5	Geocycle	Niche-innovator acting within the regime. Private company preparing solid/ordinary waste for co-processing in cement kilns. (Part of Holcim cement company)
E6	Goicoechea Municipality	Regime-level actor responsible for translating into action national waste management plans.
E7	ICE (Institute of Telecommunications and Electricity)	Regime-level actor adopting niche-innovations to reduce and recover plastic waste. The largest and most influential public institution of the country providing electricity and telecommunications services.
E8	Los Sueños Marriott	Regime-level actor adopting niche-innovations to reduce and recover plastic waste. Private international hotel company in Garabito with high volumes of plastic usage.
E9	MINAE (Ministry of Environment & Energy)	Regime-level actor. Government ministry that collaborates closely with the enforcing entity for ISWM, the Ministry of Health.
E10	Mundorep	Niche-innovator within the regime. Private national company producer of virgin plastic products and recycled plastic resins and products.
E11	Policy Advisor to the Congress	Regime-level actor. Political advisor to policymakers.
E12	Recicladora La Calma	Niche-innovator acting on the periphery. Private national company with three sorting centres in the capital city and expanding to the rural areas.
E13	School of Herradura	Regime-level actor. Public school in the municipality of Garabito.
E14	The Recycle Studio	Niche-innovator acting on the periphery. Private local company producing designed plastic sheet material from recycled plastic. Promoting a circular economy business model and challenging perceptions on waste.

Note. Own creation.

Stakeholders were approached by phone or email explaining the nature of the study and requesting a 30-40 minute interview. Overall, 14 stakeholders agreed to an interview with 10 conducted virtually over videocall, two responded in writing due to their own time constraints, and two took place during site visits. The interviews were then conducted in Spanish except for two stakeholders who agreed to speak in English. At the beginning of each interview, the aim of the study was outlined, and consent was requested to use personal information such as organisation name and job title, to take notes and to record virtual interviews to ensure accurate transcription. Consent was

granted but in one case, the interviewee requested to remain anonymous, so a generic name was selected and agreed upon with the specific stakeholder. Afterwards, the interviews were transcribed and translated into English before the recordings were deleted as agreed. The transcriptions were performed using a combination of Microsoft Word dictation feature and a tool called Descript. Translation was facilitated by Google Translate.

4.2 Data analysis

4.2.1 Thematic analysis of interviews with stakeholders and critical discussion

To answer RQ2, the data gathered through the semi-structured interviews was analysed using thematic analysis. According to Kiger & Varpio (2020) and Castleberry & Nolen (2018), thematic analysis is a qualitative data analysis method that facilitates the manipulation of data into workable themes that can then be analysed to draw conclusions from the data. For this study, it entailed disassembling the data to assign the codes informed by the MLP framework in Table 3 in Appendix 1. This was done to identify the different analytical levels, enabling, and hindering interactions and *niche* processes. We used Castleberry & Nolen's (2018) methodology which consists of five steps: compiling; disassembling; reassembling; interpreting; and concluding (Table 4). To answer RQ3 and RQ4, the results from RQ1 and RQ2 were critically analysed to assess how the transition is progressing and how national and local governments could support it.

Table 4. Steps for a Thematic Analysis

Compiling	Transcribing and translating interviews into English while getting familiarised with the data.
Disassembling	Identifying similarities and differences in the data by creating initial groupings based on the MLP analytical levels and then codes to indicate what is happening. This was done in English by one researcher and in the original language (Spanish) by the other to minimise losses of data in translations. After performing two rounds of disassembling separately, researchers came together to compare notes and create codes. The remaining steps were done together.
Reassembling	Creating themes by analysing the codes identified in the previous step. A theme *"captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set"* (Braun and Clarke, 2006 p.10).
Interpreting	Making conclusions from the identified codes and themes informed by the MLP framework. This step happens throughout the first three steps as well.
Concluding	Responding to the stated research questions using the insights gathered from the previous steps. This step relates the findings back to the MLP framework to answer how the transition is progressing and where there are opportunities to support the process.

Note. Adapted from Castleberry & Nolen (2018).

5. Results and analysis

5.1 Costa Rica's plastic waste management system

Based on the document review, preliminary interviews and the stakeholder interviews, we identified elements of the plastic waste chain in Costa Rica, which regulatory frameworks govern the generation and management of plastic waste, and how two municipalities experience plastic waste management.

5.1.1 The plastic waste management chain

Plastic waste is handled by municipalities as a subcategory of MSW which is generated by households and local businesses (e.g. does not include large industrial or hazardous waste). Figure 4 shows the generalised MSW chain for plastic, consisting of multiple actors with different roles and responsibilities. The first elements, Generation and Separation, include actors that consume plastic, generate waste, and typically dispose of most of it unsorted in one bin. Though less prevalent, inadequate disposal still happens by burning, burying or dumping in rivers, beaches, roadsides and empty lots. Goicoechea municipality (E6) reported collecting over 5,000 tonnes annually from inadequate disposal sites before disposing of in the landfill. While Garabito municipality (E4) reported just over 100 tonnes collected from roads and beaches annually (Table 4 in Appendix 1). Although some municipalities do offer dedicated recyclable collection routes, some households often fail to separate their waste as strictly as is required (cleaned, dried and packed in a transparent bag) so materials are frequently rejected.

The second element, Collection, involves municipalities, informal waste-pickers, and private companies. Municipalities are responsible for providing MSW collection services by law which should include dedicated recyclable collection routes. However, neither Garabito and Goicoechea offer a regular recyclable collection routes despite having MSW coverage for over 90% of households (National Institute of Statistics and Census, 2011). Goicoechea has recently piloted a recyclable collection route in four neighbourhoods with plans to scale-up. Garabito has a sporadic municipal route performed by a subcontractor and benefits from informal waste-pickers, however it was estimated that 5% of MSW going to landfill in Garabito in 2020 was plastic. If there was better sorting capacity, this plastic could be recovered. Preliminary interviews with condominium staff and residents highlighted the problem with municipal recyclable collection as high volumes are rejected despite dedicated sorting on site. They found private and informal collectors were more lenient and accepted more recyclable waste.

After collection, the majority (96%) of unsorted MSW including plastics is directed to the nearest landfill or open-air dump. The remaining waste goes through an ad hoc Sorting process that removes materials for recycling that are then sold for Treatment and Disposal by private national and international recyclers (3.7%). A small amount is co-processed in cement kilns (0.2%) (Table 5 in Appendix 1). Within the sorting step, material classified as not recoverable is also sent to the landfill. Although open-air dumps are in the process of being transformed into sanitary landfills, 16 officially recognised dumps remain in Costa Rica and there are additional unofficial ones. Meanwhile, landfills are reaching or have reached the capacity for which they were designed to operate safely. Existing partnerships, such as the one between the landfill operator and Geocycle (E5), are helping to divert non-recyclable waste from the landfills thus extending the lifespan of one of the landfills in the country.

A private, national sorting company (E12) shared that informal waste-pickers are the most important collector for all materials including plastic, even over formal collection services. The actor attributes this to the payments for materials being dependent on careful sorting. This motivates the informal waste-pickers to separate in a way which maximises recovery so they can earn more money. This is despite the very low price they get for selling the material, between CRC 50 and CRC 270 per kilogram depending on the type of plastic at this location.[12] These prices seem aligned with what other informal waste-pickers are getting in other parts of the country. The few plastic treatment processes that do occur in the country are mainly done by private, incumbent actors such as: Coca-Cola which recycles PET bottles; Mundorep which buys and produces recycled resin; and Geocycle/Holcim which co-processes plastic waste along other solid waste as thermal and material input in cement kilns. Within recycling, up-cycling and down-cycling are also present to a lesser extent. Several actors (E2,E7,E9) reported that down-cycling to create low-grade products such as plastic wood was the current predominant transformation of plastics in the country.

[12] Informal waste-pickers at this location receive the following amount for each plastic type: PET and HDPE CRC 50/kg (USD 0.076/kg) and PE CRC 125/kg (USD 0.19/kg) while the sorting company sells the PET at 125 CRC/kg (USD 0.19/kg), HDPE at 100 CRC/kg (USD 0.15/kg), and PE at 270 CRC/kg (USD 0.41/kg).

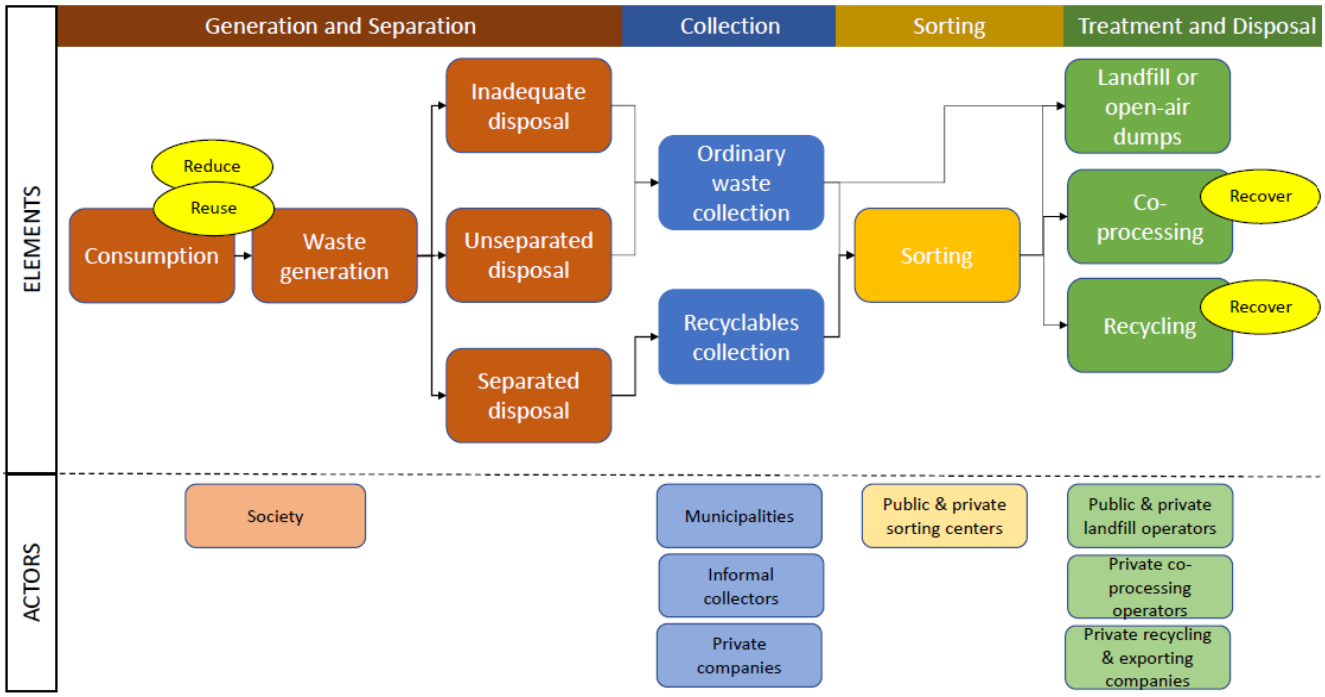

Figure 4. Waste management elements and actors in Costa Rica
Note. Ordinary waste includes everything in MSW disposed of without sorting. Own creation based on the ISWM conceptualisation by Wilson et al., 2013.

5.1.2 Legal framework and implementation gaps

Costa Rica's ISWM system operates in accordance with a substantive ambitious legal framework that was established in 2010. The framework aims to prevent negative impacts on the environment and human wellbeing by operationalising the 3Rs through laws, policies and plans on ISWM and plastic pollution. There are two laws governing the management of plastic waste: Law No.8839 on Integrated Waste Management (2010); and Law No.9786 on Combatting Plastic Contamination (2019). These are mobilised through policies, such as No.41032 on Sustainable Consumption and Production 2018-2030, and plans/strategies including: The Plan for Integrated Waste Management 2019-2025; the Strategy for the separation, recovery, and valorisation of waste 2016-2021; and the Strategy for the Substitution of Single-use Plastics for Renewable and Compostable Alternatives 2016-2021. In addition, the Decarbonisation Plan 2018-2050 includes a transformation of the waste management system as well as a shift to a circular economy. See Table 6 in Appendix 1 for further detail on how each relates to plastic waste management. These are established at the national level and must be translated into action plans by municipalities.

According to a comprehensive analysis (Soto, 2019), there are substantial implementation gaps for the ISWM regulations. As of 2019 here has been no measurable progress for six out of the 15 objectives proposed in Law No.8839, only one objective had been met (establishing a legal

framework) and eight face serious challenges. Table 5 shows the unmet objectives and the challenges identified by Soto in 2019 as well as examples we identified from stakeholder interviews.

Table 5. Implementation challenges for Law No.8839 with stakeholder examples

Unmet objectives	Current state as of 2019	Example identified in 2022
Ministry of Health and local governments establish and implement enforcement mechanism.	Lack of capacity results in >60% of complaints unaddressed.	Goicoechea has one Environmental Manager responsible for updating, implementing and enforcing the ISWM action plan in addition to other duties.
Ministry of Health establishes a monitoring and evaluation methodology.	Lack of standardised data collection leads to conflicting information and hinders progress.	Goicoechea has minimal data on budget allocation, waste composition, or monitoring of the ISWM action plan which expired in 2021.
Ministry of Health should coordinate actors to develop coherent plans.	Non-alignment between private and public waste management actors due to differing ambition levels and role redundancy.	Garabito has minimal political will at Mayoral level to address environmental issues so implementing ISWM plan is not prioritised. Goicoechea has prioritised capital infrastructure projects above waste management services.
Ministry of Health should promote new markets for waste management.	Reduction in authorised waste management companies due to burdensome bureaucracy.	Municipalities and the private actors struggle to adequately dispose of waste as there are limited authorized options. E1,E8, E12 report actors unable to meet high registration and operational permit costs.
Ministry of Health should support the improvement of waste management infrastructure.	Lack of investment in waste management infrastructure prevents a functioning ISWM with sorting, mechanical and chemical recycling facilities in the country.	Many recyclables are exported for recovery overseas. Despite promoting the substitution of fossil-based plastic for bio-plastics or biodegradable products, facilities have not been built to process this new type of waste so they end up in the landfill, frustrating efforts made by actors (E8) to comply with regulations.
Ministry of Health should promote separating and sorting at the source by households, businesses and public institutions.	Over-reliance on 'recovery' strategies with almost no efforts to promote 'reduce' and 'reuse' strategies despite their higher position in the 3R hierarchy.	High-profile national newspaper campaign published in 2022 showcased 'recovery' strategies employed by incumbent actors with minimal educational information on 'reducing' or 'reusing' (Jiménez, 2022).
Ministry of Health should influence behavioural patterns for consumption and waste generation.	Lack of high-level support to promote sustainable consumption through behaviour campaigns.	A teacher from Garabito (E13) reported the need for the Ministry of Education to incorporate environmental issues into the curriculum so that teachers are empowered to teach about these crucial topics. There is only one short science class about recycling and teachers can get in trouble if they deviate too far from the curriculum.
Ministry of Health and municipalities to develop volume-based waste disposal fee structures for citizens.	Reduction of waste is not incentivised, so citizens do not take responsibility for their waste generation.	Both municipalities reported no progress had been made due to lack of capacity to develop appropriate fee structures and the economic impact of Covid-19 on citizens has complicated this approach.

Note. Based on Soto (2019) and interviews.

5.2 Transition dynamics, interactions and processes of change

Based on the analysis of primary data from stakeholder interviews, specific themes and characteristics (codes) were identified as contributing factors to the transition. Each characteristic was mentioned at least once by any of the stakeholders. Table 6 and 7 present the results of the thematic analysis of stakeholder interviews. Table 6 shows the types of dynamics which are driving interactions between the *landscape* and *regime* levels. Based on whether these contribute to stabilising or destabilising the *regime*, they are categorised as enabling or hindering the transition progress. Interactions are 'enabling' when they destabilise the *regime-level* to create windows of opportunity for niche-innovations to breakthrough and elicit reconfigurations or adjustments. Interactions are 'hindering' when they stabilise or limit destabilisation of the of the existing regime in ways which could create windows of opportunity.

Table 6. Landscape and regime dynamics affecting the transition

Type of dynamic	**Characteristic of the dynamic**	**Examples of dynamic characteristics**
Directional change (E)*	Institutional narratives of climate & environment	Need to address plastic litter in oceans and climate change urgently
	Social-cultural concerns	Growing concerns of environmental contamination including plastic contamination
Compounding issue (H)**	Entrenched and stigmatised poverty	People's livelihoods dependent on informal waste collection with high levels of homelessness, drug-misuse, seen as dirty and dangerous
Rapid shock (H)	Global pandemic	Economic impacts of pandemic, shift in priorities and government spending
Destabilising dynamics (E)	Government adoption of plastic regulations	ISWM and 3R-compliant regulations for plastic waste management (Table 6 in Appendix 1)
	Market adoption of sustainable plastic policies	Plastic pledge and brand corporate social responsibility policies
	Recognition of need for a planned just transition	Need for long terms plans that support livelihoods and businesses
	Shift in behavioural norms in younger generations	Advocating for environmental policies by incoming young legislators, adopting new products
Stabilising dynamics (H)	Citizen-state relations	Burdensome bureaucracy, culture of not paying taxes, normalised bribery

Note. *(E) means the dynamic is enabling the transition **(H) means the dynamic is hindering the transition. Own creation based on thematic analysis of stakeholder interviews.

Table 7 shows the areas of niche-innovation towards a 3R-compliant PWMS and the types of social processes being undertaken by actors to build momentum. The MLP proposes that niche-innovations need to build momentum to create seeds for systemic change to replace, reconfigure or transform the regime. Momentum builds when there is alignment between social processes which include learning processes, the expansion of social networks, and a clear articulation of expectations amongst actors. This is critical for niche-innovations to capitalise on instability within the regime and breakthrough when windows of opportunity occur.

Table 7. Stakeholder characterisation of niche-innovations and characteristics of social processes

Innovations	**Examples of innovations**	**Niche-level social processes**
Advocacy & engagement	Engagement with municipalities to help with research and policy drafting, promoting national level regulation, meetings with legislators, dissemination campaigns	Articulating expectations • Need for harmonisation and enforcement of regulations • Need for sustainable fiscal policies • Need for mainstreaming ISWM plans • Need for a planned just transition Building social networks & enrolling actors • Strengthening the informal waste-picking sector • Incumbent actors join networks • Engaged in collaborations/partnerships Learning • Monitoring, evaluation, and learning • Research & development • Knowledge sharing & capacity building
Collection & sorting	Informal waste picking to sell recyclables, beach clean-ups, removal of recyclables before co-processing	
Recovery processes	Upcycling, recycling, downcycling, co-processing	
Reduction strategies	Elimination of plastic waste through substitution, use of alternatives, and overall reduction in the use of plastic products	

Note. Own creation based on thematic analysis of stakeholder interviews.

5.3 Transition progress in Costa Rica

Progress towards a 3R-complaint PWMS has been made across all analytical levels and multiple dimensions. Based on the analysis of the existing system (Section 5.1) and thematic analysis of stakeholder interviews (Section 5.2) we identified enabling interactions, niche-innovations and change processes at the *niche*-level which positively contribute to the transition.

5.3.1 Enabling interactions

At the *landscape-level*, two promising developments observed were the shift in *global narratives on climate and the environment* and *socio-cultural concerns.* Both cases represent a directional change towards greater environmental awareness and a move towards more sustainable practices for

plastic. These changes have exerted pressure on the *regime*, primarily the government and incumbent companies to *adopt ambitious regulations and policies* to address plastic waste generation, management and pollution. These have initiated a *shift in institutional behaviour* through the adoption of Sustainable Procurement strategies, part of the Sustainable Consumption and Production policy (E4, E6, E7,E9). These policy changes have induced companies to adjust their practices to comply. For example, by adopting corporate sustainable plastic policies to increase the proportion of recycled plastic content or substituting single-use plastic products within their operations (E3,E8).

These changes have created opportunities for new markets of recycled plastic products, plastic inputs, and plastic substitutes/alternatives to emerge. Furthermore, stakeholders described a *shift in norms and values* towards a more sustainable mindset leading to incoming young legislators to advocate for stronger environmental policies (E11), and adopting emerging products in their work, (e.g. architects and designers using up-cycled plastic sheets) (E14). A sorting actor (E12) noted that the volume of plastic collected had fallen over the last 25 years due to shifting perceptions. Across the policy, market and socio-cultural dimensions, the transition can be viewed as situated between phases 2 and 3 of the MLP, in which new regulations, policies and norms stabilise and begin to diffuse into the mainstream. However, this process is slow, with the first ISWM regulation adopted over a decade ago and still not fully implemented.

5.3.2 Niche-innovations

Four categories of niche-innovations were identified through the analysis of stakeholder interviews (Table 7): *advocacy and engagement*; *collection and sorting*; *recovery processes*; and *reduction strategies*. These all support the operationalisation of the 3Rs and represent a deviation from Costa Rica's plastic waste management *regime*.

Advocacy and engagement include activities which aim to influence citizens and policymakers: campaigns and engagement with citizens raising awareness to shift perceptions and behaviours to 'reduce' plastic consumption and sort for 'recovery' at home; and engagement and collaboration with policymakers and municipalities to promote ISWM implementation, increase 'recovery' and advocate for social and environmental concerns. These activities are being performed by multiple stakeholders primarily focused on enabling greater 'recovery' (E1,E2,E4,E7,E8,E11,E13,E14) with much less attention to 'reduction' and 'reuse' strategies.

This innovation area is being driven by many diverse actors including those working on the periphery of (E1,E2,E14), and those within, the regime (E5,E7,E11). For example, E2 operates as a periphery actor at a local level working to educate citizens through talks, workshops and activities to promote sorting and recycling. They also plan to expand their reach to the tourism sector by offering tours of their upcoming recycled plastic wood facility. Whereas E7 is a regime actor that has adopted ISWM and mainstreamed 3R strategies through workshops and training for employees on procurement and sorting. The shift in behaviours of their staff was so profound, they had to set up a separate collection day to accommodate employees bringing their household recycling because they did not have adequate recycling collection provided by their municipalities.

In contrast, E1, also on the periphery, operates across levels advocating for more radical changes. From grassroots community organising with waste-pickers, to supporting the drafting of national laws and updating municipal comprehensive waste management plans. As these plans must be revised every 5 years by law, there is a window of opportunity for niche-innovations to breakthrough and help reconfigure the underlying *regime* rules. Other actors engaging with government actors include E5, which emerged as a niche-innovation from within the industrial regime. It has hosted meetings with congress, field visits to the plant, and supported drafting the 2010 integrated waste management law. Although these actors represent the interests of very different groups, there was alignment in their aims of achieving coherent regulations for waste management that increases recovery and delivers a social and environmental benefit in Costa Rica.

Collection and sorting activities collect plastic waste that has been improperly disposed of from the environment before sorting for 'recovery'. This could be waste that has been illegally dumped, littered, or ended up in landfills or open-air dumps. Although the municipalities are responsible for collection of recyclables, many lack adequate routes and recycling facilities, or reject large volumes of recyclable material which has not been cleaned. Several innovations in this area have emerged from outside the *regime* in response to the visible pollution on the beaches (E2,E3,E14) or to generate an income in harsh socio-economic conditions (E1,E14). For example, some actors coordinate beach clean-ups with volunteers, typically these are hotel guests, tourists or young citizens (E2,E3,E4,E8,E9,E11,E14).

In contrast, informal waste-pickers are often people living on the margins of society such as those living on the streets or in basic shelters in open-air dumps. These people collect recyclable waste from dumps, the environment and even landfills to sell to sorting facilities who then sell on to

recycling companies domestically and overseas (E1, E12). They typically work in dangerous conditions for extremely little income and are stigmatised for the work they do despite fulfilling an essential, though often invisible, role within the waste management system. As open-air dumps are being systematically closed, waste-pickers are being displaced and further marginalised. In one municipality, waste-pickers organised to negotiate with the municipality formal access to a sorting site before waste is taken to landfill, creating a mutually beneficial working relationship. This supports the country's efforts to reduce the amount of recoverable waste sent to landfill and supports employment.

One actor (E5) operates at an industrial scale, receiving and processing MSW to be used for co-processing in cement kilns (Section 2.1). It has committed to responsible business practices and therefore, in partnership with the landfill operator, has established an industrial sorting process to remove recyclables from the material before it is used. This process is relatively crude now but represents a step-change to increase recycling. As the landfills are quickly reaching capacity and should not be the final disposal point for any recyclable materials, this innovation area is contributing by diverting waste from landfill, extending their lifetime and increasing recovery rates.

Recovery processes include recycling, up-cycling, down-cycling and co-processing, all of which keep waste out of the landfill, prevent pollution and 'recover' materials for further use. There are limited recycling facilities with much of the sorted waste being exported for recycling overseas. One recycling actor (E10), a national plastic production company, has innovated by developing a recycled plastic division which is being expanded to substitute more of their virgin plastic production. Another actor (E3), an international FMCG company, is increasing the proportion of recycled plastic content for its products by using plastic recovered from beaches and the oceans. While it is not yet using plastic waste from Costa Rica, it anticipates that demand for recycled plastic will continue to rise as large companies transition their production from 100% virgin plastic.

Co-processing, done by one actor (E5) emerged decades ago from within the regime for cement production. Initially used to reduce reliance on finite resources (e.g. limestone and fossil-fuels), it has evolved to offer several co-benefits for the country. It uses processed MSW as thermal and material input, reducing the need for fossil-fuel input and contributing to the decarbonisation of the cement industry, creating jobs and providing a safe way to handle waste. E5 is owned by cement company Holcim providing a relatively protected operating space, with a guaranteed market and substantial

capital backing. They supply the cement producer which currently substitutes 32% of the fossil-fuel input with processed waste and aims to substitute 70% by 2025.

Up-cycling and down-cycling are done by small, private companies outside the regime (E2,E14). They have been developed with the explicit aim of addressing the problem of plastic pollution and offering opportunities for education. One actor (E14) up-cycles plastic to create a high-quality product which is designed to be easily recycled in-line with circular economy principles. This company benefited from access investment capital from the government in its early stages and is in the process of stabilising, building a team to increase capacity and secure a market for the new product. There is interest in investment to scale up in due course. Another actor, (E2) developed a down-cycling operation to handle plastic collected from beach clean-ups. This innovation creates low-grade plastic products that have long lives (e.g. fence-posts, benches or flowerpots) keeping plastic safely contained.

Reduction strategies include eliminating the purchase of plastic products where possible, and substituting (e.g. glass bottles instead of single-use plastic bottles) or using alternatives (e.g. bio-plastics) where not possible (E3,E7,E8). This type of innovation is being undertaken by actors within the regime and represents a radical shift in consumption patterns, driven by the changes in regulations. Actors implementing reduction strategies include luxury hotels (E8) and public institutions (E7,E9). One actor (E8) replaced all single-use plastic in its client-facing offering by substituting with bio-plastics (e.g. food packaging or utensils), paper or glass (e.g. laundry bags or shampoo bottles). Another actor (E7) has undertaken inventory processes with extensive monitoring and staff training workshops to mainstream the reduction and recycling of plastics in their operations. While these examples are significant, there are limitations as the market for alternative products and processing facilities is not yet established, so bio-plastics currently end up in landfills.

5.3.3 Building momentum

Within Costa Rica's transition, there are windows of opportunity which could enable stronger niche-innovations to breakthrough. The following processes were identified through thematic analysis as enabling niche-innovations to build momentum (Table 7). It is notable that while the niche-innovations cover all 3Rs, the momentum is focused on efforts to improve and increase 'recovery'.

Learning processes include monitoring and evaluation, research and development, and knowledge sharing and capacity building. Monitoring and evaluation enables actors to assess progress and make adjustments along the way (E1,E5,E7,E8,E9,E11). Research and development supports the production

of new materials or substitutes (E5,E14) and a deeper understanding of specific operational contexts such as informal waste-picking or public institutions (E1,E7,E9). Knowledge sharing and capacity building teaches technical skills for plastic shredding and recycling (E14), and allows for collaborations between niche-innovations and municipalities (E1,E4,E9,E14). Learning processes underpin the advocacy and engagement innovation area which is facilitating a more systematic exchange of knowledge development within the *niche*-level, to wider networks and with larger transformational scope.

The expansion of social networks refers to the enrolment of new actors (incumbent and new) to increase the resource base and add legitimacy to innovations. This was identified as an active area with many niche-innovations engaged in collaborations or partnerships (E1,E2,E3,E4,E5,E7,E9,E14). In some cases, collaborations are with other niche-innovations, but networks include incumbent actors such as Walmart, Pali (established supermarket chain in Costa Rica), Coca-Cola and Ebi (Canadian landfill company operating most of the landfills in the country). While the presence and support of powerful regime actors can lend legitimacy, publicity and help to stabilise niche-innovations in a dominant design, there is a danger that they may also dilute more radical systemic changes. This is because promoting changes to consumption patterns would conflict with growth-oriented business models. Within these examples there is a mix, with Walmart and Pali banning plastic bags and promoting reuse of alternatives (e.g. cardboard boxes or cotton bags), while Coca-Cola are increasing the recycled content and promoting sorting for recycling by consumers. Grassroots networks help strengthen the waste-picking which is important for securing socio-economic co-benefits and increasing recyclables collection and sorting (E1,E9,E12).

The articulation of clear expectations amongst actors and niche-innovations appears to be aligning across different dimensions and becoming more precise. This process is important to provide guidance for identifying gaps or challenges and finding solutions. This seems to be happening simultaneously as learning processes occur and as social networks expand. Stakeholders across the waste value chain are articulating several barriers to transitioning and calling for similar types of governmental responses (Table 7). As this happens, demands for change become stronger and chances of breaking through to reconfigure the local and national government regime are higher.

5.3.4 Barriers and hindering interactions

At the *landscape* and *regime* levels, the transition faces several challenges which are slowing progress. Some of these sustain the existing *regime* by strengthening incumbent actors' position vis-a-vis *niche* actors.

One compounding issue is the *entrenched and stigmatised poverty* in Costa Rica which has led to people living on the margins of society and dependent on waste picking for their livelihoods. This work is unregulated, informal and often takes place in dangerous environments. Due to the stigma surrounding homelessness, substance misuse and deep poverty, workers are perceived as dirty and dangerous (E1, E9, E12). As a result, these workers struggle to gain recognition and are not formally integrated into the waste sector, missing out on social security (E1,E9,E12). This issue has been exacerbated by the rapid shock of the *global Covid-19 pandemic* which has shifted priorities within the government. Resources have been cut or constrained for: monitoring and evaluation of plastic waste policy implementation (E6,E7,E13); research and development (E1,E2,E6,E14); and collaborations and partnerships (E2). This has prevented iterative learning and adjustment (E6,E7,E13); delayed progress in innovations (E1,E2,E6,E14); and inhibited social networks growth (E2). In addition, the economic impact on households has been significant, inhibiting municipal plans to introduce user-fees for waste management services (E4,E6).

Stabilising dynamics were identified as the counterproductive *citizen-state relations* which include burdensome and inefficient governance practices which have delayed and/or prevented the emergence of adequate transportation, collection, sorting, treatment/recovery, and disposal actors and of new products in new markets with a transparent supply chain (E1,E2,E7,E8,E9,E10,E12,E14). This was posited as one reason for the lack of recycling companies and the difficulty for municipalities to find compliant ones locally. In addition, bribery and not paying taxes have become normalised hindering efforts to enforce the regulatory framework to ensure compliance. One stakeholder (E5) expressed concerns that even if the government introduced a tax on waste generation and disposal, people would find ways to not pay for them.

5.4 Implications for local and national government

Through analysis of the results from RQ1-3, supporting actions at the municipal and national government level in Costa Rica have been identified.

5.4.1 National level

At the national level four action areas to address the challenges presented in Section 5.1.2 and 5.3.4 are the: development of a planned and just transition; harmonisation and enforcement of regulations; adoption of sustainable fiscal policies; and the formalisation of the waste picking sector.

Firstly, *developing a planned and just transition* which involves long-term planning, coherent and mutually reinforcing legislation and policies, support for implementation, and opportunities for key stakeholders to participate in decision-making processes. For example, by looking beyond short election cycles (four years), challenges related to adverse knock-on effects (e.g. jobs are lost as businesses cannot adapt quickly or costs are passed down to users), constraints to implementation (e.g. lack of substitute material suppliers or recycling facilities) or excessive operational costs (e.g. burdensome bureaucracy to establish waste recovery facilities) could be overcome. Supporting implementation by designing appropriated targets and fiscal policies that are adapted to the local context could reduce the economic burden on citizens, smaller businesses and ensure that waste management is adequately funded at national and municipal levels. The inclusion of key stakeholders in decision-making processes could also open routes for informal waste-pickers to articulate their needs and work with ministries. This is an overarching recommendation which aligns with calls worldwide to centre citizens and workers in transition plans.

Secondly, the *harmonisation and enforcement of regulations* to ensure regulations are mutually reinforcing and effectively enforced is necessary to create an even playing field that promotes the 3R and encourages innovation. Although Costa Rica has made laudable strides towards an ISWM system at the regulatory level, legislation has been introduced piecemeal without consideration for interactions with existing regulation. For example, no plastic should be sent to landfill, however the number of registered facilities has fallen because the set-up and maintenance bureaucracy is so high. One prevailing issue in transitions is the fall in competitiveness as actors adopt new products, services or production operations which have higher costs (e.g. substitute materials, increased input of recycled plastic from virgin plastic, transporting recyclable waste to facility). This can be exacerbated if compliance with regulations is not consistent. Inducing actors to comply could increase market demand for several niche-innovation products and services including substitute materials or recycling processes.

Thirdly, the *adoption of sustainable fiscal policies* such as tax breaks, reductions or credits, subsidies or penalties. These mechanisms should be designed to incentivise the 3Rs for plastic waste

management while increasing the relative cost for unsustainable behaviours such as landfilling recyclables, virgin plastic production or not sorting recyclables at the household/business level. This addresses a typical challenge for niche-innovations in which their products and services are often more expensive (relative to incumbent actors) due to the combination of limited experience or, in the context of new products, lack of access to economies of scale and the need for new infrastructure. In Costa Rica, this could address issues such as the Value-Added-Tax charged on plastic waste which penalises recycling actors[13]. This response could adjust relative costs for niche-innovations and support a new market.

Fourth, the *formalisation of the waste-picking sector* by recognising and integrating informal waste-pickers into the ISWM system. By adding waste-picking as a distinct job role within the Ministry of Work, workers would have visibility within the formal employment system. Critically, this would include social security insurance and would necessitate the development of safe and effective working practices. By addressing the needs of the informal waste-pickers, the country may realise increased capacity for the *collection and sorting* of recyclables and achieve co-benefits by increasing employment opportunities for marginalised people. To improve their visibility to society and the government, waste-pickers should organise to advocate for their rights and enable effective municipal collaboration.

5.4.2 Municipal level

In order to effectively implement and operationalise the 3Rs and ISWM regulatory framework, the following supporting actions were identified: increasing collaborations with civil society; improving the provision of dedicated collection routes and processing facilities for recyclables; integrating the informal waste-picking sector; and mainstreaming the ISWM plans.

Collaborations with civil society to promote and mainstream the 3Rs by conducting awareness campaigns. These campaigns should be designed to reach the entire society. For example, by collaborating with schools the youngest generations would learn about the problem of plastic pollution and how to use the 3Rs to do their part. Children could influence their families and surrounding communities as they become environmentally responsible citizens. Several stakeholders (E4,E11) referenced a successful campaign by the transit police to promote the use of seatbelts which dramatically changed citizens' behaviour. In this case, children learned about seatbelt safety

[13] During the life-cycle of plastic, VAT is charged twice. Once at the point of sale for plastic products and again when sorted plastics are sold for recycling processes.

and influenced their parents to use them as standard. These collaborations and campaigns are low-tech and relatively low cost but play a crucial role in shifting citizens' mindsets and behaviours concerning plastic waste which is vital for a successful and sustained transition.

Secondly, the *provision of collection routes and processing facilities for recyclables* to increase 'recovery'. This involves prioritising the ISWM action plans and financing them accordingly. This action could be pursued through public-private partnerships to address capacity constraints. One option could be to collaborate with the landfill operator which has water-treatment facilities that are needed to increase the clean sorted plastics. Having facilities to clean plastic waste would increase recovery because inadequate cleaning results in substantial volumes being rejected. Similar to the partnership between E5 and the landfill operator, this action could provide the appropriate service and infrastructure to ensure that waste sorted by citizens is collected and recycled in-line with their expectations. This could ensure that momentum in shifted practices is not lost as sorted waste ends up in landfills due to infrastructure gaps.

Integration of informal waste-pickers into the ISWM system could increase municipalities' capacity to sort waste, increase 'recovery', and clean-up pollution and secure socio-economic co-benefits. One example, a collaboration with the landfill operator to provide a place for waste-pickers (as municipality employees or subcontractors) to collect plastic waste from the environment, sort and clean. This action is contingent on the *formalisation of the waste picking sector* at a national level and organising at the grassroots level.

Lastly, *mainstreaming the ISWM action plans* by developing adequately resourced long-term plans with appropriate enforcement mechanisms. This could include fines for inadequate sorting or volume-based waste fees which incentivise citizens to implement the 3Rs. By improving data collection for monitoring, the municipalities would be able to develop coherent plans which reflect the operational reality of their specific municipality. This could also be used in knowledge-sharing between municipalities, facilitating opportunities to learn from each other and developing precise demands for support from the national government. These actions could be supported by the *harmonisation and enforcement of regulations* at the national level and are contingent on the political will to provide appropriate funding.

6. Discussion and conclusion

6.1 Concluding remarks

The aim of this thesis was to analyse the sustainability transition in Costa Rica from the existing PWMS to a new system in which the 3Rs are operationalised. This was achieved by applying the MLP to analyse documents, literature and stakeholder interviews to understand the existing system and the characteristics of the transition dynamics and change processes. Findings showed that there are substantial gaps between national regulatory frameworks and the current state of ISWM implementation in Costa Rica. We found very little in place to support and enable municipalities, citizens, businesses or institutions to transition successfully. However, the results also demonstrated some progress. Windows of opportunity are emerging as *landscape* changes pressure the political and market *regime* to adopt progressive PWMS policies. There are niche-innovations aligned with the 3Rs that are building momentum to transition towards a 3R-compliant PWMS through learning, network expansion and the articulation of their needs. However, the focus of initiatives is on 'recovery' with 'reduce' and 'reuse' strategies less developed. In light of these results, we identified several national and municipal-level actions that could be taken to help realise the transition. Policies and implementation plans must strive to generate the necessary and relevant social and economic incentives and market conditions. National and local government action is an essential enabler for operationalising the 'reduce' and 'reuse' strategies in particular, because they are not currently economically viable.

The findings from this study highlight the disconnect between current global ambition and strategies to address plastic waste and pollution and the operational realities of Costa Rica. The prominent role 'recovery' processes and their adoption by incumbent actors, plays in the transition in Costa Rica reflects the potential for monetising or marketing plastic waste. This is in contrast with 'reduce' and 'reuse' strategies which, despite their higher waste hierarchy position and potential for plastic waste and pollution reduction, are not prioritised. As such, other countries are likely to face similar challenges in their efforts to operationalise 3R-compliant PWMS because they too are subject to the lock-ins related to the growth-oriented global economic system and the pressures of inadequate waste management systems.

Accelerating the transition could secure Costa Rica’s sustainable reputation and future and provide environmental and social co-benefits. As Costa Rica hosts important ecosystems which underpin its sustainable tourism image, addressing adverse environmental and social impacts of the growing plastic waste pollution problem is imperative. However, Costa Rica cannot address this problem

within its own borders. Due to the highly globalised plastic production and the interconnectedness of the global economy, it will require global coordination and collaboration to implement measures that can meet the challenge.

6.2 Limitations

There were several limitations identified during the study. The sample of stakeholders to interview was relatively small due to time, capacity and access constraints. It would have been useful and insightful to interview more actors at each part of the waste value chain and in different parts of the country. In addition, the ongoing Covid-19 pandemic meant that many stakeholders requested to meet virtually which limited the opportunity to visit their sites of work. However, the virtual meetings did make it simpler to record and transcribe the interviews. This was especially useful as most interviews were performed in Spanish before being translated into English. To gain a contextual understanding of the operational environment for waste management in Costa Rica, the researchers explored the area independently.

Although individuals are important to the plastic waste system, due to ethical and safety considerations, the decision was taken to interview organisational level stakeholders. This resulted in the exclusion of citizens who may have provided insight into the transition in a very different way. Despite efforts to locate informal waste-pickers, the researchers were advised against entering the open-air dump where many waste-pickers live as it could be dangerous and perceived as trespassing by the community. To counter this challenge and ensure the study considered this crucial stakeholder group, we identified an NGO representative with almost 30 years experience working with waste-pickers closely.

The application of the MLP to this transition was insightful, however the explanation of social processes explanation of how change occurs was superficial and limited the depth of analysis. For example, understanding how large-scale advocacy and behaviour change campaigns might be implemented to shift socio-cultural values and practices is not adequately accounted for in the MLP.

6.3 Future research

For further research, coordinating with organisations to arrange introductions or facilitate interviews with waste-pickers might help researchers engage with this group in a safe and respectful way. Additionally, engaging with citizens to understand their consumption patterns and disposal practices could provide insight into how strategies for ‘reduction’ or ‘reuse’ could be developed. Lastly,

evaluating the potential impact of niche-innovations for reducing the total plastic waste generated, reused, and recovered could provide relevant indicators.

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8. Appendix 1

Table 1. Outline of preliminary interview process.

Stakeholders contacted	Example questions
Four municipalities Three condominiums (staff & residents) One sorting facility Nine citizens	How do you handle plastic waste? Do you sort it? If so, how and how often? Who collects the waste? Do you know where the waste goes?

Note. Own creation based on field notes from preliminary interview process.

Table 2. Semi-structured stakeholder interview protocol.

Topic area	Example questions
Stakeholder profile	Can you introduce yourself and the organisation/ company, its creation and focus?
Plastic waste management	Can you outline how your organisation/ company handles plastic waste (within MSW)?
3R activities / potential activities	Can you outline any measures and partnerships the municipality takes to promote a circular economy for plastics? Are there any initiatives in place to reduce plastic waste generation and/or maximise resource recovery within your operations?
Challenges	What do you perceive as the barriers / challenges for the implementation of ISWM plans? What challenges do/ would you encounter in scaling up the recycled plastic products to reduce your dependence on virgin plastics?
Opportunities	Where do you see opportunities to transition to a circular economy with ISWM? Can you outline some of the social, technological, economic, political opportunities and co-benefits you see in addressing plastic waste and pollution?

Note. Own creation based on sample of interview guide. Questions were tailored to each stakeholder but followed a similar format.

Table 3. Thematic analysis coding framework.

Preliminary grouping	Code	Theme
Niche-innovation	Advocacy & engagement Collection & sorting Recovery processes Reduction strategies	Niche-innovation
Niche-process	Monitoring, evaluation & reporting Research & development Knowledge sharing & capacity building Engaged in partnerships / collaborations Incumbent actors join networks Strengthening informal waste-picking sector Need for a planned just transition Need for coherent and enforced ISWM regulations Need for sustainable fiscal policies Need for mainstreaming ISWM plans	Learning Expanding social networks Articulating expectations
Regime enabling interaction	Government adoption of ISWM regulations Market adoption of sustainable plastic policies Recognition of need for a just transition Shift in behavioural norms in younger generations	Destabilising dynamics
Regime hindering interaction	Citizen-state relations	Stabilising dynamic
Landscape enabling interaction	Institutional narratives on environment and climate change Socio-cultural concerns	Directional change
Landscape hIndering interaction	Entrenched and stigmatised poverty Global pandemic	Compounding issue Rapid shock

Note. Own creation based on MLP framework and thematic analysis process.

Table 4. Key information on municipalities

	Garabito	**Goicoechea**
Population	17,229	115,084
Per capita daily collection (kg)	2.34	0.89
1. Total ordinary waste collected (2+3) (tonnes)	14,805	37,434
% of plastics in composition	19%	n.d.
(2) Ordinary waste collected by municipal routes (tonnes)	14,697	32,418

(3) Ordinary waste collected from the environment (tonnes)	108	5,016
Total recoverable waste collected (tonnes)	149	348
% of plastics in composition	6%	5%
(4) Total recycled waste (tonnes)	96.85	348
% of recycled	0.65%	0.93%
Landfill (1-4)	14,708	37,086
% of residues going to landfill	99.3%	99.1%
Burning or dumping waste	>6%	n.d.

Note. Information extracted from the ISWM plan, the National Institute of Statistics and Census (2011), and through field interviews with municipalities.

Table 5. Total municipal solid waste data for 2018

Per capita generation	0.29	
Population	5,003,393	
Total generated MSW (1+2) (tonnes)	1,462,397	100%
(1) Residential	1,063,012	72.7%
2) Other (commerce, schools and universities, offices)	399,385	27.3%
Recycled (tonnes)	53,473	3.7%
Composted (tonnes)	4,857	0.3%
Incinerated (tonnes)	3,040	0.2%
Disposed in landfills and dumps (tonnes)	1,296,202	88.6%
Inadequate disposal* (tonnes)	104,825	7.2%

Note. Own creation based on data from the Ministry of Health.
*Inadequate disposal includes waste that is burned, buried, disposed in waterways or left behind on roadsides, sidewalks and empty lots.

Table 6. Main national policies, plans, and strategies related to Integrated Sustainable Waste Management

Regulatory framework	**Summary of key features related to the management of plastic waste**
Laws & regulations	
Law on Integrated Waste Management (no. 8839) est. 2010	• Define responsibilities of key actors. Municipalities are responsible for providing an adequate ISWM service. • Set up a judicial framework to promote the implementation of ISWM. • Assigns the Ministry of Health as the governing body overseeing the implementation and enforcement of this law.

	• Encourage recovered products market • Improve waste management infrastructure • Encourage sorting at the source • Support local governments in the implementation • Influence consumer behaviour to encourage clean production and sustainable consumption and disposal • Develop incentives to support the implementation of ISWM. • Promote citizens responsibility for their waste generation • Collaborate with innovations and products for ISWM
Law on Combating Plastic Contamination (no. 9786) est. 2019	• Prohibition, with some exceptions, of commercialisation of plastic straws, bags, bottles • Banning of single-use plastic in public procurement • Education programs dedicated to study of the integral management of plastic waste with special emphasis on the substitution, reduction and elimination of single-use plastic. • Encourage companies to only use reusable packaging in their products • Retail selling plastic products must have containers for the appropriate disposal of plastic products
Policies	

Policy on Sustainable Consumption and Production 2018-2030 (no. 41032)	• Consists of seven strategic aims: Sustainable non-food Production, Sustainable Agrifood Systems, Sustainable Tourism, Sustainable Lifestyles, Sustainable Construction, Sustainable Public Procurement, and Institutional Strengthening.
	  ○ Sustainable non-food production: generate the necessary conditions to facilitate the transformation of the private sector into a more sustainable whilst maintaining competitiveness.
	  ○ Sustainable Public Procurement: gradually implement a sustainable environment, social, and economic criteria for public procurement to diversify and impulse the market of sustainable products and services.
	  ○ Sustainable lifestyles: promote and facilitate sustainable lifestyle practices through adequate information campaigns, product labelling and certifications, and appropriate infrastructure

Plans & Strategies	

Plan for an Integrated Waste Management 2019-2025	• Creation of regulations aimed at compliance and implementation of what is established in Law No. 8839
	• Identified priority sectors for the implementation of the law:
	  ○ Regional projects for an ISWM
	  ○ Technology for treatment options
	  ○ Extended producer responsibility
	  ○ Awareness and education
	  ○ Intersectoral coordination roles and responsibilities
	• Strengthen governance at the national, regional and local levels for the protection of the environment and the improvement of the quality of life of the population through a comprehensive waste management.
	• Promote the separation and selective collection through the implementation of participation activities and communication strategies aimed at the family, community, institutions, commerce and industry that contribute to cultural change.

	• Promote national actions to adopt technological alternatives that give value to waste in the selection, collection, recovery and final disposal
Strategy for the separation, recovery, and valorisation of waste 2016-2021	• Develop an inclusive model for the comprehensive management of solid waste in the country that allows the strengthening of capacities between the public sector, private sector and civil society through the following components: o Mechanisms to harmonise the waste separation system at the national level o Harmonisation of the waste collection system at the national level. o Formalisation and strengthening of waste-pickers o Digital market for waste o Waste recovery tool
Strategy for the Substitution of Single-use Plastics for Renewable and Compostable Alternatives 2016-2021	• Promote and publicise municipal regulations to eliminate single-use plastic or to replace with renewable and compostable alternatives. • Facilitate the issuance of institutional mandatory guidelines for their suppliers to eliminate the consumption of single-use plastic and replace it with renewable and compostable alternatives. • Promote the replacement of single-use plastic products with renewable and compostable alternatives among merchants, wholesalers and retailers throughout the country • Stimulate research and development between specialised laboratories, private companies, universities, technical colleges and training centres to create and design renewable and compostable packaging, bags and containers for solid and liquid products. • Stimulate investment in projects that contribute to the substitution of single-use plastic for renewable and compostable alternatives
Decarbonisation plan 2018-2050	• By 2050, 100% of CR territory will have solutions for collection, separation, reuse, and disposal of waste. • By 2030, CR will have an industry and business culture oriented towards generation less waste and a proper management of it, through the lens of circular economy. • By 2022, CR will have a Strategy Plan for improving technological options to reduce methane derived from organic waste

Note. Own table developed by reviewing regulations, policies and plans from (Government of Costa Rica, n.d.-b)