TRANSFORMING THE FUTURE OF DURBAN BAY: STRENGTHENING SOCIO-ECOLOGICAL RESILIENCE

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Transforming the Future of Durban Bay: Strengthening Socio-Ecological Resilience

Report to the Water Research Commission

By

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Executive Summary

Ports play a crucial role in global trade, influencing surrounding urban and coastal areas while supporting diverse stakeholders. However, they often become pollution hotspots due to unmanaged waste and stormwater runoff, evident throughout the Western Indian Ocean. The Port of Durban, South Africa, situated in a deepwater estuarine bay, faces significant environmental challenges, including plastic pollution from local rivers, exacerbated by urbanization and climate change. Despite the ecological importance of the Bay, over 90% of its habitats have been lost, including a complete loss of seagrass beds and significant constriction of both mangroves and sandbanks, negatively impacting water quality and biodiversity. This translates into a loss of essential ecosystem services, the ecosystem's contributions supporting human well-being. Plastic waste is a complex problem, spanning the full landscape-seascape continuum manifesting at the nexus between social, ecological, and economic. This situation necessitates a comprehensive understanding of the interactions between river catchments and port activities to identify key areas to lever sustainable change. A socio-ecological system (SES) model allowed for a comprehensive analysis of the interconnectedness of ecosystems and socio-economic systems within Durban Bay, using a cross-disciplinary approach, fostering stakeholder collaboration, and enhancing both environmental health and economic resilience, aiming for a sustainable and improved system.

The SES model for Durban Bay was co-developed in three stages. Firstly, a draft SES model was conceptualized using a desktop literature review. This SES model was then sense-checked by key local stakeholders in an interactive workshop and amendments to the model were made based on stakeholder feedback. Subsequently, the SES model has been refined as insights from other work packages become available. This included incorporating two supporting studies designed to provide locally relevant socio-ecological data. Key being a case study analyzing the governance and socio-ecological dynamics of the Umbilo River, a significant contributor to plastic pollution in the port. This report examined the Transformative Riverine Management Programme launched in 2021, aimed at improving catchment governance through community-driven river rehabilitation projects. It found that despite efforts to address pollution and flooding, chronic issues like ageing infrastructure and poor waste management persist. The study emphasized the importance of collaborative governance and community engagement in tackling plastic pollution effectively. In addition, an ecological report evaluated the origin and type of plastic pollution in Durban Bay instead of relying on anecdotal evident, and through an extensive literature review attempted to understand the impact of this on ecosystem services and the potential consequence for the people relying on them. It documented significant plastic waste, primarily single-use plastics that were ubiquitous throughout the Bay causing smothering and physical disturbance of local ecosystems. Despite sustained clean-up operations waste continued to enter the Bay all year

round, but in higher volumes during high rainfall events. These findings allowed for the final updating of the SES model, and served to identify some key context and site-specific levers to affect change.

Based on the updated SES model and a thorough analysis of the system's drivers and actors to tackle plastic pollution in Durban Bay, several key recommendations are proposed.

1) **Improved Waste Management Systems**: Upgrading of eThekwini's waste collection and recycling infrastructure is essential, including expanding access to disposal services in underserved areas and implementing litter traps in waterways to prevent plastic from entering the bay.
2) **Integrated Catchment Management**: Effective action against plastic pollution requires collaboration across multiple departments and sectors through a cooperative approach that clarifies responsibilities and enhances existing management plans.
3) **Enforcement of Legislation and Policies:** Strengthening the enforcement of current laws, such as penalties for illegal dumping and compliance with Extended Producer Responsibility (EPR) regulations, is crucial for reducing plastic waste generation.
4) **Support for Informal Waste Reclaimers**: Providing support to informal waste pickers can significantly enhance plastic recovery, including initiatives like accessible reclaiming centers and financial assistance that would empower these essential workers.
5) **Education and Awareness Campaigns**: Raising awareness about plastic pollution and promoting sustainable habits among all stakeholders will help reduce waste.
6) **Encouraging Private Sector Involvement**: Motivating businesses to invest in sustainable packaging and recycling programs through incentives can foster innovation and enhance sustainability efforts.

Addressing plastic pollution in Durban Bay requires a coordinated, multi-sectoral response, recognizing it as a complex socio-ecological issue affecting urban resilience, public health, biodiversity, and local economies. The report emphasizes immediate interventions to manage existing pollution and long-term strategies to reduce plastic waste generation. The co-developed socio-ecological system (SES) model identifies key leverage points for action and serves as a roadmap for transforming plastic production, consumption, and disposal systems, fostering ecological, social, and economic resilience in Durban Bay, and promoting a sustainable future.

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Acronyms and abbreviations

ARPP	Aller River Pilot Project
CMAs	Catchment Management Agencies
CSIR	Council of Scientific and Industrial Research
NGOs	Non-governmental organization
NPOs	Non-profit organisation
PCRP	Palmiet Catchment Rehabilitation Project
SES	Socio-ecological systems
SDG	Sustainable Development Goals
UKZN	University of KwaZulu-Natal
WRC	Water Research Commission
WWWC	Wise Wayz Water Care
YES	Youth Employment Services

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1. Introduction

1.1 Motivation and Rationale

> "*Waste is not an isolated technical problem but is a symptom, a physical manifestation, of much deeper problems with the current economic, political and social systems. Waste is the visible face of a development model built on the assumption that some people matter more than others, that pollution is the inevitable price of progress and blind economic growth is the highest possible good. Until we see waste through a broader systems lens our interventions are at best limited, and are often worse, perpetuating the environmental health and social problems which motivate our interventions in the first place*". (Annie Leonard, 2008, cited in Hallowes and Munnik, 2008, p 1).

Ports are central to global trade and transport, serving as key facilities for imports and exports and significantly influencing surrounding coastal and urban areas. They provide shared benefits to multiple stakeholders, including shipping companies, businesses, industry, recreational clubs, conservation organisations, the tourism sector, and citizens who live in cities with ports, as they are significant drivers of economic activity and employment. Ports are often located at the terminus of the land-sea continuum, with estuaries in the lower reaches of urban catchments becoming pollution hotspots due to unmanaged solid waste. Pollution is further exacerbated by manmade stormwater systems that drain densely populated areas into and onto ports, beaches, and oceans. Ports are also internally polluted due to shipping waste, cargo spills, and industrial discharges. This pollution threatens both environmental and social sustainability.

African ports in the West Indian Ocean, including Durban on South Africa's east coast, face these challenges amid rising economic growth and shipping demands. Durban's port, situated in a large estuarine bay, is connected to three river catchments and supports a range of ecological functions, including remnants of mangrove forests, which are vital for climate adaptation and mitigation. Despite its ecological significance, over 90% of the bay's estuarine habitat has been lost to development, severely impacting water quality, biodiversity, and ecosystem function. In Durban Bay, plastic pollution from urban runoff, particularly from the uMbilo, uMhlatuzana, and aManzamnyama rivers, exacerbates these issues, leading to frequent clean-up efforts particularly after heavy rains. These rivers not only transport waste into the bay, but impact communities who live adjacent to them, facing challenges such as flooding and the impact of polluted water flowing through their neighbourhoods posing a public health risk. Ongoing urbanization and climate change magnify these impacts, as more hardened surfaces lead to increased surface water flow into rivers. Unmanaged urbanisation leads to waste, not dealt with at source nor collected, moving through and accumulating in river systems. Climate change in Durban leads to increased surface water flow and flooding, which rapidly transfers waste stored in the environment adjacent to and within rivers, into the port.

Rivers also offer opportunities to those living within their catchments, as they provide a wide range of ecosystem services (Martel, 2020). Durban is a city of rivers (Martel et al., 2022) with the majority of land use types and settlement areas in the city connected to a stream or a river. Martel et al., (2022) argue that rivers can be considered sustainability pathways in the city, as they act as 'the veins and arteries of the city' (Martel et al. 2022a).

> "Rivers *reflect, hold, move and address multiple urban problems and challenges, through their hydrological and ecological processes and their relationships with their catchments. These challenges include rapid urbanisation; pollution; poor delivery of infrastructure and services; path dependencies created through hard infrastructure, which use rivers as buffers when engineering systems fail; the growth of informal settlements; sand winning; densification and hardening of catchments; poor storm water management, which is being exacerbated by climate change; and cycles of droughts and floods*" (Martel et al., 2022, p 185).

Rivers therefore provide a wide range of ecosystem services in the eThekwini Municipal Area, including provisioning, regulating, supporting and spiritual services. Given the challenges with solid waste management and industrial pollution in the city, as well as the lack of basic services, rivers provide these services, by holding or moving waste for communities, industry, and businesses. This happens in the absence of municipal services or through poor internal waste management, particularly for those living in informal settlements and peri-urban areas. As such, rivers support life in the city. However, this happens at great cost, and in a manner that is counter-productive to the health and well-being of people, river systems, ports, and oceans. Rivers have become overwhelmed with the amount of waste they need to transport and deal with as a result of service and infrastructure failure. The outcome of this process is evident at the mouth of rivers, particularly after storms and heavy rainfall events, where in the case of this study, the waste is deposited in the Durban Bay. Adopting both a land-to-sea perspective, understanding the connection between river catchments, rivers, and the bay, and a port activity and management perspective, to analyse plastic pollution in the bay, is therefore essential. To address these challenges, a socio-ecological system (SES) model for the Durban port has been developed, to provide insight as to where the levers for change to improve this system may be. This model aims to bridge social and ecological capacities, identify key interventions, and promote coordinated actions among stakeholders. The project seeks to support restoration of Durban Bay, enhancing its ecosystem services, and ensuring sustainable economic opportunities, ultimately transforming it into a healthier, more resilient port system.

1.2 Project History and Vision

In 2015, in recognition of these challenges and the need for a healthier regenerative system to be re-established, a "Blue Port Initiative" led by the WILDTRUST and implemented in collaboration with TRANSNET, Council of Scientific and Industrial Research (CSIR) and other partners, was launched. This Blue Port Initiative has a Vision of the Durban port as "*a*

productive asset to a thriving blue economy, providing exemplary services to the maritime industry and a healthy environment that supports vibrant tourism and recreational activities." This Vision was developed in 2020 through key stakeholder process and speaks directly to Durban Bay Estuarine Management Plan. The Blue Port project has installed waste traps for inlets to the port and employs community members through the Nedbank Youth Employment Services (YES) Programme to assist TRANSNET to remove plastic waste from the bay and deliver it to recycling facilities. This Water Research Commission (WRC) Project is part of the Blue Port Initiative, and is a collaboration between WILDTRUST, the University of KwaZulu-Natal (UKZN), the University of Stellenbosch Centre for Sustainability Transitions, and the CSIR. The WRC project aims to contribute to building socio-ecological resilience in the Durban Bay and its connected water catchment areas using a participatory modelling and multi-disciplinary action research approach. A socio-ecological model (SES), which recognises the complexity of the social, ecological and governance systems will be developed to guide the policy and practices of multiple stakeholders to transform the Durban Bay, from a degraded environment towards a restored and regenerative, productive state that is an asset to the blue economy. This co-development, participative development of an SES model, using innovative methods, will generate a collective understanding amongst diverse stakeholders about how and where key strategic interventions can best be made to achieve enhanced social, economic, and ecological resilience and regeneration in the system.

Our Theory of Change is that through the process of co-designing a conceptual model that maps pathways and relationships and describes how and where key interventions can be made in the system, can lead to a collective vision of and practices for a healthy, vibrant, and productive port SES. The Theory of Change further expresses that multi-partnership dialogues and engagement processes are necessary for long term success to surface important trade-offs in social and ecological variables linked to development decisions. As such all individuals, organizations, and stakeholders must be incorporated as key actors in the SES. This approach presents an opportunity to assess the effectiveness of current environmental interventions in the port against predicted outcomes, and opportunities for further targeted solutions to systemic issues (Figure 1).

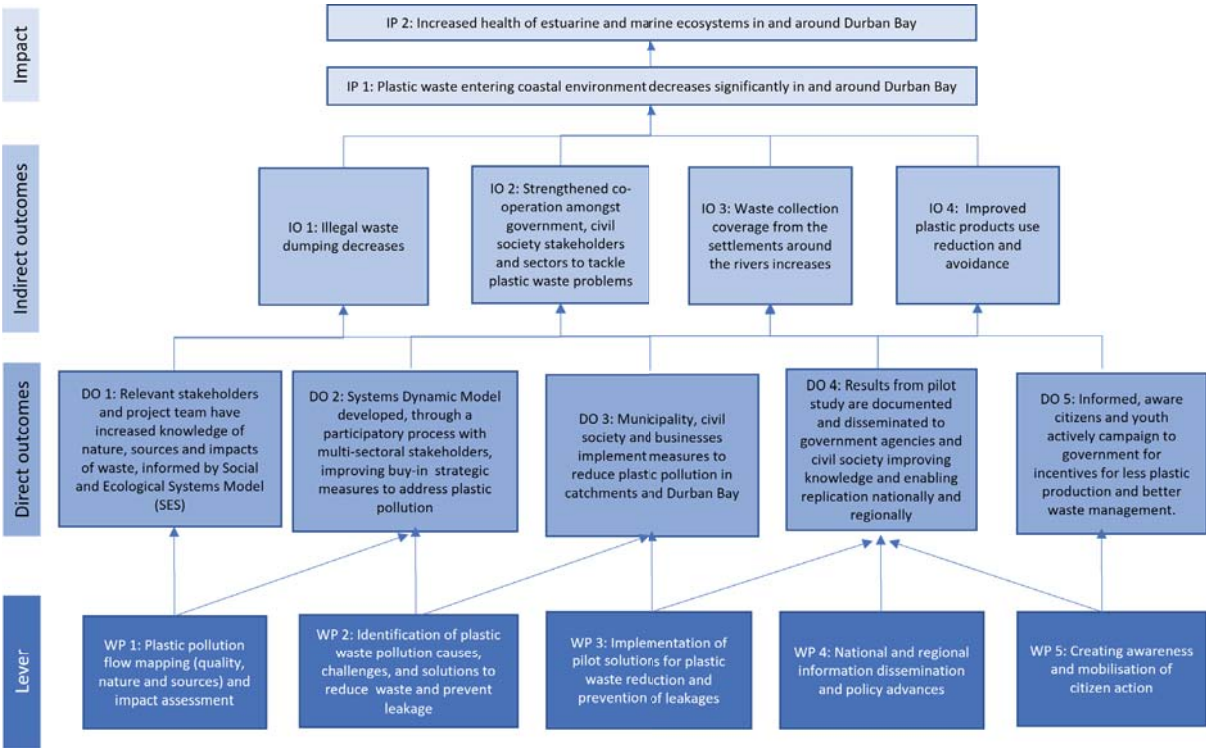


FIGURE 1: THEORY OF CHANGE

1.3 Supporting studies

Two additional studies were undertaken supporting the SES model to provide important local context from a social and ecological perspective and ensure the model is locally relevant.

Social Case Study

A social study on rivers and plastic pollution was conducted to understand the social and governance aspects of the degradation of the river systems, and the consequent impact on the bay environment. The research examined the socio-ecological and governance relationships between people and river catchments, given the importance of rivers in plastic pollution transfer to the port, using the Umbilo Catchment as the case study. The Umbilo River is one of three rivers that flows into the port. The study was set within the context of Durban's Transformative Riverine Management Programme, launched in eThekwini Municipality in 2021 to improve the governance of the city's catchments and their rivers. The programme evolved out of experimental governance and learning from multiple catchment management projects across the city, which led to the development of a municipal wide programme (Martel et al., 2022b; C40, 2021; Martel, 2020). The Transformative Riverine Management Programme is a city-wide programme that was developed as a result of the learnings and benefits of a range of river rehabilitation projects emerging from the bottom up across Durban (Martel et al., 2022a, 2022b). Combinations of actors in different settings recognised the value of ecosystem services or ecological infrastructure in supporting sustainable development and climate adaptation in the city. The river rehabilitation projects were developed to deal with pollution, flood risk and lack of basic service provision.

As both linear and circular systems, rivers reflect and address urban challenges as they absorb, transport, and process the effects of human activities on the environment. Along with their associated ecosystems, they support infrastructure and provide crucial services to urban areas, improving quality of life and mitigating urban impacts, by acting as buffers across various systems. However, in Durban, rivers are increasingly degraded due to chronic issues such as aging infrastructure, pollution, a lack of service delivery and waste management systems, poor sanitation, as well as acute events like floods and droughts. While the three levels of government in South Africa (national, provincial, and local) are responsible for protecting rivers and their catchments, the lack of functioning Catchment Management Agencies (CMAs) and limited local government capacity has spurred action from civil society, research institutions, and the private sector. This has led to a range of river rehabilitation projects in Durban, driven by environmental, development, and poverty alleviation goals, and led by various actors in different collaborations (Martel et al., 2022a, 2022b; Martel and Sutherland, 2019). These projects are often experimental and adopt a learning-by-doing approach, focused on water security. Although spatially bound within catchments, they also reflect broader hydro-social-spatial relations, linking the economy, society, and water in each unique context. These projects highlight pressures on environmental resources, the challenges of managing pro-growth and pro-poor policies, growing inequality in cities, and the effectiveness of legislation and policy frameworks. All these factors affect the ability of the functioning catchment rehabilitation projects in Durban, the Palmiet Catchment Rehabilitation Project (PCRP), Sihlanzimvelo, the Aller River Pilot Project (ARPP), and Wise Wayz Water Care (WWWC) projects to contribute to the Sustainable Development Goals (SDGs) (Martel et al., 2022a).

Martel et al. (2022a) have documented the goals and approach of the Transformative Riverine Management Programme. Different governance models have emerged across Durban's four river rehabilitation projects. In the Sihlanzimvelo project, local government uses a hierarchical approach to manage community cooperatives. Meanwhile, the PCRP and ARPP rely on collaborative partnerships between local government, civil society, research institutions, and communities. In the WWWC, the private sector, local communities, and local government interact, with the project team governing the initiative. Across all projects, strong relationships between local government and citizens have been crucial for addressing river rehabilitation's social, environmental, and political aspects of, contributing to sustainability. However, the economic impact has been limited, aside from minimal funding for community cooperatives and employment of enviro-champs. These river rehabilitation projects aim to promote sustainable development within spatially defined catchments by tackling waste management, pollution, and flooding while strengthening state-citizen relations and improving monitoring efforts. Each project involves local community members who receive stipends to contribute to river health. The projects also feature intermediaries who connect municipalities with communities, ranging from university researchers to consultants. Funding comes from various sources, and the governance models vary significantly. While the Sihlanzimvelo project is

government-led, the other three emerged due to the absence of a Catchment Management Agency (CMA) and gaps in water governance, evolving as experimental spaces for sustainable development.

The learnings from the catchment rehabilitation projects in the Transformative Riverine Management Programme informed the way in which the study of the socio-ecological relationships in the Umbilo Catchment was framed. The social study aimed to understand the relationships between society and the Umbilo River and its catchment, so as to explain how and why the river impacts on plastic pollution in the port. The study which was conducted between 2021 and 2024 included a literature review (Martel, 2020); a desktop analysis of the Umbilo Catchment and land use within the catchment, the selection of three sites where more detailed analysis of the relationship between society, plastic waste and the Umbilo River was undertaken, a review of the Transformative Riverine Management Programme, and data collected from workshops and learning labs held within eThekwini Municipality, to address catchment management. The 2022 floods in Durban were significant and provided insight as to how climate change events in the future, will impact catchments, rivers, and plastic pollution and how solid waste increases climate risk.

The main challenges impacting the well-being of river systems also influence levels of plastic pollution and are influenced by high levels of plastic pollution. These challenges are described in the business case for Durban's Transformative Riverine Management Programme (C40, 2021).

TABLE 1: CHALLENGES IMPACTING ON THE FUNCTIONING OF RIVER SYSTEMS IN DURBAN

Challenge	Description
Land use	Rapid urbanisation and densification Impacts of accelerated run-off Threat to remaining natural systems
Water quality	Water quality issues Sewage and industrial pollution Impacts on human health Impacts on ecosystems Impacts estuarine systems Impacts the coastal economy
Waste management	Solid waste dumping Poor service delivery
Invasive alien plants	Infestations dominating indigenous species Greater water use Shallow root systems – washed out during flood events Causing blockages
Dysfunctional infrastructure	Dysfunctional wastewater treatment works Surcharging sewers Stormwater impacts – combined sewers
Accelerated erosion	Stormwater impacts Accumulation of sediments
River habitat destruction	Due to agriculture, urban development and sand mining

The results of the social study revealed the following drivers of plastic pollution in the Umbilo Catchment and the Umbilo River, which would apply to all three rivers that feed into the port, given similar land use patterns and governance and management arrangements within the catchments.

TABLE 2: DRIVERS OF PLASTIC POLLUTION IN CATCHMENTS WHICH IN TURN IMPACT ON THE PORT

Drivers of plastic pollution	Explanation	Levers for change
Plastic pollution is not due to the actions of the individual stakeholder.	Most people interviewed in the study stated that 'plastic pollution comes from somewhere else'. There is an understanding that plastic moves from somewhere into each context, there is a shifting of responsibility and a blaming of someone else for the high levels of plastic pollution.	Engage with stakeholders in the upper, middle and lower reaches of the catchment to determine where the pollution is being produced, getting everyone to understand that pollution is being produced somewhere, reflecting on their role in producing the waste. Develop a communication and education campaign that uses radio, local newspapers and social media, that explains that plastic pollution is present, but no one feels they are producing it, show how catchments and rivers hold and move plastic pollution and the impacts on the Durban Bay. Citizens need to take responsibility for plastic pollution through the way in which they purchase and consume goods and how they dispose of plastic waste and move through the city with it (for example in the transport systems they use). They need to be responsible for waste produced through their own choices and behaviour.
Plastic pollution is outside the locus of control of the stakeholder	Most people feel that they are trying to manage pollution but that the bigger systems that are supposed to be managing it are failing around them. Those that produce plastic pollution for the consumption of good and services do not	The local government needs to improve waste management in the city, through its waste collection system. The local state needs to get the basics right and waste management services need to be delivered equally across the city. New approaches to waste management in informal contexts, that understand and are integrated with local systems need to be developed. Local government needs to ensure contractors that deliver waste bags and collect waste in different contexts are doing their job. Local government needs to engage with local organisations to align local practices with state interventions.

	take responsibility for the amount of plastic produced and released into society and the environment.	Plastic producers and retailers, which are predominantly the private sector, need to take responsibility for the large amount of plastic pollution they release into society and the environment. Far more pressure needs to be placed on these actors to reduce plastic pollution, by making them responsible and accountable for plastic pollution in their triple bottom line. They need to take greater responsibility for using less plastic in services and goods that are consumed and in driving recycling initiatives.
Once plastic waste moves, it is not considered the responsibility of the producer of that waste.	If other agents pick up waste and move it, the producer of that waste no longer sees it as their responsibility or feels connected to it, as it has moved away from their context and local environment.	Build knowledge, capacity and capabilities in communities to understand the concept of *ubuntu* and building social cohesion through improved waste management. In other words, *my waste becomes your waste and your waste becomes my waste, and together our waste impacts on our quality of life and on the environment.* This would need to be done through media campaigns, communication and engaged in collaborative local governance platforms that include local government, and which draw the private sector in, particularly those who produce plastic waste and nappies.
Plastic pollution is managed in a local context due to social norms and rules	Within each context, citizens develop norms and standards with regard to what is acceptable in terms of solid waste in their environment. This is shaped by inequality in waste management practices. Public spaces are not considered the responsibility of citizens, and these can	Implement the approach of the Transformative Riverine Management Programme to develop collaborative and participatory approaches to solid waste management and catchment rehabilitation. Through building partnerships between the state, citizens, NGOs, NPOs, research institutions and the private sector, a common vision of what the environment should look like and how plastic waste should be produced, consumed and disposed of can be agreed upon, with the state and citizens being held to account for meeting the constitutional right of access to a clean and healthy environment. Unless we reframe the responsibility for waste and enable and require of everyone that we are responsible for plastic pollution in the bay,

	become depositories for pollution. This is evident in open spaces.	with all its negative impacts, we will not resolve the problem of the pollution.
Plastic pollution has become endemic in the environment and so we cannot do anything about it, it is everywhere	Research within the Umbilo River and within 1 km of it, revealed how plastic is embedded and hidden in open spaces and the riverbed, and how plastic once it is broken down becomes part of the environment, it is found between rocks and stones, within sand, trees and bushes, it forms part of bird nests and it is intertwined in all natural systems.	Plastic pollution that is still intact in terms of its original form can be collected and removed, but the scale of its presence appears overwhelming. Green Corridor and other NGOs/NPOs collect litter once it moves through river system using litter booms which have been successful. Heavy rain and flood events release and move plastic pollution in the catchment and river, concentrating it in places where it can be collected as part of post-event clean-up campaigns. Once plastic starts to break down and it is moved by agents such as wind, water and animals, it becomes very challenging to collect, and it becomes part of the environment. This problem is even more concerning when the broken-down plastics become microplastics. This problem provides strong support for collecting plastic at source and disposing of it correctly and hence the state and citizens, and the private sector that produces plastic, need to be continually informed and reminded about the impact of the plastic value chain.
Plastic pollution is hidden in spaces within the catchment and is released during periods of environmental change (such as winds, heavy rain and floods)	The research revealed how much plastic pollution hides in the environment. The freeways and roadways adjacent to the Umbilo River were not as polluted with solid waste as other road routes in the city, the river	Plastic pollution needs to be dealt with at source. Once it moves, it becomes hidden and then it moves again, making it challenging to control and deal with. Building knowledge on the plastic value chain and where plastic should go, will help people to understand why plastic should be dealt with at source. If plastic moves through a formal system of waste management that is working correctly (within-grid), it will be collected, managed and dealt with correctly, but as soon as it moves through a waste management system that is incomplete or informal, it becomes a challenge to manage. Given that so

	itself, in all three sites visited, did not contain large volumes of plastic pollution, but the edges of the river, the riverine corridor and the vegetated spaces adjacent to the river was full of plastic waste and it was evident in unmanaged waste sites that were created through practices of informality adjacent to the river. Under conditions of heavy rainfall, flooding and wind, and through the impacts of animals such as birds, monkeys, rats, dassies, cats and dogs, this waste is moved into the river system and finds its way to the bay.	much plastic waste moves into the off-grid system, waste management service providers need to adapt their systems to try and catch and collect this waste along the way. Using informal practices and citizen responsibility towards waste *ubuntu,* can help. This is evident in Kigali in Rwanda where the government and society ensure that all citizens collect and pick up waste collectively on the last Saturday of each month, in a practice called *Umuganda.* Good policing, community surveillance and fines encourage those who do not wish to participate to join the collective.
Pollution in rivers such as chemical and industrial waste, creates a perception and discourse that rivers are spaces of degradation and hence are not worth being	Chemical and industrial waste is released into rivers through the practices of unethical businesses. This is common when businesses use stormwater systems to illegally dispose of their	This perception is countered by the high value the residents of Durban place on a clean and healthy environment, arguing that the environment in the city is valuable and should be protected by the state, citizens and the private sector (Sutherland et al., 2024). There is therefore a disjuncture between the level of environmental awareness and consciousness and how citizens value the environment, and the level of environmental degradation. This can be attributed to structural inequality, lack of education, poverty and inequality,

considered part of the duty of care.	waste, or where they stormwater systems are connected to other waste management systems. Some businesses discharge directly into rivers. Sewerage pipes and manholes that are meant to be maintained by eThekwini Water and Sanitation Unit, but which are damaged or leaking, can also release sewerage into rivers, as do malfunctioning wastewater treatment plants. Modernist infrastructure is designed with rivers as buffers or overflow spaces to failed systems. This creates the perception and discourse that rivers in cities are polluted spaces and that they are there to manage pollution and waste.	human behaviour, and failed municipal systems. It is most likely a combination of all these factors which do not align with the level of environmental citizenship expressed by residents. Addressing this disjuncture through the Transformative Riverine Management Programme and using policy and legislation to ensure compliance to service delivery mandates and citizen responsibility can address this challenge. The Kloof Project in Kloof, Durban provides a very good example of the positive benefits of investing in ecological infrastructure, improving pathways and transport routes and greening these corridors, on waste management practices, as rehabilitating the environment has created a clear message that is visual, verbal and textual, that waste has no place in public and private spaces. A good clean environment promotes positive attitudes and agency around waste management. This is also evident in the Queensburgh Caravan Park adjacent to the Umbilo River.
Transport routes produce plastic pollution with people	Transport routes contain high level of plastic pollution on their edges. This is due to	Zero tolerance for plastic waste moving out of vehicles has to be supported and enforced. This is a direct example of getting the basics right, and for society as a whole, and those who police it, providing a clear indication that

throwing plastic out of vehicles.	plastic waste either being thrown out or blown out of uncovered vehicles.	solid waste has no place in our city, rivers, neighbourhoods, business areas and open spaces.
Plastic pollution is moved by a wide range of agents	A wide range of agents move plastic pollution including people, vehicles, wind, water and animals (including birds, monkeys, rats, dassies, cats and dogs).	Understanding how waste moves and why it moves, and which agents are most responsible for moving waste in each context can assist with reducing this second and third etc displacement of waste. Waste moves first from being a product to being a waste product through human consumption. Humans then move this waste again, either into waste management systems or they move it in a way that becomes pollution. Other agents can move waste that has both been contained or displaced as pollution, by humans.
Plastic pollution is not being managed nor adequately governed in the catchment	The waste management system and its governance arrangements are failing as plastic pollution is overwhelming the bay and the three catchments that feed it.	Waste governance can be conceptualised as a social function that assists with regulating the development and management of waste and associated services, coupled with the offering of guidance to steer waste from an undesirable to desirable state. The governance of waste includes, policy and strategy, coordination, planning and preparedness, financing, management arrangements, regulation, and capacity development, as well as monitoring, evaluation and learning (Jimenez et al., 2020). Governance attributes illustrate how governance functions are executed, and include multi-level governance, participation, deliberation, inclusiveness, accountability, transparency, evidence-based decision-making, efficiency, the impartiality of rule of law and adaptiveness (Jimenez et al., 2020). There are four 'orders' of outcomes in a governance program, and these are interdependent and interlinked (Jimenez et al., 2020). These orders include the development of enabling conditions to foster the governance initiative; behaviour change of resource users and governing institutions; the realisation of sought-after

		changes in the condition of society and environment; and a resilient socio-ecological system where preferred conditions are maintained (Jimenez et al., 2020). With this approach, waste governance is conceptualised as a means to an end, instead of being an end in its own right (Jimenez et al., 2020). The governance of waste currently is failing, as the state is mandated to manage waste in partnership with citizens who collect and store it, but this system is no longer working, and the responsibility for poor waste management in the environment is being passed from one set of actors to another, with no one taking responsibility or showing the leadership required to address the problem.
The combination of alien vegetation and plastic pollution is a challenge.	Alien vegetation is a threat to the environment in Durban and undermines the city's efforts to rehabilitate ecological infrastructure to support human and environmental well-being and climate adaptation.	Alien vegetation combines with solid waste, including plastic waste to block bridges and culverts, due to it being ripped up and moved along rivers during heavy rainfall events, as a result of its often-shallow roots, which leads to significant infrastructure damage during flooding. This was evident across Durban after the 2019 and 2022 floods. This occurred on the Umbilo River in the April 2022 floods where the Caversham Road bridge was blocked with alien and indigenous vegetation and solid waste, causing it to change course, which led to significant damage to buildings and infrastructure.
The combination of poor sanitation services and plastic pollution is a challenge. This includes water and sewerage flows as well as diapers	Poor sanitation services, particularly poor grey water management from communal ablution blocks and unmanaged black water and sanitation waste where toilets are not available, combine	Poor sanitation and waste management services need to be addressed in an integrated manner to improve human and environmental well-being. Greater integration between national, provincial and local government departments responsible for sanitation, water and waste management is required. The Transformative Riverine Management Programme, the city's informal settlement upgrading policy and its innovative programme to support climate resilient non-sewered sanitation need to be integrated with state

(nappies) and menstrual hygiene products.	with plastic is countless ways to increase health hazards. The movement of sanitation and plastic waste together in the system, with sanitation waste attached to plastic waste, further increases the impact of plastic waste on the environment and the port. There are not adequate disposal systems for diapers (nappies) and menstrual hygiene products and both of these represent plastic pollution (and their reflect the gender inequalities evident in plastic pollution).	and non-state actors collaborating to fulfil the principles and goals of these programmes and policies and to put their practices into action. Urgent attention needs to be given to the safe and more context appropriate disposal of diapers (nappies) and menstrual hygiene products to both reduce plastic pollution and to improve gender equity.

Using the Transformative Riverine Management Programme as a framework as well as the data collected and evidence from the Umbilo River, the following recommendations are made with regard to reducing plastic pollution in the port. State agencies[1] that are responsible for the three catchments which influence pollution in the bay, in partnership with all primary and secondary stakeholders who live, work or have influence within these catchments, will need to:

- develop multi-actor partnerships in local spaces to support catchment rehabilitation and reduction of pollution in rivers;
- develop governance platforms which support co-production of knowledge, collaboration and build state-citizen relationships, with intermediaries such as universities, NPOs and NGOs, and in some cases private consultants playing a bridging role;
- engage the private sector which is largely absent from these governance platforms;
- develop environmental education programmes that are relevant and participatory;
- support ongoing education in schools, drawing on local contexts, so that those who live and interact with these rivers, understand their impact on them. Studies have shown that education programmes in schools are important as children return home and raise the profile of these issues in their households;
- engage with and support local-level initiatives, such as environmental forums and community groups at schools, in informal settlements and linked to neighbourhood watches;
- develop context appropriate recycling programmes all along the catchment and ensure that this waste is collected and that residents understand where it is going to and how it is re-used and re-made;
- implement and ensure compliance to legislation and policy to drive behaviour change;
- hold the private sector and retailers who produce and sell plastic products to account, and to engage them in being part of the solution to plastic pollution;
- develop waste management systems that are appropriate for each context and to ensure waste management systems function effectively in the city;
- empower all actors in the catchment and develop their capabilities to address the crisis of plastic pollution;
- promote positive behaviour change, and ownership of and responsibility towards the environment with all actors in the catchment, including state actors;

[1] Local, provincial and national government are mandated to lead on and take responsibility for the reduction of pollution in river systems.

- engage with communities living informally in the catchments to improve waste management in their settlements and to understand how the transitory nature, which in reality is long term, shapes their perceptions and actions in the informal spaces within which they live;
- engage in informal settlement upgrading programmes to ensure waste management projects are a central part of these upgrading processes.

Capabilities need to be built within catchments that ensure that all stakeholders or actors understand their responsibility for dealing with these challenges. Figure 2, which was developed by Martel et al., (2022b) provides four critical ways in which catchment rehabilitation projects can build capacities and capabilities. As reflected in Table 1 all four are relevant to the reduction of plastic pollution in the port and improved waste management.

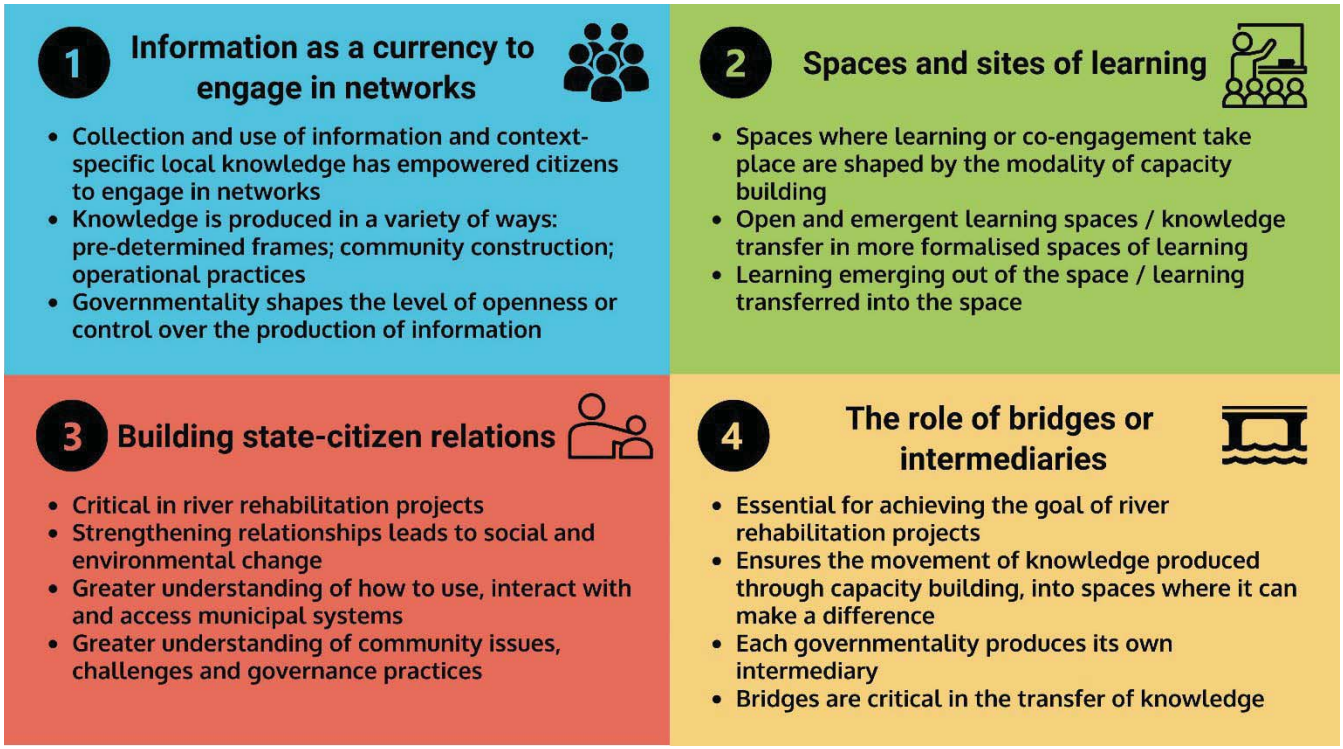


FIGURE 2: DEVELOPMENT OF CAPABILITIES AND CAPACITIES IN CATCHMENT REHABILITATION PROJECTS (MARTEL ET AL., 2022B)

The research on socio-ecological relationships in catchments has revealed the complexity of managing plastic pollution. While managing plastic waste at source should be a simple process, using municipal or private waste management systems to dispose of waste safely does not happen. Understanding why plastic waste is endemic and entangled in natural systems is critical to finding solutions to its prevalence and persistence. The social science research has shown that political, structural, social, economic and environmental factors all shape plastic pollution outcomes in Durban. The study has shown that investing in building collaborative governance partnerships and reframing both the state and citizen's

understanding of plastic pollution and its impacts is central to supporting the reduction of plastic pollution in the port.

Ecological Impact Assessment and Recommendations Report

On completion of the Social Case Study, it was evident that a diverse range of opinions existed on the source of waste entering the bay, however, they were primarily based on anecdotal evidence. An Ecological Impact Assessment was therefore undertaken to assess the type and volume of plastic pollution and map the plastic pollution pressure within Durban Bay. The results of this study were then coupled with an extensive literature review to contextualise the potential impact of plastic waste on the receiving environment and the effect that this waste would have on ecosystem services. Recommendations and guidelines were then formulated to support a more resilient ecosystem.

For the Ecological Impact Assessment existing habitats were categorised into nine sites by geography but spanning two primary habitat types, mud/sand bank and mangroves. Standing stock and accumulation studies were undertaken concurrently to contextualise the impact of plastic pollution. Standing stock surveys (Figure 3a&b) were conducted for three weeks every month, where the YES teams collected all visible waste before sorting and classifying Accumulation studies were conducted a week after standing stock surveys, where five quadrants (5 x 4 m) were situated randomly withinalong a 100 m transect line on a high tide line (Figure 3c&d). Visible litter within quadrants was enumerated and categorised *in situ*. Additional data e.g. the product, plastic type and manufacturing company was also recorded.

A total of 5 634.4 kg of litter was collected by standing stock surveys from September to February, with October recording the highest weight. Waste primarily included single-use plastics. Echoed in the accumulation surveys, plastic comprised 90% (Figure 4) of the overall waste recorded, with an abundance of 0.81 ± 0.07 items·m^{-2}. The plastic waste abundance varied significantly monthly, but although differences were evident between sites, these were not significant ($p(perm)<0.001$; $p(perm)=0.672$). This likely indicates that waste continuously enters the bay despite continued clean-up operations. Single-use plastics (SUPs) such as plastic bags and chip/biscuit packets were identified as major plastic types in Durban Bay in alignment with international findings (Figure 4). A small number, only nine, polluting companies were identified with Truda and Frimax dominating (Figure 5). These results, coupled with an extensive literature review on the impact of plastic waste on the environment, specifically SUPs, highlighted the significant negative effect on ecosystem function. The findings were used to formulate recommendations including the continuation of the regular clean-ups by the Blue Port Team and proposals for policy changes, such as Extended Producer Responsibility (EPR) and SUP bans, aimed at reducing plastic waste. Addressing these challenges is crucial to preserving Durban Bay's ecological integrity and ensuring the continued provision of ecosystem services

FIGURE 3: STANDING STOCK SURVEYS (A&B) CONDUCTED BY THE YOUTH EMPLOYMENT SERVICE (YES) TEAM AND ACCUMULATION SURVEYS (C&D) UNDERTAKEN WITHIN A 100 M TRANSECT

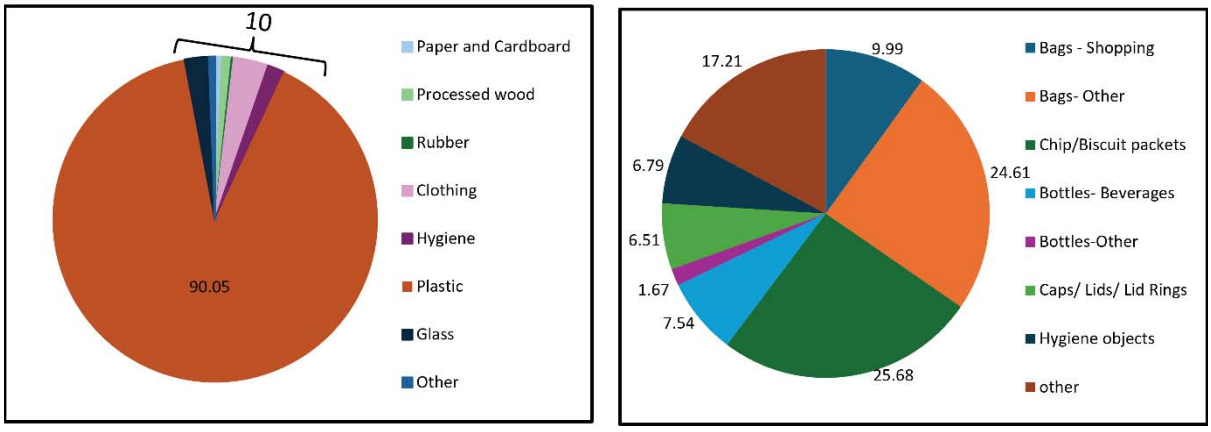


FIGURE 4: DOMINANT WASTE TYPES (%) PRESENT BETWEEN SEPTEMBER AND FEBRUARY IN DURBAN BAY

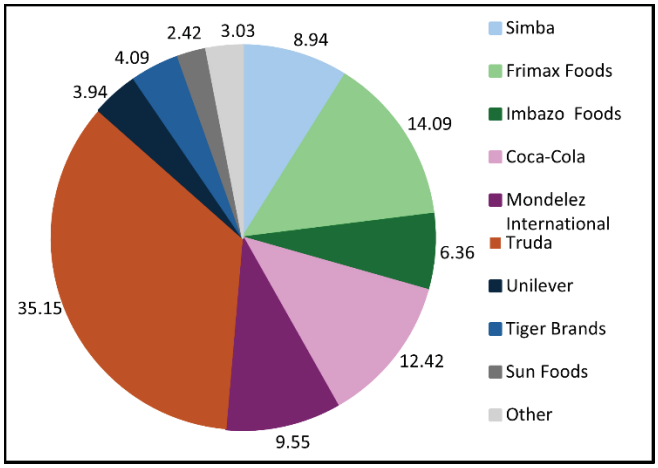


FIGURE 5: TOP CONTRIBUTING COMPANIES TO POLLUTION (%) IN DURBAN BAY

The learnings from the Social Case Study and Ecological Impact Assessment and Recommendations Report have been used to update and finalise the SES model.

2. Socio-ecological Model

2.1 Introduction

Plastic pollution has become an important point of discussion in the sustainability discourse. The increasing effects of plastic pollution track the exponential increase in plastic pollution from two million tonnes in 1950, to over 450 million tonnes in recent years (Ritchie et al. 2023). The increased attention is particularly true for marine plastic pollution, which has even been proposed as a contender to be a critical planetary boundary (Villarrubia-Gómez et al. 2018). Planetary boundaries describe the guardrails for the impacts of human activity on the Earth system and were first proposed in 2009 (Rockström et al. 2009) but continue to be updated in various iterations (Steffen et al. 2015). While there is growing recognition of the impacts of plastic pollution on marine environments, few studies provide insight into its distribution and effects across other ecosystems. *Plastic pathways* connect the land and the sea, since plastic travels from various terrestrial ecosystems to marine environments. Even fewer studies contribute to understanding the drivers and impacts of plastic pollution from a socio-ecological systems (SES) perspective (Windsor et al. 2019; Riechers et al. 2021). This project uses an SES approach to better understand plastic pollution within the hydrological catchments of the Durban Port and its connection to the larger Durban Bay system.

2.2 Study site

Durban Port, located on South Africa's east coast, is the busiest and one of the most industrialized ports in Africa. Ecologically significant, it is nonetheless a heavily transformed and degraded system due to waste inflow, urban runoff, and industrial activities (Naidoo et al. 2015; Preston-Whyte et al. 2021). As a pollution hotspot, these factors threaten the environmental, economic and social sustainability of the port and wider Durban Bay area. Since 2017, the WILDTRUST has worked to collect recyclable waste from beaches and

waterways, employing 140 people in the last three years, and recovering over 96,000 kg of waste.

Plastic pollution in Durban Bay results from a complex set of processes at the wider scale, linked to increased use of plastics in society (e.g. in agriculture, domestic and personal care, waste management, and industry). There is limited understanding of the interconnections between sources, fluxes, sinks, and flows in rivers, and how these influence pollution in the bay. Rivers, identified as pollution hotspots, serve as conduits for plastic transport across terrestrial, floodplain, riparian, benthic, and transitional ecosystems (Krause et al. 2019; Tibbertts et al. 2018; Windsor et al. 2019). Understanding the socio-ecological feedback and interconnections that drive plastic pollution across the Durban Port catchments is critical to identifying key leverage points for effective interventions (Riechers et al. 2021).

The plastics challenge

Plastic pollution poses significant challenges to urban resilience, undermining health, the environment, infrastructure, the economy, and social cohesion. Key impacts include:

1. **Health:** Plastic pollution has an impact on water quality. The breakdown of plastic into microplastics and chemicals can harm humans and animals that come into contact with these materials, leading to adverse health outcomes.

2. **Environmental degradation:** Accumulation of plastic waste in waterways diminishes the environmental quality of those areas and disrupts ecosystem functioning. This has negative impacts on urban residents' quality of life and reduces the aesthetic value of these areas.

3. **Infrastructure damage:** Blocked drainage systems due to plastic waste cause flooding and property damage, creating health hazards.

4. **Economic impacts:** Plastic pollution affects tourism revenue, particularly when beaches are closed, and clean-up efforts divert resources from other critical services.

5. **Social impacts:** Unsafe conditions created by plastic waste exacerbate social inequalities and reduce community resilience. Plastic pollution impacts on social identity and social cohesion in the city, as it creates an 'us' and 'them' scenario of polluters and non-polluters and it undermines perceptions of neighbourhoods and their value.

This deliverable specifically aims to complete the SES model of Durban Bay and its river catchments, which was co-designed with key local stakeholders and informed by other work packages and literature on plastic pollution. This model visualises drivers, impacts and identifies strategic interventions to enhance the social, economic, and ecological resilience of Durban Port.

2.3 Approach and Methods

Socio-ecological systems approach

The study site, Durban Bay and associated catchments that drain into it (Figure 6), is an example of a coupled socio-ecological system (SES). Framing the port as a socio-ecological system means that social and natural activities are intertwined, and society is completely embedded within natural systems. This acknowledges the long history of people and ecosystems shaping and being shaped by each other (Folke et al. 2016). The inseparability of SES presents an entry point for exploring the challenges of plastic pollution within the limits of finite resources, governance arrangements, and increasing human pressures. Through the SES framing, we are able to identify key feedback between social and ecological dynamics, as well as leverage points for interventions that support more socio-ecologically sustainable outcomes.

For the purposes of this project, we define leverage points as places to intervene in a socio-ecological system, in which small interventions can have a relatively large influence to catalyse system change and can hold great potential for transforming systems to enhance ecological and social outcomes (Meadows 1999). Current thinking on leverage points (see Lam et al. 2021; Riechers et al. 2021) has played a key role in the co-development of suggested intervention points for change in the Durban Bay area.

The socio-ecological system under analysis in this project is Durban Bay (Figure 6), including Durban Port and the main river catchments that feed into the bay (Ngcobo 2023; Preston-Whyte et al. 2021). For the initial purposes of developing a **qualitative SES model** (Box 1), we focused on the uMbilo River and Durban Port, including any associated ecological and built infrastructure, stakeholders, and institutions who are involved in, or impacted by, the formal and informal movement and governance of plastic pollution in the Durban Bay. Of course, the Durban Bay system is nested within a larger context of important national, regional, and global drivers of change, which are explored in the stakeholder discussions (Box 2).

The co-development of a conceptual qualitative SES model for Durban Port took place in three stages:

1) Creation of a draft SES model, based on a desk-based study of existing literature on (plastic) pollution in Durban Bay, including scientific and grey literature sources;
2) Sense-checking of the draft model with key local stakeholders in an interactive online workshop, and amendment of the model based on stakeholder feedback (Box 2);
3) Refinement of the model as insights from other work packages became available, resulting in the final conceptual model (Figure 7).

The focus of the SES model is on the interactions most important for mediating the sources, sinks, and flows of plastic pollution, especially in relation to local livelihoods and socio-

economic inequalities (e.g. inequitable access to adequate housing and associated municipal services like solid waste removal).

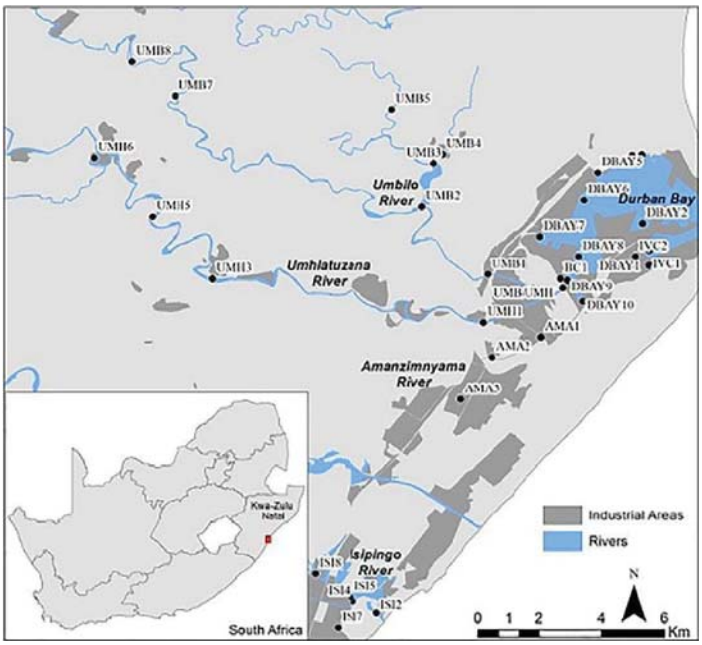


FIGURE 6: LOCATION OF THE STUDY SITE IN SOUTH AFRICA, THE DURBAN BAY AND ASSOCIATED RIVERS THAT DRAIN INTO IT. OUR STUDY WILL FOCUS ON THE UMBILO RIVER AND THE BACK OF PORT AS THEY RELATE TO THE DURBAN BAY (ADAPTED FROM VOGT ET AL. 2019)

Box 1: Qualitative vs quantitative models

Qualitative and quantitative SES models differ primarily in their approach and focus. Qualitative models aim to capture the complexity of human-environment interactions through narratives, conceptual frameworks, or diagrams, emphasising relationships, feedback loops, and uncertainties in a descriptive manner. They are particularly useful for exploring new ideas, understanding complex dynamics, and facilitating stakeholder engagement. Quantitative models, on the other hand, rely on numerical data and mathematical equations to simulate system behaviour, allowing for precise predictions and scenario analysis.

The model parameters differ in how they represent system components and interactions. Qualitative parameters are often descriptive, capturing non-numerical aspects such as stakeholder perspectives, observations, institutional rules, or social norms. These parameters are typically expressed in terms of categories (such as drivers or impacts), relationships, or narrative descriptions, and are useful for exploring complex, context-specific dynamics. In contrast, quantitative parameters are numerical, representing measurable variables like population size, resource extraction rates, or economic outputs. These parameters allow for calculations and simulations, requiring data-driven inputs to predict system behaviours.

While quantitative models provide measurable outputs and are essential for detailed forecasts, qualitative models are better suited for capturing the richness of human values, behaviours, and institutional dynamics that may not be easily quantified.

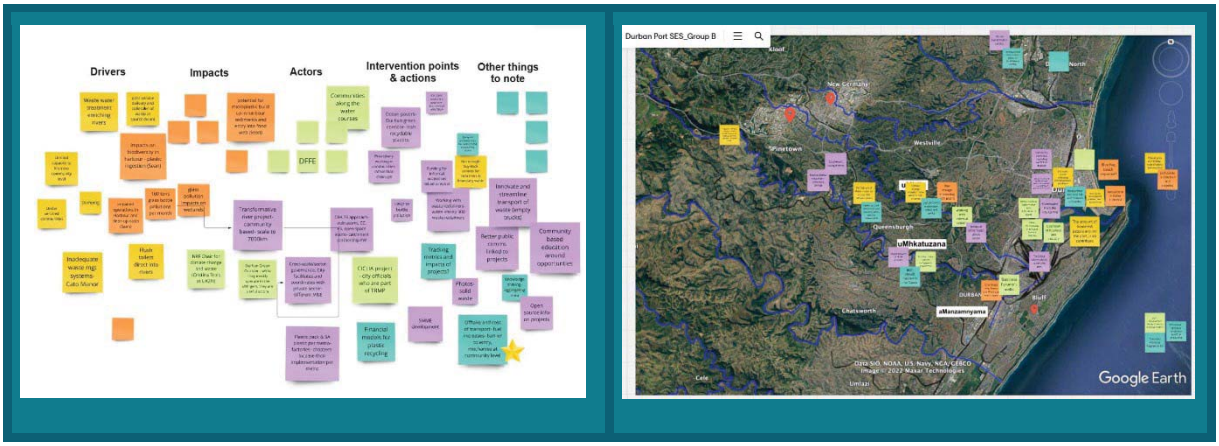
Collaborative approach

When the draft SES model was first developed, information on the dynamics underlying plastic pollution in the Durban Bay was gathered from scientific and grey literature, and a preliminary sense-check was performed within the project team. The initial draft model was created using the online mapping tool Kumu.io (https://kumu.io/) and acted as a "boundary object" (Mollinga 2010; Huang et al. 2018; Cuppen et al. 2021). For the purposes of this research, "boundary objects" are tools/approaches that can be used to build a common understanding among diverse stakeholders by facilitating communication about the multi-dimensional nature of plastic pollution. As such, the model lays out the intricate connections between various socio-ecological activities in the area, for which each stakeholder can identify challenges and opportunities relevant to them and their interest. The SES model as a boundary object is therefore a powerful tool to map both the overall complexity of the system, as well as specific areas of interest for actors in the system, all connected through feedback, impacts and drivers. The draft model was used to this effect in the stakeholder workshop (Box 2).

Box 2: Stakeholder engagement process

The stakeholder engagement process for the SES model aimed to explore plastic pollution in the Durban Port and gather insights from various sectors. It began with stakeholder mapping to identify key individuals and institutions across government, industry, business, and conservation sectors (see Appendix 1). An online workshop (via Zoom) was then organised to bring these stakeholders together for an interactive discussion (see Appendix 2 for participant list). The workshop's goals were to build a shared understanding of the port's socio-ecological dynamics, identify drivers and impacts of plastic pollution, and surface potential intervention points for collective action.

The workshop included an introductory "Polak game" to gauge participant sentiment about the port's future. This was followed by a presentation of the draft SES model, which had also been shared with participants beforehand. Participants were divided into breakout groups to discuss key drivers, impacts, and missing components of the model, as well as possible systemic intervention points to address challenges. Insights were captured using Miro boards (see images below), which facilitated visual engagement with maps and the draft model. The workshop concluded with a plenary discussion to reflect on key insights and next steps.



The final SES model presented in this report builds on the initial draft model, and incorporates stakeholder feedback from the workshop, as well as key insights that emerged from Deliverables 2 and 3 of the projects. Figure 7 shows the final conceptual SES model, where key additions or updates are highlighted with a bold outline, and relationships or drivers of change that were identified as important are depicted with a thicker line. A synthesis of the focal issues, drivers, impacts, and interventions is provided in the following sections.

2.4 SES Model

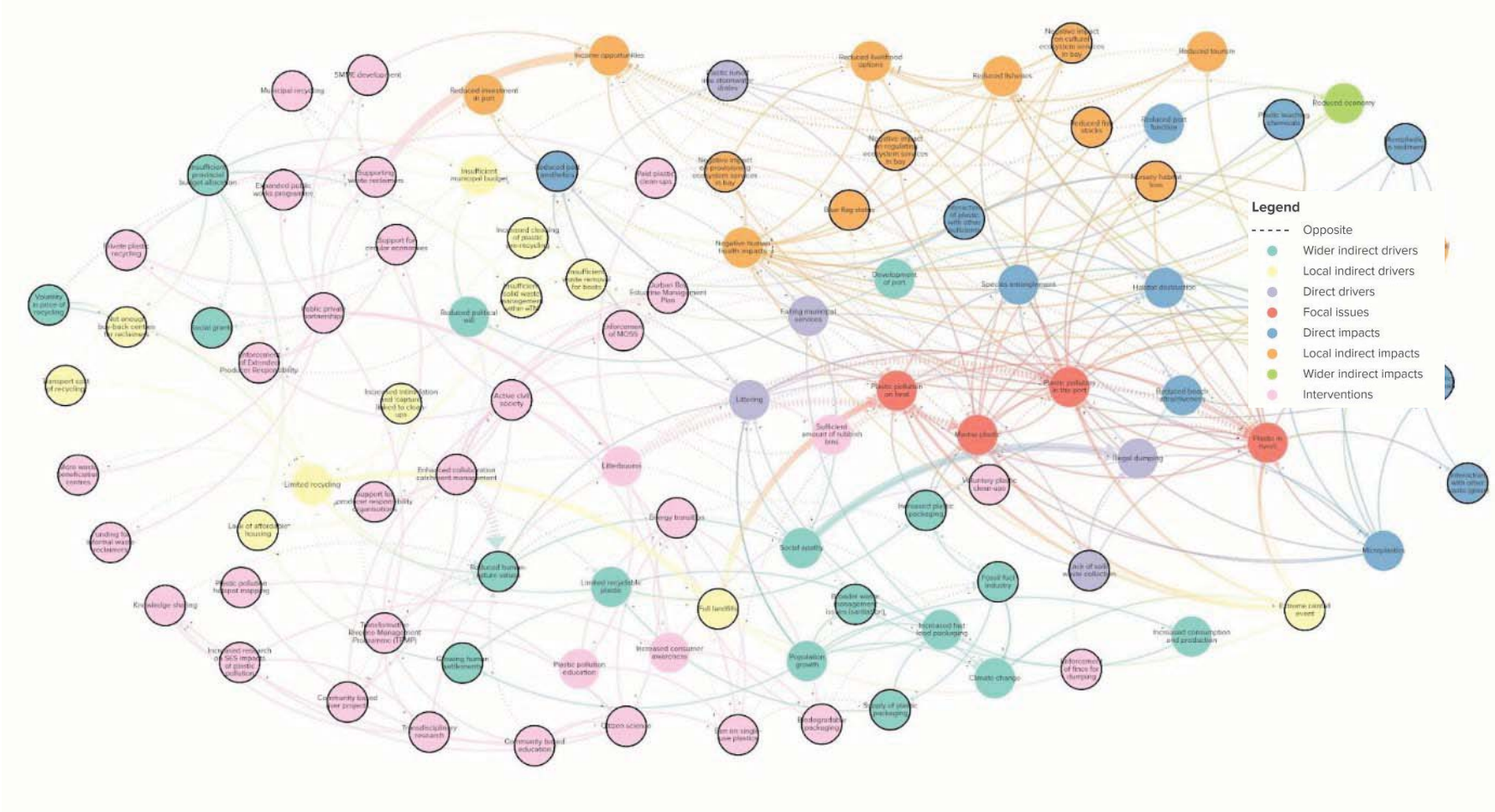


FIGURE 7: FINAL SES MODEL OF DURBAN BAY AND RIVER CATCHMENTS (ACCESS MODEL ONLINE AT THIS LINK)

2.5 Synthesis of SES Model

Plastic in the environment

The focal issue of the study was to gain a better understanding of plastic pollution in Durban Bay. This section of the report consolidates findings that emerged from the other work packages to provide an overarching view of plastic in the system (Figure 8).

FIGURE 8: PLASTIC POLLUTION IN DURBAN BAY

Common types of plastic in the environment

The project team conducted a standing stock survey between September 2023 and February 2024, covering the different habitat types found in the bay (Deliverable 3). This survey provided valuable insights into the types of waste entering the environment. Plastic waste was the dominant type collected, accounting for 90% of the total waste. The plastic items collected included plastic bags, chip and biscuit packets, plastic bottles, caps, lids, rings, wrappers,

buckets, containers, tubs, diapers, straws, coffee cups, and various sizes of plastic fragments (Figure 9). Among these, plastic bags and chip and biscuit packets were the most prevalent. Further analysis of sufficiently intact plastic items identified a set of only nine parent companies that were the main contributors to plastic waste in Durban Bay: Simba, Frimax, Imbazo Foods, Coca-Cola, Mondelez International Inc., Truda, Unilever, Tiger Brands, and Sun Foods. Chip packets from various companies were the most common intact plastic item, followed by sweets wrappers and drink bottles. This type of plastic pollution represents macroplastics pollution.

FIGURE 9: COMMON TYPES OF PLASTIC FOUND IN STANDING STOCK SURVEY

How plastic enters the environment

Understanding how plastic waste enters the environment is crucial for building a comprehensive view of plastic pollution in the SES. Sources of plastic are both land and sea based, and these include both macro- and microplastics. Other project work packages provided valuable insights into this process (Figure 4 & Table 2). The most direct pathway is littering, where individuals discard small amounts of plastic packaging after use, or through illegal dumping of larger quantities of waste. In addition to these direct methods, plastic waste also enters the environment unintentionally. The current centralised waste management system requires residents to place black rubbish bags in the street for collection. It is important to note that the Cleansing and Solid Waste Unit only collects waste that is properly bagged, not scattered. This system creates opportunities for bags to be damaged, inadvertently releasing plastic into the environment. As noted in Deliverable 2, rubbish bags are frequently torn open by animals such as monkeys, dogs, cats, and birds, searching for food. While waste reclaimers or “waste pickers” fulfil an important informal recycling service, they may also

damage bags and spill waste in the process. Erratic waste collection by the eThekwini Municipality exacerbates this issue, as bags remain on the streets for extended periods, increasing the chances of damage and plastic leakage.

How plastic moves through the environment

Once plastic waste enters the environment, it rarely stays where it was initially discarded and tends to move through the system. The two primary environmental forces driving this movement are water and wind (Figure 8). Plastic waste often enters river systems through direct dumping, wind transport, or surface water runoff. Stormwater drains often serve as conduits for waste, which enters the drains via wind (natural or generated by passing vehicles) and water runoff on roads. The stormwater drains feed into the river systems. This constant input of waste is moved by the rivers into the bay and eventually into the ocean. Additionally, the bay is subjected to direct plastic littering or waste dumping along the harbour edge, along with plastic waste that is transported directly into the harbour through surface runoff or wind. The movement of waste through the system is intensified by heavy rainfall events that increase runoff, causing pulses of large amounts of waste to enter the rivers and bay system. Alongside macroplastics, microplastics also travel through the environment, either from the breakdown of larger plastic items or from direct releases, such as microplastics from washing machine greywater that enters wastewater networks and river systems.

The standing stock survey and analysis of plastic waste in Durban Bay underscores the persistent presence of plastic in the environment. The findings highlight not only the dominance of plastic waste but also the complexity of its pathways into and through the environment. From direct littering and illegal dumping to unintentional releases due to damaged rubbish bags, plastic waste moves continuously through the system, primarily through water and wind, ultimately reaching marine environments. These insights emphasise the urgent need for comprehensive waste management strategies to address both the sources and movement of plastic pollution in this system.

Drivers

The SES model synthesis focused on drivers that are closely related to plastic waste entering the environment. These include:

- wider indirect drivers that are present at levels beyond the local system but influence local dynamics;
- local indirect drivers that occur within the system and do not directly contribute to plastic waste, but alter the level or rate of change of one or more direct drivers; and
- direct drivers which contribute directly to plastic waste entering the system.

During the synthesis process, a set of core themes emerged from an analysis of the drivers of plastic pollution at different levels. These core themes underpin the presence of plastic in the environment (Table 2 & Table 3).

TABLE 3. DESCRIPTION OF CORE THEMES THAT EMERGED FROM AN ANALYSIS OF WIDER INDIRECT DRIVERS OF PLASTIC POLLUTION IN DURBAN BAY

Core themes	Description
Human-nature values	This encompasses the interconnectedness of people and nature and how people value and connect to nature. Changes in ideological orientations, political influence, social norms and institutional arrangements result in people becoming more disconnected from the natural world, leading to reduced human-nature values. One way this deteriorated relationship manifests is in the form of increased production and use of plastic, inadequate discarding of plastics, and generally poor waste management. Essentially the plastic value chain reflects a disconnectedness to nature.
Political will	This encompasses the lack of willingness of political actors, industry actors, and key decision-makers to realise change and uphold the law. This arises from competing priorities, economic constraints, complexity of challenges, and external influences such as influential groups or global pressures that hinder progress.
Value of plastic	Plastic is perceived as a valuable resource that is affordable to produce and has a wide range of applications. However, plastic is also perceived as a cheaper and more convenient alternative to more sustainable products. This makes it both a desired product because of its affordability, but also an easily discarded product due to the same affordability.

Reduced human-nature values are enforced by the belief that people are separated from the environment, which is seen as an unlimited resource to provide people with food and other materials. In the same narrative, the environment offers a seemingly unlimited waste removal service. **Reduced-human nature values and a disconnection from nature allows people to accept the environment as a place to dispose of waste.** The persistent presence of plastic waste in the environment has been normalised, which leads to a lack of recognition of the problem and reinforces reduced human-nature values. People's perception of nature can contribute to social apathy, especially regarding environmental issues, reducing their engagement in social-environmental activities or interactions.

In South Africa, reduced political will stems from short-term election-driven goals, alongside the country facing multiple urgent issues such as economic instability, unemployment, poverty and service delivery challenges. Political will is also undermined by corruption and governance issues that lead to reduced accountability and ineffective implementation of policies, causing delays or failures in addressing critical issues. These combined factors triggered public distrust in government, which further diminishes political will and leads to

the prioritization of quick fixes over meaningful reforms to maintain public support. This is evident in the waste management system within Durban Bay. Deliverable 2 highlights the belief that waste management is the responsibility of government. **Lack of political will yet reliance on government for waste management creates a problematic intersection that contributes to waste management challenges in Durban Bay.** Similarly, lack of industry will and responsibility is primarily driven by the profit motive, and no real consequences for the continued production and use of plastic.

The third key theme that emerged from an analysis of the drivers is the value of plastic. Plastic plays a significant role in people's lives due to its versatility, affordability, and wide range of uses across various sectors. Plastic has advanced many industries such as food preservation and medical safety and hygiene. It is also used in various industries, including construction, transportation, and electronics. As a relatively inexpensive material, plastic allows for the production of cost-effective goods, from food packaging to consumer electronics, making these items more accessible to a broader range of people. **The wide application and affordability of plastic contributes to increasing consumption and lower perceived value of plastic goods, which tend to be discarded without much thought.** This is especially evident in single-use plastic items that are considered to have little to no value but are often a more affordable and convenient alternative to reusable and recyclable plastic or other sustainable materials.

The core themes outlined above influence the local system but are shaped by regional and global trends and perceptions. They underpin the presence of plastic in Durban Bay and connect to various levels of drivers (Figure 10 & Appendix 3).

Wider indirect drivers

The development of the SES model in collaboration with the stakeholders revealed a number of wider indirect drivers that do not directly lead to plastic entering the system but influence local dynamics in such a way as to contribute to the plastic pollution problem.

Overall, the increasing cost of plastic waste management is a challenge due to increasing consumption, the perceived value of plastic waste, and the volatility of recycling prices. The increasing cost combined with limited budget allocations for waste management means that the current system is plagued by insufficient waste disposal and management solutions. This leads to full landfills without adequate funding to create new landfills, and limited recycling facilities to minimise the need for additional landfills. Recycling capabilities are not only limited by the available facilities but also by the limited recyclable plastic that is produced due to:

- the acceptance and affordability of single-use alternatives;
- the volatility in prices for recycled goods that deter investment in recycling facilities; and

- the increasing need to pre-clean recycling due to contact with other chemicals and waste in the system, which increases processing costs.

Local indirect and direct drivers

The results of the model development point towards governance issues at the local level (see Table 2). Because of some of the wider indirect drivers outlined above, eThekwini Metropolitan Municipality is not able to provide sufficient waste disposal and management solutions, leaving some residents - especially in informal areas - with limited to no options for disposing waste. This leads to littering and illegal dumping. Other residents experience erratic waste removal, which increases opportunities for waste to enter the natural environment inadvertently through wind and runoff.

The constrained municipal funding landscape also means that there is limited capacity to improve waste management and remove waste that has already entered the environment. This situation is exacerbated by concerns about mismanagement and corruption within the municipality, further eroding available funding and political will. This is evident by the intimidation and capture of clean-up initiatives, which also contributes to increasing social apathy. The persistent presence of plastic waste in the environment also normalises the situation and reinforces behaviours such as littering and dumping of waste, further eroding human-nature values. **An important insight that emerged from the drivers is that the majority of the drivers that contribute to plastic waste entering the system is also contributes to waste remaining in the system.**

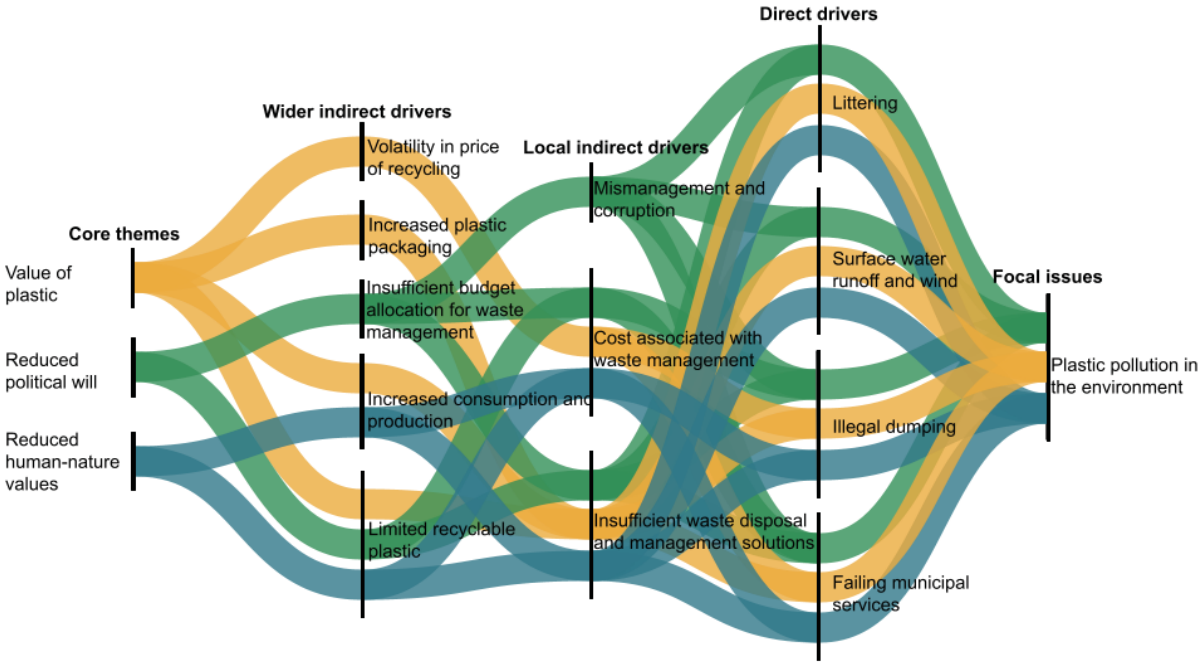


FIGURE 10: SYNTHESISED DRIVERS OF PLASTIC POLLUTION IN DURBAN BAY. THE LINES CONNECTING THE DIFFERENT DRIVERS REPRESENT A QUALITATIVE INTERPRETATION OF LINKAGES BETWEEN DRIVERS. THEY ARE NOT BASED ON QUANTITATIVE DATA

Impacts

The synthesis approach focused on impacts that are closely related to plastic waste in the environment. Similar to the drivers, these include:

- direct impacts that can be observed in the environment due to the presence of plastic waste;
- local indirect impacts which are caused by direct impacts and tend to be more widespread in the system; and
- wider indirect impacts that emerge at levels beyond the system due to both the direct and local indirect impacts.

Direct impacts

The most obvious direct impact of plastic pollution is the visibility of plastic in the environment that reduces the aesthetic appeal of the natural environment (Figure 11 & Appendix 4). Durban Bay is a well-known tourist area that relies on the attractiveness of the natural environment, in particular the beaches and ocean. Visible pollution of the environment can reduce the number of tourists visiting the area, negatively impacting the tourism industry. Tourism is an important sector for Durban, providing important livelihood opportunities for the communities and support for the local economy.

Plastic pollution can also cause damage to important infrastructure in the system, such as blocking stormwater drains, and reducing the efficient functioning of the port. This can lead to flooding and additional costs to deal with the fall-out of the waste accumulation. Especially in the context of climate change, with an increased frequency and severity of extreme rainfall, flood damage is a key concern for the Durban area. Plastic waste blocking stormwater drains does not only increase costs associated with flood damage but can lead to injury and death of residents caught up in the flooding.

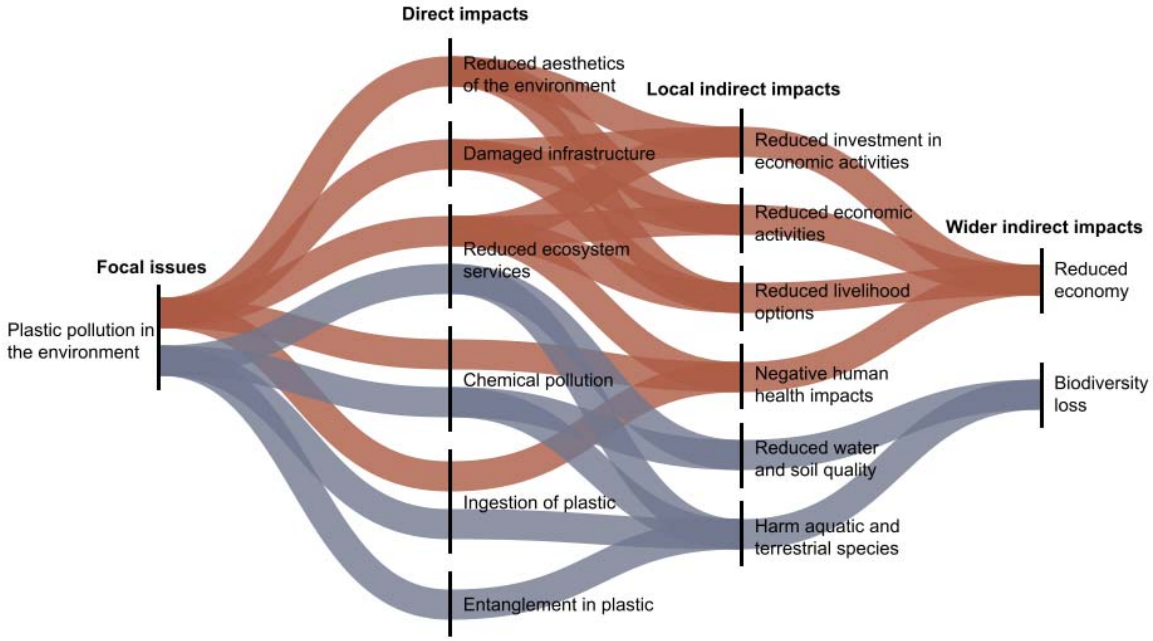


FIGURE 11: SYNTHESISED IMPACTS OF PLASTIC POLLUTION IN DURBAN BAY. THE LINES CONNECTING THE DIFFERENT IMPACTS REPRESENT A QUALITATIVE INTERPRETATION OF LINKAGES BETWEEN IMPACTS. THEY ARE NOT BASED ON QUANTITATIVE DATA

Plastic waste can impair the function of ecosystem services that provide essential benefits to humans and maintain the health of natural systems. This includes cultural services that connect people and nature through religious, cultural, and recreational practices; provisioning services that provide valuable natural resources such as food and building materials; and regulating services such as water filtration that moderate and control ecosystem processes. All of these ecosystem services are negatively impacted by plastic pollution, often disproportionately affecting marginalized communities that rely on natural environments to meet certain basic needs.

One especially problematic effect of plastic in the environment is that the breakdown of plastic releases toxins and chemicals, which degrade water and soil quality. Poor water and soil quality is harmful to human health, several industries such as agriculture and tourism, and the health of ecosystems more broadly. Furthermore, aquatic and terrestrial animals can become entangled in macroplastics that are present in the environment, leading to injury and death. Similarly, the presence of microplastic in the environment, particularly in aquatic environments, also poses a risk for various species. Ingestion of microplastics can cause physical harm to species and impact their ability to absorb nutrients, which impairs their ability to survive and reproduce. Microplastics can also accumulate in the tissues of animals, including fish, creating a toxic build up over time. This will negatively impact the fishing industry in Durban Bay, as the bio-accumulation of microplastics can reduce fish stocks and poses a health risk to humans that consume the fish.

Local indirect impacts

Overall, the impacts of plastic pollution are widespread in the system. Several important industries in Durban Bay are affected by plastic pollution, negatively impacting livelihood opportunities of people connected to these industries, reducing the appetite for investment in these industries, and reducing economic activities in the region. In addition, plastic pollution in the area poses a threat to human health, as well as the health of local ecosystems by degrading water and soil quality, and harming aquatic and terrestrial species.

Wider indirect impacts

Due to the damage done to local communities and industries tied to the port and the greater Durban Bay environment, plastic pollution negatively affects livelihoods, well-being, and therefore the economy of the region and South Africa as a whole. Furthermore, plastic pollution negatively impacts the ecosystems in the area in a number of different ways, leading to species declines and reducing biodiversity, which is a global concern.

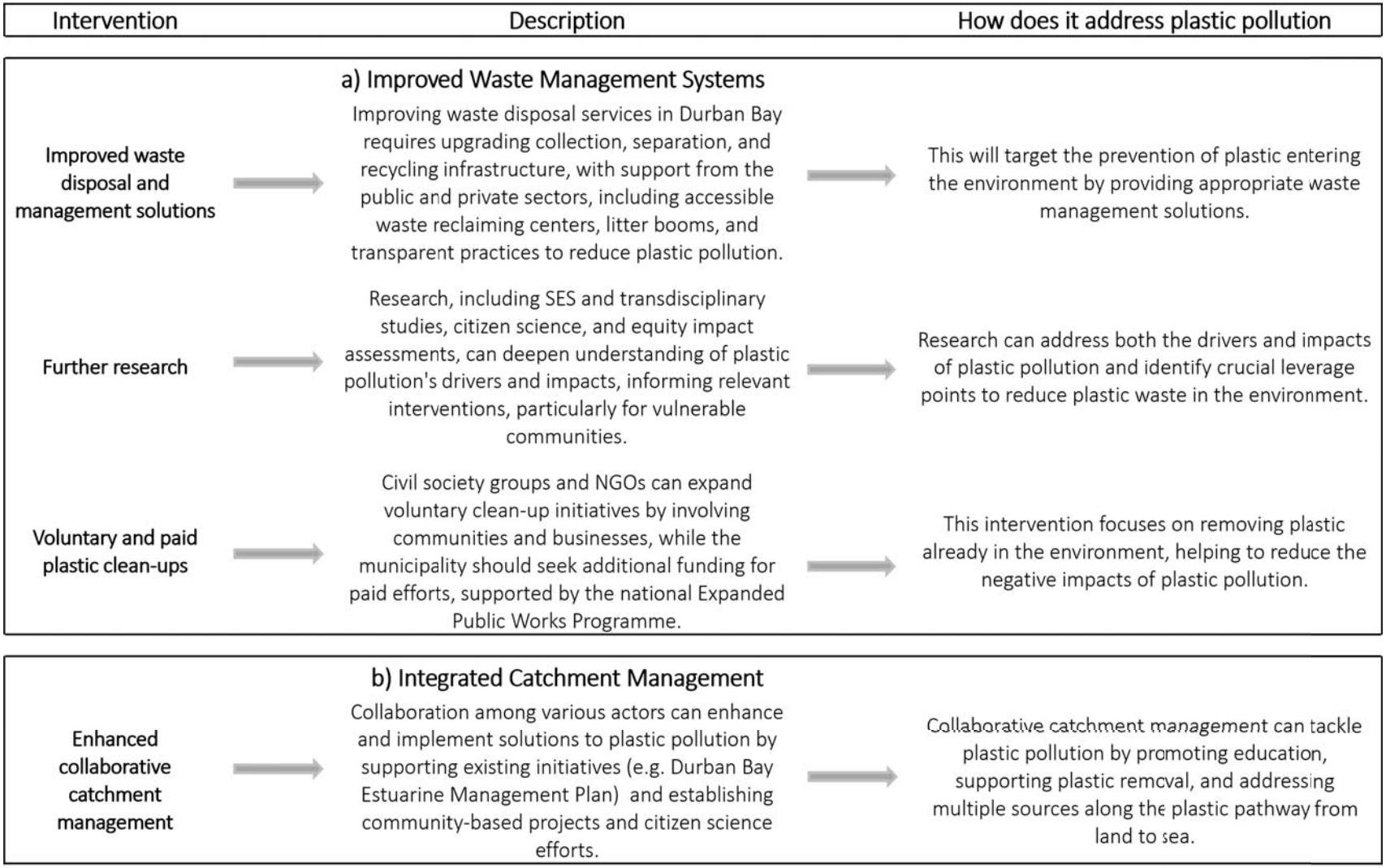
Several of the impacts may also reinforce the drivers of plastic pollution. A reduced economy places additional strain on provincial and municipal budgets that are already struggling to maintain waste management services. Degraded ecosystems and biodiversity loss can further erode human-nature values. **The reinforcement of drivers by negative impacts at different scales will only intensify the plastic pollution challenge**.

2.6 Interventions and Recommendations

The SES model provides an overview of the diversity of drivers that contribute to plastic pollution in Durban Bay, as well as the widespread impacts. This highlights the complexity of plastic pollution, and underscores that the problem cannot be addressed by just focusing on the removal of plastic waste from the environment.

Figure 12 provides a summary of potential interventions based on the SES model and outlines how these would address the plastic problem, not only within Durban Bay but the wider catchment. These interventions could help unlock mutual synergies in the system, addressing different drivers and impacts of plastic pollution at multiple levels.

FIGURE 12 DESCRIPTION OF THE INTERVENTIONS AND THE CONNECTION BETWEEN INTERVENTIONS, DRIVERS AND IMPACTS OF PLASTIC POLLUTION IN DURBAN BAY



Intervention	Description	How does it address plastic pollution
	c) Enforcement of Legislation and Policies	
Enforcement of legislation & policy	Governments should strengthen enforcement of existing laws, such as fines for illegal dumping and EPR regulations, while supporting policies like single-use plastic bans to reduce plastic pollution.	Effective legislation and policy, supported by enforcement and incentives, can reduce plastic pollution by addressing its drivers, holding producers accountable, and transforming plastic production and use.
	d) Support for Informal Waste Reclaimers	
Support for informal waste reclaimers	The municipality and private sector should provide easily accessible waste reclaiming centers for waste pickers and offer stable funding to support their services, improving efficiency and sustainability.	This intervention aims to reduce plastic waste in the environment and ease landfill pressure by supporting waste reclaimers with tangible incentives to collect and recycle more plastic.
	e) Education and Awareness Campaigns	
Education and knowledge sharing	Education on plastic pollution is essential for governments, industries, and consumers, focusing on policy awareness for industries, responsible waste practices for communities, and knowledge-sharing to ensure effective and context-appropriate solutions.	Education should focus on understanding the sources, movement, and impacts of plastic pollution, emphasizing its environmental, health, and social consequences to reduce plastic entering the environment.
	f) Encouraging Private Sector Involvement	
Private sector involvement	The private sector should be encouraged to invest in plastic reduction, recycling, and sustainable packaging, supported by civil society and government policies, while fostering partnerships with government, businesses, NGOs, and communities to implement effective solutions.	Encouraging the private sector to increase recyclable plastic production, adopt sustainable alternatives like biodegradable packaging, reduce single-use plastics, and provide innovative waste management solutions can address key drivers of plastic pollution.
Active civil society	Community engagement is essential for creating equitable strategies to address plastic pollution by ensuring that local voices are heard and their needs and priorities are reflected.	Civil society engagement can tackle plastic pollution by pressuring governments and businesses for change and implementing local initiatives like beach or river clean-ups.

Based on an analysis of the drivers, impacts, intervention points, and actors in the system, the following key focal areas are put forward to address plastic pollution in Durban Bay:

- **Improved Waste Management Systems**: Upgrading waste collection, separation, and recycling infrastructure is critical to prevent plastic from entering the environment. This includes expanding access to waste disposal services, especially in underserved areas, and deploying litter traps in key waterways to capture plastic waste before it reaches the bay.
- **Integrated Catchment Management**: The SES model clearly illustrates that addressing plastic pollution is not within the remit of just one department, agency, or sector. Catchment-wide cooperation is required across multiple actors to clarify responsibilities and mandates, and act upon or improve existing catchment management plans.
- **Enforcement of Legislation and Policies**: Strengthening the enforcement of existing legislation and policies, such as imposing penalties for illegal dumping, is vital. Ensuring compliance with the Extended Producer Responsibility (EPR) regulations and enforcing bans on single-use plastics can drastically reduce plastic waste generation.
- **Support for Informal Waste Reclaimers**: Strengthening support for informal waste pickers, who play a crucial role in waste collection and recycling, can significantly reduce the amount of plastic waste in the environment. Initiatives such as providing accessible reclaiming centres and offering financial support for their work would increase plastic recovery rates.
- **Education and Awareness Campaigns**: Raising awareness about the impacts of plastic pollution and promoting sustainable consumption habits can reduce the amount of waste that ends up in the environment or in landfills. Education efforts should target all stakeholders, from industry representatives to local communities, to encourage recycling, reusing, and reducing plastic consumption.
- **Encouraging Private Sector Involvement**: Encouraging the private sector to invest in sustainable packaging alternatives, plastic reduction initiatives, and recycling programs will drive innovation and increase the availability of more affordable sustainable materials. Incentives such as tax breaks or subsidies can motivate businesses to prioritise sustainability.

Table 4 elaborates on key actionable guidelines and recommendations as well as identifying key responsible role players based on the findings of the SES model.

TABLE 4: KEY GUIDELINES TO ADDRESS THE PLASTIC WASTE ISSUE IN DURBAN BAY AND ITS CATCHMENT AND ASSOCIATED RECOMMENDATIONS

a) Improved Waste Management Systems		
Recommendations	**Description**	**Key actors and institutions to engage**
Infrastructure Development for Waste Management	• Champion the development of a network of waste management infrastructure, including collaborating with public and private sectors to ensure clear mandates and responsibilities for all stakeholders involved.	eThekwini Municipality supported by private entities
Continuation of Focused Clean-Up Operations	• Support and reinforce the efforts of the Blue Port Team and Transnet crews, who currently undertake daily clean-up operations, ensuring they have the necessary resources and support to continue their work. • Prioritize clean-ups in areas identified as plastic retention hotspots to maximize the impact of clean-up efforts. • Reinvigoration of Boom Traps	WildTrust, Transnet
b) **Integrated Catchment Management**:		
Recommendations	• **Description**	**Key actors and institutions to engage**
Establish a Catchment Management Forum	• Provide a platform to discuss water-related issues, in this case plastic pollution, of common concern to	eThekwini Municipality, Transnet, Researchers, NGOs, local/provincial

	people living in the catchments and seeking ways of addressing these. • Committee should include a focused subcommittee dedicated to the restoration of Durban Bay and its catchment area to oversee plastic waste research and solutions.	government, private sector, and communities
Bi-Annual Monitoring of Plastic Waste to support management	• Conduct bi-annual monitoring of plastic waste and its ecological impacts within Durban Bay. • Use monitoring results to inform adaptive management strategies and waste management practices for the subcommittee, policymakers, and stakeholders.	Transnet, WildTrust, Academic institutions
c) Enforcement of Legislation and Policies		
Recommendations	• **Description**	**Key actors and institutions to engage**
Implement Extended Producer Responsibility (EPR)	• Encourage major companies, especially those contributing significantly to waste, to implement measures to mitigate their environmental impact. • Require producers to set collection and recycling targets in accordance with EPR regulations (e.g., the targets set for 2023-2027). • Advocate for collaboration with local initiatives, such as the Durban Bay Plastic Pollution Committee, to	Department of Forestry, Fisheries and the Environment (DFFE)

	develop effective Extended Producer Responsibility Schemes (EPRS).	
Promote Deposit-Return Schemes	• Support the implementation of deposit-return schemes for plastic products, encouraging consumers to return containers for a refund. • Learn from successful international examples where deposit-return systems have led to high collection rates.	eThekwini Municipality
Address Single-Use Plastics (SUPs)	• Develop and implement policies to phase out or tax single-use plastics, including plastic bags, chip packets, and polystyrene containers. • Explore sustainable alternatives to SUPs and drive manufacturers to adopt these measures.	DFFE
d) Support for Informal Waste Reclaimers		
Recommendations	**Description**	**Key actors and institutions to engage**
Integrate Waste Pickers into Formal Waste Management	• Develop clear policies and laws that formally include waste pickers in the waste management value chain. • Refer to the "Waste Picker Integration Guideline for South Africa" (DFFE, 2020) for detailed strategies on incorporating waste pickers into formal systems.	eThekwini Municipality

Adopt a Rights-Based Framework	• Integrate an embedded rights-based approach into strategies aimed at addressing plastic pollution in Durban Bay, aligning environmental sustainability with community rights.	All interested parties
Prioritize Community Rights	• Recognize and uphold the rights of individuals, particularly marginalized groups, to a healthy environment, access to clean water, and participation in decision-making processes.	All interested parties
e) **Education and Awareness Campaigns**:		
Recommendations	• **Description**	**Key actors and institutions to engage**
Implement Education Programs for Stakeholders	• Develop educational initiatives for both industry professionals and consumers to raise awareness about waste management and plastic pollution. • Design programs that target specific audiences, including businesses, local communities, and tourists, to ensure tailored messaging.	WildTrust, Academic institutions
Facilitate Inclusive Dialogue	• Organize workshops and forums that bring together diverse stakeholders, including government representatives, businesses, NGOs, researchers, and local communities.	Transnet

	• Create platforms for open dialogue to share perspectives, challenges, and solutions related to plastic pollution.	
Foster Partnerships for Collaboration	• Encourage partnerships between businesses, NGOs, government agencies, and South Africa's informal waste picker network. • Leverage the expertise and resources of these collaborative projects to enhance recycling efforts and address plastic pollution more effectively.	Transnet and WildTrust
f) Encouraging Private Sector Involvement		
Recommendations	**Description**	**Key actors and institutions to engage**
Foster Public-Private Partnerships	• Encourage collaboration between government and private sectors to enhance recycling infrastructure and capabilities. • Develop initiatives that ensure collected plastics are effectively processed and reintegrated into the production cycle.	All interested parties

3. Conclusion

Addressing plastic pollution in Durban Bay is a complex challenge that demands a comprehensive and coordinated response across multiple sectors and scales. **The findings of this report underscore the importance of viewing plastic pollution not just as an isolated environmental issue, but as a broader socio-ecological problem that affects urban resilience, public health, biodiversity, and local economies.** Tackling this issue requires both immediate interventions to manage the current levels of pollution, as well as long-term strategies to reduce plastic waste generation at the source.

The co-developed SES model of Durban Bay highlights key leverage points where targeted actions can create significant positive change. These include improving waste management infrastructure, fostering collaboration between local stakeholders, enforcing legislation and policies, supporting informal waste reclaimers, educating the public about more sustainable consumption habits, and encouraging private sector involvement in sustainability initiatives. The model also emphasises the importance of addressing the social dimensions of plastic pollution, such as public attitudes toward waste disposal, trust in government, the socio-economic inequalities that exist in waste management, and the need for community involvement in developing and implementing solutions.

By improving waste management systems, particularly in underserved communities, plastic waste can be intercepted before it enters the natural environment, thereby reducing its harmful impacts on ecosystems and communities. Supporting informal waste reclaimers, who are often on the frontlines of waste collection and recycling, can significantly increase plastic recovery rates, while providing economic benefits to marginalized groups. Furthermore, stronger legislation and policy enforcement will hold individuals and industries accountable for their contribution to plastic pollution.

Collaboration is essential for the success of these initiatives. The SES model points to the need for integrated catchment management that brings together government agencies, private enterprises, local communities, and NGOs. By working together, these stakeholders can align their efforts, share knowledge, and pool resources to create more effective and scalable solutions. Public-private partnerships, community-based clean-ups, and education campaigns will also play a crucial role in raising awareness and ensuring that local solutions are adapted to the unique context of Durban Bay. Education and awareness are foundational to achieving long-term behavioural change. Efforts to educate the public, industry, and government about the impacts of plastic pollution and the importance of sustainable practices will help shift societal norms and improve human-nature values.

The role of the private sector in addressing plastic pollution cannot be understated. Businesses are key drivers of plastic production and consumption, and they have the capacity to innovate in the areas of sustainable packaging, recycling technologies, and waste management solutions. Encouraging companies to adopt greener practices and holding them accountable

through policies like the EPR will ensure that the burden of waste management does not fall solely on the municipality and its citizens.

Ultimately, addressing plastic pollution in Durban Bay is not just about cleaning up the waste that currently exists, but about transforming the underlying systems that drive plastic production, consumption, and disposal. The SES model provides a roadmap for identifying and implementing interventions that will not only reduce plastic waste, but also enhance the social, economic, and ecological resilience of Durban Bay. By integrating scientific research, stakeholder input, and innovative policy and management strategies, this project offers a pathway toward a cleaner, more sustainable and just future for Durban Bay.

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APPENDIX 1: STAKEHOLDER MAPPING FOR DURBAN PORT

Stakeholder group	Name	Organisation
Government	Siraj Paruk	Transnet National Ports Authority
	Bonga Sitole	Transnet National Ports Authority
	Thandiwe Ntuli	Transnet National Ports Authority
	Nelson Mbatha	Transnet National Ports Authority
	Jo Douwes	Environmental Planning and Climate Protection Department,
	Nondumiso Dumakude	Department of Economic Development, Tourism and Environmental Affairs
	Chumisa Thegwa	EThekwini Municipality
	Richard Mngoma	EThekwini Municipality/ Water
	Marcus Mahadasen	EThekwini Municipality/ Water
	Melanie	EThekwini Municipality ward councillor
	Geoff Tooley	EThekwini Municipality
	Sean O'Donoghue (Manager)	Climate Change Adaptation Branch
	Ayanda Sikobi	eThekwini Marine cluster
Industrial/shipping		Durban Chamber of Commerce and Business
		Kenfield Supermarket
		Harcon Sandblasting
	Marshal Huriparsad	MEDITERRANEAN SHIPPING COMPANY

	Preston Reddy	MEDITERRANEAN SHIPPING COMPANY
	Preola Adam	Unilever
	Bonginkosi Gumbi	Imperial logistics
	Lualan Reddy	
	Thumela Mkhize	Sandock Austral Shipyards
	Andrew Akkers	Sandock Austral Shipyards
Boat cruises/recreational/tourism	Mrs Zandi Cele	Maritime Museum
		ISLE OF CAPRI PLEASURE CRUISES. Durban
		TAG Diving Services
	Josh Thompson	Umhlanga ocean charters
	Helga Du Preez	SODURBA
	Suzette	SODURBA
	Melissa Lee	SODURBA
Recreational Clubs		Point Yacht Club
		Royal Natal Yacht Club
		Bluff Yacht Club
		Durban rowing club
Restaurants		9th Avenue Waterside
		Julios restaurant
Conservation/other	Cameron Service / George van der Schyff	The Litterboom Project
	Paolo Candotti (Take back our Rivers project)	Kloof Conservancy
		Duzi uMngeni Conservation Trust (DUCT).
	Janet Simpkins	Adopt a river

	Fonda Lewis	Umgeni cost of plastic surveyor
	Msephi Mtshali	Port waste collector and recycler
	Lindsay Hopkins	Waste action tribe
	Logan Moodley	SDCEA
	Thomas Bongani Hart	Expeditionists
Project team	Catherine Sutherland	UKZN
	Elzette Henshilwood	CST
	Jean Harris	Wildtrust
	Maike Hamman	CST
	Nadia Sitas	CST
	Natasha Rambaram	Wildtrust
	Patrick Martel	UKZN
	Roelie Kloopers	Wildtrust
	Steven Weerts	CSIR
	Vineshree shadmorgan	Wildtrust
	Wendy Dunn	Wildtrust/ On site supervisor
	Zuzile Hlatswayo	Wildtrust
	Fanele Magwaza	UKZN
	Masha Ramsamooch	Wildtrust

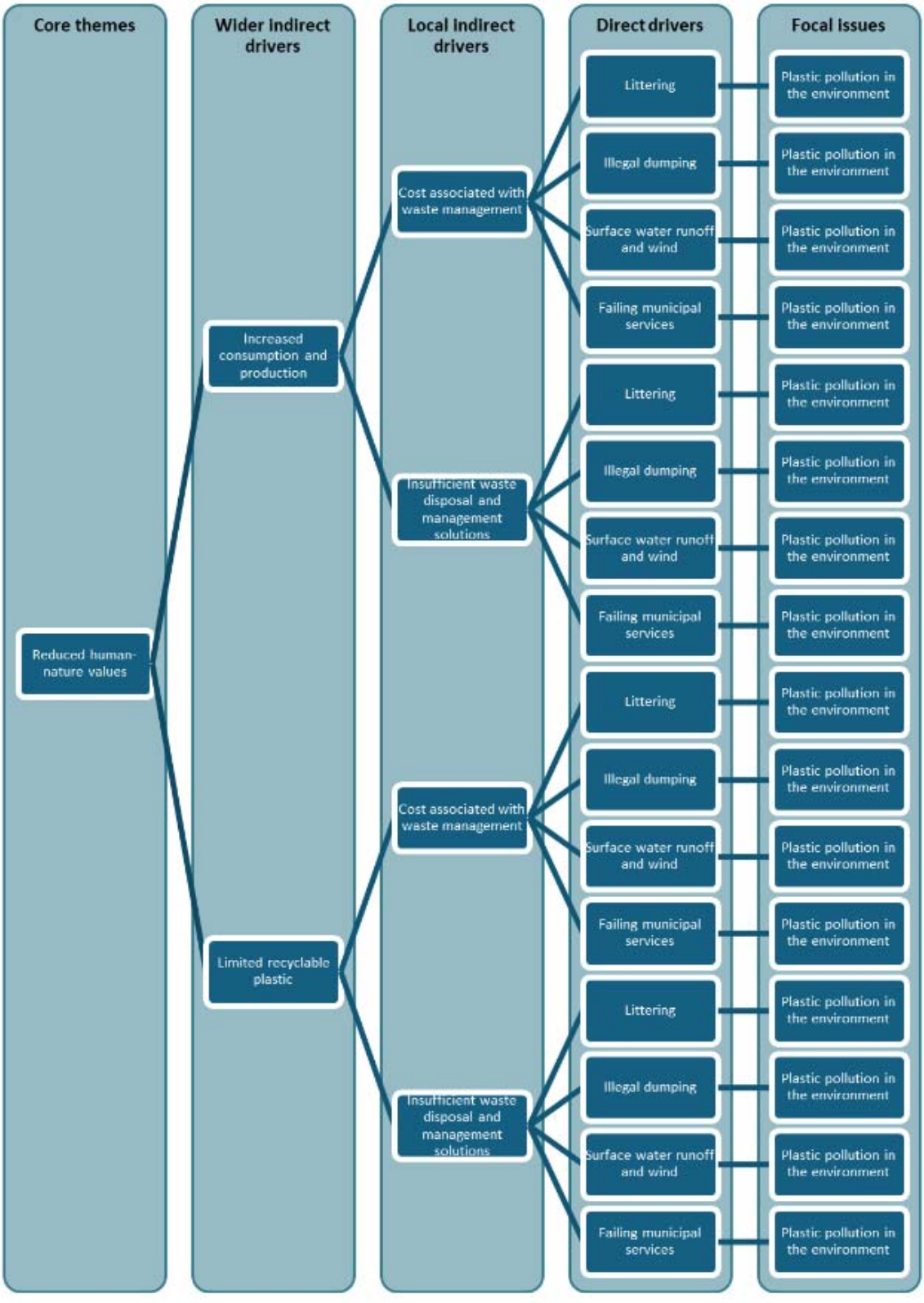
APPENDIX 2: STAKEHOLDER WORKSHOP PARTICIPANT LIST

Name	**Organisation**
Andrew Akkers	Sandock Austral Shipyards
Ayanda Sikobi	eThekwini Maritime Cluster
Cameron Service	The Litterboom Project
Catherine Sutherland	UKZN
Elzette Henshilwood	Centre for Sustainability Transitions, Stellenbosch University
Fanele Magwaza	UKZN
Geoff Tooley	Durban eThekwini Municipality
Helga du Preez	Sodurba Tourism
Janet Simpkins	Adopt a River
Jean Harris	WILDOCEANS
Lindani Mtshali	WILDOCEANS
Logan Moodley	Durban resident/SDCEA
Maike Hamann	Centre for Sustainability Transitions, Stellenbosch University
Masha Ramsamooch	WILDOCEANS
Msephi Mtshali	Waste collector and recycler
Nadia Sitas	Centre for Sustainability Transitions, Stellenbosch University
Nitish Singh	Sandock Austral Shipyards
Nondumiso Dumakude	Dept of Economic Affairs, Tourism & Environmental Affairs
Patrick Martel	UKZN
Sean O'Donoghue	eThekwini Climate Change Adaptation Branch
Siraj Paruk	Transnet
Thandiwe Ntuli	Transnet

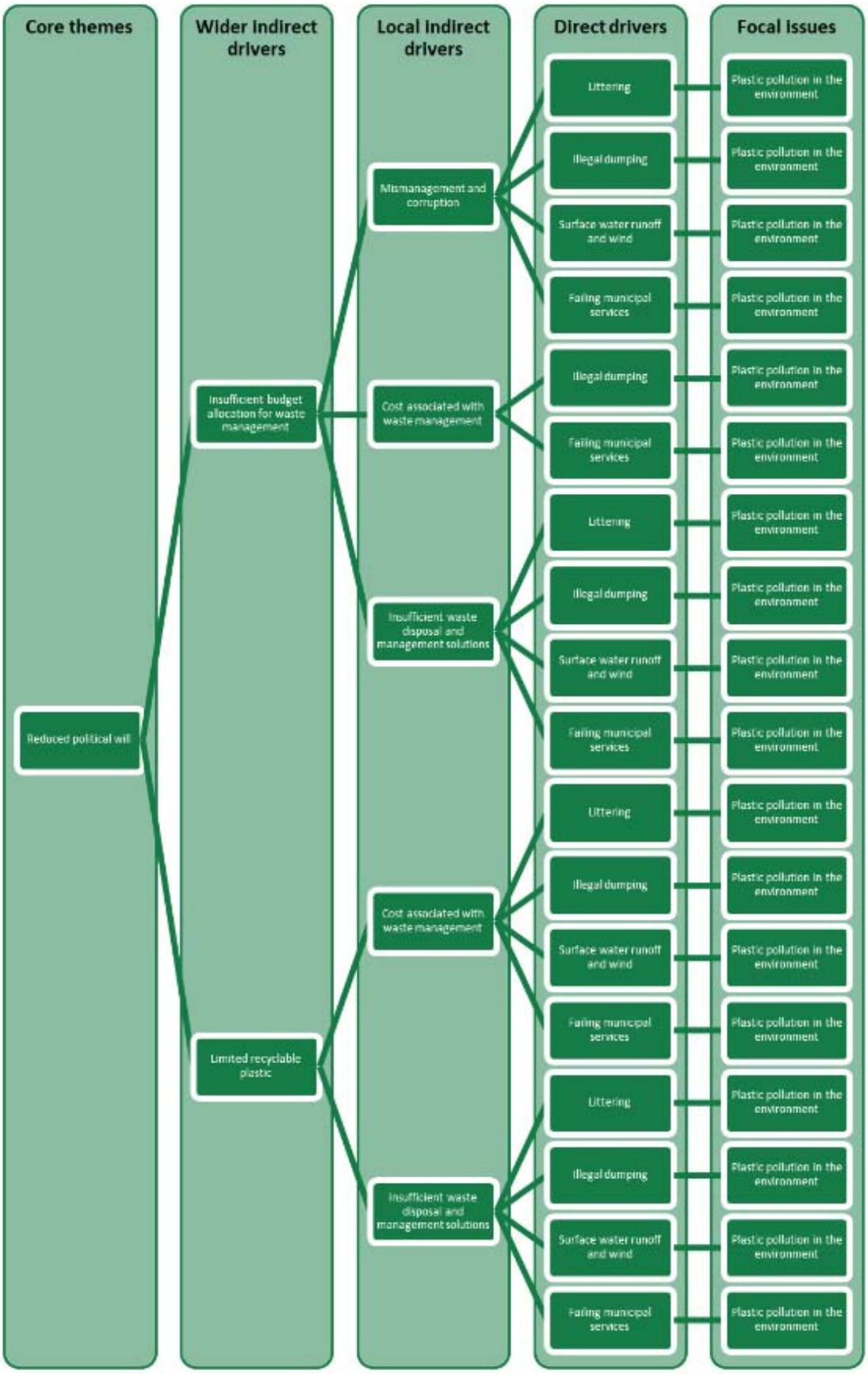
Thomas Bongani Hart	UKZN/Expeditionist
Vanashrie Gounder	eThekwini Municipality
Vineshree Shadamorgan	WILDOCEANS
Wendy Dunn	WILDOCEANS
Zandi Cele	African Vision Trust

APPENDIX 3: FLOW DIAGRAM OF DRIVERS OF PLASTIC IN DURBAN BAY

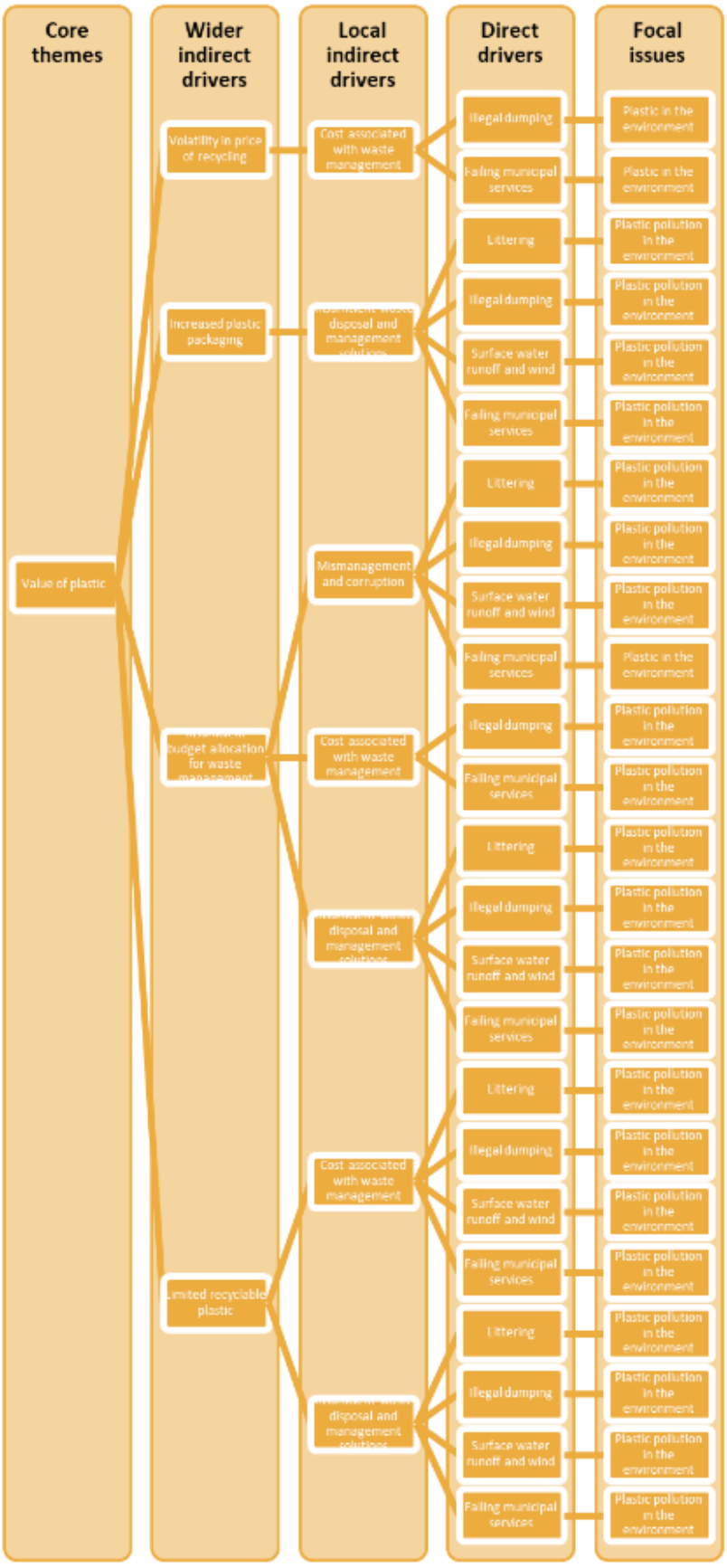
Core theme - Reduced human-nature values



Core theme - Reduced political will

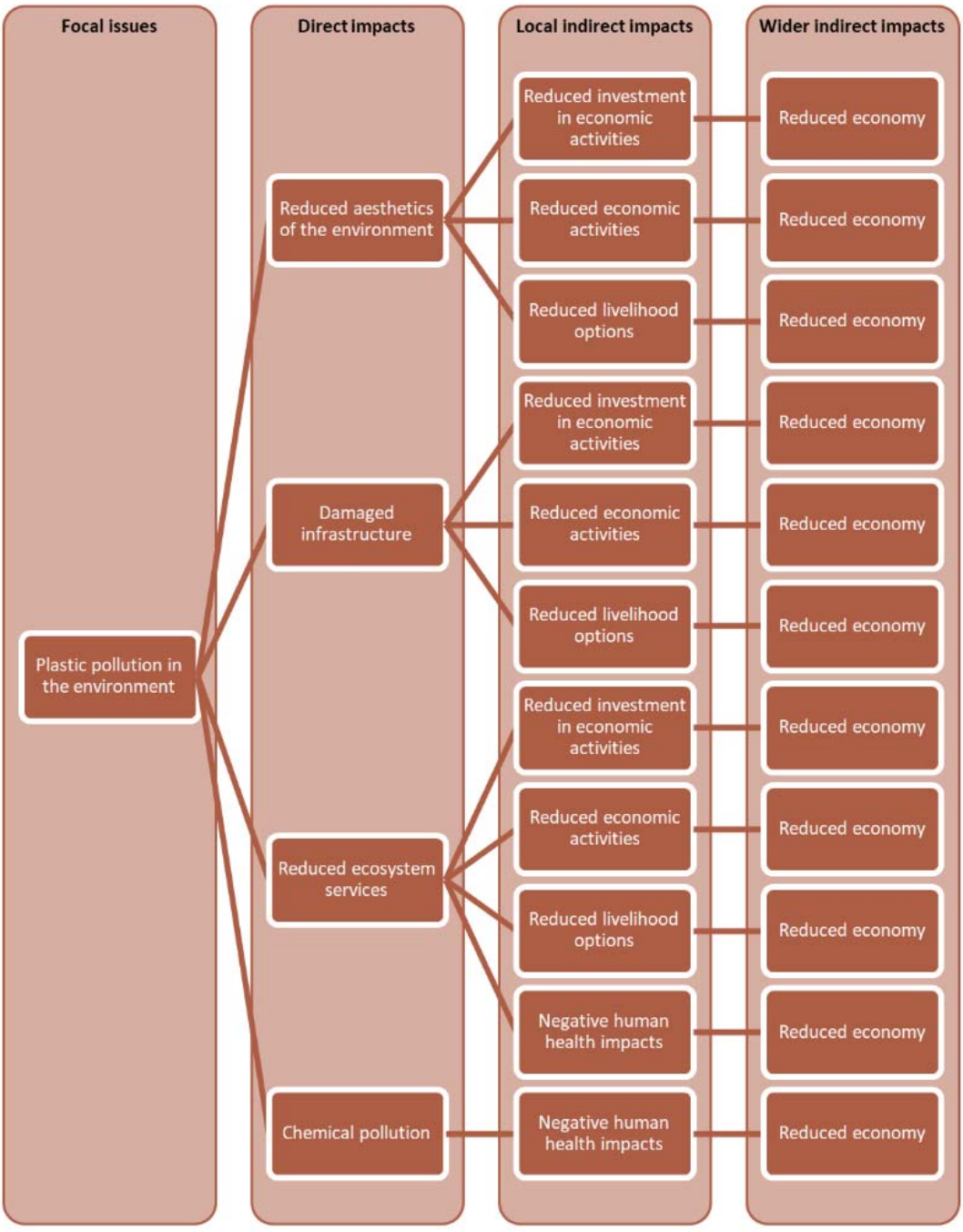


Core theme - Value of plastic



APPENDIX 4: FLOW DIAGRAM OF IMPACTS OF PLASTIC IN DURBAN BAY

Wider indirect impact - Reduced economy



Wider indirect impact - Biodiversity loss