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POLICY BRIEF: CREATING A STRONG INTERFACE BETWEEN SCIENCE, POLICY AND SOCIETY TO TACKLE GLOBAL PLASTIC POLLUTION

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Plastic pollution has increased dramatically to reach even the most remote parts of our planet. It affects all natural environments from deep oceanic sediments to the atmosphere and agricultural soils, and threatens human health through plastic found in blood, the brain and breastmilk. Plastic pollution is a global problem that extends beyond environmental and human health concerns, with additional implications for socio-economics, intergenerational justice and human rights.

Over the past few decades, scientific studies have unveiled the mounting threats and risks posed by plastic pollution, which require immediate global action. Current negotiations on a legally binding instrument to tackle plastic pollution, including in the marine environment, require a strong science–policy dialogue to facilitate the uptake of existing scientific knowledge. Implementation of this instrument also requires long-term and sustained scientific participation through a mechanism at the interface between science, policy and society. This policy brief provides a set of functions and principles to guide the scope, objectives and institutional arrangements of such a mechanism.

Photo: Close-up of empty plastic milk bottle on the ground. Ivan Radic/Flickr.

KEY MESSAGES

1

Plastic pollution is a rapidly accelerating and complex challenge that affects the entire planet. The versatile properties of plastics have led to increased production over the past 60 years, resulting in extensive accumulation of waste and growing risks. Overcoming this crisis **requires urgent global-scale action** drawing on the most up-to-date and multidisciplinary science.

2

Addressing global plastic pollution **requires a systems approach** – to comprehensively tackle the entire life cycle of plastic and associated multidimensional effects, and focus on integrated solutions that can address the interconnected nature of social, environmental and economic impacts.

3

Significant scientific advancements have deepened our understanding of some of the risks and consequences associated with plastic pollution, including for ecosystem, biodiversity and human health, and of the behaviour, fate and persistence of plastics in the environment. Ongoing research aims to explore emerging areas and fill gaps in knowledge, as well as ensure effective strategies for tackling the plastic pollution crisis.

4

Vested interests limit current actions to reduce plastic pollution and constrain efforts towards a complete approach. For instance, some approaches that involve recycling or alternative materials, and which claim to be 'sustainable', may have adverse consequences. Effective transformation therefore **requires understanding the politics of the plastic crisis** along with economic, sociological, anthropological and cultural dimensions.

5

Integrating **rigorous scientific knowledge can significantly bolster ongoing negotiations**, and reinforce the international instrument to tackle plastic pollution. Interaction between Member States, scientists and other stakeholders could be enhanced through a platform established under the Intergovernmental Negotiating Committee on Plastic Pollution (INC) Secretariat. The platform would aim to foster a two-way dialogue among stakeholders for jointly framing policy questions and needs, providing evidence, assessing solutions and communicating risks effectively.

6

A **mechanism at the science–policy–society interface** could guide and inform implementation and monitor effective progress on the international instrument. This mechanism would provide scientific guidance, support and up-to-date evidence from a wide range of scientific fields – guided by principles of independence, policy relevance, interdisciplinarity and inclusivity.

I. GLOBAL PLASTIC POLLUTION: A COMPLEX AND RAPIDLY ACCELERATING PROBLEM ADVERSELY AFFECTING PEOPLE AND NATURE

Plastics are found everywhere nowadays, even in the most remote locations like polar regions and the deepest point on Earth, the Mariana Trench, as well as in human blood (Leslie et al., 2022) and lung tissue (Jenner et al., 2022). The inexpensive, versatile, durable and lightweight nature of plastic materials have enabled significant advances in construction, electronics, transportation, food and medicine; for example, plastics are used for a wide range of medical applications including blood bags, tubing, disposable syringes and surgical gloves (Hahladakis et al., 2018). These characteristics have led to a sharp increase over the past 60 years in plastic production, use and waste. It is estimated that approximatively 6,300 million metric tons (Mt) of plastic waste were generated by 2015, of which 79% accumulated in landfill or the natural environment. Substantial increases are projected if current trends continue unabated, with 12,000 Mt of plastic waste expected to end up in landfill sites or the natural environment by 2050 (Geyer et al., 2017).

More than 98% of plastics are produced from fossil fuel sources. They comprise complex mixtures of polymers, with chemicals added to improve the performance, functionality and life span of the final product. This mixture of polymers and chemical additives poses biological and ecological health risks and undermines systems designed to ensure safe, toxin-free and responsible waste management and to promote reusing, refilling and recycling. Plastic materials have been acknowledged as 'threat multipliers' (Ford et al., 2022), acting together with other stressors such as climate change, environmental degradation, pollution and waste to cause huge damage through intensified and combined pressure on our planetary boundaries (Bachmann et al., 2023).

Of increasing concern are microplastics and nanoplastics, released into the environment either as primary microplastics or through the gradual fragmentation of almost all plastics into smaller particles as they enter the air, water, soil, food, flora and fauna. Evidence shows that these small fragments, less than 5 mm in size, can be ingested by small organisms at base of the food web; these include zooplankton, chaetognatha, ichtyoplankton and salps (Hollman et al., 2013). This allows plastic particles to move through food chains and affect a wider range of species, including humans. Research has shown that due to their small size, nanoplastics potentially penetrate the

Photo: Plastic recycling. Adam Cohn/Flickr.

physiological barriers of organisms and accumulate in their organs (Lai et al., 2022). Furthermore, microplastics and nanoplastics can adsorb, transport and leach toxic chemicals, such as heavy metals and organic pollutants, amplifying harmful effects as they enter different organisms and ecosystems.

Plastic pollution poses a global threat with far-reaching consequences. Its impacts extend beyond environmental and human health concerns, and encompass socio-economic implications relating to consumption patterns, resource management and environmental and intergenerational justice (Stoett, 2022). Addressing this global issue requires a systems approach to comprehensively tackle the entire life cycle of plastic, and a focus on integrated solutions that can address the interconnected nature of social, environmental and economic impacts. In addition to drastically changing current practices, some safer and more sustainable solutions and strategies include minimizing production of virgin plastic, and eliminating harmful polymer precursors and additives, primary microplastics and nanoplastics, and unnecessary, non-durable plastic products such as many single-use and disposable items. Another key focus should be funding the research and development of alternative, science-based safe and sustainable solutions without adverse consequences, in order to avoid 'regrettable substitutes'.

Multidimensional and unequal effects

Plastics and related chemicals harm or pose risks to all environmental spheres and human health as they contain known human carcinogens such as acrylonitrile, perfluorinated and polyfluorinated substances, endocrine disruptors such as Bisphenol A, phthalates, neurotoxicants and persistent organic pollutants such as polybrominated diphenyl ethers. Inappropriate use, disposal and recycling may lead to the undesirable release of potentially toxic substances, leading to human exposure and pollution, which can result in various health conditions. For example, plastic-related toxicants can contaminate protein sources, such as fish and seafood, which can have negative impacts on human health. The impacts of chemical additives are especially concerning for infants and young children, as early-life exposure to plastic-associated chemicals can increase the risk of multiple non-communicable diseases later in life (Landrigan et al., 2023).

In addition, there are strong linkages between plastic pollution and loss of biodiversity and ecosystem resilience. For example, plastic materials can carry invasive species and pathogens through waterways, potentially harming local ecosystems and wildlife. Pathogens such as bacteria and viruses can attach to plastic, be ejected by the bubbles of breaking waves, and be transported across oceans and other water bodies, increasing the risk of disease outbreaks among marine animals and humans exposed to contaminated water (Beans, 2023).

Plastic production, use and disposal also play a role in exacerbating the causes and impacts of climate change. For instance, sunlight and heat cause plastics to release methane and ethylene (Ford et al., 2022) – and at an increasing rate as the plastic breaks down into ever smaller pieces. In addition, microplastics can affect the ability of marine microorganisms to absorb carbon dioxide and release oxygen, potentially disrupting carbon cycling and the ability of the ocean to mitigate climate change.

Beyond health and environmental concerns, plastic pollution has a wide range of socio-economic costs that particularly impact economically and politically marginalized groups and geographies (Paul et al., 2023). For example, the millions of waste pickers who live near massive trash dumps in places such as Manila, Rio de Janeiro and Bengaluru and depend on plastic waste for their livelihoods are vulnerable to health impacts: increased evidence shows that prolonged exposure to plastics can potentially decrease fertility and affect metabolic, hormonal and neurological functions (Stoett, 2022). Another example is Small Island Developing States (SIDS), which are both economically vulnerable to and disproportionately affected by plastic pollution (Guillotreau et al., 2023). The impact of plastic pollution ripples through SIDS economies, which are predominantly dependent on tourism and fishing (Owens et al., 2011). While dirty beaches deter tourists, marine litter damages fish stocks and boats; both result in economic loss and instability. A binding international agreement on plastic pollution could serve as a lifeline to these vulnerable nations and populations, while also

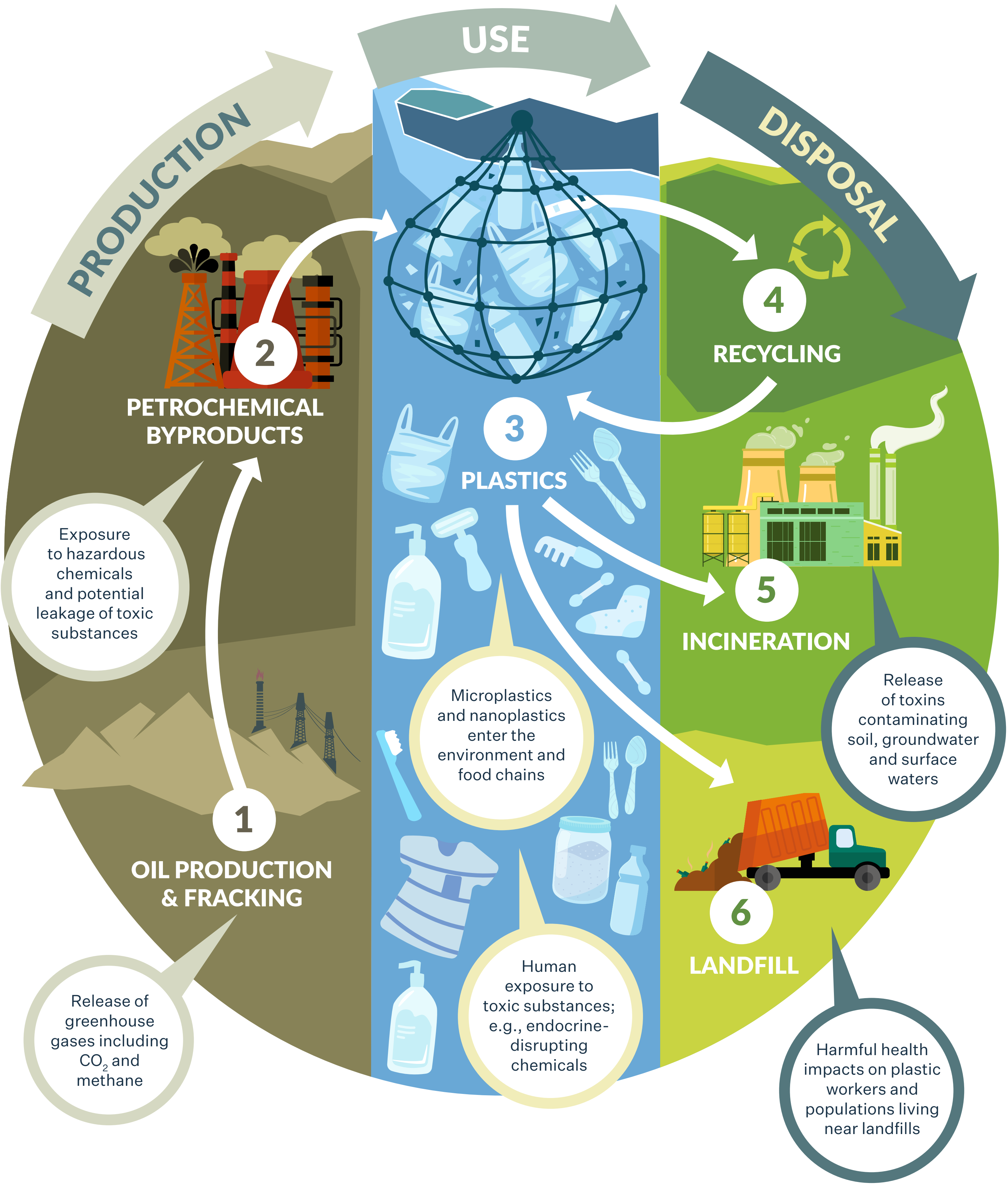

Figure 1: Multidimensional impacts of plastic pollution across the plastics life cycle

emphasizing the global significance of addressing this critical issue.

A systems approach to address global plastic pollution

Reducing and ultimately eliminating plastic pollution require a systems approach to guide action throughout the entire life cycle of plastics (Courtene-Jones et al., 2022). This includes addressing not only the environmental, human health and economic challenges posed by plastics, but also underlying factors such as the current practices, attitudes, behaviours and cultural and geographic influences that drive unsustainable polymer and plastic product manufacture and use.

It is therefore imperative for action to be guided by integrated, interdisciplinary scientific research that examines the whole life cycle of plastics, from production to disposal, and embraces the interconnected nature of the plastic pollution issue. Moreover, the international response to plastic pollution should employ multistakeholder and cross-sectoral approaches, including traditional knowledge, innovations, the practices of Indigenous peoples and local knowledge systems. Designing sustainable and integrated solutions that respect cultural diversity and environmental integrity while addressing the multifaceted dimensions of the global plastic pollution crisis will ultimately require a wide range of perspectives and expertise across different scales, sectors and geographies.

Furthermore, transformative and holistic approaches require an understanding of the political economy of the plastics crisis. Vested interests limit current approaches to reduce plastic pollution, and some approaches that involve recycling or alternative materials and claim to be 'sustainable' potentially have adverse consequences – as shown by recent scientific studies on the impacts of take-away paper cups (Carney Almroth et al., 2023) and plant-based and eco-friendly straws (Boisacq et al., 2023) on the environment and human health. Tackling plastic pollution holistically also requires careful consideration and understanding of sociological, anthropological and cultural dimensions, which play a crucial role in shaping people's behaviour and contemporary habits related to plastic consumption and disposal.

II. PLASTIC POLLUTION SCIENCE: CURRENT STATE OF KNOWLEDGE, NASCENT RESEARCH AREAS, GAPS AND ISSUES LACKING SCIENTIFIC CONSENSUS

Over the past few decades, scientists have conducted extensive research on various aspects of plastic pollution, including its sources, distribution, impact on ecosystems and wildlife, and human health effects. This has led to significant advances in understanding the behaviour, persistence and environmental consequences of plastic pollution; see, for example, Thompson et al. (2009) and Geyer et al. (2017). Moreover, research has increasingly delved into a broader spectrum of concerns, moving beyond environmental and public health implications to address economic, governance and societal dimensions, for example, as documented by Beaumont et al. (2019).

New evidence of the threats posed by plastic pollution underscores the importance of mobilizing existing scientific evidence to inform the development of an international legally binding instrument. In this regard, independent scientific consensus is a vital foundation for guiding INC deliberations and decision-making and shaping an effective science-based instrument. Even in situations where uncertainties exist, it is essential to apply the precautionary principle, relying on independent scientific consensus and informed by the best available science and technology.

Long-term engagement of science is essential. Research efforts to explore emerging areas and fill gaps in knowledge are ongoing, and must be considered if a global agreement is to effectively enable the development of informed strategies and pathways to tackle the plastic pollution crisis. In addition, an independent assessment and review of strategies to mitigate plastic pollution, and solutions developed, proposed or implemented at different scales, can ensure that plastic production is reduced alongside the introduction of safe substitutes, and that the methods used for managing plastic waste are equitable, safe and environmentally sound.

While the independent scientific consensus provides a robust body of research to inform ongoing negotiations, the topics highlighted below are examples of areas that require continuing research to deepen understanding and inform future decision-making in the implementation of the international instrument.

Environmental and human health impacts

- Understanding long-term and intergenerational impacts of plastic pollution on ecosystems and human health, such as contamination and interference with gene expression caused by endocrine-disrupting chemicals.
- Identifying, refining or developing scientific criteria on health and environmental protection for polymers, additives and plastic products to prevent the adoption of 'regrettable substitutes' and ensure safe handling and environmentally responsible management.
- Understanding the complex relationships between plastics and environmental and health impacts, including assessing leakage, emissions and releases across the entire plastic life cycle.

Socio-economic impacts

- Understanding the sociological, anthropological and cultural factors steering modern practices relating to the use and disposal of plastics – to identify limits to and opportunities for lasting change.
- Undertaking research on mitigation strategies beyond waste management, including compensation, liability and full assessments to determine the real economic costs and impacts of plastic pollution on the environment, public health and vulnerable groups.

Cumulative impacts

- Carrying out investigations that account for the potential cumulative effects of plastics with other pollutants as well as climate-related environmental stressors. Such multiple stressor scenarios could enhance the susceptibility of plants and animals to pollutants and/or climate change.

Transport and monitoring

- Understanding the dynamics, behaviour and large-scale transport of plastics in the environment. For example, emerging scientific evidence indicates that microplastics and nanoplastics are transported through the atmosphere, which serves as a significant pathway for entry into the oceans and even remote regions. Understanding the magnitude of this atmospheric route is crucial for developing effective policies to control plastic influx.
- Developing harmonized and reliable methods for monitoring and tracking plastic pollution and waste at national and global levels, to ensure consistent and replicable data collection and to increase data coverage both spatially and temporally. This includes establishing a global integrated observation system to better measure plastics in the environment.

In addition, there is a need for further comprehensive research, scientific evaluations and transparent assessments to determine effective and safe plastic pollution mitigation strategies and solutions (Aliani et al., 2023). This involves:

- Obtaining data, carrying out research and establishing transparency guidelines regarding the safety and necessity of plastic formulation and ingredients. Specifically, this involves studies to assess potential hazards, toxicity, health and environmental impacts of polymers, processing aids and additives. Additionally, mandatory data sheets on all plastic products on the market, detailing polymer properties and additives, are key for enhancing transparency.
- Establishing clear and harmonized definitions of recycling, including distinguishing between 'recycling' and 'downcycling' or 'energy recovery' processes. Additionally, there is a need for comprehensive assessments of the effectiveness, hazardousness and toxicity of different recycling methods.
- Commissioning evaluations by independent experts to assess the effectiveness, toxicity and hazards of biobased plastics as substitutes for fossil-based plastics. Research should also investigate the potential formation of microplastics and nanoplastics associated with biobased plastics.
- Assessing and evaluating the effectiveness and impact of already-implemented policies, such as extended producer responsibility programmes and plastic bans. This should include metrics to measure success, identify best practice as well as areas for improvement, and provide lessons for future policy development and implementation.

III. WAY FORWARD: BUILDING A 21ST CENTURY SCIENTIFIC MECHANISM TO SUPPORT MULTI-SCALE ACTION

Mobilizing existing knowledge is vital for informing INC negotiations towards a robust and science-based global agreement on plastic pollution, and the implementation of commitments and objectives. Several reasons underscore the imperative for scientists and policy-makers to engage closely and on the long term: a lack of studies assessing the effectiveness of solutions and strategies already in operation at different scales, a lack of scientific consensus on a range of issues and significant knowledge gaps. In dealing with these difficulties, engagement should take place during two stages, as outlined below.

The immediate future – preceding the adoption of the global instrument

Different parties could consider mandating the INC Secretariat to establish a platform that facilitates a two-way dialogue between INC Members and scientists (and the joint framing of policy questions and challenges) and identifies scientific requirements with an aim to:

- Ensure that objectives and provisions are grounded in rigorous science by providing, in an agile and timely manner, the best available and independent scientific information grounded in the precautionary principle. This is essential to foster a shared and coherent understanding of the different aspects of plastic pollution across parties, including issues that lack scientific consensus, which need to be addressed under the instrument.
- Make available and review the latest scientific evidence on impacts and suggested solutions, along with robust analyses of their appropriateness in different contexts; for example, assessing current or proposed activities under negotiation with regard to their technological readiness and social feasibility in different geographic areas and environments.
- Communicate clearly and compellingly causal chains, risks and uncertainty.

The platform could:

- Facilitate engagement and consultation with the wider scientific community and incentivize country delegations to engage with scientists.
- Enable full and meaningful participation, particularly of those most impacted by plastic pollution – Indigenous peoples, coastal communities, waste pickers, subsistence fishers and agriculturalists – in the negotiation process. Engaging with real life stories can demonstrate the connection between scientific evidence and peoples' lived experiences.
- Provide open access to scientific evidence and inputs channelled into the negotiation process, and translate these into all UN languages. Communication should be accessible and understandable for policy-makers, community organizations and the broader public.

A set of webinars, workshops, knowledge-sharing sessions, as well as written inputs such as policy briefs and factsheets could be developed to serve the abovementioned purposes.

The medium to long-term future – supporting the implementation of global commitments

Scientific advancements and solutions are ever-changing in nature. However, an ongoing mechanism at the science–policy–society interface could ensure effective implementation of the global instrument on plastic pollution – drawing on the most up-to-date and robust scientific evidence from all relevant disciplines across the natural and social sciences, and engaging with communities and practitioners.

In designing such a mechanism, it is useful to consider the following functions:

- **Evaluate, synthesize and serve as a repository** for available scientific information and knowledge, including identifying information and knowledge gaps. This function could include reviewing evidence on existing and proposed 'solutions' and evaluating safer alternatives to problematic plastics by assessing environmental and health impacts in collaboration with experts, relevant organizations and communities. It could also facilitate dialogues and consultations with a wide range of stakeholders to review, test and validate existing knowledge and solutions, and provide rapid responses drawing on reliable scientific consensus as it evolves, across all relevant disciplines.

- **Facilitate knowledge generation** based on the identification of knowledge gaps, implementation needs and priorities undertaken together with policy-makers and other relevant stakeholders. This function could also contribute to generating knowledge on new and emerging risks – for example, the range of impacts from microplastics and nanoplastics, plastic-related harmful effects and plastic contamination in food chains – by coordinating research efforts with academic institutions, environmental organizations and affected communities.
- **Support policy advice, implementation and monitoring** by, for example, identifying opportunities for sustainable solutions and strategies; identifying effective methods for removing plastic pollution from ecosystems, including oceans, rivers and terrestrial environments; and ultimately phasing out plastics. This function could also inform the development of criteria for safe and sustainable solutions and associated testing protocols; safe and sustainable plastic remediation methods; and clear labelling standards to ensure accurate representation of product sustainability.
- **Provide communication and outreach** by translating scientific findings and communicating useable knowledge and policy-relevant advice to policy-makers and all stakeholders, public and private, who have a role in supporting implementation at different scales. This function can equally facilitate information-sharing with countries in terms of research and technological solutions.
- **Enable capacity-building/sharing** by nurturing a coherent and comprehensive understanding of plastic pollution across all parties, and providing the training and technical assistance required for effective implementation of the instrument, particularly in developing countries.

In fulfilling these functions, the following principles can ensure that any mechanism is effective, with regard to both the scientific body and the uptake of advice provided by a wide range of stakeholders:

- **Independence.** The established scientific advisory body should be independent from political considerations and the interests of industry and other external pressures. Ensuring independence involves appointing scientific advisory members with a strong foundation in both scientific excellence and ethical integrity, allowing the established structure to organize its work within its overall mandate (ISC and INGSA, 2022), and defining clear, distinctive roles and mandates between those operating at the science–policy–society interface.
- **Demand-driven and outcome-focused approach.** It is essential for the mechanism to keep a high level of integration with policy, while safeguarding its independence, to ensure that the scientific advice produced is useable and corresponds to the implementation needs of governments: policy relevant but not policy prescriptive. However, the body should also be able to act autonomously, in a supply-driven manner, whenever necessary.
- **Diversity of scientific disciplines (interdisciplinarity) and inclusion of other knowledge systems.** Given that plastic pollution is a multifaceted issue with multidimensional impacts, it is important to ensure that a diversity of scientific disciplines across the natural and social sciences is represented in the mechanism. Integrated knowledge and solutions are key for addressing the issue from multiple angles and along the entire plastics life cycle. The mechanism should also seek to engage with other types of knowledge, including local, traditional and indigenous.
- **Openness to other stakeholders and co-production.** The mechanism should have a strong linkage with the wider scientific community, and allow for the participation of other relevant stakeholders across the entire range of the abovementioned functions, with a particular focus on evaluating, synthesizing and generating

new knowledge. The mechanism should develop a clear approach to engaging stakeholders, whose roles can include participation in meetings and consultations, testing, reviewing or validating knowledge and solutions, and contributing to work programmes and agenda setting. This is crucial to co-production, where all parties work together on an equal basis, and is key for jointly framing and addressing policy challenges and needs, and achieving useable, legitimate and trusted knowledge and solutions (Maas et al., 2022).

- **Collaboration with other existing initiatives.** At the international level, various Multilateral Environment Agreements (MEAs) such as the Basel, Rotterdam and Stockholm Conventions, cover aspects of the global plastic governance and associated chemicals. These agreements have their own mechanisms for generating knowledge and advice. In addition, replication and overlap might occur with other global scientific assessments such as the Intergovernmental Panel on Climate Change and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services – when assessing knowledge on the impacts of plastics on climate change, biodiversity and ecosystems, and potential solutions. Other emerging mechanisms such as the science–policy panel on chemicals, waste and pollution prevention will also deal with relevant aspects. All these international mechanisms need to be mapped and measures undertaken to promote effective and synergistic collaboration.
- **Learning and reflexivity.** The mechanism should include a learning/reflexivity dimension in order to constantly self-assess, monitor impacts and improve practices. This would allow the mechanism to adapt and evolve towards effectively addressing the growing challenges of plastic pollution, and to enhance its efficacy and legitimacy overall. This principle ensures that the mechanism can remain dynamic and resilient, capable of questioning its objectives and evolving to address plastic pollution in the most comprehensive and sustainable manner possible.

CONCLUSION

Mobilizing scientific knowledge is crucial for ensuring a science-based and effective global instrument on plastic pollution and for informing the implementation of commitments and goals. The policy brief outlines key functions and principles for a science–policy–society mechanism within the framework of the international legally binding instrument to combat plastic pollution. It is however essential to acknowledge the operational challenges associated with their practical and effective implementation. These relate to the demand-driven and outcome-focused nature of the mechanism, the intricacies of cross-scale dynamics, and the effective combination of diverse scientific disciplines, to name a few – all of which must be carefully addressed through clear guidelines, frameworks and methodologies.

Establishing a successful mechanism therefore requires a comprehensive understanding of operational challenges and how to address them, as well as of the lessons emerging from existing mechanisms. In this process, this paper serves only as a foundational guide: true success depends on an ability to practically implement these principles in real-world situations, while leveraging the extensive knowledge base provided by the scientific community.

The ISC stands ready to work with all parties. It is uniquely placed to apply its extensive knowledge and expertise to the development of an effective mechanism to support global efforts on combating plastic pollution and creating sustainable solutions.

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Cover image
Person collecting rubbish from a waste heap.
Shardar Tarikul Islam/Pexels.

International Science Council
The global voice for science

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The International Science Council (ISC) works at the global level to catalyse and convene scientific expertise, advice and influence on issues of major concern to both science and society. The ISC has a growing global membership that brings together over 240 organizations, including international scientific unions and associations from natural and social sciences, and the humanities, and national and regional scientific organizations such as academies and research councils.

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https://council.science/publications/plastic-pollution-policy-brief/

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