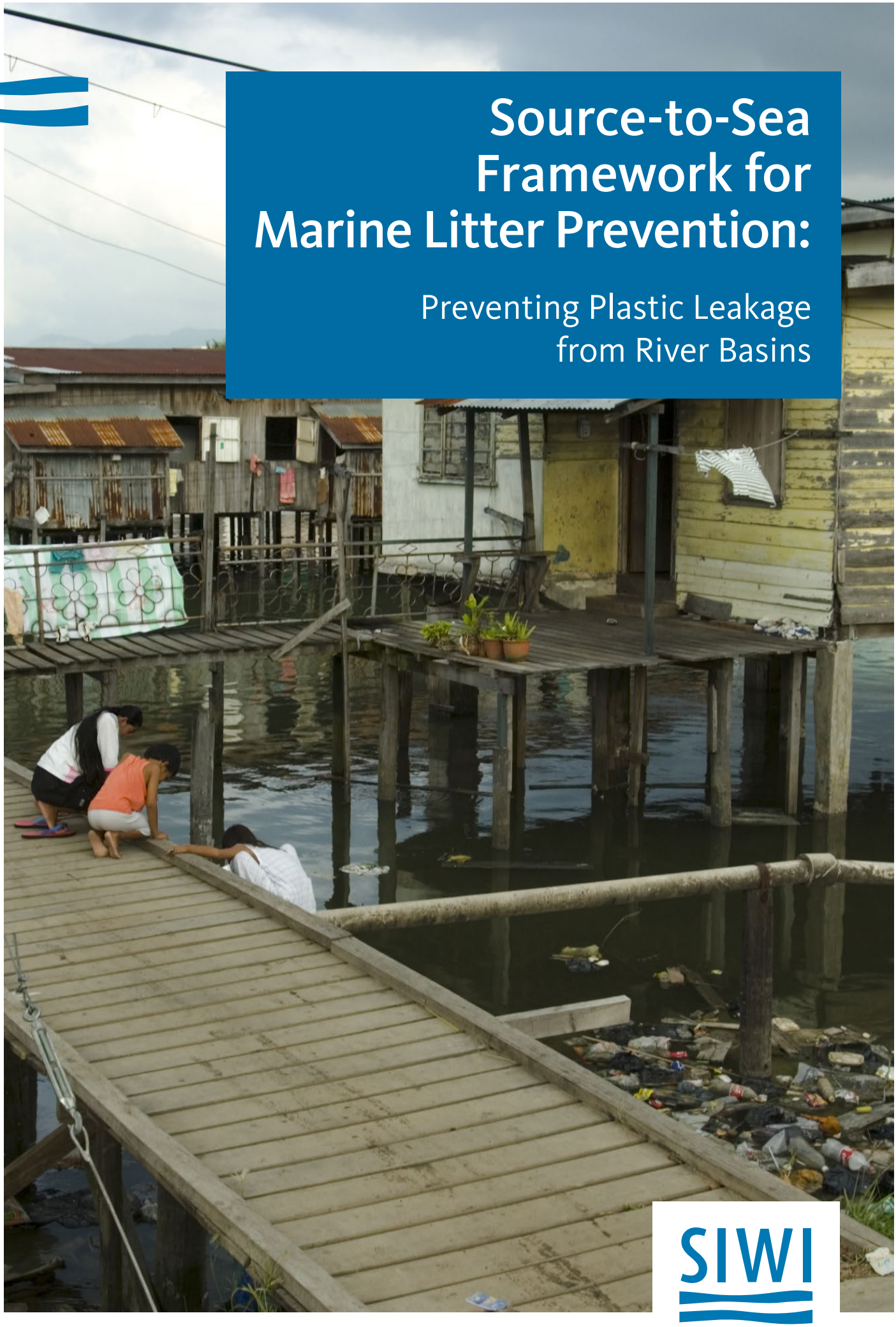
Source-to-Sea Framework for Marine Litter Prevention:

Preventing Plastic Leakage from River Basins



SIWI

Contents

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Figures

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Abbreviations

USD	United States Dollar
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
ISWA	International Solid Waste Association
UNEP	United Nations Environmental Programme
MAP	Mediterranean Action Plan
G20	Group of 20 (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, México, Russia, Saudi Arabia, South Africa, Korea, Turkey, the United Kingdom, United States and European Union)
WEEE	Waste from electric and electronic equipment
IWRM	Integrated Water Resource Management
RDF	Refuse Derived Fuel
EPR	Extended Producer Responsibility
SDG	Sustainable Development Goals

Executive Summary

This report presents a framework for preventing marine litter based on the source-to-sea conceptual framework presented in Granit et al., 2017 and the practitioners' guidance for implementing the source-to-sea approach in Mathews et al., 2019. Addressing issues from the holistic perspective of the source-to-sea system and strengthening coordination between sectors is central to the source-to-sea approach. The Source-to-Sea Framework for Marine Litter Prevention is intended to be useful when determining measures concerning governance, management, practices and behaviour which facilitate progress toward a reduction in the quantities of plastic entering the oceans. It can guide both the public and private sectors in addressing the issue of plastic waste in rivers and oceans.

Current approaches to the problem of marine litter often focus on individual segments of a source-to-sea system and/or on one sector. This makes them poorly suited for addressing all the root causes of plastic ending up in riverine and marine environments. Plastic waste tends to be managed by local authorities and communities in isolation, which can result in outcomes that may not be optimal for the entire source-to-sea system. Policies, procedures and regulations for different sectors are also developed in isolation, resulting in investments and management practices that maximize local benefits and are blind to their upstream and/or downstream impacts. This can result in benefits for one sector, or within one source-to-sea segment while having negative consequences on another. These consequences are often not adequately accounted for when the costs and benefits of local investments in managing plastic waste are being considered.

The Source-to-Sea Framework for Marine Litter Prevention combats this tendency by taking a holistic view of the sources of and solutions to the problem. It follows six steps that will:

- Characterize the sources, types, behaviour and impacts of plastics in riverine and marine environments;
- Identify who is impacted by plastic pollution, both directly and indirectly, who contributes to plastic leakage and who can provide solutions;
- Diagnose how waste is managed /mismanaged and how the current governance framework is or is not preventing plastic from entering the riverine and marine environments;
- Describe the changes needed to prevent plastic leakage, e.g. governance, waste management services, infrastructure, behaviour change, design, production and use of plastic goods, etc;
- Develop interventions to prevent plastic leakage, at local to global scales and identify financing mechanisms for these interventions; and

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- Monitor the outcomes of the interventions, identify key uncertainties and gaps in knowledge that need to be addressed, disseminate learning globally and manage for progressive development.

The Source-to-Sea Framework for Marine Litter Prevention highlights the central role of the river basin in shaping the interventions needed to prevent plastic leakage. It brings together upstream and downstream parties to build a common understanding of the issue of marine litter and feeds information about both sources and impacts of plastic pollution into the prioritization of the steps needed to address the issue. The Framework establishes coordination across sectors that each have a contribution to make in getting control of plastic waste while also addressing behaviour change from an individual scale to the global community through establishing enabling conditions that facilitate this change.

By providing an integrated understanding of pollution sources and pathways throughout the source-to-sea system thus linking the sources of the problem with the areas and people being impacted, the Framework expands the actions to be taken and the parties responsible beyond the local waste managers. By considering the losses in economic and ecological value across the entire source-to-sea system, it helps build a business case for making systemic changes: using financial incentives as well as regulations to address core physical, regulatory and reputational risks. The Source-to-Sea Framework for Marine Litter Prevention promotes a shared understanding among all actors within a river basin, creating a common objective that supports cooperation between actors when taking action on the right scale and location within the source-to-sea continuum.

Introduction

The issue of plastic in the oceans is increasingly receiving global attention, which raises the question of how we can address and reduce the amount of plastic reaching the marine environment. The rapidly increasing use of plastics and its subsequent release into the environment demands urgent action on a massive scale to combat the fast-growing levels of plastic pollution worldwide. While present concerns are focused on cleaning up the oceans, preventing plastic from entering the oceans in the first place requires addressing the sources of plastic. Rivers are conveyors of large quantities of plastic litter to the ocean. Keeping plastics from entering waterways and subsequently the oceans is likely to be far less costly than removing plastics once they are there. Developing an approach that explicitly links land, freshwater and marine systems, from source to sea, could make a significant contribution to the prevention of marine litter. Furthermore, controlling plastic waste requires coordination between different sectors, something that is often not well established.

This report presents a Source-to-Sea Framework for Marine Litter Prevention based on the source-to-sea conceptual framework presented in (Granit, et al., 2017) and the practitioners' guidance for implementing the source-to-sea approach in (Mathews et al., 2019). Addressing issues from the holistic perspective of the source-to-sea system and strengthening coordination between sectors is central to the source-to-sea approach. The Framework is intended to be useful when determining measures with regards to governance, management, practices and behaviour that can advance progress toward a reduction in the quantity of plastic entering the oceans. It can guide both the public and private sector in how to address the issue of plastic waste in rivers and oceans.

Terminology for talking about the issue of plastic in the marine environment is not yet sharply defined. In broad terms *marine litter* (or debris) describes all types of pollution of the seas containing solid, non-dissolved items and is commonly used as a reference term to the overarching problem. Other terms, such as *plastic leakage* or *land-based sources* specify the type of pollution but are not as common and easily understood as marine litter. In this report, the term *marine litter* is used to refer to the overall problem of waste of any size entering rivers and oceans. As this report is focused on land-based sources of marine litter and of these plastics are a main contaminant, the report uses the term *land-based sources* to indicate the exclusion of marine-derived plastic waste e.g. from fishing, shipping and cruise liner activities. The terms *plastic pollution* and *plastic leakage* are used to specify the particular relevance of plastics.

The report does not address how to remove plastic waste that has already entered the ocean environment. Some specific land-based sources such as abrasions from textiles or tyres are described only in broad terms. The Source-to-Sea Framework and guidance presented here are directed toward preventing plastic leakage to rivers and the oceans and therefore focus on the role of activities within river basins in contributing to or preventing plastic waste from entering the riverine and marine environments.

The scale of the problem

Versatility, low density, durability and comparatively low cost all make plastics ideal materials for use in diverse production chains for a wide range of manufacturing and packaging applications. Due to its practicality, plastics are rapidly become one of the most used materials in the manufacturing and packaging of goods. Their popularity and demand are reflected in the rapid annual increase in the amount of primary plastics produced over the last few decades. It is estimated that production increased from 335 in 2016 to 348 million tonnes in 2017 (PlasticsEurope, 2019). All projections for conventional growth indicate that our use of plastics will continue to increase.

Plastic waste is produced by nearly every sector of our economies. Households dispose of products and packaging they no longer use; businesses dispose of both packaging and obsolete or returned products. Industry produces plastic waste in their pre-processing stage as well in their production by-products and residues. Plastics are added to improve the quality or other aspects of many products, varying from cosmetics to paint. Agriculture uses large amounts of plastic for greenhouses and crop protection and to transport and store food or fertilizer. Hospitals consume vast quantities of single-use medical items, such as syringes, which for hygienic reasons are packaged in plastic. Construction also uses plastics for packaging purposes and as building material for wiring or piping, as an additive as well as in many other applications. During construction and when houses are demolished, such plastics turn into waste.

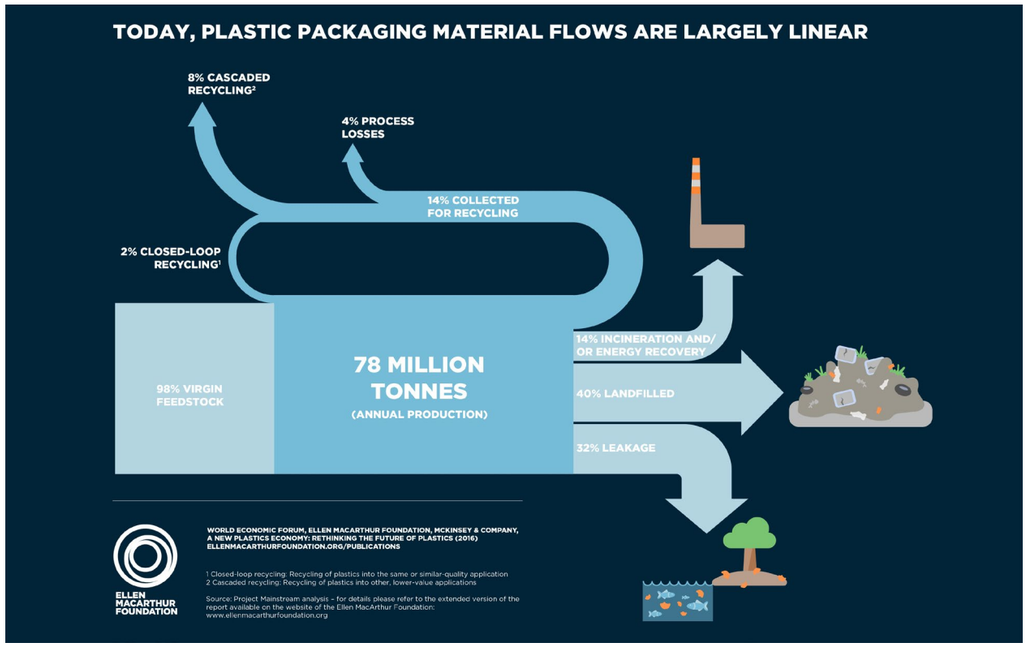

Figure 1: Global flows of plastic packaging in 2013 (World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, 2016).

Figure 1 shows estimated quantities worldwide of plastic packaging and its fate once used. Plastic packaging represents about 39.9 per cent of global plastic use (PlasticsEurope, 2019). As plastic production increases, a contributing factor to the scale of the marine litter problem is the limited application of a circular approach to plastic goods. Out of the 78 million tons of plastic packaging produced annually worldwide today, 14 per cent is recycled, but only two per cent enters closed loop recycling, i.e. is recycled to a product of same or similar quality application (World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, 2016). Most of the collected waste is then either treated (e.g. incineration) or directly disposed of at landfills. Leakage can occur at all stages of the production and consumption system, particularly when systems for capturing the waste are not adequately established and functioning. It is estimated that about 32 per cent of an annual total of 78 million tonnes of plastic packaging worldwide leaks uncontrolled into the environment. This and other sources of plastics are entering the riverine and marine environments along different pathways as shown in Figure 2.

Surveys show that plastic waste makes up 60–90 per cent (Derraik, 2002) of marine litter and an estimated 4 to 12 million tonnes of plastic waste end up in the oceans, annually (Jambeck, et al., 2015). The actual quantification of land-based sources of marine litter is still an ongoing research process.

Inadequate waste management on land, lack of awareness, indifferent behaviour in the absence of adequate disposal systems – resulting in plastic being dumped or abandoned wherever it is convenient – all contribute to the uncontrolled release of plastics into the environment. When plastic waste is not properly managed on land, much of it enters waterways and is carried to the oceans, where it remains for long periods of time. The "Stemming the Tide" report from Ocean Conservancy (Ocean Conservancy, McKinsey Center for Business and Environment, 2015) estimates that an additional five billion USD per annum would be needed to increase waste collection services to 80 per cent coverage in the five main contributing countries. Delivery of plastic waste to the oceans can also be amplified by extreme weather events, e.g., floods, typhoons, tsunamis, etc.

The impacts of plastic litter are wide ranging, affecting both riverine and marine environments and are felt not only locally and regionally but even on a global scale. Businesses dependent upon clean water and a litter-free environment such as fisheries, tourism and food and beverage companies, may experience economic losses. Infrastructure maintenance costs may be higher due to the accumulation of plastic litter while disaster risk may rise due to increased flooding from plastic waste congesting waterways. While not yet comprehensively investigated, human health might also be affected by toxic chemicals entering water and the food chain as well as from an increase in waterborne diseases. Plastic pollution degrades ecosystems and affects riverine and marine species in myriad ways. It also diminishes human quality of life.

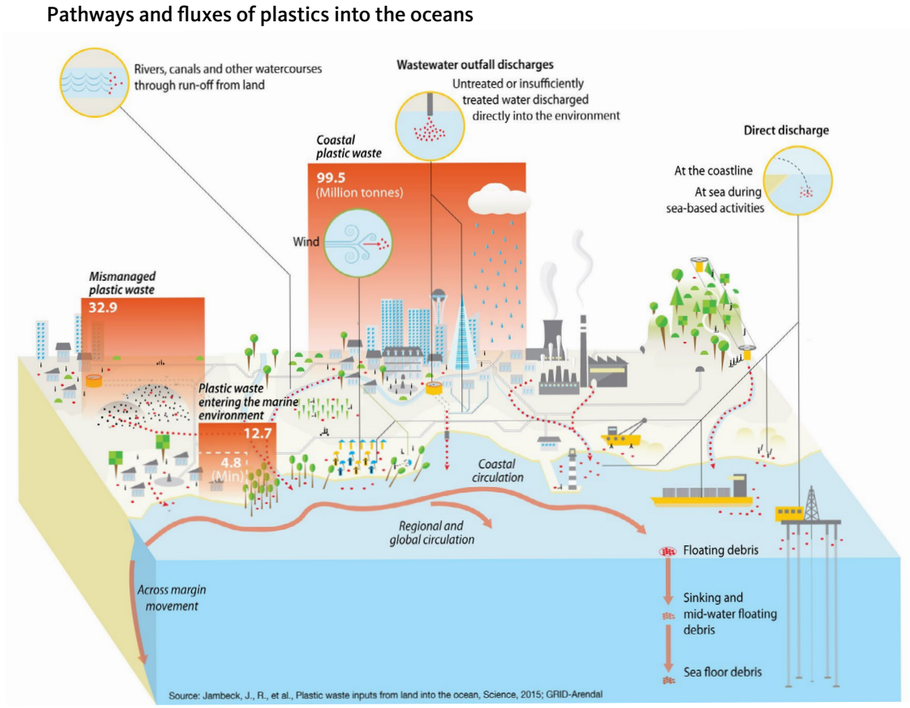

Figure 2: Sources and pathways of marine litter (Jambeck, et al., 2015).

Figure 2 demonstrates that as plastics move along a range of pathways to the ocean there are many different actors which are contributing to plastic pollution or along with ecosystems are being impacted by it. Rivers as substantial conveyors of pollution, which are often transboundary, (Lebreton, et al., 2017) link stakeholders and ecosystems.

A source-to-sea framework

Source-to-sea system

The source-to-sea system is defined as the land area that is drained by a river system, its lakes and tributaries (the river basin), connected aquifers and downstream recipients including deltas and estuaries, coastlines and near-shore waters, the adjoining sea and continental shelf as well as the open ocean (Figure 3). A source-to-sea system can also be defined on a larger scale to include a sea and its entire drainage area, which may include several river basins.

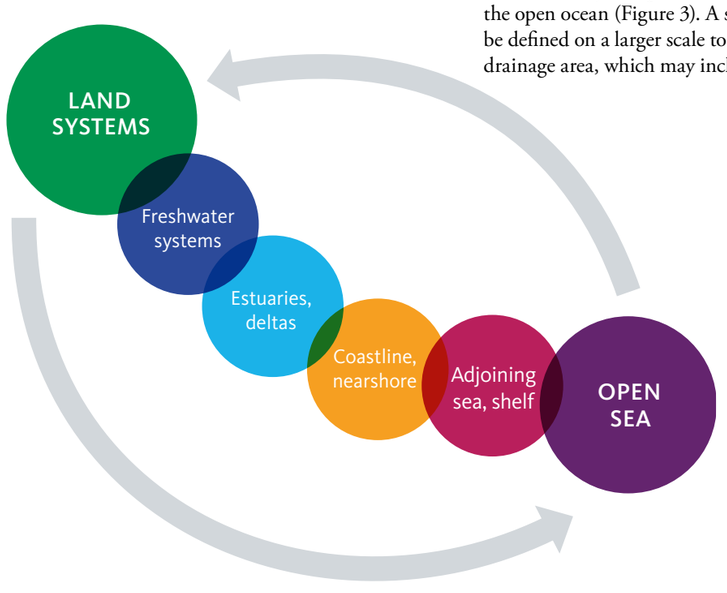

Figure 3: The source-to-sea system (Mathews et al., 2019).

Source-to-sea key flows

The source-to-sea approach identifies six key flows that connect the source-to-sea system from land systems to open oceans: water, sediment, pollutants, biota, materials and ecosystem services (Figure 4).

Figure 4: Source-to-sea key flows of water, biota, sediment, pollutants and materials combine to condition the ecosystem services that the source-to-sea system provides (Mathews et al., 2019).

Source-to-sea approach

The source-to-sea approach Figure 5 begins with understanding the pressures and drivers altering key flows. Combined with selecting an appropriate scale of intervention, engagement of stakeholders (both upstream and downstream and across sectors) and a thorough understanding of the governance context this sets the basis for defining a theory of change. The theory of change captures the expected linkages between actions and outcomes and can guide planning and implementation. Monitoring and adaptive management round out the process and can be used to refine the theory of change and ensure continuous improvement toward long-term outcomes.

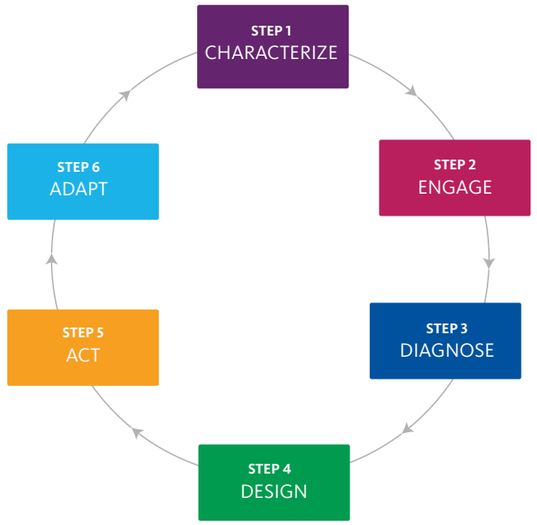

Figure 5: Six steps of the source-to-sea approach (Mathews et al., 2019).

Applying the six steps to the problem of plastics entering rivers and the oceans provides insights into the linkages that occur across the source-to-sea continuum and supports coordination between sectors, which can form the basis for designing initiatives that prevent marine litter.

Building a source-to-sea framework

Current approaches to the problem of marine litter are often focussed on individual segments of a source-to-sea system and/or on one sector, making them poorly suited when attempting to address all the root causes of marine litter. Plastic waste tends to be managed by local authorities and communities in isolation, which can result in outcomes that may not be optimal nor take into consideration the entire source-to-sea system. Following in line with the segmentation of policies, procedures and regulations – investments and management practices are often directed toward maximizing local benefits and are blind to their upstream and/or downstream impacts. This can result in benefits for one sector, or in one source-to-sea segment while having negative consequences on another. These consequences are often not adequately accounted for when the costs and benefits of local investments in managing plastic waste are being considered.

Source-to-sea management can combat this by enhancing coordination in two dimensions 1) across the source-to-sea continuum from land to freshwater to marine environments; and 2) between sectors, e.g., land, water resources, coastal and marine management (Figure 6). These two dimensions are fundamental to the source-to-sea approach and this Framework.

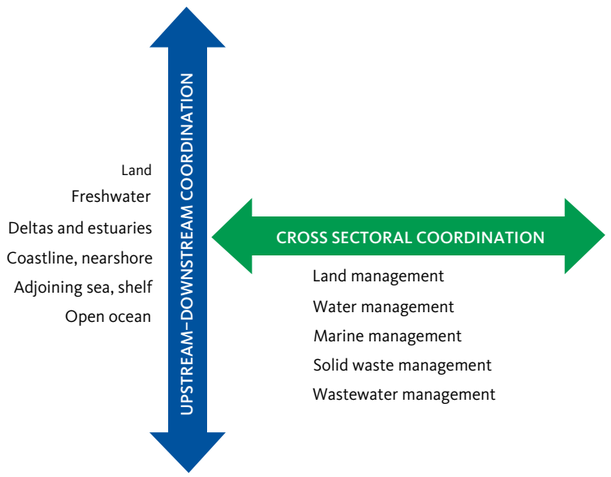

Figure 6: Longitudinal and lateral dimensions of source-to-sea management.

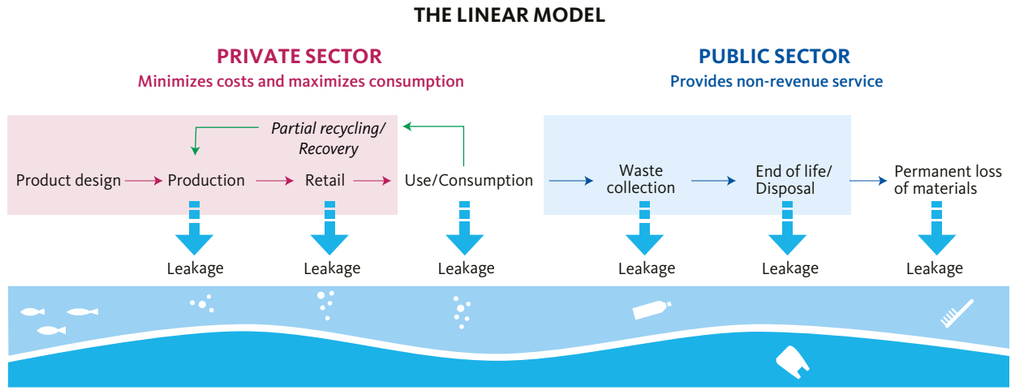

Figure 7: The linear model of production and consumption.

The linear model in Figure 7 shows a generic overview of the plastic production and waste cycle. It is not only valid for plastics entering the solid waste management system, but also for microplastics, which enter wastewater streams after use. The linear system results in ever increasing amounts of wastes being generated as a direct result of increasing consumption. Transitioning from the linear approach to one that captures and values plastic goods can help drive a reduction in the amounts of plastics that become waste, which may end up in riverine and marine environments.

While solid waste management and wastewater treatment has traditionally been considered a local responsibility, the issue of marine litter has highlighted that failures at the local level can have impacts throughout the source-to-sea system and, in some cases, globally. Any approach to preventing marine litter needs to address these local to global linkages. Doing so can help direct much needed resources toward resolving the local failures in controlling plastic waste, thereby creating benefits locally and beyond.

Considering these realities, the Source-to-Sea Framework combines the central principles of coordination across source-to-sea segments and management sectors with the need to address the production and consumption of plastic goods and changing behaviours from individual to global levels (Figur 8).

This then begins to define the solution space for preventing marine litter, indicating a holistic approach that addresses four dimensions: 1) the source-to-sea system; 2) cross-sectoral coordination; 3) production and consumption; and 4) local to global linkages (Figure 9). When addressing marine litter in a specific location, e.g., a municipality, river basin or sea, or a particular form, e.g., single use plastics, microplastics or durable goods, the solution space will be further defined through the application of the source-to-sea approach. This approach is elaborated in the next section.

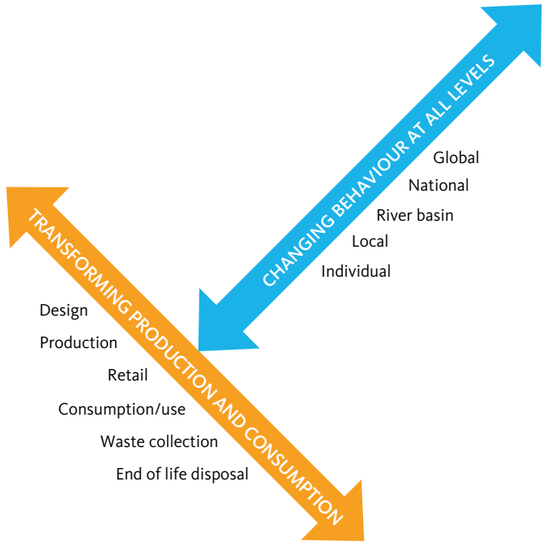

Figure 8: Cross-cutting dimensions of marine litter prevention.

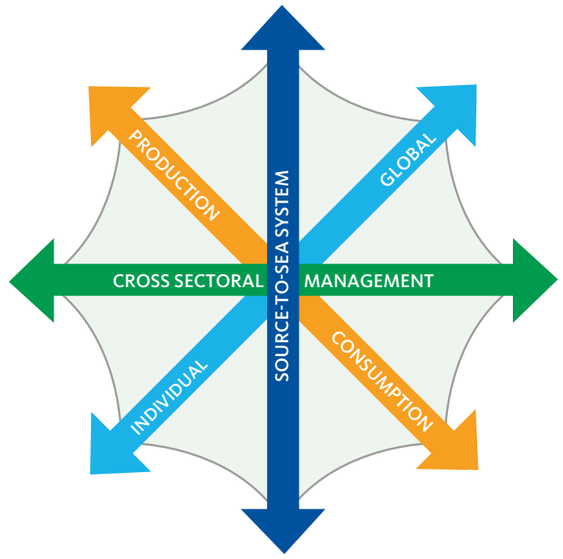

Figure 9: Solution space defined by dimensions of the Source-to-Sea Framework.

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Applying the source-to-sea approach

The source-to-sea approach follows six steps, which can be applied to the specific issue of marine litter prevention as desribed below.

Source-to-sea approach for marine litter prevention

- **STEP 1 – CHARACTERIZE**: Characterize the sources, types, behaviour and impacts of plastics in riverine and marine environments. Define the system boundaries and regional scale of the assessment. Which linkages beyond the boundaries could or should still be considered?
- **STEP 2 – ENGAGE**: Identify who is impacted by plastic pollution, both directly and indirectly, who contributes to plastic leakage to the riverine and marine environ-ments across the full supply chain and who can provide solutions through enabling conditions that support behaviour change, finance, strengthening political will, etc.
- **STEP 3 – DIAGNOSE**: Understand how waste is managed /mismanaged and how the current governance framework is or is not preventing plastic from entering the riverine and marine environments.
- **STEP 4 – DESIGN**: Describe the changes needed to prevent plastic leakage, e.g. governance, waste management services, infrastructure, behaviour change, design, production and use of plastic goods, etc.
- **STEP 5 – ACT**: Develop interventions to prevent plastic leakage from local to global scales and identify financing mechanisms for these interventions.
- **STEP 6 – ADAPT**: Monitor the outcomes of the interventions and adapt as needed to keep progress toward the goal, identify key uncertainties and gaps in knowledge that need to be addressed and disseminate learning globally.

The Source-to-Sea Framework can be applied for targeting quite different levels and scales of intervention. Its main contribution is to integrate the various dimensions shown in Figure 9 into one comprehensive understanding. The Framework is applicable for a municipality that wishes to understand what its contribution to plastic pollution is, how it is impacted and what it can do about it. To do this, the municipality needs to look upstream and downstream in the affected river systems it is part of to make an informed decision of how to change the situation most effectively. In the same sense the Framework can be applied on a regional, national or even transnational level. On such levels the conflicting interests of polluters and those impacted can be assessed and translated into targeted actions.

While not the core scope of the Framework, linkages beyond river basins such as global production and consumption cycles should be considered as a way to reduce the load of plastics needing to be managed in the first instance. The Source-to-Sea Framework's main functionality is to link sources of plastic leakage (and those responsible for them) with their impacts (and those impacted) in order to seek solutions that address these linkages across the source-to-sea system.

The six steps and their application to preventing marine litter are described below.

"The Source-to-Sea Framework links those responsible for the sources of plastic leakage with those who are being impacted in order to seek solutions that address these linkages across the source-to-sea system."

STEP 1 – CHARACTERIZE:
The nature of plastic in the source-to-sea system

In Step 1, the sources, types, behaviour and impacts of plastic pollution are characterized and the system boundaries defined.

GUIDING QUESTIONS

1. How much plastic, of which types, is entering riverine and marine environments?
2. What are the main sources of plastics entering riverine and marine environments?
3. What are the environmental, economic and social impacts of plastic waste in riverine and marine environments?
4. Given the amounts, types and sources of plastic waste and its impacts, what are the system boundaries for the planning of interventions along the four framework dimensions?

Characteristics and sources of plastics

Characteristics of plastics in riverine and marine environments

Given the wide variety of types and applications of plastics a concise typology would exceed the frame of this document. However, a few characteristics determine at large how different types of plastics behave in the environment, particularly the aquatic one (Figure 10).

The four main categories of plastics released into the environment are:

- Packaging for all types of products and goods;
- Products that are disposed of after use;
- Additives as an ingredient to e.g. paint, shower gel, toothpaste and many other consumables; and
- Microplastics released as abrasion from certain products, such as microfibers from clothing and rubber from tyres.

Due to its characteristics and its behaviour in the water system there are some key aspects to be considered when assessing the problem of plastic leakage in a source-to-sea system.

- With enough time most plastics entering the water system will break up into microplastics and end up in the ocean causing negative effects along the way;
- The quality of plastics, hence their recyclability and potential economic value decreases significantly over time after entering the water system; and
- The level of effort required to remove plastics from the water system becomes more expensive and technically challenging the further away from the source we try to capture them.

Therefore, stopping leakage before it enters waterways would prevent negative impacts from occurring throughout the source-to-sea system.

TYPES OF PLASTIC WASTE?	WHICH SIZE?	HOW CAN IT BEHAVE?	WHAT HAPPENS?
• **Packaging waste** (e.g. paper wrapping, bottles, plastic film) • **End of life products** (e.g. toothbrush) • **Additives** (e.g. microbeads in toothpaste or paint)	• **Regular size** (e.g., lighter, bottle) • **Bulky** (e.g. chair) • **Micro-plastics** <5 mm (e.g. microbeads, disintegrated foil) • **Nano-plastics** <0,001 mm	• **Buoyant** (either less dense than water or encapsulated air) • **Hovering in the water column** (same density) • **Sinking** (higher density)	• **Reduction in size due to breakdown of material** • **Adhesion of toxins** • **Release of toxins**

Figure 10: General characteristics of land-based sources of plastic pollution.

Sources of plastic litter

When assessing plastic leakage into the riverine or marine environment, it is important to know who generates plastic waste in order to identify the sources as well as the pathways that plastic pollution travels through the source-to-sea system (Figure 11). The generation and distribution of plastic leakage is characterized by dynamic and complex processes so understanding this in totality may be difficult at first but estimates of sources can be a basis for taking the first steps toward gaining control of waste.

WHO IS GENERATING PLASTIC WASTE	HOW DOES IT ENTER THE WATER?
• **Commerce** • **Individuals/household** • **Agriculture** • **Industry**	• **Inadequate waste management** • **Stormwater drainage** • **Sewer/wastewater systems** • **Direct littering or dumping**

Figure 11: Examples of sources and pathways of plastic pollution.

Plastic waste generators are mainly classified as:

- Consumers (households, public spaces, tourism);
- Commercial activities (retail, services, institutions);
- Industry (mining, processing, manufacturing); and
- Agriculture.

Plastic leakage from land-based sources occurs along four main paths:

- Inadequate waste management that loses control over the waste generated, with waste entering the environment and eventually reaching water bodies (e.g. during storms, floods, windblown, etc);
- Direct littering or dumping of waste into water bodies, e.g. at beaches or along riverfronts;
- Illegally discharged waste entering water bodies through surface water drainage systems (storm water drains): and
- Plastics or waste that are discharged into sewage or wastewater treatment systems (e.g. micro-plastics from laundry or cosmetics) and not retained in the treatment stages.

The sources and pathways of plastic pollution can be combined to understand the quantities of plastics leaking into the environment and the main drivers behind this. Examples might be:

- Packaging and end of life products generated by households and commerce enter water bodies due to inadequate waste management; and
- Microplastics leaking from plastic processing facilities through wastewater discharged into the sewage system.

Different sources will require different measures and involve different actors and governance structures. Understanding the sources and pathways early on is essential for a successful application of the Framework.

Measuring plastic leakage and pollution in waterways and oceans

In recent years, there has been substantial progress in estimating the amount and distribution of plastics in our seas. However, there is not yet accurate information regarding how much plastic from land reaches the oceans. Rough estimations calculate that between 4 to 12 million metric tonnes of plastic are released into the oceans every year (Jambeck, et al., 2015) and around 51 trillion microplastic particles contaminate our oceans already (UN news, 2017). Furthermore, 90 per cent of land-based leakages (between 1.15 and 2.41 million tonnes annually) can be traced to only 10 major rivers worldwide (Lebreton, et al., 2017), seven of them in Asia. Much uncertainty remains regarding the different transportation pathways of plastic leakage into the oceans due to their multitude of sources and complex migration along river systems and in the seas.

The large number of sources, its non-linear behaviours together with the fact that plastics appear in a wide variety of materials, forms, shapes and compositions make it very challenging to develop a practical measurement approach. Nevertheless, there are models under development to assess the scale of plastic leakages. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has developed a simplified transmission model for assessing plastic leakage, identifying municipal waste sources as main contributors at the local level in developing countries (Renaud et al., 2018). This model is currently being refined together with a mass flow assessment for municipal waste management. The American Association for the Advancement of Science also has developed a formula based on population density and the economic status of a country to estimate both the amount of plastic waste produced and the amount then entering into the ocean (Jambeck, et al., 2015). The Lebreton study (Lebreton, et al., 2017) developed a model for estimating the amount of plastic entering the oceans from rivers. The International Solid Waste Association (ISWA) is developing a plastic pollution calculator that can be scaled beyond municipal boundaries (ISWA, 2019). All these models use information regarding the performance of local waste management systems and estimate the percentage leaking into water systems based on that information. So far, there is no methodology based on actual measurements nor does this seem practically achievable yet.

Models, such as the ones described above, need to be individually adapted and tested locally to be able to generate usable numbers. These models target mainly municipal waste as the major source of leakage. The quantification of other pathways is less researched but

new publications on different sources and types of plastic pollution are published at a constantly increasing rate. Even with the limited tools and knowledge currently available, stakeholders have the possibility to gather fundamental information about the leakage of plastics and assess the level of pollution along beaches, in rivers and the sea using well-established methodologies (UNEP, 2015).

Impacts of plastic leakage

The impacts of plastic leakage are manifold, multi-scale, transboundary and felt in not only the marine environment but also in terrestrial and freshwater environments. Depending on the scale of pollution and the specific geographical and hydrological situation the impacts of plastic pollution can be felt close to its source. Since plastics move freely once in the ocean and are transported across large distances, the impacts can also be felt in areas far from where the waste originated and by actors and sectors that are not necessarily responsible for its generation. In addition, the versatility which makes plastic so attractive for a broad range of uses, is also one of the main problems since, for example, its durability means that it remains in the ocean for a long time.

So far, research has focused on measuring the prevalence of plastic contamination and its distribution as well as understanding the transport pathways along river systems and the influence of currents. Plastic pollution's impacts on riverine and marine species and ecosystems are being described in increasing detail. Less understood are its direct (by ingestion) or indirect (through bio-accumulation of toxic substances) impacts on both animal and human health. The question of whether the finest plastic particles would be able to cross the cellular barrier and enter blood and tissue is still being investigated.

The direct and indirect impacts of plastic in the ocean can be grouped in five main categories: economic losses, biota and ecosystems, human health, infrastructure and disaster risk, and quality of life (Figure 12).

Comprehensive assessments on the various impacts are not yet available. This is further complicated by the complex interlinkages between ecosystems and anthropogenic use which are influenced by a multitude of factors of which plastic pollution is only one aspect. Determining and eventually quantifying the impacts of plastic pollution is a task for future research and strategies.

In contrast to current approaches that focus on either local intervention levels (e.g. municipalities) or particular products (e.g. plastic bags, single use plastics), the source-to-sea perspective establishes a link between sources of plastic pollution and the negatively impacted locations and stakeholders. By taking a more comprehensive approach through linking specific stakeholder interests with the potential for interventions to address these interests, a more efficient approach to preventing plastic pollution can be implemented.

While there is no established methodology for assessing the economic and other impacts, as a first step the most relevant impacts for a given area could be identified and qualitatively described. Stakeholder engagement undertaken in Step 2 of the Framework will enable gathering feedback on the impacts including difficult to quantify impacts such as quality of life and long-term health impacts.

Photo: iStock

DIRECT	INDIRECT
Economic losses	
• Higher cost of drinking water due to the increased amount of plastic pollution in the water • Less income and reduced employment in coastal communities due to decreased tourism related to dirty and less attractive beaches (2) • High costs for coastal and beach clean-ups (13) • Loss of employment in fisheries due to reduced catch resulting from ghost fishing and fish mortality (7)	• Stress on commercial species and higher losses/costs for the fishing industry (7) (13) • Reduced availability of water-based food due to the lower rates of reproduction • Less productive aquaculture • In the shipping sector, damages by marine litter harming ship propulsion equipment (6) • Higher operational and maintenance costs of propellers, intake pipes and other infrastructure
Biota and ecosystems	
• Pressure on aquatic species due to plastic debris ingestion or entanglement (1) • Loss of biodiversity in aquatic ecosystems • Spread of invasive species (4) • Threat of collapsing ecosystems • Smothering of organisms, reduced light penetration, and dragging along the sea floor causing physical damage (3)	• Damage to coral reefs due to debris entanglement • Bioaccumulation of toxic substances due to ingestion of hazardous chemicals that are in the plastic or adsorbed on its surface (5)
Infrastructure and disaster risk	
• Increased risk of flooding due to blockage of stormwater systems and drainage (11) • Higher cost of flood damage due to increased frequency and stage of flooding • Increased melting rates of sea ice (15)	• Higher maintenance for water-using infrastructure (e.g. cooling systems of power plants, dams) and decreased lifetime • Higher maintenance and clean-up costs for stormwater drainage and other water transport infrastructure
Human health	
• Reduced drinking water quality • Contamination of water-based food with microplastics • Risk of microplastics consumption through the food-chain (9) • Health risks to coastal visitors through ingestion of contaminated food (12)	• Cumulative impact of plastic pollution on human well-being resulting in Increased overall stress on health of the population • Risk of cancerogenic diseases (10) • Contamination through water-based food (12) • Higher expenses for public health
Quality of life	
• Reduced opportunities for recreational activities • Decreased quality of recreational and social services due to plastic pollution across the source to sea system • Air pollution/bad smell in recreational water zones	• Reduction of aesthetic value and beauty of rivers, coasts and oceans • Degradation of riverine, coastal and marine environment

Figure 12: Direct and indirect impacts of marine litter.

(1) UN, 2017; Factsheet: Marine Pollution, for the Ocean Conference June 2017, New York, https://sustainabledevelopment.un.org/content/documents/Ocean_Factsheet_Pollution.pdf

(2) McIlgorm et al., 2011; The economic cost and control of marine debris damage in the Asia-Pacific region, Ocean & Coastal Management, Volume 54, Issue 9, Pages 643–651.

(3) Kühn et al., 2015; Deleterious effects of litter on marine life. In Marine anthropogenic litter, page 75ff, Springer Open 2015.

(4) Kiessling et al., 2015; Marine litter as habitat and dispersal vector. In Marine anthropogenic litter, page 141ff, Springer Open 2015.

(5) Rochman, C. M., 2015; The Complex Mixture, Fate and Toxicity of Chemicals Associated with Plastic Debris in the Marine Environment, In Marine anthropogenic litter, page 117ff, Springer Open 2015.

(6) McIlgorm, et al., 2008; Understanding the economic benefits and costs of controlling marine debris in the APEC region (MRC 02/2007). A report to the Asia-Pacific Economic Cooperation Marine Resource Conservation

Working Group by the National Marine Science Centre (University of New England and Southern Cross University), Coffs Harbour, NSW, Australia, December 2008.

(7) *Van Acoleyen, et al. (not dated); Marine Litter study to support the establishment of an initial quantitative headline reduction target, ARCADIS Belgium for the European Commission DG Environment, Brussels.*

(8). *UNEP, 2016; Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change. United Nations Environment Programme, Nairobi.*

(9) *Van Cauwenberghe et al., 2014; Microplastics in bivalves cultured for human consumption in Environmental Pollution, Volume 193, pages 65-70.*

(10) *Meeker, et al., 2009; Phthalates and other additives in plastics: human exposure and associated health outcome, in Philos Trans R Soc Lond B Biol Sci. 2009 Jul 27;364(1526): 2097–2113.*

(11) *Clapp, et al., 2009; Doing away with plastic shopping bags: international patterns of norm emergence and policy implementation, Environmental Politics, 18:3, 315-332, DOI: 10.1080/09644010902823717.*

(12) *Smith, et al., 2018; Microplastics in Seafood and the Implications for Human Health. Current environmental health reports, 5(3), 375–386. doi:10.1007/s40572-018-0206-z.*

(13) *https://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/index_en.htm*

(14) *Werner, et al., 2016; Harm caused by Marine Litter. MSFD GES TG Marine Litter - Thematic Report; JRC Technical report; EUR 28317 EN; doi:10.2788/690366.*

(15) *Geilfus, et al., 2019; Distribution and impacts of microplastic incorporation within sea ice, Marine Pollution Bulletin, Volume 145, pages 463–473.*

Defining system boundaries

The system boundaries need to be defined to focus the following steps of the source-to-sea approach. In defining system boundaries, attention should be paid to the geographic locations of both the sources of plastics entering riverine and marine environments and their impacts. The geographic scope can range from a small locality to one or several municipalities, part or all of a river basin, a nation, several nations sharing transboundary interconnections of rivers and/or seas or global. Once the sources being addressed are selected, this informs the locations and actors that will be targeted for behaviour change. Understanding the impacts of marine litter will be useful in identifying stakeholders who will benefit from the intervention strategies. Stakeholder engagement will be presented further in the next section on Step 2 of the source-to-sea approach. The system boundaries will help determine the level at which governance will need to be addressed, which is elaborated upon in Step 3.

It is also important to think about relevant factors outside the selected system boundaries. Large river basins stretch beyond countries and a particular intervention area might already receive significant pollution from upstream sources. Here the source-to-sea approach suggests identifying the relevance of such pollutants in terms of impacts within the system and assess what actions can address upstream sources.

"The geographic scope of analysis and action can range from a small locality to one or several municipalities, part or all of a river basin, a nation, several nations sharing transboundary rivers and/or seas or global."

STEP 2 – ENGAGE: The key stakeholders

In Step 2 stakeholders are mapped under the following categories: primary, targeted, enabling, supporting and external and then an engagement plan is developed.

GUIDING QUESTION

1. Which individuals or groups are affected by plastic pollution and will directly benefit from its prevention? These actors are known as **primary stakeholders**.
2. Which individuals or groups are contributing to plastic pollution and whose behaviours and practices must be directly targeted to prevent it? These actors are known as **targeted stakeholders**.
3. Which institutions provide or should provide enabling conditions for behavioural changes and benefits to occur and be sustained over time? These actors are known as **enabling stakeholders**.
4. Are there development partners or financiers whose strategies are aligned with marine litter prevention? These actors are known as **supporting stakeholders**.
5. Are there individuals or groups outside the system boundary who share an interest in marine litter prevention? These actors are known as **external stakeholders**.

Poor waste and wastewater management has generally been considered a local problem with limited impacts beyond the borders of a municipality. The responsibility for implementing and funding waste and wastewater management is mainly placed on municipal authorities and locally sourced taxes and fees. In developing countries, waste and wastewater management may be considered a lower priority than other development goals such as jobs, health, education, transportation, etc, leading to insufficient resources for addressing this issue. This might be exemplified by the fact that international financial support for solid waste management projects in developing countries averages around 0,99 USD per capita (in 2012), compared to 2,43 USD in the water and sanitation sector and 31 USD per capita of total financing (UNEP, ISWA, 2015).

Limiting engagement in resolving the problem of plastic leakage to local waste managers constrains the 'solution space', i.e. it narrows the field of potential actors who could contribute to solutions, build political will and provide financial support. The growing attention on plastics in oceans is directing focus to the inadequacies of waste management in many countries. Taking a source-to-sea approach can highlight the role of actors beyond local waste and wastewater managers in addressing the problem of plastic leakage into rivers and oceans.

The source-to-sea approach fundamentally recognizes that the linkages across the source-to-sea continuum go in both directions – upstream and downstream – so that it is important to engage stakeholders across this continuum. Stakeholders can be engaged as individuals or at the local, river basin, national and global levels. Designing a course of action for preventing plastic pollution and its impacts requires a thorough understanding of this full set of source-to-sea stakeholders and their interests and motivations for contributing to reduced plastic leakage.

Source-to-sea stakeholders in preventing marine litter

- **Primary stakeholders**: those who are negatively impacted by plastic pollution and who will benefit from intervention strategies preventing it.
- **Targeted stakeholders**: individuals or groups whose practices are contributing to the amount of plastic pollution leaked to riverine and marine environments and whose behaviour change is directly targeted.
- **Enabling stakeholders**: institutions that provide enabling conditions for behaviour changes and benefits to occur and be sustained over time.
- **Supporting stakeholders**: development partners or financiers whose strategies are aligned with preventing plastic leakage.
- **External stakeholders**: individuals or groups outside the system boundary who share an interest in preventing marine litter.

Stakeholder Categories

Primary stakeholders

Primary stakeholders are individuals or groups that are affected by marine litter and will directly benefit from its prevention. The impacts to these stakeholders motivate

action to prevent marine litter and may include e.g., fishermen whose livelihoods are threatened when fishing is hampered by plastics in the water, power utilities whose turbines at hydropower stations are compromised by plastics in the water column, local communities adjacent canal systems that flood due to blockage from plastic waste or health impacts from increased breeding areas for mosquitoes. When assessing who the primary stakeholders are, it must be considered how the impacts also move upstream and can be felt far away from the sources of plastic leakage. For example, if the toxic chemicals associated with plastic litter are entering the food chain through bioaccumulation in marine fisheries, the fish may end up on the plates of the people in upstream communities. Human health impacts can also range widely as seafood is transported around the world for consumption. In the case of plastics in the oceans, the primary stakeholders include individuals, communities and businesses whose health and welfare are negatively impacted as identified in Step 1. Given the dispersal of plastics in oceans by winds and currents and the regional and global trade in commercial goods, primary stakeholders can also be as widely dispersed. This is, in part, why the issue of plastic in oceans has attracted global attention.

Targeted stakeholders

The targeted stakeholders are those responsible for the most relevant sources of plastic leakage as characterized in Step 1. Depending on the system boundary defined in Step 1, targeted stakeholders are those who contribute to leakages at one or more stages, i.e. production, retail, use/consumption, collection, disposal/end of life and can include companies in the petroleum and chemical industry, design, production and sale of goods containing plastic materials, consumers using those goods or parties responsible for waste management and reuse or recycling. Addressing the problem of plastic leakage requires engagement with each of the targeted stakeholder groups (Figure 13) and the different ways in which they contribute to plastic reaching rivers and the ocean.

Targeted stakeholders may be located in the immediate vicinity of plastic leakage, e.g. local citizens disposing plastic at informal dumpsites or may be geographically distant, e.g. chemical companies producing plastic raw materials. The parties involved in each step from production to consumption, disposal and reuse/ recycling could make changes to behaviours which would result in the prevention of plastic reaching the ocean from land-based sources. By engaging this range of targeted stakeholders, the source-to-sea approach expands the responsibility for the failure of adequate waste and wastewater management from solely the local waste managers to a broader set of stakeholders who can each contribute solutions at one or more stages of the production and consumption of plastic goods. It is a challenge to engage all the actors beyond the system boundaries that are still having a major impact on the way plastic is produced or consumed. Here reasonable decisions have to be made regarding whom to target when designing the engagement plan and subsequently the interventions.

Enabling stakeholders

The enabling environment within which plastic waste management occurs is comprised of policies, the legislative and regulatory framework as well as financing and investment structures. The enabling environment reflects societal values and influences the behaviour of the public, private and civil society sectors. It can operate on a global, regional, national, river basin or sub-national level and can address behaviours at each stage of the production and consumption cycle where plastic leakage can occur.

Enabling stakeholders are the individuals, institutions and organizations that determine the characteristics of the enabling environment, including not only the content of policies, laws, regulations and financing strategies but also their implementation and enforcement. In the case of preventing marine litter, a source-to-sea approach to developing the enabling environment draws in stakeholders across the source-to-sea continuum as well as from each stage of the linear system and distributes among them the responsibility for reducing the amount of plastics reaching the oceans. Governance, management, operations and finance can then arise from a broader set of stakeholders rather than the traditional approach of responsibility residing solely with local waste managers. Enabling stakeholders may include those responsible for different segments along the source-to-sea continuum e.g. those responsible for managing land, water, coastal and marine resources as well as different sectors e.g. public or private utilities for water, wastewater or solid water management, etc.

Figure 13: Targeted stakeholders along the plastic supply chain.

Supporting stakeholders

Plastic in the oceans is sparking interest at all levels of government, in development banks, international organizations, private foundations, the private sector and in international development cooperation. Supporting stakeholders may commit new sources of funding, strengthen political will and advocate for change thereby supporting the transition to behaviours that prevent marine litter. The careful assessment and prioritization done through implementing the Source-to-Sea Framework with ensure these supporting stakeholders contribute resources where they are most needed.

External stakeholders

The issue of plastic waste in the oceans is gaining momentum, in part, through the activities of external stakeholders, e.g., concerned individuals, civil society, private sector organizations, etc. that are raising the issue, primarily at national and international levels. This advocacy by external stakeholders, who may be far from the sources of marine litter, can bring attention, raise awareness and increase interest in the issue. By engaging global and national attention on the matter of the scale of plastic leakage to riverine and marine environments and its impacts, external stakeholders can catalyse new focus on and innovative solutions for preventing marine litter.

Photo: iStock

Stakeholder assessment

Following the above-mentioned descriptions and guiding considerations, Step 2 is assessing the various stakeholders, their interests and motivations to act on (or counteract) marine litter prevention and the existing dependencies between stakeholders. Depending on the scope of the interventions, a stakeholder assessment is required in order to know what (and whom) to look for in the subsequent steps. Guiding questions could be:

- Are primary stakeholders aware of the negative impacts and can they quantify them? Do they compensate for negative impacts already? Is there an understanding of the implications if the situation does not change? Are they aware of the sources of pollution?
- Are targeted stakeholders aware of the negative impacts they generate, maybe far from their location? What incentivizes them to pollute or not to avoid leakage? Do they have alternatives? What are implications of such alternatives? How do they perceive their behaviour?
- Are enabling stakeholders aware of impacts, sources and the scale of the problem? Are any of them already engaged in measures combatting the problem? Are they familiar with approaches and options for such engagement? Would they be interested in financially supporting solutions? What are their motivational drivers? Would they be able to coordinate interventions with other sectors?
- What leverage and outreach do supporting stakeholders have? What motivates them? Do they have resources, knowledge, practical experience to share? Are they linked with other actors beyond the scope of the intervention?
- How well does the specific situation within the system boundaries fit within the topics and interests of external stakeholders? What support can they provide? Can they bring additional dimensions, motivation and resources to the problem at hand?

These questions are for orientation only and by no means an exhaustive list. However, they are geared towards creating a better understanding of the pressures, incentives and resources which can help to determine a more efficient implementation strategy. Besides the individual assessment of each stakeholder, the dynamics between them has to be understood. Is there a general mistrust between primary and enabling stakeholders? Would targeted stakeholders be willing to discuss the impacts of plastic pollution with primary stakeholders? Guided exchange formats such as multi-stakeholder dialogues or partnerships are suitable instruments to establish a shared interest in solving the problem between the different actors.

STEP 3 – DIAGNOSE: Governance for preventing marine litter

In Step 3, the governance systems and behaviours related to marine litter prevention are analyzed.

GUIDING QUESTIONS

1. What are the institutions, legal and regulatory frameworks, rights, ownership, informal agreements that define the framework for preventing plastic leakage at each step of the cycle of plastic production, consumption and disposal?
2. Are these in conflict with or complementary to one another and where are the gaps in governance that lead to plastics leaking to riverine and marine environments?
3. In addition to the public sector, are there other actors, e.g., companies or non-governmental organizations, that can improve governance related to plastics and what is the relative capacity of each to prevent marine litter?
4. Is the behaviour of the targeted stakeholders in line with the governance framework or is there a failure in enforcement?
5. Are there mechanisms for stakeholders to be involved in decision making, are there procedures in place for resolving conflicts that may arise between stakeholders and are these being effectively applied?

The governance system is made up of policies, laws, regulations, plans, procedures and the institutions that deliver them. This sets the stage for how individuals, businesses and public managers behave within the cycle of production, consumption and disposal of plastic goods and packaging. Plastic leakage into riverine and marine environments is taking place within governance systems that could address product specifications, consumption patterns, waste management, and end of life disposal.

The problem of plastics in the oceans is evidence that current governance systems fall short in enabling sound management of plastic production, consumption/use, collection and resource recovery. The failure of governance to provide the conditions under which plastic waste is properly managed arises from both the lack of an appropriate legal and regulatory framework and inadequate enforcement.

In most locations, governance does not explicitly address the upstream-downstream linkages between sources of plastic leakage and the locations and stakeholders being impacted by plastic pollution. It ignores the reality of the source-to-sea continuum resulting in often disjointed and sometimes contradictory actions. For example, a coastal community may invest in periodic beach clean-ups while upstream communities use the river as a conduit to flush plastic waste downstream. Taking a source-to-sea perspective on the problem of marine litter will help avoid these inefficiencies.

Source-to-sea management increases collaboration and coherence across the source-to-sea system by establishing governance, operations, behaviours and finance in full recognition of the physical, social and economic connections from source to sea. The river basin is central to preventing marine litter given that plastics found in oceans often result from activities on land and are then transported to the oceans by rivers (Figure 14). A governance system that supports actions to prevent marine litter at the individual, local, national and global levels will lead to river basins with no plastic leakage.

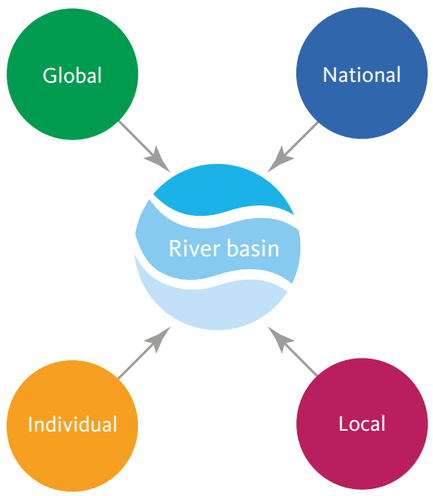

Figure 14: Plastic leakage from river basins is prevented through governance defining individual, local, national and global behaviours

Governance at different levels

Governance from source to sea

To gain control of plastic and prevent marine litter governance must address the behaviour of actors at each of the levels – individual, local, river basin, national and global. Source-to-sea management takes a geographic view on this, for example:

- What does the source-to-sea continuum tell us about the types of actions and investments needed to prevent plastic leakage?
- Where can action and investments be prioritized for maximum benefit when looking at one whole river basin or multiple river basins?
- What is the suite of management mandates and therefore institutions that need to be involved to address plastic leakage?
- Who are the supportive and external stakeholders who can support these governance and behaviour changes being made at each of the levels?

Governance may be needed to address different stages of the linear model from production, to retail, consumption, collection and disposal and may be oriented toward creating a circular economy that captures plastic after use as a resource for reuse or recycling. To drive this change from a linear to circular economy will require behaviour change, as well as investment and finance, at all levels. In the following sections, some examples of governance that will drive behaviour change toward preventing marine litter are presented.

Governance on the global level

Global governance of marine litter prevention can support the development of a common understanding of marine litter and its sources by providing and supporting research and knowledge exchange. The global perspective can provide valuable information regarding the priorities for action within and between countries and river basins; it puts pressure on national governments to act and on global companies to revise their products and packaging. Providing technical assistance and financing support to implement projects or programmes in developing countries can help quicken progress. Given the global nature of the sources of plastic and their impacts, a globally binding agreement on how to tackle the threat of marine litter pollution could drive change as comprehensive and fast as needed.

The topic of marine litter prevention is receiving a high level of attention on the international agenda. At the G20 ministerial meeting in June 2019 (Wahlén, 2019) in Japan a new implementation framework to tackle marine plastic waste was adopted. That framework focusses on land-based sources, sound waste management and the prevention and reduction of plastic waste generation and littering. It also includes the concepts of sustainable consumption and production, circular economy and resource efficiency. Many international organisations such as UNEP (UNEP, 2019), Ellen MacArthur Foundation (World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, 2016) and others recently released documents describing the problem and providing a way forward.

Global pressure and leadership provides the necessary pressure for national governments to take action. It can also motivate international companies to re-think their product and packaging strategies and their active involvement in developing circular economy approaches across the globe. Gearing international support to a source-to sea understanding of marine litter prevention will promote its adoption by national and local government institutions.

Governance on national level

Addressing the problem of marine litter and plastic pollution requires behaviour change supported by new governance instruments for various sectors and governing levels. It is not only solid waste management and wastewater systems that have to be strengthened but also the way the economy produces and distributes products. National governments provide the legal and strategic frameworks for the different sectors and define the rules and priorities of resource allocation. Governments must balance the different interests of those who leak plastics into the environment and those who suffer from the consequences. Behaviour change, at all levels from multi-national companies to local governments and individuals is needed to fully address the problem of plastic pollution. As the governing regulator, it can provide positive or negative incentives to drive change on local and individual levels. By taking a source-to-sea perspective, national governments can direct investment to the highest priorities – those that will have the greatest impact on reducing and preventing marine litter.

Examples of governance instruments at the national level are:

- Legally binding targets for waste management services in localities (e.g. collection coverage, recycling targets);
- Investment support for required infrastructure and equipment (access to international grant funding, guarantees for loans, government investment funds);
- Financing mechanisms such as earmarked ecotaxes and product levies;
- Redistribution of responsibilities through instruments such as extended producer responsibility (EPR), particularly for packaging waste;
- Banning or taxing particularly polluting products such as plastic bags or single use plastics;
- Subsidizing recycling value chains;

- Defining standards and quality requirements for products and services (e.g. labelling of recyclability, resource efficiency); and
- Monitoring and control of environmental compliance of local administrations and the private sector.

In many countries, national governments recognize the problem of marine litter and are initiating actions to combat it. They face two systemic challenges: the integration of actions across sectors with different entities being responsible for different aspects of the problem of plastic pollution and the gap between national strategies and plans and local administrations' capacities and priorities. Depending on the vertical governance structure of the country, municipalities might not be obliged to implement certain measures dictated by central government. Therefore, a key consideration when assessing the national governance structures is their leverage and interaction with local structures. It is also important to understand to what extent those operating at a national level are aware of motivations and limitations at the local level.

Governance on local level

At the local level governance defines the interface between public services and their beneficiaries. The responsibilities of municipalities or rural communities range from investing in and maintaining infrastructure, providing public services such as waste or water and wastewater management. They determine local fees and taxes and issue permits for construction and businesses. Across this broad range of responsibilities, other local sectors have to be considered when assessing governance related to plastic pollution, wastewater management and maintaining control of all waste. Lack of waste collection services, insufficient waste management and poor treatment and disposal practices are all indicators of poorly performing public administrations. In such cases, illegal behaviour is rarely controlled effectively and is often sanctioned.

Currently, the main burden for addressing plastic leakage from land-based sources is on municipalities and their provision of waste management services. In many cases they are also the weakest actor with limited resources, limited capacities and an extensive list of other priorities. As is demonstrated by the growing problem of plastic pollution in the riverine and marine environments, if left alone, many municipalities are not able to gain control over their wastes. While much of the required action needs to be taken at the local level, municipalities alone cannot drive all the changes needed. Some key aspects of waste management that contribute to insufficient services are:

- Waste management is an expensive service, consuming more than half of the city's limited budgets in some developing countries;
- Municipalities lack sufficient funds for adequate investments in infrastructure, operations & maintenance;
- Waste fees or other financing mechanisms provide insufficient revenues to sustain operations and fund investments in new infrastructure and services;
- Municipalities as public entities often do not attract or maintain qualified and experienced staff;
- Investments and spending in waste management is often a low priority for political decision makers; and
- Necessary legal provisions are not adequate or are not implemented and enforced.

This causes a lack of service provision or sound operation of waste management facilities, both of which lead to waste being released uncontrolled into the environment with the risk of entering waterways. The rapid increase of waste due to increased consumption of single use or packaged products puts an additional burden on communities in developing countries. In more developed waste management systems, leakage increases when illegal discharge becomes economically beneficial and is not properly monitored and sanctioned.

While state or central governments define waste policies, strategies and the overall budget allocation, the responsibility for waste management usually lies with municipalities or comparable local administrations. Legislation is cascaded down from a national waste or environmental law to local by-laws and executive orders. Services are provided either by public employees and equipment or tendered to private service operators. Usually local administrations become the owner of the waste once the one responsible for generating the waste wants to dispose of it. Special provisions apply for different waste streams, such as hazardous, medical, electrical and electronic equipment (WEEE), construction and demolition, etc. Recycling value chains develop when fractions of waste possess direct or indirect value (e.g. metals, but also high-quality plastic residues from production processes).

While some localities are promoting recycling or reuse, the vast majority of plastic goods become waste. In most places, informal waste collectors are harvesting valuable materials from different waste streams: collecting a wide variety of materials directly from households, waste storages or landfills that can be separated and prepared for recycling. Some plastics have a high value and can be a relevant income source for many people. If completely unregulated, the destination of residues of such separation efforts cannot be easily identified or controlled.

In addition to waste management, other sectors such as stormwater and wastewater management are relevant for understanding and combatting plastic leakage. Drainage and sewer systems are the physical links between waste and riverine and marine environments. If waste collection is not working properly, drainage and sewer systems then serve as convenient options for disposing of waste. These sectors might be governed by different departments in the municipality or even by wholly different institutions. To address the complex issue of plastic leakage, integration between these different sectors needs to be established.

Governance on the local level has to ensure that sufficient public services are provided and that plastic leakages are avoided to the greatest extent possible. To achieve this, municipalities (or any responsible entity on local level) require the necessary infrastructure and equipment, sustainable financing (of maintenance and operations), the required skills as well as institutional capacities. It is important that responsibilities and duties of local enabling stakeholders are clearly defined and commonly understood. Most of all, political will to address this issue is crucial.

Municipalities are often not the sole entity responsible for public services. Municipalities might form associations to jointly invest in and operate larger scale facilities to reap the benefits of economies of scale. Electricity, road management, water supply and wastewater management and others are often managed on a regional or even national level.

Key motivational drivers for improving management of solid waste are citizen satisfaction, access and control over funding as well as reputational benefits (e.g. being awarded "cleanest city"). The external economic impacts of environmental pollution in general and plastic leakage in particular is rarely understood and considered in political decision making. Therefore, national and even global leverage and incentives should be considered to support and motivate municipalities to actively tackle the problem. This could include technical assistance and financial support to overcome limitations on the local level in a shorter timeframe. Investing in capacity development on the local level supports the long-term sustainability of such measures. Local governance must be connected to national or even global actions, standards and financing.

Governance to change individual behaviour

The above forms of governance are in large part aimed at changing the behaviour of individuals in relation to how they dispose of plastic materials. How individuals buy, use and dispose of plastics is an important factor when assessing plastic leakage. Their behaviour is influenced by the enabling environment that either provides incentives for certain behaviour or establishes rules and enforcement against undesired practices. Consumer demand is one of the key drivers for the increased production of plastic products. In the absence of proper services, littering becomes a means of disposing of waste and can be a substantial contributor to plastic leakages. Lack of awareness or simple convenience can motivate people to throw waste on the street, into a river or at the beach.

To change individual behaviour, governance needs to support: 1) reduced consumption; 2) increased opportunities for and enforcement of waste collection, reuse and recycling; and 3) production of more durable, repairable, recyclable products. Triggering behavioural change requires education on the pathways and impacts of plastic pollution, which can travel upstream to the sources of plastic leakage. Individual behaviour is strongly influenced by one's surrounding conditions and cannot be improved if local services are not functioning adequately.

Governance instruments to address individual behaviour directly fall into four main categories:

1. **Inform and educate** about negative impacts of plastic pollution locally, within the river basin and globally and what steps can be taken to reduce it. Examples are:
   - Public awareness campaigns of source-to-sea issues of plastic pollution;
   - Discussion and exchange platforms between upstream-downstream stakeholders;
   - Inclusion of the issue of plastic pollution in regular education programmes, e.g. school curricula; and
   - Community involvement activities to prevent and/or address littering.
2. **Influence** how certain products or packaging are consumed and disposed of. Examples are:
   - Fees or bans on plastic bags;
   - Deposit refund systems for beverage containers or other return systems;
   - Bans on single use plastics;
   - Buy-back centres; and
   - Demands for more durable and recyclable goods.
3. **Regulate and enforce** behaviours that prevent plastic leakage. Examples are:
   - Fines on littering or illegal disposal;
   - Targeted enforcement in hotspots; and
   - Enforcement of segregating wastes for collection.
4. **Improve access** to related services to reduce incentives to use informal or illegal waste disposal. Examples are:
   - Reducing distances to collection points;
   - Increasing periodicity of collection to discourage informal disposal; and
   - Regional waste management solutions that reduce costs.

Integration of governance aspects in the river basin

As global, national and local governance that supports marine litter prevention is established, behaviours should change, resulting in reduced levels of plastic leakage in river basins. The global level can provide standards and international agreements that facilitate negotiations on actions between countries in larger river basins. To complement these efforts regional, river-based frameworks such as Integrated Water Resource Management (IWRM) or transboundary cooperation agreements should also address the need to prevent plastic pollution. To date, there has been little attention to the issue of solid waste management in river basin agreements as it has been seen as a municipal issue. The growing understanding of the role of river basins as conduits for plastic leakage to the oceans, necessitates addressing the sources of plastic pollution through river basin frameworks.

Taking a river basin view of the problem can help with identifying the hotspots for sources of plastic leakage and lead to prioritization among locations and types of interventions undertaken. Given the scale of the challenge, it is important to avoid a generic approach to investments and instead utilize the unit of the river basin to select priorities. The impacts of plastic pollution within the river basin, before it reaches the marine environment can also be addressed by taking the river basin view. Impacts may affect priorities within river basin agreements such as infrastructure within the basin being damaged or needing higher maintenance costs or basin flood control planning having to deal with increased flooding due to blockage of drainageways, etc.

Tackling the problem of plastic pollution from the river basin perspective can bring together upstream-downstream actors who may have not previously cooperated on waste and wastewater management. Addressing plastic leakage in river basin agreements can facilitate cooperation between municipalities across the source-to-sea system and can reduce conflicts between upstream and downstream parties. It can also facilitate relations between countries in transboundary river basins.

When establishing source-to-sea management and focussing on actors within a river basin, it becomes obvious that current governance structures have often been developed without taking the connections across the river basin into account. The challenge is not only to engage all actors along the source-to-sea continuum but to address the causes of pollution and the drivers of change across various management sectors as well. National level understanding of the linkages between different sectors and actors is crucial to be able to balance individual interests against the broader interest of maintaining the functions, economic potential and environmental protection of river basins and the oceans. Only with such understanding can coherent, fair and effective governance instruments be developed and successfully applied.

The prevention of plastic leakage and solid waste management are not yet developed as coherent services along the source-to-sea continuum. It is important for municipalities to understand the implications of their actions or inaction related to the reduction of plastic leakage and be held responsible. Source-to-sea governance for combatting marine litter incorporates into regulatory, financial and strategic decisions the links between plastic pollution and its impacts.

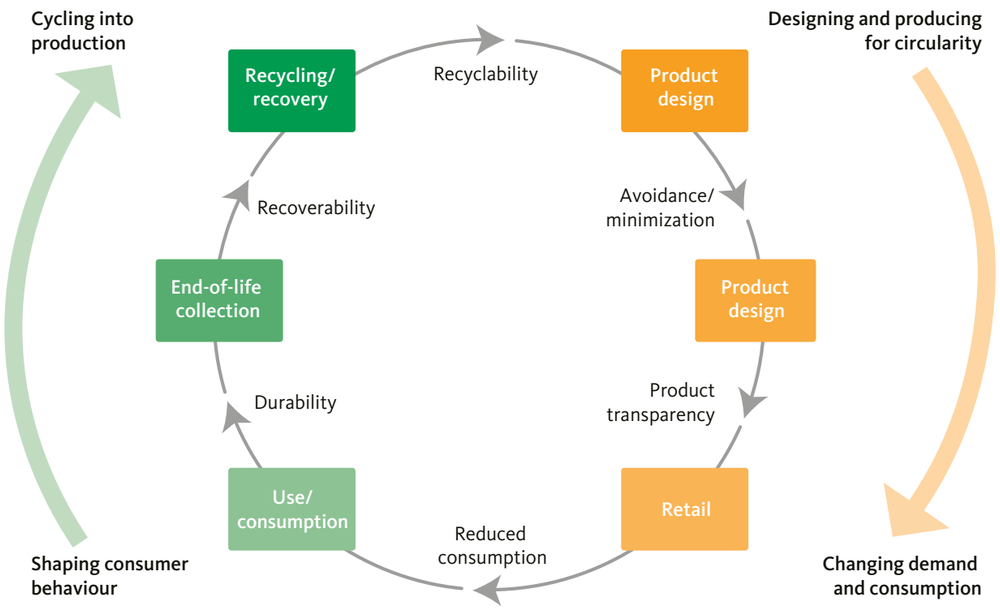

Figure 15: The steps of the circular economy.

Strengthening interaction and cooperation between municipalities broadens their response options and can link polluters with impacted parties. While a few examples exist where several municipalities share or co-finance larger investments such as treatment and disposal facilities, mostly waste management is handled locally. Taking a river basin perspective can facilitate novel approaches to regional governance, finance and management of waste and wastewater.

Connecting with the circular economy

The Source-to-Sea Framework for Marine Litter Prevention focusses on the transformation needed to gain control of plastic waste once it has already arrived in the river basin. The transition to a circular economy, on the other hand, is aimed at capturing plastic packaging and goods after their use and transforming them back into the production cycle (Figure 15). When fully functioning, this will eliminate plastic waste as it retains its value as a resource.

With its focus on getting control of plastic waste, source-to-sea management can reduce plastic leakage while steps are taken to develop a circular economy for plastics. Linking these two approaches together – source-to-sea management and the circular economy - presents the greatest opportunity to prevent marine litter (Figure 16).

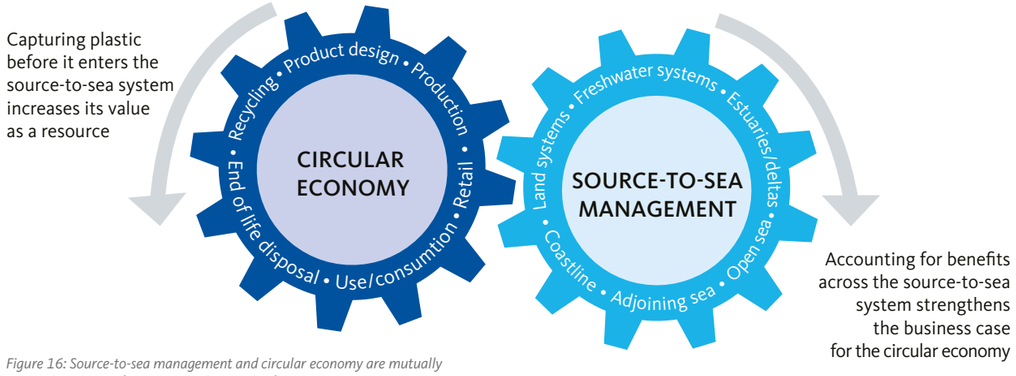

Figure 16: Source-to-sea management and circular economy are mutually supporting approaches to preventing marine litter.

Governance for circular economy

- **Avoidance / Minimization:** At product design level reducing the amount of material being used and avoiding, to the extent possible, the quantity of waste along the production line. This entails production processes as well as packaging requirements. Directly polluting ingredients or packaging, such as microbeads or Styrofoam, should be prohibited.
- **Transparency:** Producers disclose information not only about the ingredients of their products and the packaging but also about how well plastic packaging and products are being captured and recycled after consumption. Thus, enabling the consumer to make informed decisions on purchases.
- **Reduction:** Reduce the use of packaging material to the greatest extent possible and provide economic advantage or incentives to recyclable packaging and products. Single use plastics and non-recyclable packaging and products should be prohibited when alternatives are available or economically disincentivized to increase consumer ***demand for reusable and recyclable products.***
- **Durability:** Products should be manufactured in a way that extends their lifespan to avoid them becoming waste. Being easy to repair or to upgrade are further considerations that should be incentivized.
- **Recoverability:** After their useful life, goods and packaging need to be retrieved from the user or recovered from waste streams. The use of designs or materials that are easier to recover should be incentivized.
- **Recyclability:** In the same line as recoverability, goods and packaging should be designed in a way to facilitate their dismantling and recycling. Closed loop recycling needs to have a significantly higher incentive than downcycling.

STEP 4 – DESIGN:
What needs to change and how to get there

Steps 1, 2 and 3 shape our understanding of the linkage between plastic pollution and its impacts, of who is contributing to and who is suffering from such pollution and how governance on different levels tries to address plastic leakages. In Step 4, these three steps guide the design of a theory of change that can be used to design interventions that will lead to changes in behaviour and long-term impact.

GUIDING QUESTIONS

1. What is the desired long-term impact?
2. What social, environmental and/or economic benefits will be reaped by the primary stakeholders and to what extent will pollution be decreased as a result of the interventions?
3. What changes in practices or behaviours used by the targeted stakeholders are needed to achieve the desired long-term impact?
4. To what degree are enabling conditions present for the desired changes in practices or behaviours to occur and sustain over time?
5. What activities and intervention strategies will change the practices or behaviours of the targeted stakeholders and establish the necessary enabling conditions?

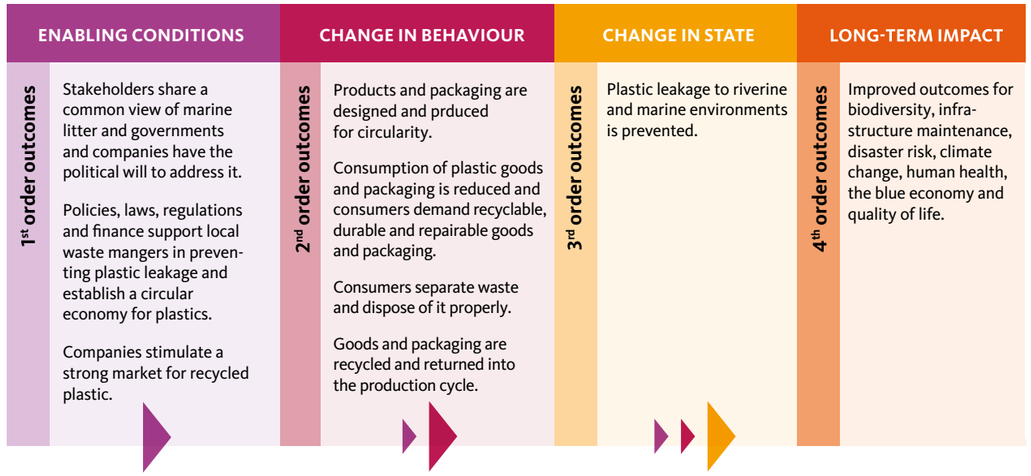

Figure 17: A theory of change framework for the source-to-sea approach– measurable outcomes disaggregated into four "orders".

A theory of change delineates intermediate steps that will lead to marine litter prevention. It describes the anticipated relationships between the actions that will be taken to establish the enabling conditions that will lead to the desired changes in behaviour. The intermediate steps in the theory of change indicate how the impact of interventions will be transferred to the goals of reducing plastic waste and preventing marine litter.

Four orders of outcome

In developing a theory of change, it is useful to look at four orders of outcome (Granit, et al., 2017) that can organize the design of interventions (Figure 17).

- *First order outcomes* are the **enabling conditions** that support the required changes in the behaviour of the targeted stakeholders as determined in Step 2.
- *Second order outcomes* are the **changes in practices or behaviours** identified in Step 3 as necessary to realize the desired changes in the source-to-sea flows and the resulting benefits for the primary stakeholders.
- *Third order outcomes* are the desired **changes in the status of the source-to-sea system** resulting from the restoration of priority flows that were characterized in Step 1.
- *The fourth order outcomes* are the expected **economic, social and environmental benefits** to be gained through implementation of the intervention strategies. The benefits accrue to the primary stakeholders identified in Step 2 and result from the improved status of the source-to-sea system due to preventing plastic leakage. For the full range of fourth order outcomes to be assessed, both direct and indirect benefits across all relevant source-to-sea segments should be considered.

Building a theory of change around these four orders of outcome links together the enabling conditions that are needed, e.g., governance, finance, infrastructure, capacity, with the behaviours and practices that need to change in order to prevent plastic leakage in river basins (Figure 18). Through seeing these links, it is possible to design interventions that most specifically drive change to the desired goal.

Photo: iStock

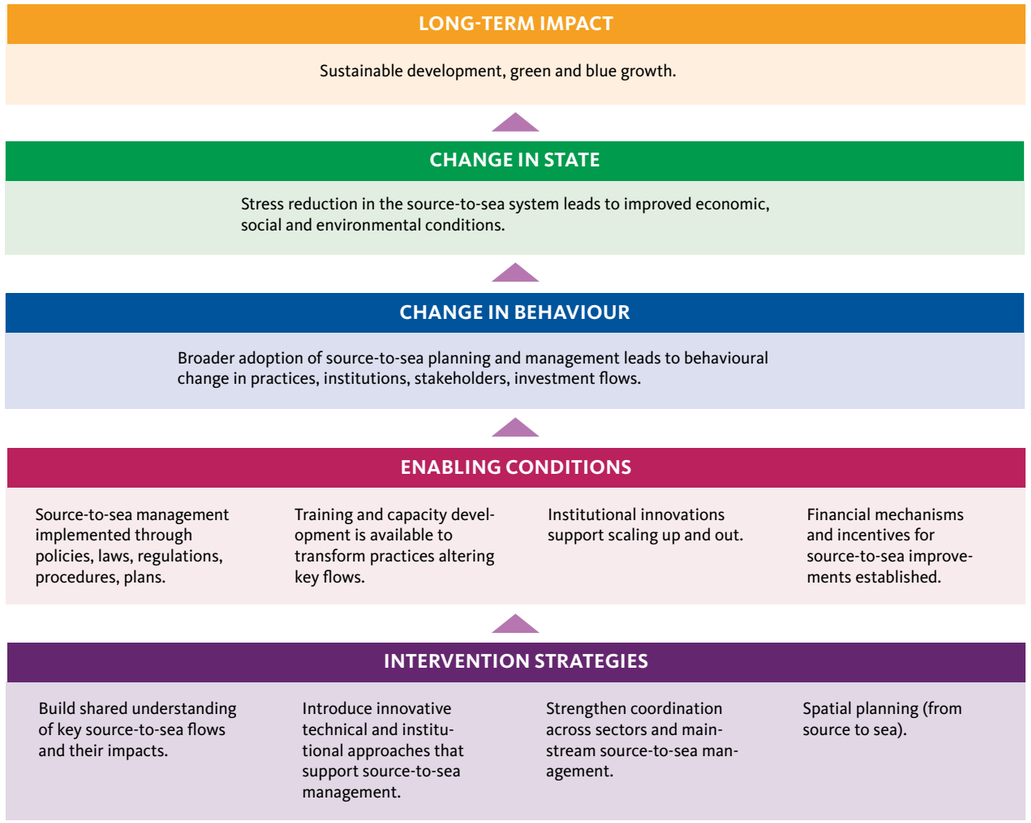

Figure 18: An example of a source-to-sea theory of change (Mathews et al. 2019).

Levels of intervention

Interventions are designed for each of the governance levels – individual, local, river basin, national and global – to contribute to reaching the ultimate goal of preventing marine litter (Figure 19). Starting with individuals, changes in behaviour contribute to less plastic leakage at the local level, while improved local waste management improves river basin conditions. Changes at the individual, local and river basin levels reduce the overall amounts of plastic leakage nationally, leading to less marine litter globally. Changes at the individual, local, river basin and national levels are facilitated by global commitments to address the problem of plastic pollution. These commitments filter down to national level policies, laws and regulations, as well as finance allocations, that improve waste management within river basins, at the local level, and support individual behaviour change. River basin agreements and plans also strengthen local level action.

The Source-to-Sea Framework links between levels and suggests a cascading attribution of responsibility from individuals and local governments, who cannot achieve the change alone, to the global community, where awareness is constantly growing. This will also promote a financial link descending from global sources of finance and capacity to local recipients, who need to bridge the gap between a current underfinanced and low performing system to gaining full control over their wastes.

The priorities at each intervention level vary according to the specific characteristics of each source-to-sea system. Generally, the local level needs increased capacity and financing and to connect with actors who support the change process. At the same time, the required shift in how we produce, trade and consume plastic products and packaging can only be achieved through changes at the global level.

Depending on priorities and the selected interventions, different actors must be involved and engaged to work collaboratively on the required solutions. As described in Step 3, different levels of governance play a vital role in combatting plastic pollution but those are rarely integrated within a river basin and most river basins have no dedicated governance structure. Working towards an integrated governance system from source to sea and across intervention levels, will contribute greatly to gaining control of plastic waste most efficiently. This does not necessarily require new formal institutions but could be based on, for example, voluntary commitments by all relevant actors.

Another continuous challenge is to identify the actors who best able to be the drivers of change. There is no rule for this. A national government might be motivated due to its political agenda or in response to international pressure. Individual municipalities might take the lead, because they are suffering the most or want to change their image. The plastic industry might step in to address the reputational risk of being seen as a polluting industry. There may be more than one driver of change, with different actors motivating change at different levels. The mapping of interests in Step 2 might give good indications of who could be a potential driver for change.

Based on such an understanding of the situation of plastic leakage in a river basin and its impacts, the priorities of what should be addressed first or what should be achieved have to be set. The questions to ask here are:

- On what governance level can the major sources of plastic leakage be best tackled?
- Is there a regional area within the river basin that includes these major sources or are they dispersed throughout the basin?
- Which sources should be addressed first?
- With these priorities in mind, which interventions will be the most effective?

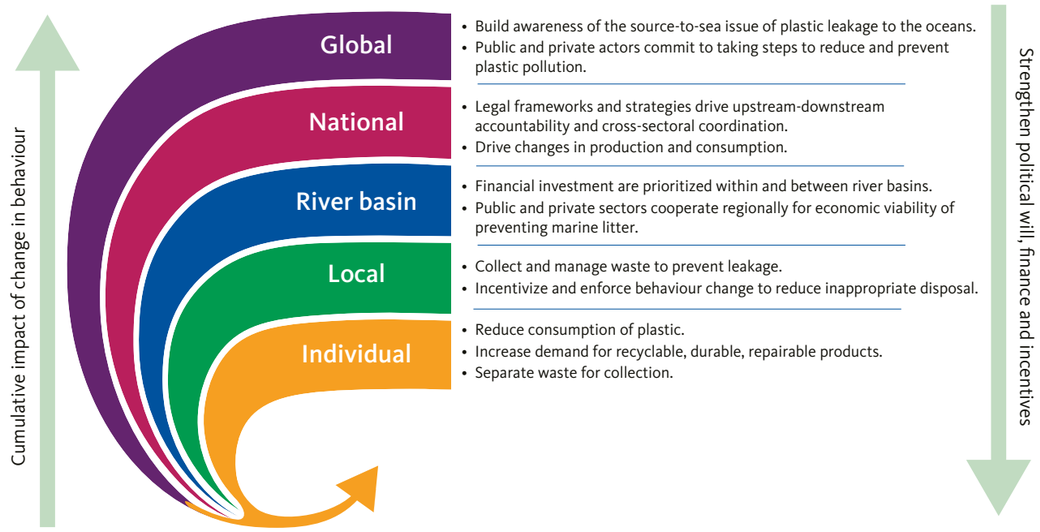

Figure 19: Interventions at each level support change toward marine litter prevention.

"The Source-to-Sea Framework links between levels and suggests a cascading attribution of responsibility from individuals and local governments, who cannot achieve the change alone, to the global community, where awareness is constantly growing."

Targeting local change

Applying the Source-to-Sea Framework can help direct resources available due to the growing global interest in marine pollution to solving issues at the local, regional and national scales where funding, capacity and infrastructure are insufficient to tackle the task of marine litter prevention. The immediate need is to direct the growing global, national and regional awareness and commitment to radically improving the capability of local waste managers to gain control of, reduce and capture waste plastics (Figure 20).

Accounting for the full economic and environmental value of direct and indirect negative impacts of plastic leakage along the source-to-sea continuum increases the economically viability of avoiding plastic pollution. Local management capacities and operations require support through adequate governance frameworks, sustainable financing and responsible behaviour. National provisions, in terms of regulations, financing and development support should back up the local efforts for reducing plastic leakage. While partly provided on the national level, full transformation of the waste management sector will require exchange, dialogue and conflict resolution, financing mechanisms across the source-to-sea system (i.e. as an economically expressed interest of downstream impacted stakeholders for upstream avoidance) and international funding. The costs of such measures should be weighed against the economic benefits of avoiding plastic pollution.

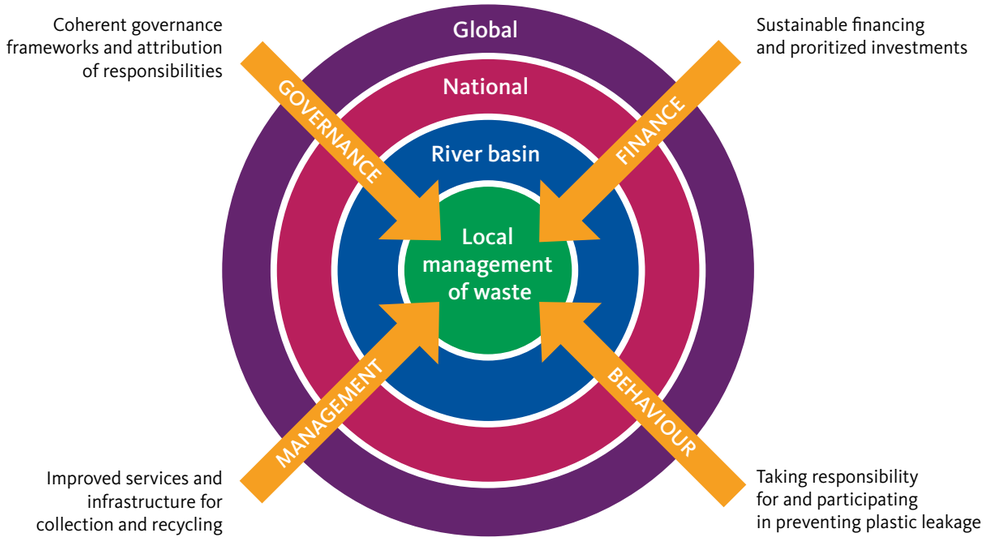

Figure 20: Gaining control of plastic waste at the local level through enabling interventions across levels and dimensions.

STEP 5 – ACT: Fund and implement intervention strategies

In Step 5, selected actions to prevent marine litter are funded and implemented.

GUIDING QUESTIONS

1. What are the intervention strategies needed to achieve the four orders of outcome elaborated in the theory of change in Step 4? Given the local context, what are the priorities, what changes in behaviour are needed, what level of governance, e.g., local, river basin or national, will support those changes?
2. What courses of action are needed to establish the conditions and commitments required to ensure long-term sustainability of source-to-sea capacity, funding and partnerships? Can the link between generators of plastic leakage and those impacted by it be established?
3. Are there financing partners or mechanisms that will support implementation of source-to-sea management? What are the links to global developments and interventions?

Based on the theory of change developed in Step 4, action has to be taken to reduce and ultimately prevent plastic leakage to the oceans. Several core principles direct what intervention strategies should be undertaken. Firstly, the Source-to-Sea Framework recognizes that to achieve the long-term impact of improving outcomes for biodiversity, disaster risk, climate change, human health, the blue economy and quality of life through the reduction of plastic entering the oceans (4th order), enabling conditions must be established (1st order) that support changes in behaviour (2nd order) resulting in measurable changes in the source-to-sea system (3rd order). Secondly, intervention strategies draw upon the source-to-sea approach, which builds a shared understanding of the problem of marine litter across source-to-sea segments and public, private and civil society sectors and establishes upstream – downstream linkages for action at local, river basin, national, and global levels. Thirdly, governance, finance, behaviour and management need to transform our relationship to plastic packaging and goods from a take-make-waste linear system to a circular model that maintains plastic as a resource. Lastly, local collection and management of plastic packaging and goods is the initial hotspot for intervention strategies and should be addressed first.

Achieving four orders of outcomes

Enabling conditions

As shown in Step 3, the current systems' shortfalls in dealing with plastic leakage is mostly founded in inadequate capacity of institutions charged with addressing the problem. In order to instigate substantial changes and long-lasting effects such capacities have to be built. One building block is an adequate legal, regulatory and procedural framework. Interventions need to address structural shortcomings such as a lack of legal definitions and adequate attribution of responsibilities along the whole source-to-sea continuum. Implementing and supervising institutions need to be equipped with the necessary legal and regulatory tools to conduct their tasks. Clearly defining procedures, elaborating forms, IT-based tools and other support are examples.

Improving institutional and individual capacities for all involved stakeholders is another relevant building block. This reaches beyond mere training programmes and should develop into a comprehensive capacity development approach. Specific to the issue of plastic leakage is to convey its mechanisms and environmental implications. Necessary budget allocations and long-term feasibility of the required governance structures have to be assessed and secured.

New or adapted infrastructure will be necessary to enhance waste management and more so, recycling capacities, and to improve their efficiency. While there is always an urge to aim for large scale, modern technology investments, these are in many cases not the most effective approaches. Infrastructure needs to be designed at appropriate scales and with the long-term development of the whole system around production and consumption in mind.

Investments and services need secure financing mechanisms. Regularly these are established through fees on services or on products. Approaches to finance gaps from insufficient services and poor fee collection towards adequate services and funding might need to draw from national and international support. Also, necessary funding mechanisms for innovation and improvements particularly towards circular design and production of products and packaging materials should be developed.

As plastic pollution and marine litter are just now entering the political and private enterprise agendas, building

a common knowledge and understanding of the issue and its impacts, as well as defining the language and methods to describe the problem are important steps in stimulating the buy-in from both sides.

We also understand that plastic leakage concerns not only one particular sector but rather has its causes and impacts across several sectors. The stakeholders of these sectors (such as water, waste, wastewater, coastal, tourism, agriculture, aquaculture, biodiversity, consumer goods production) need to be engaged and motivated to join cross-sectoral cooperation. Depending on the local situation, key stakeholders within the river basin will be identified. Support to coordination, cooperation, partnerships and joint initiative efforts should be provided. At the same time, local participation processes should be promoted to involve ideas and needs of citizens in the design of new management systems.

Changes in behaviour

Changes can, despite all frameworks, tools and procedures, be achieved only if the relevant actors change their behaviour or become active in their roles and responsibilities. Therefore, intervention strategies address the motivational drivers of the different stakeholders across the river basin and develop incentives for behavioural change.

Service providers and clients of waste management services need to be incentivized to contributing to system improvements. The former by setting up and maintaining adequate services, the latter by properly separating and/or disposing of their wastes. Current service providers must understand their relevance beyond the immediate service provision. Regulatory and financial mechanisms should be put in place to incentivize improved services and penalize a lack thereof. Weak enforcement capacities need to be strengthened. Hotspots of plastic leakage and their producers should be identified, holding them responsible for reducing or stopping the leakage.

In addition, the reduction, reuse and recycling of plastics through private sector activities should be encouraged through legal, voluntary and reputational mechanisms. This entails particularly the strengthening of capacities of the formal and informal sectors for reuse and recycling of plastics.

More complex is promoting the shift from the dominant linear system of production and consumption towards a circular economy approach. Here a broader group of stakeholders needs to be engaged, including the consumer goods production sector among others. Existing intervention strategies are in their very early stages and provide little guidance yet. However, interventions need to focus on providing the underlying structure for a circular economy, initially this might be mainly driven by supporting the financial value of recyclables versus the costs of becoming waste and requiring adequate treatment.

Change in state

The target of reducing the amount of waste released into the environment and potentially into waterways and ultimately preventing leakage at large would be the positive outcome of the previous two orders. Therefore, this level requires providing feedback to interventions on first and second orders to maintain or increase the dynamics of change and readjust interventions. This is closely linked with the task of quantifying the changes that have been achieved. Agreeing on potential goals, such as the reduction of plastic leakage in the river basin (or a more limited project area) by some per cent per year and implementing reliable and accepted monitoring and reporting structures are important for maintaining communications and incentives.

Monitoring should not only include the level or reduction of plastic leakage but also provide quantifications of its impacts and relate the economics of reduction measures with the economics of reduced impacts on economic losses, biota and ecosystems, infrastructure and disaster risk and human health as well as on quality of life aspects.

Long-term impact

Intervention strategies that support the long-term impact of combating plastic leakage should focus on the transformational process towards a circular economy. Here the regional and international integration of efforts to change product design, demand, customer behaviour and to close the material loop are relevant as such changes will hardly occur just on the national level. Shifting financial resources towards sustainable and circular 3R (reduce, reuse, recycle) economies should guarantee the momentum for change.

Managing from source to sea

In terms of intervention strategies, the Source-to-Sea Framework sits between the local need to fix the issue and change behaviour and the global drivers to combat plastic pollution. In this regard managing the issue from source to sea primarily requires the establishment of communication between the relevant stakeholders, both upstream and downstream. Awareness on both sides needs to be created without a one-directional attribution of blame and shame.

Constructive communication and coordination between sectors, within river basins and among nations that balances financial limitations to combat leakages with the economic and other losses caused by plastic pollution needs to be established. As elaborated in Steps 3 and 4, the assessment of economic and ecological damages and the most effective solutions have to be developed and discussed. As this is still a quite new field there are no well-established methodologies for such assessments. Most current approaches focus on economic losses in the tourism sector and potential costs for fishing vessels (Krushelnytska, 2018). Research and the development of methodologies that allow a transparent and practical quantification need to be developed. Conducting guided discussions within the source-to-sea approach between primary and targeted stakeholders on the specific relevance and priorities of impacts can work as an interim form of assessment.

Another function of the Source-to-Sea Framework is to link local and regional initiatives with internationally available funding. If regional approaches that address plastic leakage in river basins are developed, financing can be more easily secured than for individual, locally based interventions whose systemic impacts are much more difficult to measure.

The Source-to-Sea Framework illuminates the connection between all these elements and the design of interventions arises from the analysis done in Step 1–4.

Gaining control over our waste

While working towards a circular economy in the long run the most pressing issue is to establish the management systems that maintain control of wastes. In many cases the very basics of waste management services need to be established. While the topic of plastic polluting the oceans has created a significant driving force towards improving waste management services the underlying barriers are still difficult to overcome. All development steps must be addressed for sustainable waste management systems to be established.

The foremost challenge is to establish sufficient collection, treatment and disposal capacities to guarantee adequate services for all citizens. These again require suitable governance structures and of course financial resources for infrastructure, maintenance and operations. Considering the impacts of plastics on different actors along the source-to-sea continuum, regional or international financial compensation that support improvements where they are most needed could be established.

In addition to the more generic aspects of enabling conditions and changes in behaviour mentioned in Step 2, local waste management services can benefit from several specific intervention strategies. The challenge lies in the necessary rapid upgrading of collection services for large numbers of the population who cannot afford or are not used to receiving and paying for high standard waste collection services. Experience shows that deploying large investments hasn't been sustained in many cases and service levels deteriorated again. Also, in many countries recycling economies are driven by market prices and therefore capturing only valuable recyclables. Many types of products and packaging cannot reasonably be recycled and end up as waste in the environment. However, several implementation strategies have been successful in some countries and might be adapted to other localities.

Community-based collection systems require substantial support when setting them up and providing the necessary capacity for the operators. They can then be upscaled easily and provide the additional benefit of promoting active public participation on a neighbourhood level. While such systems are not suitable for every city or easily adapted in every country, they provide the proposition of sustainable basic services provided close to the citizens, as such overcoming some of the major obstacles of deficient service provision. Locally established services often allow for segregation and/or recycling close to where waste is generated.

Attributing market value to plastics that are either non-recyclable or not economically recyclable can be a strong motivation for separate collection or sorting close to the generation point for formal or informal service providers specifically in low to middle income countries. Recycling value chains operate usually with very low margins and are therefore quickly receptive to such economic incentives. Examples are buy-back centres that accept unsorted plastic waste and market schemes for non-recyclable plastics to be used as refuse-derived fuel (RDF).

Performance-based grant schemes incentivize local authorities to achieve higher levels of service provision by providing additional grants or investments based on key performance indicators, such as collection rates or sound disposal. These schemes provide, in addition to the financing, a competitive as well as a recognition element that can make the schemes highly effective in incentivizing local authorities to prioritize improvements in waste management services. They however require a certain level of capacities in the municipalities, substantial external support to establish the necessary monitoring and reporting system and quite transparent funds management.

Private sector participation has been a headline for improving waste management services worldwide for quite some time now with sometimes very mixed results. However, with local small and medium enterprises, substantial improvements in service delivery can be achieved. In any case, private sector participation requires capacity development for both the public and the private sector and a high level of transparency and monitoring capacity on the public side.

Support planning, investment and implementation in municipalities for them to adequately design and implement suitable systems. While support comes from private technology providers, municipalities often do not have the necessary capacity to assess their options and the respective cost implications. Financing is often provided through international cooperation within their development programmes but should ideally be more flexibly available for municipalities that are interested in improving their systems. Linking such municipalities through the

Source-to-Sea Framework to readily available international support would be a key driver for change.

Ban on certain single-use plastics, which examples in East Africa have showed that even in less developed economies such a step is possible, and the impacts are remarkable. Products range from plastic bags to food containers, earbuds and others. While not as efficient in terms of absolute quantities, such measures have an immediate and substantial impact on plastic littering on land and visible intake into waterways. In March 2019, the EU issued the single use plastics directive, banning selected single use products made of plastics, promoting the reduced use of products such as beverage cups, establishing extended producer responsibility (EPR) schemes to cover the costs of clean-ups (e.g. for cigarette butts) and introducing collection target of 90 per cent for plastic bottles in 2029 (European Comission, 2019).

It is important to mention that such interventions are being applied on local or national levels in different parts of the world. While these can provide specific improvements, the benefit of applying them under the Source-to-Sea Framework is that the selection and combination between these (and other potential interventions) are driven by an assessment across the whole river basin. Source-to-sea stakeholders can prioritize the interventions that support the governance systems, financing and technical assistance mechanisms that will change behaviour and prevent marine litter.

Support the transformation towards a circular economy

Transforming consumption and production patterns towards a circular economy will avoid plastics becoming waste that might enter riverine and marine environments. By differentiating the impacts of plastic leakage across the source-to-sea system, the Source-to-Sea Framework provides additional arguments for such a transformation. Understanding the economic, social and environmental impacts of plastic pollution across the river basin and in the ocean, demonstrates the benefits of implementing circular economy approaches. Accounting for the benefits from source-to-sea arising from the prevention of plastic pollution provides a basis for the argument for implementing strategies geared toward gaining control of plastic waste, ahead of a fully established circular plastic production and consumption system.

The field of measures related to circular economy far exceeds the scope of this document. However, the following box summarizes some relevant intervention strategies.

Intervention options towards a circular economy

DESIGNING AND PRODUCING FOR CIRCULARITY

- Establish extended producer responsibility (EPR); producer is fully responsible for the product, even after use
- Technical standards include criteria for recoverability and recyclability
- Fees and taxes for production waste incentivizes reduction measures
- Fund development of new designs and production methods
- Invest in research and development

CHANGING DEMAND AND CONSUMPTION

- Cooperate with industry to establish same or similar product and environmental standards for their products worldwide
- Address issues such as single use sachets through a worldwide responsibility of companies
- Extend producer guarantees and take-back requirements
- Create business models based on services provided instead of product-oriented consumption

SHAPING CONSUMER BEHAVIOUR

- Strict labelling requirements to indicate recoverability and recyclability of materials used in products
- Eco-taxes on short-lived or waste-intensive products
- Awareness campaigns on sustainable consumption

CYCLING INTO NEW PRODUCTION

- Establish progressive obligatory rates for closed loop recycling for all possible product categories
- Ban or limit the export of plastic waste to countries with limited environmental standards and/ or capacities
- Invest in research and development of recycling technologies

Photo: iStock

STEP 6 – ADAPT: Monitoring and assessment

In Step 6, outcomes are monitored and used to manage adaptively for progressive success and learning is captured and disseminated.

GUIDING QUESTIONS:

1. What baseline data and targets have the relevant stakeholders agreed upon?
2. What is the appropriate set of indicators that will monitor progress towards source-to-sea first to fourth order outcomes?
3. Have the assumptions elaborated in the theory of change been confirmed or is there new learning about the relationships between intervention strategies and outcomes?
4. What are the lessons learned and how can they be disseminated to expand the reach of the interventions?

The source-to-sea approach includes as a final step: monitoring and assessment that circles back into Step 1 and onward in an adaptive management cycle. Solving the problem of plastic in the ocean requires eliminating the sources throughout the source-to-sea system. When considering what monitoring needs to be done when applying the Source-to-Sea Framework, three aspects need to be addressed:

- The nature of plastic production, leakage to the oceans and its impacts needs to be understood;
- Comparable, comprehensive data on sources, behaviour and impacts is needed to support effective action; and
- Monitoring the progress along the four orders of outcome will strengthen understanding on relationships between actions and results.

The aim of the source-to-sea monitoring system would be to assess the progress at each level of intervention – individual, local, river basin, national and global – and provide feedback on the success of the interventions that have been implemented. Monitoring will measure advances in the reduction of plastic leakage in river basins and the oceans as well as the negative impacts. Monitoring should identify trends and capture knowledge so that it can be used to strengthen the theory of change and support adaptive management and collective learning.

Improving available data

Interventions undertaken through application of the Source-to-Sea Framework are based on stakeholder dialogue that develops a common understanding between polluters (targeted stakeholders) and those impacted by it (primary stakeholders). For this, reliable information on the amount of plastic entering water bodies and its respective sources as well as the pollution pathways is necessary.

Monitoring plastic leakage is a challenging task with no standardized comprehensive approaches available yet. Currently estimations are based on accessible data such as plastic consumption, waste generation quantities and collection service coverage. Yet, for a reasonably comprehensive baseline assessment the following data sets are relevant:

- Amount/ type of plastics produced;
- Amount/ type of plastics managed properly, including recovery and recycling percentages;
- Amount/ type of plastics leaking to waterways and entering the oceans;
- Pathways for plastics entering riverine and marine environments and amount/ type entering through each pathway; and
- Quantified negative impacts of plastic pollution, if possible, in economic terms (loss of income, repair or mitigation costs, loss of growth potential).

Given the challenge of the lack of data and agreed upon measurement methodologies at the moment it is important to build a strong and preferably participatory baseline description that is reasonably acceptable to all stakeholders. Models such as the GIZ assessment tool for plastic leakage (Renaud et al., 2018)) already support this. However, further research is needed to produce reliable and accurate numbers within a river basin, across countries and regions. Standardized methodologies would help to build a more convincing case and reduce discussion over numbers between stakeholders. Linking the monitoring of source-to-sea interventions to other and larger-scale monitoring approaches, such as the monitoring of Sustainable Development Goals (SDG), would increase the visibility (and potential recognition) of those who take action.

Monitoring the four orders of outcome

Four types of indicators can be used to monitor progress along the four orders of outcome: process, stress reduction, environmental status and impact indicators (Figure 21).

Progress indicators measure the successful establishment of the enabling conditions. Examples could be:

- Stakeholders agree on a common definition on sources and impacts of plastic pollution;
- Relevant government institutions or the private sector show clear commitment to measurable targets;
- The institutional and legal framework for combatting plastic leakage is developed and being implemented;
- Municipalities revise their planning and/or budgeting to provide better waste and wastewater management services; and
- International actors are actively linking with local initiatives.

Stress reduction indicators quantify the changes in behaviour and practices that will reduce the amount of plastic leaked to riverine and marine environments. Examples could be:

- The use of particularly polluting products or packaging is reduced or removed;
- The consumption of single-use or non-recyclable plastics is reduced;
- Waste collection services and participation in them are improved;
- Recycling rates for plastic materials have increased; and
- Waste is separated and deposited with appropriate collection services.

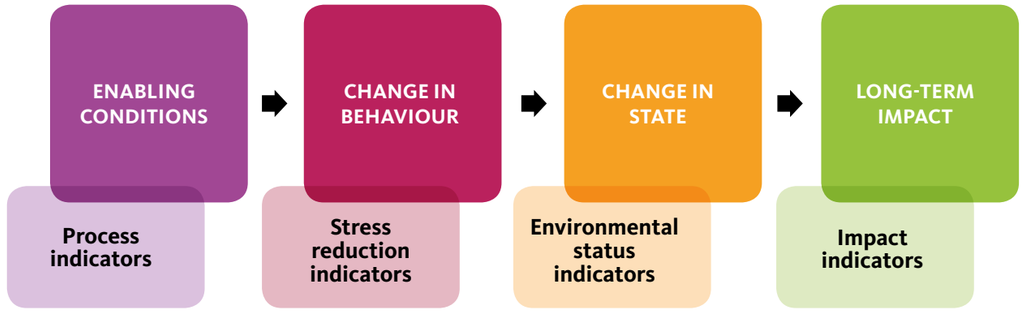

Figure 21: Indicator sets to monitor the four orders of outcome.

Environmental status indicators measure how the measures carried out on the previous level are translating into a reduction of actual pollution as observed in water bodies, including oceans. Here potential sources outside of the scope of the interventions have to be considered as well. Examples could be:

- Plastic concentrations in rivers, coastal areas or the adjacent sea are reduced;
- Visible improvements in waste accumulated along riverbanks; and
- Less concentrations at specific accumulation points (e.g., dams, water installations, drainage canals).

Impact indicators are then measuring improvements for the overall system in a long-term perspective. These aim at the six impact categories as defined in Step 1. Examples could be:

- Reduction in economic losses;
- Healthier ecosystems;
- Less burden on human health;
- Reduced maintenance costs for infrastructure;
- Decreased contributions to disasters;
- Improved ecosystem and biotic health; and
- Better quality of life.

Continuous monitoring forms the basis for an adaptive management approach that allows for a dynamic interaction between implementation and adaptation of the intervention strategies. Joint learning and continuous striving for efficiency in reducing plastic pollution and its impacts characterize a successful Source-to-Sea Framework implementation.

Conclusions

The Source-to-Sea Framework for Marine Litter Prevention (Figure 22) is a valuable contribution to the rapidly increasing need to prevent plastic leakage to riverine and marine environments. Drawing from the source-to-sea conceptual framework (Granit et al., 2017) and practical guidance (Mathews et al., 2019), the Framework follows six steps that together present a methodical approach to understanding the types, sources and impacts of land-based plastic pollution, the various actors that contribute to the sources of and solutions for plastic leakage and the analysis of the current governance, management, operations and behaviours leading to marine litter.

By stressing the linkages across the source-to-sea system, the Framework incentivizes cooperation between upstream and downstream actors, as well as coordination across sectors who can come together to prioritize investments into establishing the enabling conditions that drive changes in behaviour from individual to global levels. Engaging a broader set of stakeholders in supporting improvements in local waste and wastewater management, will help break the cycle of inadequate resources at the local level, resulting in improved services and increased local participation.

The Source-to-Sea Framework for Marine Litter Prevention is a holistic management approach that can be integrated with existing approaches such as Integrated Water Resources Management (IWRM), Coastal Zone Management (CZM) and Marine Spatial Planning (MSP). By placing the river basin at its core while being inclusive of the entire source-to-sea system, the Framework stitches these other approaches together.

Due to the global concern about plastics in the oceans, the Framework also encapsulates interventions at individual, local, river basin, national and global levels. When using a source-to-sea approach, global concern about marine litter filters down to the national, river basin, local and individual levels, elevating the priority of gaining control of plastic waste in public sector agendas. Simultaneously, the changes in behaviour, practices, management and governance on both individual and local levels combine to achieve a cumulative improvement in river basins, nations and ultimately the oceans.

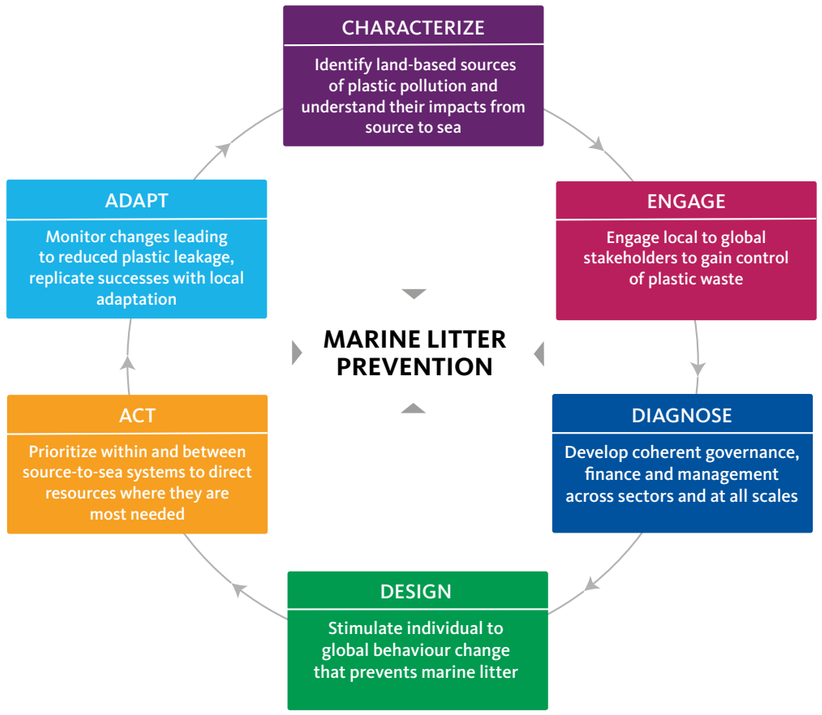

Figure 22: The six-step Source-to-Sea Framework for Marine Litter Prevention.

While the Framework provides a stepwise process for selecting priority interventions, the success of those interventions will, in part, be dependent upon the level of knowledge available as inputs to the steps. Efforts to develop methods to characterize the types, sources and behaviours of plastics in riverine and marine environments are ongoing and these methods can be further developed as they are implemented in various locations. Less developed and urgently needed is a better understanding of the impacts of plastic pollution as it travels through river basins and out to sea. These impacts can range widely from influences on freshwater and marine life to human health and climate change and can encompass broad areas of planning such as flood control, dam operations and economic development opportunities. As these impacts and their ramifications are better understood, the impetus for stakeholders from source to sea to engage and invest in changes will evolve.

The Source-to-Sea Framework for Marine Litter Prevention is founded on two tenets: taking a source-to-sea view of the problem of land-based sources of plastic pollution will funnel resources to local waste and wastewater managers to enable them to gain greater control of plastic waste and secondly, assessing the impacts of plastic pollution from source to sea will strengthen the business case for the transition to a circular economy for plastic. These two circles – from source to sea and back upstream again and from raw materials to products, to use and back to production materials – are like two intersecting cogs that drive each other, one providing services that manage end of life disposal, the other driving demand for plastic waste to be recycled. The solution for preventing plastic pollution lies in both of these working together.

Central to this is establishing the policies, laws, regulations and plans that direct funding toward priority locations and actions that will prevent plastic pollution and result in improved social, environmental and economic outcomes across the source-to-sea system and additionally, the conditions necessary to transform to a circular economy. Current priorities at the national level fall short of these aims and there is a strong need for the global interest in the plastic problem to influence changes at the national level that manifest in local and individual changes in management, practices and behaviour. Getting finance and capacity to the most important places is essential and the Source-to-Sea Framework can help with setting priorities for those investments. The Framework supports the strategic design of interventions that most concretely shift the paradigm away from uncontrolled growth in plastics in rivers and oceans. Taking a source-to-sea perspective in river basins will maximize these investments.

Plastic in the oceans has catalyzed global attention to the problem of poor solid waste management and the uncontrolled human consumption of plastic goods. It is important to keep in mind that this is just one of many issues that are degrading riverine and marine environments and diminishing those social and economic opportunities which depend upon healthy ecosystems. It would be prudent to expand the concern to include other issues. The Source-to-Sea Framework we offer here can be adapted to other alterations of the source-to-sea system and all investment in building the capacity for source-to-sea management will will be beneficial to addressing these other issues. Using this holistic source-to-sea approach to preventing plastic pollution will begin building a foundation for improved social, environmental and economic outcomes from source to sea.

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