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ORIGINAL PAPER

Is a Plastic-Free Mauritius Island Achievable by 2030? Opportunities and Challenges

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Abstract
A world without plastics seems inconceivable today. Global plastic production and utilization have reached amazing figures in the last four decades. The widespread use of plastics has been attributed to the various useful properties, plastics offer as a material. Plastics are durable, hence persist into the environment for long periods of time before undergoing degradation or fragmenting into microplastics or nano-plastics. Moreover, with trans-boundary movement of plastic wastes, plastic pollution knows no frontier and thus is recognized as one of the most dreadful global challenges, in the Anthropocene era. Countries around the globe are implementing varying policy measures coupled with economic instruments to beat plastic pollution. Likewise, Mauritius, a small island developing state in the Indian Ocean, is not spared from the detrimental impacts of plastic pollution. Ad hoc actions to deal with plastic pollution have unfortunately not yielded the expected results. The Government of Mauritius has recently set its target to make Mauritius a plastic-free island by 2030. To attain this goal, a roadmap is underway. The objectives of this paper are to undertake a situational analysis of the overall process thereby investigating the causes for failures of past measures and to determine whether the challenge of a plastic-free Mauritius could be met. Our analysis revealed that under prevailing conditions, the target would not be met. The paper therefore discusses some enabling factors that need to be incorporated in the roadmap, to successfully achieve the set target.

Keywords Mauritius · Plastic wastes · Small island developing state · Plastic-free island

Introduction

Imagining a world without plastic in our modern society seems to be awkward. The incredible versatility of plastic, its low density, strength, fabrication capabilities, moldability in virtually any shape, long life, low weight and low cost are the factors that have outgrown most man-made materials (SM 2021a; Geyer et al. 2017), and have led to a myriad of applications in almost all sectors. As a result, the annual global production of plastic has astonishingly skyrocketed from 1.5 million metric tonnes in 1950 to around 368 million metric tonnes in 2019 (Statista 2021) – an increase by almost 245 times. If this trend continues, it is projected that the cumulative global plastic production would reach 34 billion metric tonnes by 2050 (Statista 2021).

Rhodes (2019) testified that globally, 90% of all plastic items consumed are used only once prior to disposal and is equivalent to about 50% of the total mass of plastic manufactured. He also claimed that plastic packaging accounts for 36% of all plastics that are produced and represent 47% of all plastic waste. The World Economic Forum estimated that $80–$120 billion is lost annually on disposal of plastic packaging (World Economic Forum 2016). Projected increase in future plastic use in a business-as-usual scenario will account for 20% of total oil consumption and 15% of the global annual carbon budget by 2050, resulting in substantial increase in post-consumer plastic waste (Lebreton and Andrady 2019).

In 2018, UNEP drew the global attention of the dreadful impacts of plastic pollution through its World Environment Day theme 'Beat plastic pollution', whilst presenting certain

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scaring facts and figures, and calling for urgent as well as collective actions to beat plastic pollution (Schmidt et al. 2017). Some of these facts are:

- Around 300 million metric tonnes of plastic waste are produced annually.
- The fate of plastic waste was estimated as follows: only 9% was sent for recycling, 12% incinerated, whilst the bulk of 79% has accumulated in landfills, dumps, or the natural environment.
- Around 11 million tonnes of plastic wastes end up in the world's oceans every year.
- Our oceans would contain more plastic than fish by 2050, if the current trend of plastic consumption and disposal continues.

Environmental impacts resulting from mismanaged plastic waste are well documented in literature (Foolmaun et al. 2021) and are linked with multi-farious environmental problems such as impacting adversely marine life and terrestrial animals; bioaccumulation of microplastic in the food web; clogging of drains and waterways; proliferations of vector-borne diseases; unsightly environmental landscape; and depletion of non-renewable resources (Foolmaun et al. 2021). As such, plastic pollution is amplified by its long residence time and non-biodegradable persistence into the environment (Yuan et al. 2021). The ensuing bioaccumulation of microplastics and nano-plastics in the terrestrial and aquatic food webs (Bank and Hansson 2019) implicates plastic pollution as a critical environmental challenge (Yuan et al. 2021).

Mauritius, a small island developing state in the Indian Ocean, is not spared from the impacts of plastic pollution. Magnificent landscapes, watercourses, abandoned lands, public beaches, lagoons and remote land areas have been found littered with plastic waste (Foolmaun et al. 2021). A study carried out in 2018 by the Mauritius Oceanography Institute (MOI 2021) found that the amount of microplastics was almost tenfold higher in offshore waters than in the Mauritian lagoon. This points to the land-based plastic pollution that are carried through watercourses to the ocean. Drains have been often reported to be clogged with plastic wastes. The clogging has contributed to flooding, especially during flash floods, which resulted in considerable economic loss. Two memorable episodes of flash floods occurred in March 2008 and March 2013, where, besides economic losses, altogether 15 Mauritian citizens unfortunately lost their lives (Foolmaun et al. 2021). Recycling of post-consumer plastics is still in its embryonic stage, and there is no incineration plant for municipal solid waste disposal on the island.

Conscious of the serious environmental, economic and social impacts of plastic pollution, the Government of Mauritius has set an ambitious target to label the island a plastic-free country by 2030. The present paper is attempting to understand why past measures have failed to curb down plastic pollution. After analysis of the lessons learnt and the findings of literature reviews, policies, legislations,and other researches, this paper proposes strategies or enabling factors/elements that would enable the country to attain the status of a plastic-free island by 2030. These elements imperatively need to be considered whilst charting the roadmap, which is currently underway.

Methodology

The study of actions that have impacts on the environment and on people needs to be essentially multi-pronged in perspectives. Thus, our methodological approach applied a mixed method where qualitative and quantitative analyses are applied for policy analysis and exploratory studies. There are several research methods (Indeed 2022) that can be applied to this kind of study, and we adopted those that are appropriate to suit the purpose of the research. The literatures that relate to plastic pollution, its impacts and measures taken to combat these, including policies on banning and other legislations and strategies, were reviewed. Some information, both qualitative and quantitative, were gathered and examined before analysing them in a suitable way.

Our approach can be summarised as follows:

The data collected enabled us to understand the local consumption and waste disposal system of plastic products (short value chain), with some quantitative analysis. We then assessed the reasons for failures of actions (exploratory analysis), carried a strength-weakness-opportunity and threat (SWOT) analysis, for all actions/measures undertaken to combat plastic pollution.

Policy analysis (Patton et al. 2016) is an important approach to understand the success or failures of policy measures. We examined the measures put in place in Mauritius for tackling the complex problems of plastic pollution and conducted the policy analysis and planning based on the following criteria:

1. Are the measures/legislations well defined?
2. Are the measures/legislations purely technical or purely political?
3. Are the solutions proposed proven and guaranteed to achieve the intended result?
4. Are the solutions to the problem cost effective?
5. Are the effectiveness of the solutions measurable?

After assessing each of these criteria, we were better equipped to find possible reasons for any success or failures of the existing measures put in place to curb plastic

pollution. These criteria are numbered as above, and used in another assessment approach that we coined as qualitative sustainability analysis (QSA).

We devised the QSA to assess the policy formulations using a scoring method (Pluye et al. 2009) as part of our mixed methods. It is based on the triple bottom line (pillars) of sustainability and similar methodologies (Singh et al. 2009), namely the environment, economic and social aspects of the policies. The issues encountered and the challenges to be overcome, and the opportunities available under the policies, strategies, action plans and legislations, need to be fit for sustainability. Other sustainability assessments as explored by Deshpande et al. (2020) can also be useful but are cumbersome. We therefore applied the QSA, which uses a simple matrix-type table, to determine the sustainability of the actions and any roadmaps that aim to reduce pollution or any impacts caused by production and consumption of goods. The matrix comprises the five criteria mentioned above as the columns, and the three pillars of sustainability as the rows. The scores are inserted into the intersecting cells of the matrix, and the averages of each of the rows and columns determine the performances of the sustainability pillars.

The QSA involved an examination of the legislations and policies, and the rating on a scale of 1 to 5 is used where the lowest scale denotes the poorest formulations of solutions and the upper scale denotes the best solutions. The score rating (1 to 5) depended on the degree of how each of the five criteria has been met in the legislations that should also be appropriate for sustainability (Fig. 1).

Fact-Checking Plastic Pollution

Plastic wastes that are properly disposed of through municipal solid waste systems pose minimal risk to ecosystems (Miller 2020). However, plastic wastes that enter ecosystems through mismanagement and leakage cause a plethora of problems into the environment (UNEP 2021). The environmental impacts have been well documented and elaborated in numerous publications (Foolmaun et al. 2021; UNEP 2021; Frias and Nash 2019; Prata et al. 2020). One notable feature highlighted in these publications, and which is fast attracting global attention, is the issue of microplastics and nano-plastics. Frias and Nash (2019) defined microplastics as "*any synthetic solid particle or polymeric matrix, with regular or irregular shape and with size ranging from 1 µm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water*". Primary microplastics include microbeads that are manufactured for commercial purposes, for use in detergents, toothpaste or personal care products (Meaza et al. 2021). Thus, primary microplastics enter the environment for instance through laundering of clothing and detergent disposal in wastewater systems. Secondary microplastics result from slow degradation or weathering of larger plastic materials disposed indiscriminately into the environment. Slow degradation and fragmentation take place under natural occurring environmental conditions, particularly ocean current dynamics, solar radiation, abrasion and wind actions (Frias and Nash 2019). Owing to their small size, microplastics have become ubiquitous (Meaza et al. 2021). They are present in so huge numbers especially in the marine environment (Frias and Nash 2019) that exposure to human is inevitable (Prata et al. 2020) through bioaccumulation and biomagnification in the food web. There are three routes microplastics enter the human body: ingestion, inhalation and dermal contact. Prata et al. (2020) reported that exposure to microplastics may lead to various health impacts including oxidative stress, inflammatory lesions, affect the immunity system and increase risk of neoplasia, as summarized in Fig. 2 below.

Countries that have established microbead bans are Canada, France, Italy, the Republic of Korea, New Zealand, Sweden, UK and the USA. Belgium, Brazil, India and Ireland are working on regulations or laws to ban microbeads

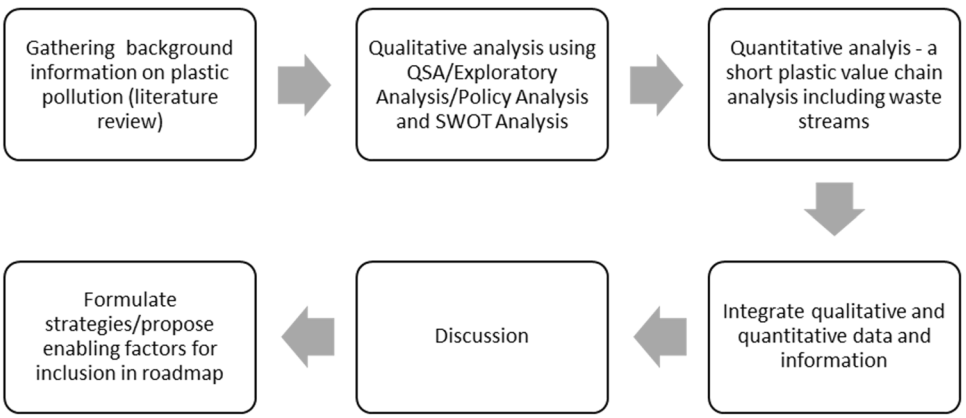

Fig. 1 Methodology adopted

Fig. 2 Impacts of microplastics on human health (courtesy: Prata et al. (2020))

(UNEP 2018). The EU is also envisaging to restrict the addition of microplastics to consumer and professional use products. Voluntary approaches to tackle microbeads are also emerging, with governments, companies and civil society organizations promoting voluntary phase-outs and ecolabeling (UNEP, Wri 2018).

Combatting Plastic Pollution – International Perspective

Plastics, once a revolutionary material, has ultimately became a global environmental threat with ubiquitous distribution (Frias and Nash 2019) on terrestrial and marine environment. Moreover, the recent COVID-19 pandemic worldwide has considerably increased the use of single-use plastics (Ardusso et al. 2021), adding further load to the existing plastic pollution.

With the alarming attention on plastic pollution, many policy efforts across the world are underway to handle the daunting dilemma. These policies are often coupled with economic instruments and fiscal incentives aiming at either banning the products straight away or curbing down the consumption of the plastic products (UNEP 2018). A review by UNEP and WRI in 2018, on national legal binding instruments to regulate disposal of plastic wastes, revealed that out of 192 countries, 127 countries have adopted some form of legislations to control plastic bags; 90 countries have exercised control on single-use plastic products; and 8 countries have established bans on microbeads. Moreover, UNEP (2018) also emphasizes that to effectively tackle the root causes of plastic pollution, governments should improve waste management practices; introduce financial incentives to change behaviours of consumers, retailers and manufacturers; promote research and development on alternatives to plastic materials as well as inspire innovative product design; and enact stronger policies and legislations (for example, setting recycling targets) that ultimately encourages circularity. UNEP (2018) equally recommends the establishment of strong public–private partnerships and voluntary agreements as an alternative to bans. Thus, there is no 'one-fits-all' solution to handle plastic pollution, but instead, it requires a broad range of either single actions, or a combination of actions adapted to local contexts. To guide governments on possible actions to curb down utilization of single-use plastics and their impacts, UNEP (2018) has drawn up a 10-step roadmap. These steps are listed below:

1. Identification of the most problematic single-use plastics.
2. Evaluation of possible actions (regulatory, voluntary, economic or a combination of these).
3. Assessment of social, economic and environmental impacts of the preferred action(s).
4. Engagement of all relevant stakeholders.
5. Awareness raising campaigns.
6. Promotion of eco-friendly and affordable alternatives.
7. Incentivization of local industries.
8. Ring-fencing revenues to support environmental incentives.
9. Enforcement.
10. Monitoring, evaluation and policy adjustment.

Examples of a few roadmaps worldwide are also highlighted below.

Examples	Assessments	Remarks
(a) *American Plastic Makers roadmap to reuse single use plastic (2020)* (America's Plastic Makers 2021)	The roadmap details a sequenced work plan to attain two prominent goals, namely, 100% of US plastic packaging will be recyclable or recoverable by 2030 and 100% of US plastic packaging will be reused, recycled or recovered by 2040	The roadmap is not legalized and its success is not guaranteed
(b) *The UK Plastics Pact – A Roadmap to 2025*	Waste and Resources Action Programme (WRAP), in partnership with the Ellen MacArthur Foundation, launched *The UK Plastics Pact* in 2018 (WRAP 2021). It proposes elimination of problematic single-use packaging (through redesign, innovation or reuse); 100% of plastic packaging to be reusable, recyclable or compostable; 70% of plastic packaging effectively recycled or composted; and 30% average recycled content across all plastic packaging	Strict enforcement will be required to ensure that the proposed recycling and recovery are carried out
(c) *EU's Directive on single-use plastics*	The EU Directives on single-use plastics (EU 2021) promote transition to circular economy by utilizing a mix of measures and incorporates the principles of the polluter pays principle and the extended producer responsibility. It also provides two specific targets: 77% plastic bottles collection by 2025 – increasing to 90% by 2029; and incorporating 25% of recycled plastic in PET beverage bottles from 2025, and 30% in all plastic beverage bottles in 2030	The targets are too ambitious due to the market size of the EU
(d) *Reunion island roadmap on elimination of single use plastics*	The roadmap details a set of practical measures with clearly defined timeline spanning from 2020 to 2040 to support a circular economy. The roadmap contains targets for banning, reduction, reuse and recycling. Examples of a few measures include banning of plastic bottles in businesses in 2021 and 20% reduction in plastic packaging by 2025	The targets are achievable but not easy to enforce

Plastic Waste Generation, Disposal and Measures to Curb Plastic Pollution in Mauritius

Mauritius Island is situated some 2000 km off the south-eastern coast of Africa and is famous worldwide as a high tourist destination. The island is only 1865 km^2 in size with a population size estimated at 1,221,759 in December 2020 (Statistics Mauritius 2021).

In Mauritius, there is very little waste segregation at source; consequently, domestic and commercial wastes are disposed of commingled. The wastes are collected on a 'door-to-door' basis by the nine local authorities that provide scavenging services at least once weekly in rural areas and thrice in urban areas. Depending on the location, the collected wastes are either transported directly to the sole sanitary landfill of the island or transited to the five transfer stations, where the wastes are compacted prior to transportation to the landfill in larger trucks.

Last year, the government has established its first civic amenity centre in one of the five transfer stations. The civic amenity centre has different compartments to receive electronic wastes, green waste, plastic wastes and glass. There is no formal sorting of wastes in the other four transfer stations. Recycling and composting are still at their infancy stages. Although there is a fairly good solid waste collection system, yet around 12% of the solid waste are dumped indiscriminately onto wastelands, abandoned lands and waterbodies (Foolmaun et al. 2011). Annual waste collection services provided by local Authorities cost around 23 million USD, whilst government altogether spent around 349 million USD on waste management, which includes waste collection, operation and maintenance of transfer stations and operation, as well as maintenance of the landfill site.

In 2000, the amount of waste disposed at the landfill was 265,817 tonnes (SM 2021b). Over the years with economic and population growth as well as change in standards of living, the amount of solid waste received at the landfill stood at 509,094 tonnes in 2020 (SM 2021b). Figure 3 shows the increasing amount of waste disposed at the sole landfill over the past 20 last year.

In 2020, the amount of plastic wastes generated was estimated at 75,000 tonnes (SM 2021a) and represented 14.5% of the annual municipal waste generated. In fact, the percentage of plastic component in municipal waste has gradually increased from 8% in 2000 to 14.5% in 2020. The increase in the percentage of the plastic component in municipal solid wastes has been attributed to the progressive increasing use, and hence disposal, of single-use plastic products.

Compared to other Small Island Development States (SIDS), the percentage of plastic component in municipal waste is slightly higher as can be observed in Fig. 4. However, when compared to plastic waste disposed per capita, Mauritius position itself among the average generators of plastic waste as shown in Figs. 4 and 5.

The different types of plastic polymers present in the 14.5% of plastic waste in Mauritius are shown in Fig. 6. These include high-density polyethylene (HDPE), polyethylene terephthalate (PET), low-density polyethylene (LDPE) and polystyrene (PS).

Plastic recycling, as stated earlier, is still at its infancy stage. In 2020, only 3000 tonnes of plastic were recycled (SM 2021a). The polymers recycled are shown in Fig. 7 below:

In 2020, 109.64 million units of PET bottles were disposed and only 40% were collected for partial recycling. Collection of post-consumer PET bottles takes place through:

- An informal network of post-consumer PET bottle pickers – who are paid per kg of PET bottles collected.
- Involvement of NGOs.
- Three hundred thirty-two PET bottle collection points.

Following regulations of PET bottles in 2004, the PET bottling companies were compelled to collect the PET bottles put onto the market for eventual recycling – as part of the Extended Producer Responsibility. As such, the PET bottlers in Mauritius have hired a company that oversees the collection and exportation of the PET bottles. Because of economies of scale, there is no PET recycling plant in Mauritius. Thus, collected PET bottles are shredded into flakes, baled and exported to South Africa for recycling.

The collection rate has been fluctuating between 40 and 43% for the past 2 years, despite government's fiscal incentives to boost up the collection rate. Figure 8 shows the fluctuating collection rate over the years.

The other polymers, namely HDPE, LDPE and the other category (includes polystyrene and polypropylene), are recycled in Mauritius and converted into products such as tables, benches and garbage bins.

Initiatives to combat plastic pollution in Mauritius

With growing environmental concern on plastic pollution and the ensuing environmental impacts, the Government of Mauritius has taken numerous incentives to discourage the use of plastics, in particular plastic bags and PET bottles, which are the most apparent forms of plastic pollution. Some main actions to curb down plastic bag usage prior to banning are summarized in Table 1, below.

Despite the numerous initiatives coupled with ad hoc sensitization campaigns, plastic bags without handles continued to be freely distributed and widely used onto the island.

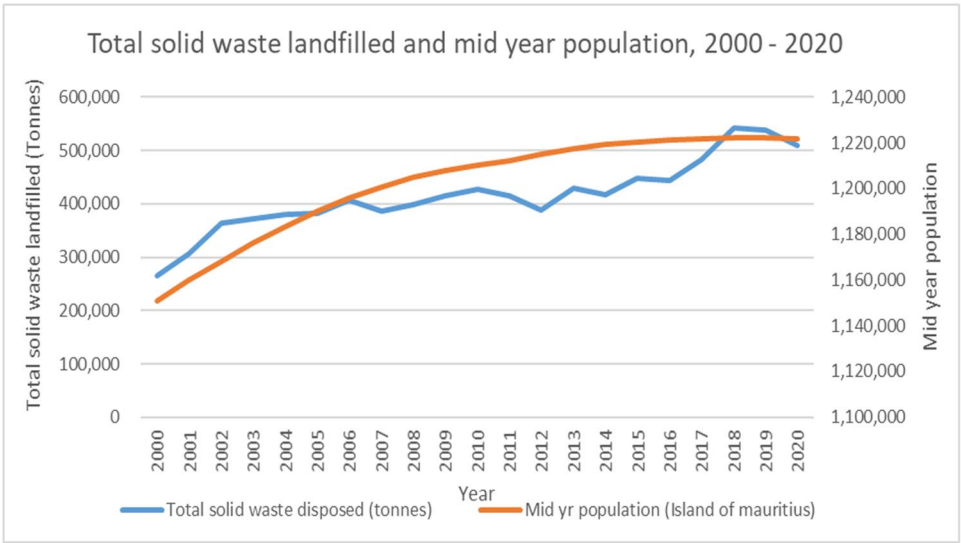

Fig. 3 Solid waste disposed at the landfill

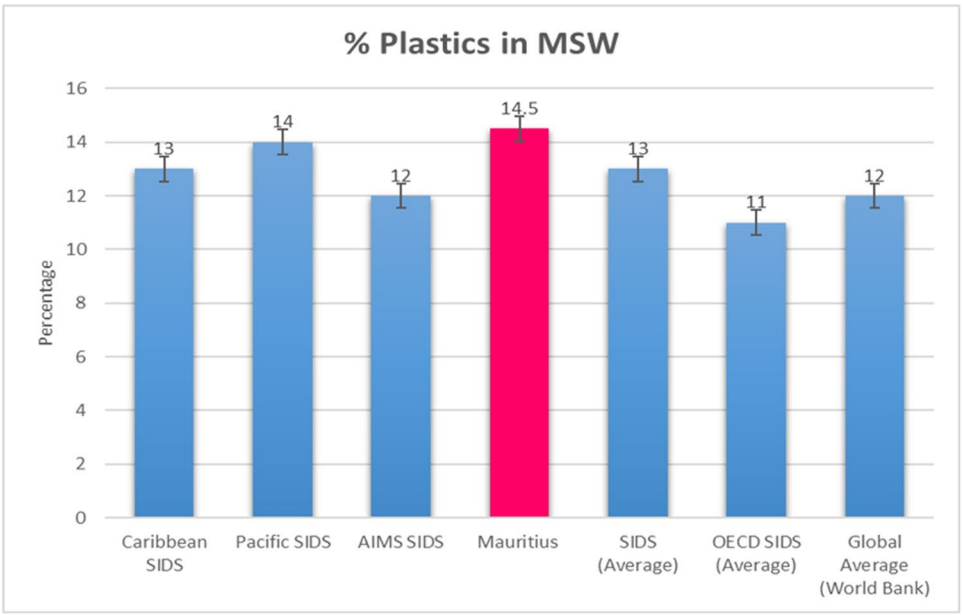

Fig. 4 Percentage of plastics in municipal waste in different SIDS regions. (Adapted from Mohee et al. 2015)

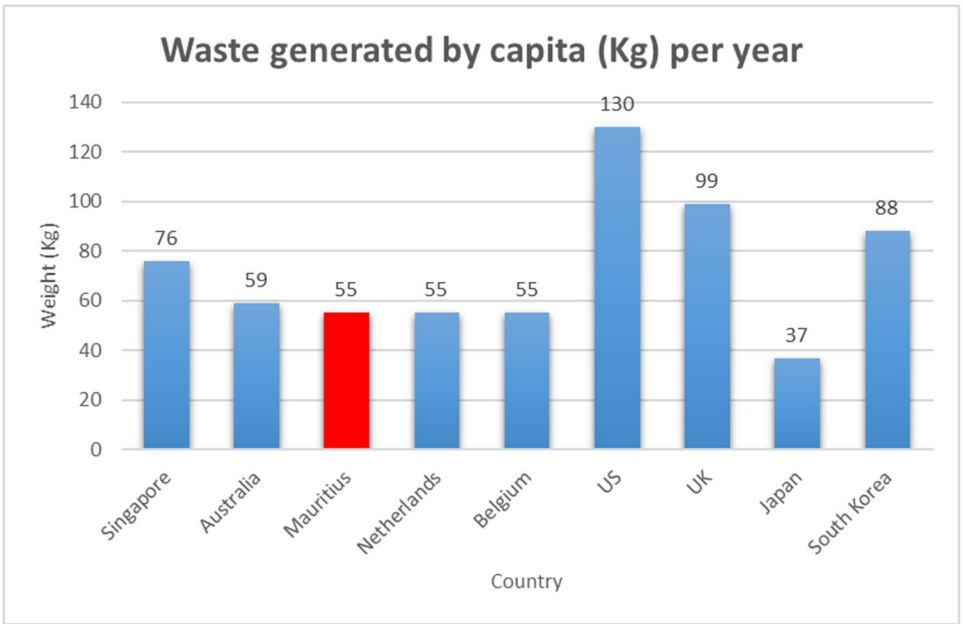

Fig. 5 Single-use plastic waste generated by different countries per capita in 2019. (Adapted from Statista (2021); Hichem et al. (2009))

Consequently, in an attempt to redress the situation, in 2020, the government introduced the Environment Protection (Banning of plastic bags) Regulations 2020, which became effective since March 2021. These regulations are stricter regulations compared to those promulgated in 2016, and offenders have to pay higher fines and even can be imprisoned. The regulations ban the use, import, manufacture, sale and distribution of any type of petroleum-based plastic bags (except for exempted ones). Under these regulations, any individual caught in possession with a banned plastic bag is an offence.

In parallel to the regulations banning plastic bags, the government also introduced another set of regulations, the Environment Protection (Control of Single Use Plastic Products) Regulations 2020, which became effective since January 2021. Under these regulations, 10 single-use plastic products such as cups, spoons, forks, knives, straws, bowl, trays, hinged containers, stirrers and lids/covers have been banned. Possession of any of these items is an offence, and the contravener has to pay fine and can even be imprisoned.

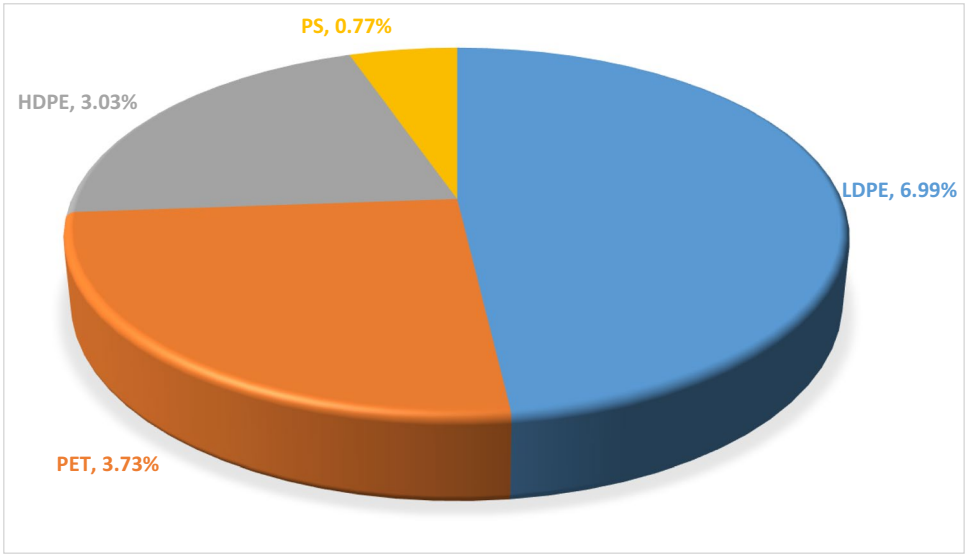

Fig. 6 Constituent polymer types in plastic waste

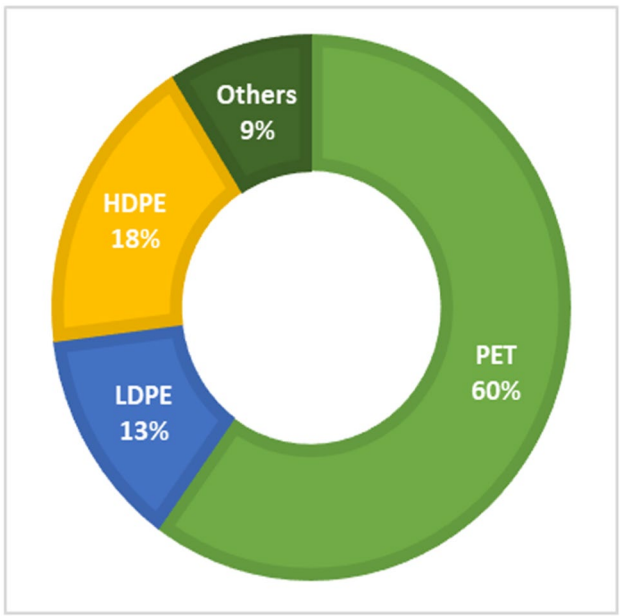

Fig. 7 Different polymers recycled in Mauritius

Assessment of Reasons for Failures of Past Actions in Mauritius

Tables 1 and 2 provide an assessment of the actions initiated to curb down plastic pollution. The last column in each table provides a clear explanation of why the actions have failed. The negative responses highlighted can be mainly attributed to lack of careful planning; lack of proper consultations and coordination with relevant stakeholders; and poor enforcement. Some of these reasons are in line with the findings of UNEP and WRI (2018) to explain failure of actions to curb down plastic pollution in countries around the world.

The results of the QSA (Fig. 9) suggest that there were many shortcomings in the formulation of the legislations. These did not cater much to meet the sustainability criteria. Whilst the environmental scores are somewhat satisfactory, the economic and social ones are not so and thus; this may be a possible reason for the partial failures to curb plastic pollution. The overall score of the QSA demonstrates the average level of success that these types of legislations can provide.

SWOT Analysis and a Short Plastic Value Chain Analysis

Two fundamental analyses, namely a strength-weakness-opportunity-threat (SWOT) analysis (Fig. 10) and a short plastic value chain analysis, including the materiality (sustainability and life cycle) and circularity (uses in a circular economy) of plastics (Fig. 11), were conducted.

Performing SWOT analysis allows us to build on what we are doing well, address what we are lacking, seize new openings and minimize risks, whilst analysis of the short value chain of plastics revealed the hidden elements from the production to the consumption and eventual disposal of plastics that otherwise would gone unnoticed. Plastics enter the market through different pathways. In Mauritius, the imported raw materials are the primary source of plastics. The enforcement of the legalized form of raw materials imported, which should essentially be biodegradable, is a crucial step in eliminating harmful plastics. After the production process, which in itself can be sources of pollutions, a rigorous distribution network allows penetration of different plastic products into the market. The point/

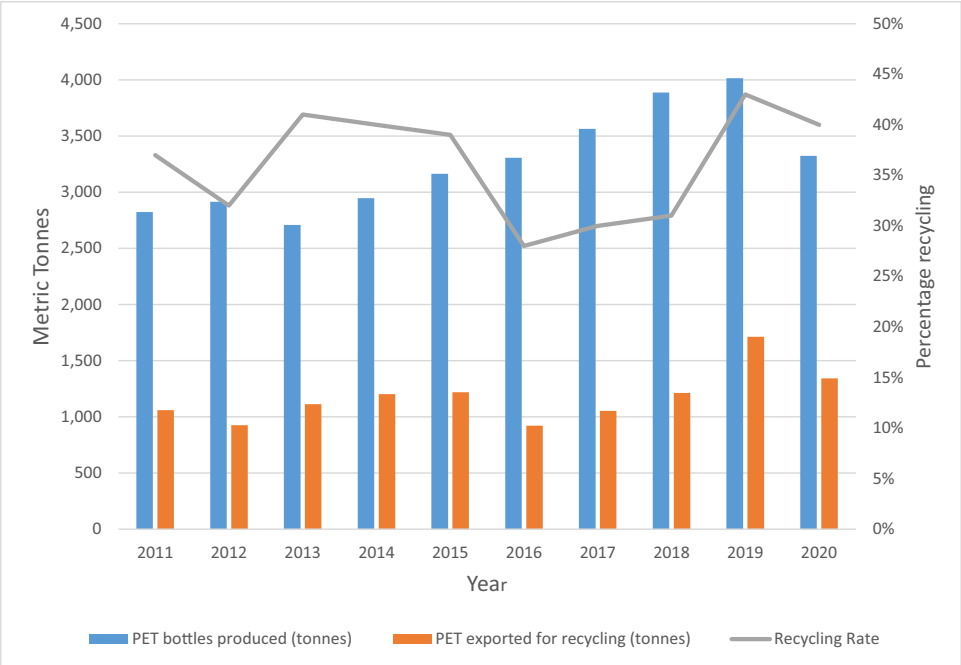

Fig. 8 Post-consumer PET collected and exported and the recycling rate

Table 1 Government initiatives to curb down plastic usage in Mauritius

Year	Government actions	Objective	Remarks
2004	Promulgation of the Environment Protection (Plastic carry bags) Regulations 2004	To prohibit manufacture and import of non-degradable plastic bags with gussets and handles having wall thickness of less than 20 microns	To counteract these regulations, importers and local manufacturers flooded the local markets with plastic bags without handles which were freely distributed. Consequently, instead of limiting plastic bag usage, the consumption of plastic bags without handles increased enormously
2006	Imposition of an excise duty on plastic bags with gusset and handles	To discourage use of plastic bags	Little to no appreciable change in consumption of plastic bags
2010	Doubling of excise duty	To encourage users to shift towards thicker and reusable bags	Not much improvement
2016	Promulgation of Environment Protection (Banning of plastic bags) Regulations 2015	To ban use of plastic bag with or without gussets and handles	A change in consumption pattern of plastic bags was noted; however, under these regulations, possession of a plastic bag was not considered as an offence. This shortcoming in the law hindered proper enforcement

stationary source of pollution, as well as mobile sources of the same, such as littering from vehicles, was identified. Moreover, the various wholesale and retail outlets, from where consumers have easy access to plastics, form part of another source of pollution. A more detailed cradle to grave approach (life cycle assessment (LCA)) would enable a better understanding of the plastic life cycle under differing circumstances.

With materiality of plastics, there are initiatives that compel actions to promote sustainability. These include adhering to standards such as the Global Reporting Initiatives (GRI) (GRI 2021), and the Green Globe

Table 2 Summary of observations post promulgation of the two recent regulations

Regulation	Positive development	Negative consequences
Environment Protection (Banning of plastic bags) Regulations 2020	Hyper-markets and commercial centres have shifted to biodegradable bags	- Operators of small markets, vegetable stall and street retails, which are present in larger numbers throughout the island, are unfortunately distributing or selling the banned plastic bags. These are procured from illegal network of suppliers and manufacturers which is difficult to track down through normal enforcement actions - Certain importers of plastic bags are even supplying fake biodegradable bags onto the markets
Environment Protection (Control of Single Use Plastic Products) Regulations 2020	Most restaurants, snacks, supermarkets and hotels have shifted to biodegradable products made from a variety of plant-based materials such as starch from corn, potatoes, and tapioca; paper; bagasse, palm leaves and poly lactic acid	- Similar to fake biodegradable bags, fake biodegradable plastic products have also been observed on the market - Certain food industries, specifically dairy products industries and industries that are using modified atmosphere packaging (MAP packaging), are complaining that alternatives to their plastic products are not yet available on the market and so are requesting for additional moratorium period (up to 2023) to abide to the regulations - Though single-use plastic straws were banned, plastic straws attached to tetra pack juices had still to be allowed as these straws were imported as an integral part of packaging. Consequently, an additional moratorium period of 4 months had to be provided - Likewise, hinged plastic containers used to package fruits, food products, birthday cakes locally were banned on the prescribed date. However, fruits or food products packaged in hinged containers were allowed to be imported up to a period of 4 months after banning- thus in a way penalizing local producers and favouring importers

sustainability certification (Green Globe 2021). These promote sustainable product uses and cover important sectors such as tourism and manufacturing which adhere to them to meet market demands and in order to become profitable whilst at the same time save the planet and people. Plastic substitution is part of these initiatives, which are gradually implemented.

Many countries, including Mauritius, have been developing with a linear-economy approach with a 'take-make-dispose' approach. On the other hand, today, circular economy is prevalent only in around 8.6% of the cases in the global economy (UNEP, WRI 2018). In order to understand the circularity of plastics, its value chains from production to consumption need to be examined. The value chain of plastic products ranges from a variety of sources and sinks. The flow of plastics in Mauritius (Fig. 11) follows a linear trend with a little circularity. Therefore, if more circularity were promoted across the various value chains, the gradual elimination of plastics would be a tangible reality.

Discussion

Plastic pollution knows no boundaries. Recognized as one of the major global environmental challenges in the Anthropocene (De-la-Torre et al. 2021), the fate of plastic pollution would be entirely dependent on human behaviours, policies, strategies and ultimately actions. As such, there is a dire need for the global community to join hands to come up with a multi-lateral agreement to combat plastic pollution. The operationality of such agreement imperatively needs to embrace or mainstream concepts or principles such as circular economy; life

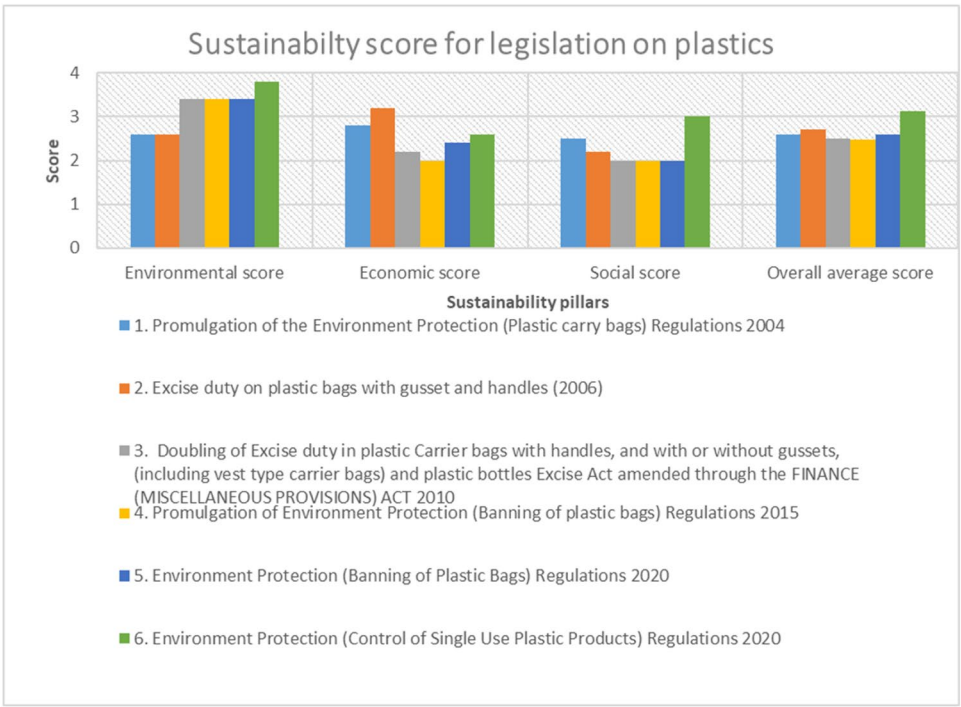

Fig. 9 QSA results

Fig. 10 SWOT analysis

cycle perspectives or life cycle sustainability assessment frameworks (a combination of Life Cycle Assessment, Environmental Life Cycle Costing and Social Life Cycle Assessment); and inclusiveness and promote nature-based solutions including nature-based alternatives to plastic products.

The objective to make Mauritius a plastic-free island by 2030 is indeed a bold step of the government. Ad hoc measures taken so far to beat plastic pollution have unfortunately not yielded the desired results as clearly highlighted in Tables 1 and 2.

The Government of Mauritius is currently having consultations with various stakeholders to chart a roadmap for plastic-free Mauritius. In fact, charting a roadmap should have been the very first step prior to embarking on any action tackling plastic pollution. Nonetheless, it is hoped that the roadmap contains concrete policies/strategies/directives/action plan with clearly defined objectives/actions and timeline for each stakeholder, else the ambitious target set for 2030 would not be attained.

The present study has presented a situational analysis of the overall process, thereby pointing out the reasons for

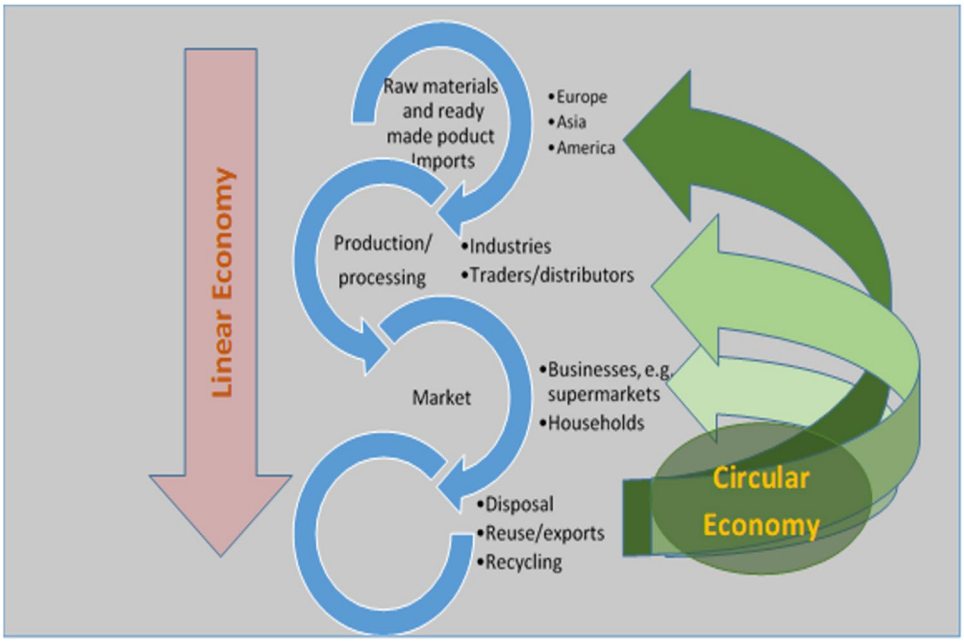

Fig. 11 Short plastic value chain analysis

failures of past actions (i.e. lessons learnt), the strengths, weaknesses, opportunities and challenges. The QSA points to the weaknesses of the legislations, as they do not meet the sustainability criteria. One of a success factors for banning consumer products is to provide viable and sustainable alternatives. These have been proven to be crucial in several cases. In Mauritius, the banning of sand for construction was successful as rock or basaltic sand was proposed as alternative. Likewise, Horská et al. (2015) showed that suitable alternatives are the best solution to reduce plastic bag pollutions. Moreover, promoting circular economy can ensure that plastic pollution can be sustainably managed, as found by Muposhi et al. (2022). In addition to these vital information, the literature review from international perspectives has also taught us global practices as well as enabling factors or essential elements for a roadmap to tackle plastic pollution. With these ingredients in hand, the authors have worked out a series of key elements that need to be incorporated in the roadmap which is underway. The authors firmly believe that by integrating these elements in the roadmap, the set target for 2030 could be easily met.

Recommendation

The proposed six key elements for inclusion in the roadmap are presented below:

(a) Scoping the term 'plastic-free Mauritius'

Recognizing the vast panoply of plastic products, their applications and durability, it would be practically impossible to eliminate all plastic items being utilized on the island. It is therefore important to perform an inventory of plastic products being utilized prior to clearly defining the types or categories of plastics that need to be eliminated. For example, single-use plastic products could be defined as one of the categories.

(b) Prioritize the categories to be banned and propose tangible alternatives

It is true that not all categories of plastics could be banned at the same time. Banning would depend on several factors including availability of alternatives to the products being banned; affordability of the alternatives and whether require fiscal incentives from government; and the environmental impacts of the alternatives being proposed. As such, a phase banning approach is proposed.

For each category of plastics to be banned, it is essential to have the following information:

- Whether the biodegradable alternatives of the plastic products to be banned are readily available onto the local market or need to be imported.
- Are there any potential locally available natural materials that could serve or be promoted as alternatives to the plastic product to be banned?
- Has there been a cost benefit analysis conducted with respect to importation v/s locally manufacturing alternatives?
- Whether fiscal incentives have to be provided, if any, to promote the alternatives to plastic products.
- Has there been any research conducted to determine whether the alternatives to be proposed have lower environmental impacts?

In the absence of local research on the environmental impacts of the alternatives, it would be most appropriate to undertake a comparative life cycle assessment (LCA) of the products to be banned and the alternatives proposed. This is central step as LCA is a tool to systematically evaluate the environmental impacts that occur throughout the entire supply chain of a product from resource extraction to ultimate disposal or reuse. This study would be carried out in the local context whose results do not necessarily reflect studies conducted in other countries where various research parameters such as the assumptions made, processes defined within the system and transportation distances are different, as highlighted by Miller (2020). Moreover, in case relevant data are available and time permits, the research could even be broadened into a life cycle sustainability assessment (LCSA). LCA would offer comparative environmental impacts whilst LCSA would provide information from environmental, economic and social perspectives on the products to be banned and its proposed alternatives. Thus, results of both LCA and LCSA would motivate evidence-based policy decision.

(c) Define timeline and roadmap for each category of plastics to be banned

Once all the relevant information has been obtained, stakeholders' consultation (government, researchers, private sectors – including importers, manufacturers and civil society) should be performed to jointly define the timeline and the roadmap for banning of the category of plastics.

(d) Promulgation of regulation for banning the category of plastics across its value chain

The relevant regulation be drafted and promulgated using elements as defined jointly under step (c) and lessons learnt on loopholes in former regulations. The regulations should target the steps involved in the manufactures, import, use/reuse, exports and other processes in the plastic life cycle.

(e) Awareness campaign and strict enforcement

Awareness campaign be started well before the coming into force of the regulation and should be not be a one-off exercise. A sustained campaign should be planned. Once the regulation is promulgated, strict enforcement to be conducted.

(f) Feedback and corrective mechanism

The stakeholders' committee should meet at a defined time interval to review the status of the whole mechanism and accordingly propose corrective measures to meet the set objectives.

Finally, the roadmap should also consider the possibility of promoting circular economy, that is divert plastic wastes from landfill to ultimately serve as feedstocks for manufacture of products such as benches, tables, plastic barrier or fences for garden.

Conclusion

The assessment of the possible reasons for failures to avoid the ever-increasing plastic pollution problem has been undertaken with our mixed approach. This approach allowed a thorough examination of policies and legislations, as well as other instruments and mechanisms that have been put in place so far to combat plastic pollution. International, as well as national measures, has shortcomings, and the consequent impacts have been felt worldwide, as the pollution levels are still persistent.

Many countries, and particularly Mauritius which was the focus of our study, have certainly implemented various measures in an attempt to beat plastic pollution. However, proper enforcement and other additional measures and mechanisms remain a challenge. The vision to propel towards a plastic-free island is plausible, if a holistic and a phase banning methodology is adopted in consultation with all relevant stakeholders. Inclusion of the elements highlighted in the recommendation section in the forthcoming roadmap would successfully contribute to reach the ultimate objective.

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Author Contribution RKF prepared the general layout of the manuscript and worked on the introduction, discussion and developed key recommendations. AS devised the methodology section, the referencing and contributed some of the discussions and conclusion. DSC prepared the tables and figures. KKB worked on the plastic initiatives undertaken in Mauritius and the reasons for failure in combating plastic pollution. GJ worked on the literature review on plastic pollution from international perspective. All authors read and approved the final manuscript.

Data Availability Data have been collected from various sources including Google Scholar, Ministry of Environment, internet and literature search.

Declarations

Conflict of Interest The authors declare no competing interests.

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