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Circular Economy: Optimising private sector investment in Mauritius

ABOUT THE REPORT

This report is a joint publication of Business Mauritius and the United Nations Development Programme (UNDP) Mauritius.

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ACKNOWLEDGEMENTS

This report is the product of a partnership between Business Mauritius and the United Nations Development Programme (UNDP), with financial support from the Government of Japan as part of efforts to facilitate the socio-economic response and recovery from the COVID-19 pandemic in Mauritius.

Special appreciation goes to Riad Sultan and Nikhil Treebhoohun, the lead experts for this report. The preparation of the report was technically guided by a core technical team that included Daden Venkatasawmy, Mickael Apaya, and Asif Jeetun, from Business Mauritius, Tony Muhumuza and Renooka Beejan from the UNDP, and Vimal Motee and Kelly Peerun from the Mauritius Chamber of Commerce and Industry (MCCI).

This work would not have been possible without the contribution of key informants and business operators. Special thanks go to Jean Noël Humbert, Raj Makoond, and Gérard Boullé from ECLOSIA, for facilitating the collection of information from stakeholders; Muhammad A. Z. Bhundoo (Solid Waste Management Division); and Dinesh Surroop (University of Mauritius), for the technical insights. The operators and sustainability managers dedicated their valuable time to attend meetings and fill the research instruments for the study. Data provided by the Solid Waste Management Division, Ministry of Environment and Sustainable Development, was instrumental in shaping the analysis. We also acknowledge the institutions that participated in the validation meeting that further enhanced the quality of this report. Members of these institutions included: W. Elahee-Doomun (Ministry of Finance, Economic Planning and Development); K. Manna (Ministry of Industrial Development, SMEs & Cooperatives); Bhaguthsing Beerachee (Solid Waste Management Division); Deujen Mungur (Economic Development Board); Sanjev Bhonoo and Dhanwantee Ramphul (Statistics Mauritius); and Rushaa Badaloo and Mr. Ganessen Chinnapen (MCCI). Appreciation also goes to Stéphane Bellerose and Sharon Sunassee from UNDP, for editing and managing the publication of this report.

The successful implementation of the Circular Economy will require an integrated approach that coordinates the efforts of all stakeholders in collaboration with the private sector. We are hopeful that the insights contained in this report will be a useful guide for policymakers and actors in the private sector.

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GLOSSARY

Concepts	Definitions as used in this report.
Closed-loop recycling	Recycling a product and manufacturing it into the same product again and again.
Composting	Treatment process that decomposes organic matter in an oxygenated environment. The result is nutrient-rich fertilizer or soil amendment.
Direct employment multiplier	The change in employment directly related to the direct gross output.
Direct gross output	The output of one industry.
Indirect employment multiplier	The change in employment in other local industries due to the purchases of intermediate inputs to produce a unit of direct gross output.
Indirect gross output	The change in output of other local industries due to the purchases of intermediate inputs produce a unit of direct gross output.
Input-Output (IO) model	An Input-output (I-O) model provides a detailed picture of the flow of products and resources within a given economy.
Material flow	The quantity and rate at which materials move through a system.
Material flow analysis (MFA)	A method to evaluate the material flows into and out of a system.
Municipal Solid Waste	Waste that is generated by households, schools, hospitals and businesses in each city or region.
Output multiplier	The output multiplier measures the combined effect of a Rs1 change in its sales on the output of all local industries.
Recovery	Process of extracting material, energy or water from the waste stream for reuse or recycling.
Recyclable materials	Materials that can be recycled.
Recycling	The collection, sorting and processing of disposed materials for use in another manufacturing process.
Resource efficiency	A percentage of the total resources consumed that make up the final product or service.
Reuse	Using a product or material again, either for the same or an alternative function.
Reverse logistics	Process of collecting and aggregating products, components or materials at the end-of-life for reuse, recycling and returns.
Waste hierarchy	The priority order available for managing wastes, ranked in descending order of preference, based on the best environmental outcome across the lifecycle of the material. (1) Prevention, (2) Reduce, (3) Reuse, (4) Recycle, (5) Incineration, (6) Landfill.
Zero waste	Program to divert all (at least 95 percent) waste from landfill. The scope of zero waste may or may not include incineration depending on reference.

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LIST OF ABBREVIATIONS

GHGs	Greenhouse gas emissions
CE	Circular Economy
CEB	Central Electricity Board
GDP	Gross Domestic Product
HDPE	High-density polyethylene
I-O	Input-Output
IS	Industrial Symbiosis
IWA	Industrial Waste Assessment
LCA	Life Cycle Assessment
LDPE	Low-density polyethylene
NCET	National CE Task Force
PC	Polycarbonate
PET	Polyethylene terephthalate
PLA	Polylactic acid
PS	Polystyrene
PU	Polyurethanes
PVC	Polyvinyl chloride
WEEE	Waste Electrical and Electronic Equipment

EXECUTIVE SUMMARY

The management of solid waste is one of the major environmental challenges facing Mauritius, in part due to unsustainable production and consumption patterns, and to the traditional linear business model of 'take-make-use'. Solid waste increased by 29 percent between 2010 and 2020, and by more than 100 percent over the last 20 years. With a population of 1.27m (2019), the average amount of solid waste per capita disposed at the landfill daily has increased steadily from 0.6 kg in 2000 to 1.1 kg in 2019[1], generating around 537,147 tonnes annually. In 2019, waste was the second largest contributor to greenhouse gas emissions (GHGs) estimated at 23 percent after fossil fuel energy emissions which stand at 74.2 percent of GHGs[2]. Around 95 percent of wastes originated from households and commercial activities (514,020 tonnes), 3 percent from industrial sector and the rest from the construction sector. The Government spends around Rs 1.5 billion annually on the operation and maintenance of the transfer stations and of the landfill site, and on transportation of wastes to landfill.

The establishment of a Circular Economy (CE) as a business and consumption model is a promising avenue for closing the material loops. The CE aims at lengthening the life cycle of products and promoting the reuse, recovery and recycling of products and materials continually, using renewable energy as far as possible. The current level of wastes disposed at the landfill represents untapped opportunities to generate wealth.

The report describes the scope of CE within the Mauritian economic and social context through an analysis of the main types and quantities of wastes which could be brought back to the economy, and examines the economic opportunities to turn waste into material resources. The study provides insights into the direct and indirect gross output which could be generated if the wastes disposed at the landfill were used as materials in the production system, the level of private investment and the number of jobs that could be created for 2021-2030. Finally, the report discusses the challenges, institutional reforms and strategies which could make CE a reality.

The study adopts a three-tier approach. First is the characterization of wastes from the domestic, commercial and industrial sector. A forecast of waste is carried out for the period 2021-2030 under three growth scenarios: 2, 4, and 6 percent. The second tier collects information on recycling practices and material recovery for the major types of wastes from a sample of existing enterprises, literature and interviews with key experts. The third involves the use of economic data associated with recycling and material recovery to estimate the economic impacts assuming that the main wastes were brought back to the economy. Consideration is made on the types of wastes generated by the domestic, commercial, and industrial sectors in significant quantities, with the potential to be brought to the economy (e.g., household biodegradable, poultry, fish, plastic, paper and cardboard, glass, textile, used tyres, e-waste, and used engine oil). The report leaves out some aspects for further research.

Findings

- **Domestic and commercial waste is expected to increase by 11 percent, 35 percent and 64 percent relative to 2019 in 2030** under the low, medium and high growth scenarios, with a waste level of 572,233 tonnes, 694,871 tonnes and 840,678t, respectively. Organic waste (food and yard waste) represents a great scope for CE activities (which amount to 54 percent), followed by plastic, paper, textile and glass waste. Metal already forms part of recycling/recovery activities over the island. The amount of waste is not solely generated by the production in the manufacturing sector but also comes from imported goods.

- **The scope for CE lies to a large extent on the material recovery of household and domestic waste and to a lesser extent on Industrial Symbiosis of a few types of wastes.** The following are identified as forming the components to closing the production-consumption material cycle: (1) household biodegradable waste, (2) poultry waste, (3) fish waste, (4) PET, (5) other forms of plastic waste, (6), paper/cardboard waste, (7) glass waste, (8) wood and wooden pallets, (9) textile fabric waste, and (10) used tyres. The two hazardous wastes treated in this report are: (11) e-waste and (12) used motor oil. The total amount of wastes mentioned, excluding used engine oil and e-waste, was 427,000 tonnes, which makes up 83.3 percent of household and commercial waste disposed at the landfill.

- **Integrating these wastes to the production and consumption cycle will require an estimated investment of Rs 7.5 billion to Rs 11.2 billion for the 2030 optimal capacity.** Several wastes such as PET, HDPE and glass are currently treated to produce secondary raw inputs in Mauritius. Data collected indicates that around 30 percent to 40 percent scale of investment is required to turn these raw inputs into final products, but the market and necessary conditions include product design and standards for the raw materials.

- **Converting organic waste into compost will increase GDP by 0.69 percent**, followed by tyre retreading at 0.19 percent, textile waste to secondary raw input at 0.10 percent and glass waste to secondary raw input at 0.07 percent. Turning PET and HDPE plastics into final products would bring an increase of 0.06 percent and 0.08 percent, respectively. If all wastes are converted into inputs and to some extent to final products, by 2030, the scope of economic activities will stand at Rs 6.1 billion, Rs 7.4 billion and Rs 8.6 billion for a GDP growth of 2 percent, 4 percent and 6 percent. The total additional contribution to economic activity at this stage will stand at 1.32 percent of GDP. The total employment, direct and indirect, ranges from 6,000 to 9,000 by 2030.

- **The survey roughly estimates the hidden cost to an enterprise, of organizing waste ready for recycling, at around 0.04 percent of turnover.** This gives an indication of the investment and operating cost of Rs 70 million to Rs 90 million annually, at firm level in the manufacturing sector.

- **The investment costs if 30 percent of electricity is produced from renewable energy sources by 2025, and 60 percent by 2030, stand at Rs 16 billion to Rs 38.3 billion,** depending on the types of technologies. Solar PV in the form of utility fixed is the lowest investment cost option while wind is the highest. However, this investment figure will be dependent on the production mix.

Constraints of Circular Economy

- **Insufficient wastes for closed loop:** Recyclers emphasize insufficient raw materials to carry on their business operations (e-waste. Glass, PET). Some have been forced to shut down. Most of these enterprises operate at break-even, if not loss-making.

- **Low levels of waste segregation:** One of the main causes of the low recycling rate is the limited access of wastes in segregated and unmixed forms, due to low level or no sorting at domestic level. Before wastes can be converted into valuable inputs, they require some organisation, either at household or enterprise level, which will allow the collector to transfer specific wastes to respective recovery/recycling endpoints. Enhancing efficiency will, in part, require building an incentive structure that will allow for sorting of waste at household and enterprise level.

[1] The year 2019 is the baseline for this study which is prior to the COVID-19 pandemic. The following year i.e., 2020, was hard hit by the lockdown and disruption of economic activities due to the pandemic and may not reflect the accurate situation. [2] Digest of Energy Statistics, Statistics Mauritius (various issues).

- **Absence of reverse logistic:** Reverse logistic strategies are limited, which implies that there are no mechanisms (infrastructures, incentives, etc.) to return products reaching their end of life from consumers to producers. This is the main reason for the disposal of domestic and commercial waste in the landfill.

- **Absence of synergies for Industrial Symbiosis:** As far as industrial waste is concerned, the scope for Industrial Symbiosis at large scale is limited to poultry waste, organic fish waste, and textile waste. With the proper reverse logistic, there may be other opportunities at very small scale as well. However, given data is limited to facilitate discussion, the absence of synergies among enterprises and other stakeholders remains a barrier.

- **Absence of end-of-life strategies:** Recycling enterprises treating PET and other forms of plastic waste, e-waste, and glass waste among others, manufacture intermediate inputs and hence the level of upcycle – transforming waste materials in high perceived value - is quasi non-existent.

- **Lack of R&D and product development:** Using the wastes as material inputs could also create wide business opportunities. However, there is a need to conduct R&D in product design, undertake technical and economic feasibilities, establish the necessary standards for the inputs produced from wastes, and create the necessary market for final products.

- **Uncertainty and risk:** Enterprises that are keen to invest in the CE are faced with uncertainty and risk of securing raw materials once investment in machinery and equipment has been made. The process of competing for tenders on a regular basis poses a risk, because if tenders are not successfully obtained, enterprises would run at a loss. This concern is accentuated when foreign companies which may benefit from well-defined incentive structure in their country of origin would be more competitive to succeed in their attempts relative to local companies. When wastes are exported, they are not brought back to the domestic economic system and the opportunities to generate wealth and create jobs are limited. A scheme such as 'pioneering status' over a defined period could play a key role to promote CE activities in Mauritius.

- **Contracting:** Most of the CE operators are SMEs, and often create and self-enforce new rules outside the boundaries of the formal legal framework. For instance, the local small enterprise who needs to procure input material from several other businesses who wish to dispose of their waste have no means of legally ensuring the quality of what they receive. There are no formal contracts that they can use for their business model and must devise their own contractual terms with respective suppliers.

- **Financial Mechanisms:** Securing finances for vanguard business concepts (and by SMEs mostly) is a daunting task in an economy that only considers linear value chains. Accessing finance for end-products that have not entered mainstream production lines puts CE practitioners at a disadvantage. Referring to the difficulties of inter-firm interactions complicates the claim to financial viability as there is limited scope for shared investment prospects between actors along the same value chain.

Transitioning to a Circular Economy: the way forward

Multi-stakeholder Involvement and Ownership: CE requires a shared responsibility among different stakeholders.

Government: Strategies that need to be deployed by the Government include, inter alia: establishing a clear vision on CE and policies towards waste management to 2030; introducing the necessary incentive framework for actors involved in CE activities; reforming the waste collection system towards segregation with investment in the necessary logistic and infrastructure; establishing the necessary logistic to enable recyclers to secure waste as raw materials in a timely manner; facilitating the industry-university research into R&D and product design from waste; and not least, establishing the necessary standards and certification of material recovery from waste.

Consumers: Consumers are positioned at the start as well as at the end of the supply of chain. It is imperative to engage more with civil society to foster eco-effectiveness (as opposed to eco-efficiency) in the economy, with a culture of segregation. The appropriate incentives and regulations are required.

Business Community: The business community is likely to bear the biggest risk of the supply chain since survival would require securing markets for the products. This will necessitate innovative ideas in transforming waste to final products. A clear vision of CE is crucial to mitigate the uncertainty and risk of their investment. First-movers should be guaranteed a pioneer status to allow them to securely invest in the CE.

Institutional Framework: An institutional framework is required to address issues related to demand and supply. It would be recommended to set up (i) a National CE Task Force (NCET), and (ii) a Stakeholder platform and promote chain coordination.

National Circular Economy Task Force (NCET): The NCET will be designed to promote CE principles, facilitate the acceleration of CE activities and enable the growth of the system, to act as a channel of communication for different stakeholders to ensure policy coherence.

Stakeholder platform (Infrastructure): Information exchange is at the nexus of a CE system that is underpinned by interdependencies that connect the upstream and downstream actors in the production chain. To redress some of these concerns, Business Mauritius could step in as a CE accelerating organisation that provides a platform for shared knowledge and set a standard for good practices in waste management to facilitate the task of procuring used input material of satisfactory quality for better value of refurbished product.

Chain coordination: This pertains to interaction between different actors in the value chain. The aim is to facilitate inter-firm collaborations to enable cascading activities that loop back into the product's prolonged life cycle. Currently, there is no recognised platform for information sharing or an organisational body to facilitate such interactions between different actors along a sustainable supply chain. In the present, business environment intermediary services seem to be missing; this has financial implications for CE practitioners who cannot bank on an existing interdependent symbiotic system.

Conclusion

It will take time for CE as an economic system to replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, and to become a significant contributor to national wealth. Both the EPZ and the financial sectors took almost a decade to reach their cruising speed. Whilst there is no doubt about its potential for growth in the coming years, it needs nurturing as it is bound to stagnate in the absence of a proper conducive environment in terms of infrastructure, regulations, standards, incentives, institutional support, market development, and most importantly a strategic vision shared by all stakeholders. It is hoped that this report is useful to trigger the necessary discussion at the level of the Government, and business community for concrete actions to develop the CE in Mauritius.

1.

INTRODUCTION

Mauritius has made commendable progress over the last decades or so, reaching the status of a high-income country in December 2019[3], only to be set back by the COVID-19 pandemic. The development trajectory has successfully helped to surmount many socio-economic challenges. However, with rising prosperity comes immense pressure on the island's ecosystem. The island currently faces serious environmental challenges such as rising level of wastes mainly due to unsustainable production and consumption systems, and pollution from the growing consumption of fossil fuel energy. The traditional linear business model of 'take-make-use-dispose', has led to an increase in solid waste by 29 percent between 2010 and 2020, and by more than 100 percent over the last 20 years[4]. With a population of 1.27 million (2019), the average amount of solid waste per capita disposed at the landfill daily has increased steadily from 0.6 kg in 2000 to 1.1 kg in 2019[5], generating around 537,147 tonnes annually[6]. In 2019, the sector was the second largest contributor to greenhouse gas emissions (GHGs) at a figure of 23 percent while fossil fuel energy accounted for 74.2 percent of GHGs[7]. The quest for a sustainable economy necessitates consumption and production systems which minimise waste disposal and associated negative environmental impacts.

A response to this challenge is the establishment of a Circular Economy (CE) as a novel business development and consumption model mainly to close the material loops. The CE promotes the reuse, recovery and recycling of products and materials continually, using renewable energy as far as possible[8]. It requires innovation in the chain of production, consumption, distribution and recovery of materials and energy[9], with distinct institutional and governance structures. In contrast to the 'end-of-life' business model, this paradigm is regarded as promising to the Government and business operators, because investing in the preservation of natural capital and ecosystem services through CE has the potential to promote business opportunities, create employment and generate wealth. CE could also contribute to the post COVID-19 economic recovery for Mauritius. Although the pandemic has slowed down business development, the future of Mauritius requires scaling up private sector investment - a critical direction toward build back better. CE opens a gateway for the private sector to contribute towards the twin objectives of environmental management and economic recovery, in line with the Government strategy to promote waste minimization strategy (i.e., the 3 Rs principle – reduce, reuse, and recycle)[10] .

The involvement of the Mauritian private sector in building a sustainable economy has gained momentum in recent years by adopting sustainable production practices. For instance, Business Mauritius - an independent association representing the voice of Mauritian private companies – has introduced several sustainability initiatives since 2017. A Sustainability Pact, called "SigneNatir", was finally launched in 2020, as a community initiative to enhance sustainability within business operations over the island. Moreover, in the ongoing pandemic, it observed that businesses are more inclined to align their agenda towards sustainable development. For instance, a Business Survey undertaken by Business Mauritius, in partnership with the UNDP and Statistics Mauritius in 2020, concluded that about 41 percent of Small and Medium Enterprises (SMEs) were willing to invest more in sustainable development programmes after the first lockdown that ended in May 2020.

The current level of wastes disposed at the landfill represents untapped opportunities to generate wealth. This report provides insights into their potential for business opportunities, economic growth and creation of employment. It offers an analysis of the CE using both a micro- and macro-economic perspective and builds over the findings of two previous reports: the 'Republic of Mauritius: Industrial Waste Assessment Opportunities for Industrial Symbiosis' by the Partnership for Action on the Green Economy (PAGE) and the 'Waste Management Sector Review and GHG Emission Reduction Potential by the UNDP[11].

The objectives of this report are fourfold. First, it describes the scope of CE within the Mauritian economic and social context through an assessment of the main types and quantities of wastes which could be brought back to the economy. Second, it examines the opportunities to turn waste into material resources, considering the existing recycling activities over the island. Third, it makes projections on the contribution of CE through material recovery and recycling to GDP for the period 2021-2030, assuming three growth scenarios (low, medium and high). Finally, the report discusses the challenges, institutional reforms and strategies which could make CE a reality.

It is important to read this report within its scope. The assessment considers several factors (a priori). First, to provide a realistic perspective, the study considers the types of wastes which are generated by the domestic, commercial, and industrial sectors in significant quantities and the potential to bring them back to the economy. These wastes include household biodegradable, poultry, fish, plastic, paper and cardboard, glass, textile, used tyres, e-waste, and used engine oil. It also assesses renewable energy options but does not analyse the appropriate mix among these options. In addition, material recovery from the wastes is based on existing practices in Mauritius. Consequently, it is not within the scope of this study to propose or analyse comprehensively the range of options as well as upcycle opportunities which these wastes offer. Wastes such as plastic, glass, textile, and electronic among others, are currently turned into secondary raw materials which are mostly exported. The current landscape does not consider the prospects of turning these raw materials into high end final products. Yet, this aspect could be highly rewarding but requires thorough market research and product development. CE also involves repairing and refurbishing, thereby prolonging the lifetime of the products. This facet of CE has a huge potential to create employment in Mauritius, but their extent and potential contribution cannot be examined at this stage. Industrial symbiosis has also some potential (for e.g., food, textile, and fish waste) but its development depends on many factors, the main one being the synergy among enterprises. The scope of CE in this study is therefore a first approximation and could be taken as a minimum reference point.

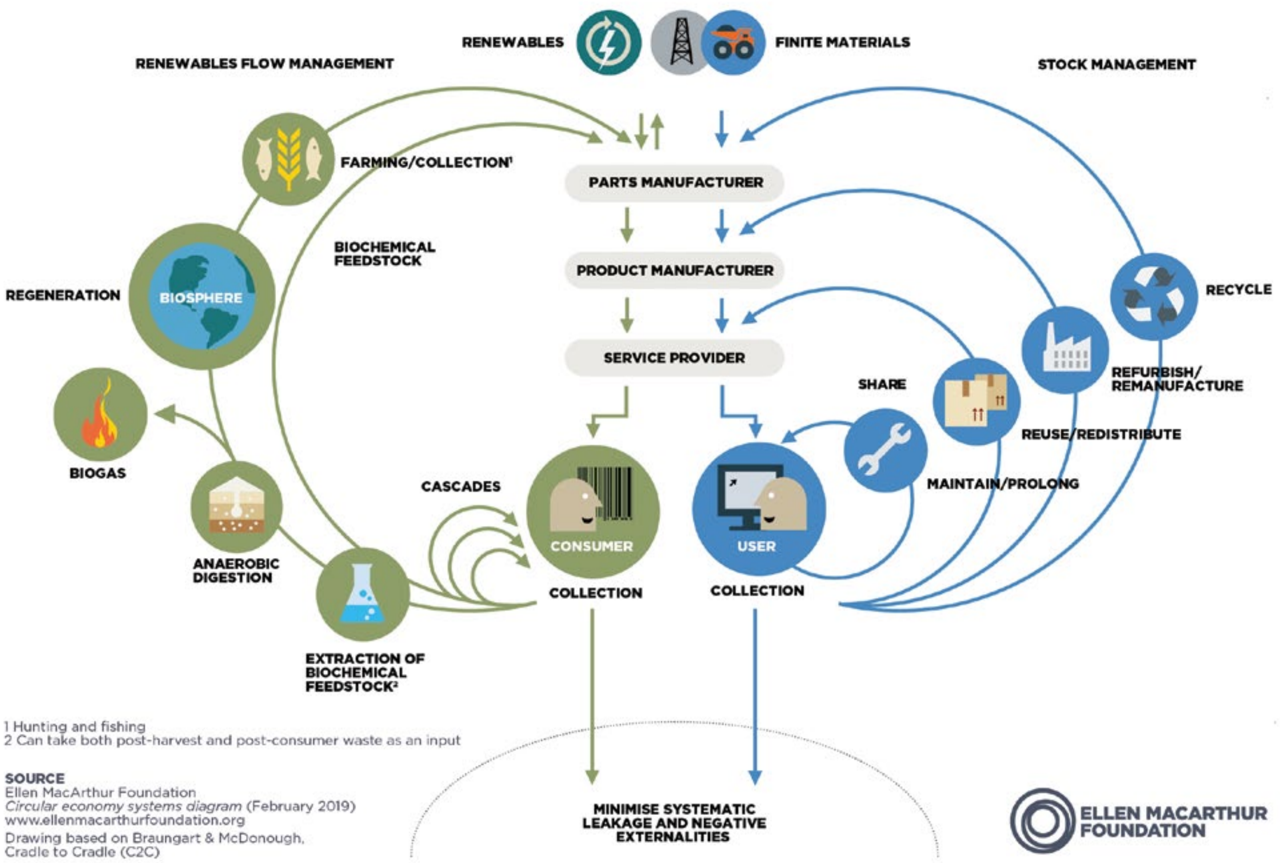
[3] World Bank 2021. https://www.worldbank.org/en/country/mauritius/overview
[4] Digest of Environmental Statistics, Statistics Mauritius (various issues)
[5] The year 2019 is the baseline for this study which is prior to the COVID-19 pandemic. The following year i.e., 2020, was hard hit by the lockdown and disruption of economic activities due to the pandemic and may not reflect the accurate situation.
[6] The figure corresponds to daily rate and is currently at 1.4kg in 2020.
[7] Digest of Energy Statistics, Statistics Mauritius (various issues)
[8] Bocken, N.M.P., de Pauw, I., Bakker, C., van der Grinten, B., 2016. Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering.
[9] Geisendorf, S., Pietrulla, F., 2018. The circular economy and circular economic concepts—a literature analysis and redefinition. Thunderbird Int. Bus. Rev. 60, 771–782.
[10] For e.g., from the Budget Speech 2020/21, all recycling activities will be classified as a manufacturing activity and will therefore benefit from the various fiscal and other incentive schemes.
[11] The report is forthcoming at the time of the write-up.

2.

THE CIRCULAR ECONOMY FRAMEWORK

Principles of Circular Economy

According to the Ellen MacArthur Foundation, CE is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems[12] . The Butterfly Infographic (Appendix A), developed by Ellen MacArthur Foundation, is considered as the most popular and comprehensive framework, aiming at changing the linear 'take-make-waste' model.



Specifications of some aspects of the CE are already covered by existing codes, such as eco-design, and LCA in ISO/TC207 environmental management and sustainable purchasing (ISO 20400:2017—Sustainable purchasing: Guidance). In 2018, the International Standard Organisation (ISO) has set up a new technical committee, the ISO/TC 323 standard, which was proposed by France - 26 countries were in favour of this new technical committee. The scope covers the standardization in the field of the CE, to develop the requirements, frameworks, guides, and support tools related to the implementation of CE projects. The proposed deliverables can be applied to any organization or group of organizations that wish to implement economic projects.

CE goes beyond reduction, reuse, recycling and disposing waste. The 9R frameworks and waste hierarchy provide a wider scope of being circular. One of these is prolonging the life of consumer goods and industrial equipment through refurbishment and re-manufacturing, which can by itself stimulate a second-hand local economy – the cradle-to-cradle and close loop concept. Upon the end of the product's lifetime, materials should return to either an industrial process or, in case of a treated organic residual, safely back to the environment as in a natural regenerating cycle[13] - referred to as reverse logistics. It operates by creating value at the macro, meso and micro levels, and exploits to the fullest the sustainability nested concept of waste (upcycle). Finally, CE requires that the

[12] EMF 2021 What is a circular economy? https://www.ellenmacarthurfoundation.org/circular-economy/concept. Accessed date 20.06.21.
[13] Nobre, G. C. & Taveres, E. 2021. The quest for a circular economy final definition: A scientific perspective. Journal of Cleaner Production, forthcoming.

sustainability nested concept be integrated in economic, social and environment aspects. Therefore, the Government, producers and consumers play an active role in ensuring correct system long-term operation using End of Life Strategies. This report provides an assessment of the CE in Mauritius across 10 principles of CE as follows:

1. 9R Framework: a set of 9 strategies to be considered for a CE approach, in order of priority: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover.

2. Waste hierarchy: a priority operations order in waste management: prevention, preparing for reuse, recycling, other recovery (including energy recovery), and disposal.

3. Upcycle: transforming waste materials, useless or unwanted products into new materials or products with high perceived value.

4. Resource Efficiency: the use of limited resources in a sustainable manner and minimizing environmental impacts, delivering greater value with less input.

5. Closed Loop: the combination of reverse and forward logistics with focus on reducing use of raw material and generation of waste by treating effluents and returning them to reuse and/or increasing the durability of products.

6. Reverse Logistics: return used or unused products (parts) from consumers to producers to generate value by reusing or proper disposing.

7. Industrial Symbiosis: cooperation among industries, where one's wastes become other inputs.

8. Cradle to Cradle: create products that allow the safe and potentially infinite (re) use of materials in cycles.

9. Clean and Renewable Energies: the use of clean and renewable energy sources instead of fossil and polluting sources.

10. End of Life Strategies: sustainable strategic actions to be performed when a product of component reaches its end of life.

Methodology for the study

The study adopts a three-tier approach to provide insights on CE in Mauritius. The first tier is the characterisation of wastes from the domestic, commercial, and industrial sector. A forecast of waste is undertaken for the period 2021-2030 under three growth scenarios: 2 percent, 4 percent, and 6 percent. An econometric approach is used for the domestic/commercial wastes, while the Input-Output model is adopted to forecast waste in the industrial sector. The second tier collects information on recycling practices and material recovery for the major types of wastes from existing enterprises, peer-reviewed studies, and interviews with key experts. A questionnaire was designed and circulated to a sample of enterprises. Given the time and resource constraints, few enterprises responded. However they also provided in-depth information on their production structure and waste composition that were very informative for the analysis. The third tier uses the economic data (e.g., operating costs, investment, and employment) associated with recycle and material recovery to estimate the economic impacts if those main wastes were brought back to the economy. The employment impact assessment has been guided by the ILO methodology[14].

[14] How To Measure And Model Social And Employment Outcomes Of Climate And Sustainable Development Policies'. published by the Green Jobs Assessment Institutions Network in 2017.

3.

MAPPING THE CIRCULAR ECONOMY POTENTIAL IN MAURITIUS

One way to map the potential of CE activities is through an analysis of the composition of wastes which are generated by the domestic, industrial, and commercial sectors. This section attempts to assess the different types of wastes which are generated by the domestic and industrial sectors and to produce forecasts for the period 2021-2030. This will provide the scope for material recovery, which is the purpose of section 4.

From published statistics[15], 95 percent of the municipal wastes disposed at Mare Chicose are generated by the domestic and commercial sector. The first step is to make projection of this component of waste for the period 2021-2030. This is achieved by estimating the long run relationship between domestic waste per capita and GDP per capita. An econometric analysis is undertaken in section 3.2 and the elasticity of waste[16] with respect to income (per capita) is estimated. This is used to forecast domestic and commercial waste for the period 2021-2030. The forecast assumes three growth scenarios: 2 percent, 4 percent, and 6 percent. The second step is to distribute the total waste according to the different types (plastic, paper, food waste, yard waste, glass, metals, textiles).

To forecast the different types of industrial waste, the Input-Output (IO) model (appendix A) is used. The IO model is relevant for the assessment of industrial waste because it considers the inter-industry linkages, i.e., the change in a specific industry's output is not only due to changes in final demand but also responds to other industries intermediate demand. The first step is to use a generic equation which estimates the total waste per industry based on the industry's gross output or turnover. The second step is to distribute the total waste by industry into different types considering the specificities of the industry. Again, the three growth scenarios of 2 percent, 4 percent and 6 percent are assumed. Section 3.4 provides the results.

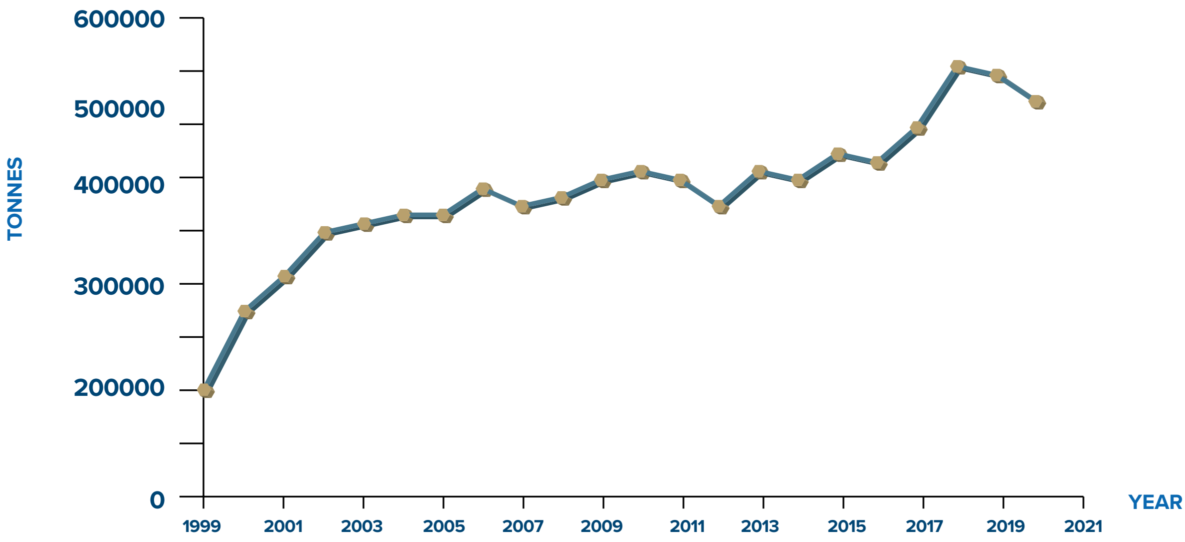
3.1. Waste characterisation in Mauritius

Waste is defined in the Local Government Act (2011) to include any solid matter, other than hazardous waste, which is discarded, rejected, abandoned, unwanted or surplus[17]. The Ministry of Local Government and Disaster Risk Management, through the five municipalities and four district councils, collects domestic and commercial waste on a door-to-door basis at least once a week throughout the island. The council taxes which are paid by residents in the five municipalities already include a Waste Management tax. The Government spends around Rs 1.5 billion annually on waste management, including collection (on some housing estates, coastal villages, traffic centres and public beaches); operation and maintenance of transfer stations; transportation of wastes to landfill; and operation and maintenance of the landfill site. The Local Authorities collectively spend around Rs 990 million annually on waste collection services.

The municipal solid waste is either sent directly to the only sanitary landfill at Mare Chicose or are compacted at the nearest five transfer stations situated at St. Martin, Roche Bois, Poudre D'or, La Laura and La Brasserie, prior to transportation to the landfill. The collection and transportation of domestic waste is contracted partly or fully to private contractors. There is no sorting of wastes at all. It is estimated that around 12 percent of the solid waste are dumped indiscriminately onto wastelands, bare lands and waterbodies[18].

Figure 3.1 shows the total solid waste disposed at Mare Chicose. The fall in 2020 reflects the impacts of the COVID-19 pandemic, in particular the slowing down of business activities and the lockdown from March to June 2020. The amount of waste in 2019, which is taken as the baseline in anticipation of the economic recovery from the pandemic, was 537,147 tonnes.

Figure 3.1. Disposal of Solid Waste at Mare Chicose 1999-2020 (tonnes)



Source: Digest of Environment Statistics (Statistics Mauritius), various issues

The different types of waste at the Mare Chicose landfill are provided in table 3.1. As shown, 95 percent of wastes originated from households and commercial (514,020 tonnes), with industrial waste accounting to less than 3 percent, and the remaining comes from the construction sector. Around 6 percent of solid waste disposed at the Mare Chicose landfill (30,000 tonnes) was treated in a composting plant. The latter ended its operation. At present, all wastes are therefore transported to the landfill.

Table 3.1. Types of waste at Mare Chicose landfill

Types of wastes	%
Domestic & commercial	95.5%
Construction	1.8%
Industrial	0.1%
Textile	0.0%
Tuna/Sludge	0.4%
Poultry	1.6%
Rubber tyres	0.1%
Asbestos	0.0%
Condemned goods	0.2%
Difficult and hazardous	0.2%
Paper waste	0.0%
Others	0.2%

Source: Digest of Environmental Statistics 2019

The Mare Chicose landfill is also equipped with a landfill Gas to Energy facility of 3.3 MW which has been operational since November 2011. Using the methane-rich gas generated through the decomposition of waste at the landfill station, it produces 22,000 MWh of electricity which is transferred to the CEB grid, representing around 1 percent of the total electricity consumed.

The composition of wastes provides an indication of the scope for material recovery for reuse, recycling, and other options. To probe into the potential options necessitates a detailed examination of the household waste collected by Municipalities' waste collectors, and industrial waste generated by the manufacturing sector. This is the focus of section 3.2 and 3.3.

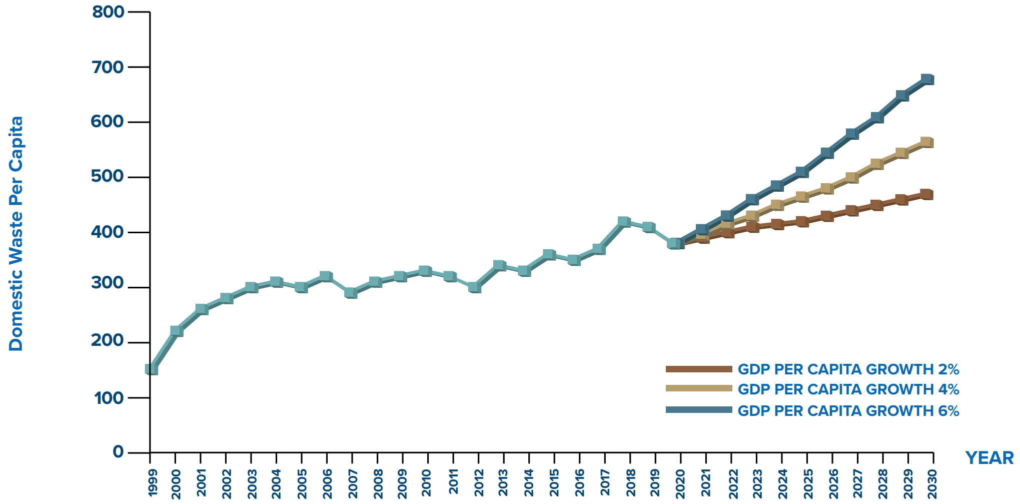
3.2. Domestic and Commercial Solid Waste

Figure 3.2.1 shows the trend of the domestic and commercial waste disposed at the Mare Chicose landfill for the period 1999-2020. In 2019, this sub-category, representing 95 percent to the total, stood at 514,020 tonnes. Using the expenditure incurred by the Government, the amount spent was around Rs 1,926[19] per tonne while the management of facility was Rs 992 per tonne. The total unit cost per tonne was therefore Rs 2,919 per tonne.

Any strategy to manage waste and invest in circular activities would be based on the quantity in 5 to 10 years. The waste elasticity to GDP per capita is estimated at 1.05. The unitary elasticity means that a one percent increase in GDP would lead to an equivalent percentage increase in domestic and commercial waste. To forecast the quantity waste for the period 2021-2030, three different annual GDP growth scenarios are assumed: low growth scenario at 2 percent, a medium or perhaps more realistic growth in GDP at 4 percent and a high growth scenario at 6 percent. In all the scenarios, it is assumed GDP would grow at 4 percent and 6 percent for the year 2021 and 2022 in a recovery phase from the COVID-19 pandemic. Figure 3.2.1 shows the projected level of waste for the period 2021-2030.

[15] Digest of Environmental Statistics, Statistics Mauritius.
[16] The elasticity measures the percentage change in domestic waste per capita when income per capita changes by one percentage.
[17] The different definitions of 'waste' in the Mauritian context, regulations and laws are well-documented in the IWA (2017)
[18] Foolmaun, R. K., Chamilall, D. S., Munhurrun, G., 2011. Overview of non-hazardous solid waste in the small island state of Mauritius. Resources, Conservation and Recycling, vol. 55, pp. 966-972.
[19] Waste collection at Rs 990 million over 514,020 tonnes; remaining Rs 510 million was the management of the facilities.

Figure 3.2.1. Projected Domestic and Commercial Waste 2021-2030 (000 tonnes)

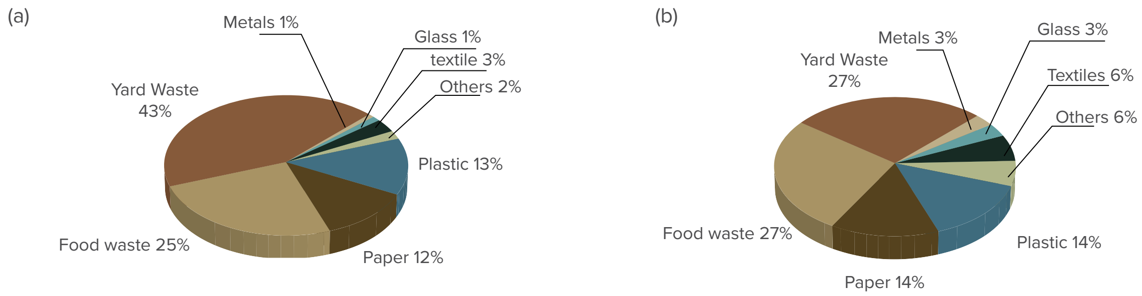


lnDomWastecapita=	**-13.77**	**+1.03lnGDPcapita**
R-bar square= 0.62	**(2.09)*** **	**(0.17)*** **

The increase in GDP by 2 percent annually would lead to a quantity of waste per capita of 415 tonnes for 2025 and 458 in 2030. In case GDP grows by 4 percent, the year 2025 and 2030 will show a quantity of 457 tonnes and 556 tonnes respectively. The high growth scenario at 6 percent shows a figure of 503 tonnes and 673 tonnes for 2025 and 2030[20] respectively. Multiplying the figures by population projections for the period 2021-2030 , table 3.2 shows the projected waste by the year 2025 and 2030. A rise of 2, 12, and 23 percent relative to 2019 is noted for the year 2025 under the low, medium and high growth scenarios, while the increase for the period 2019-2030 will stand at 11, 35, and 64 percent, respectively.

The next step is to estimate the different types of wastes. This information is extracted from two studies namely Mohee (2002)[21] and the Ministry of Environment and Sustainable Development in 2014. Figure 3.2.2 shows the types generated from the two studies.

Figure 3.2.2. Composition of waste at household level



Source: (a) Mohee (2002) (b) Ministry of Environment and Sustainable Development (2012)

Table 3.2. Domestic and commercial waste by 2030 under three growth scenarios (tonnes)

		2%		4%		6%	
Types of wastes	**2019**	**2025**	**2030**	**2025**	**2030**	**2025**	**2030**
Plastic	71,963	73,275	80,113	80,746	97,282	88,814	105,192
Paper	71,963	73,275	80,113	80,746	97,282	88,814	105,192
Food waste	138,785	141,315	154,503	155,724	187,615	171,285	202,870
Yard waste	138,785	141,315	154,503	155,724	187,615	171,285	202,870
Glass	15,421	15,702	17,167	17,303	20,846	19,032	22,541
Metals	15,421	15,702	15,702	17,303	20,846	19,032	22,541
Textiles	30,841	31,403	34,334	34,605	41,692	38,063	45,082
Others	30,841	31,403	34,334	34,605	41,692	38,063	45,082
Total	514,020	523,391	572,233	576,756	576,756	694,871	840,678

Using the most recent classification by the Ministry, table 3.2 shows the different types of waste which would be generated by 2025 and 2030 assuming a growth of GDP of 2 percent, 4 percent, and 6 percent.

[20] Digest of Demography Statistics, Statistics Mauritius.
[21] Mohee, R. 2002. Assessing the recovery potential of solid waste in Mauritius. Resources Conservation and Recycling 36(1):33-43. DOI: 10.1016/S0921-3449(02)00011-3

The above analysis shows that organic waste (food and yard waste) represents a great scope for CE activities, followed by plastic, paper, textile and glass waste. As far as metal is concerned, there is already some recycling/recovery activities over the island. The amount of waste is not solely generated by the manufacturing sector but also comes from imported goods. These forecasts are based on several assumptions: it is assumed that the consumption habits of the population will stay the same, and there is no change in production systems and technology towards sustainability.

3.3. Industrial Waste

Industrial wastes are generated by the manufacturing sector and constitute less than 3 percent of the total amount disposed at the landfill, with similar waste groups, such as paper, plastics, metal scraps, and e-waste, among others. The same recyclers operate in both supply chains: they collect from both industrial premises as well as from local authorities. The transport of industrial waste is carried out at the cost of each firm that generates waste. Some firms organize their own waste transport, but the vehicles used for the transport of waste must possess a carrier license issued from the Ministry of Local Government.

Wastes are generated according to the industrial structure (table 3.3.1). Food products, beverages, and textile and wearing apparel in large enterprises represent the main activities contributing 58.8 percent to manufacturing output. Small enterprises represent 21 percent of manufacturing output and are mostly in food and textile manufacturing.

Table 3.3.1 Manufacturing sector – industries

(a) Large establishments	%
Food products (incl. Sugar)	17.40
Beverages	14.24
Textiles	5.93
Wearing apparel	20.71
Leather and related products	0.44
Of which: Footwear	0.05
Wood and of products of wood and cork, except furniture; Articles of straw and plaiting materials	0.19
Paper and paper products	0.89
Printing and reproduction of recorded media	1.60
Coke and refined petroleum products / Chemicals and chemical products / Pharmaceutical products and pharmaceutical preparations	3.55
Rubber and plastic products	2.65
Other non-metallic mineral products	2.44
Basic metals	0.40
Fabricated metal products, except machinery and equipment	2.10
Computer, electronic and optical products	0.90
Electrical equipment	0.37
Machinery and equipment n.e.c.	0.24
Manufacture of motor vehicles, trailers and semi-trailers / Manufacture of other transport equipment	1.99
Furniture	0.73
Other	2.09
Of which: Jewelry, bijouterie and related articles	0.93
Repair and installation of machinery and equipment	0.12
(b) Other than large establishments	21.02

Source: Digest of Industrial Statistics (2017)

The Industrial Waste Assessment (2017) report is the only one which has comprehensively collected data on the types of wastes from several industries. A summary is provided in table 3.3.2 There is a significant amount of waste which are already recovered and recycled by recyclers such as paper and cardboard, plastic films and bags, wooden pallets and used oil. Given the main industries which form part of the manufacturing sector, the IWA concluded that there are opportunities for Industrial Symbiosis (cooperation among industries, where one's wastes become other inputs), based on the waste from the food products, beverages, textile and wearing apparel, paper and printing of recorded media, and chemical and pharmaceutical products.

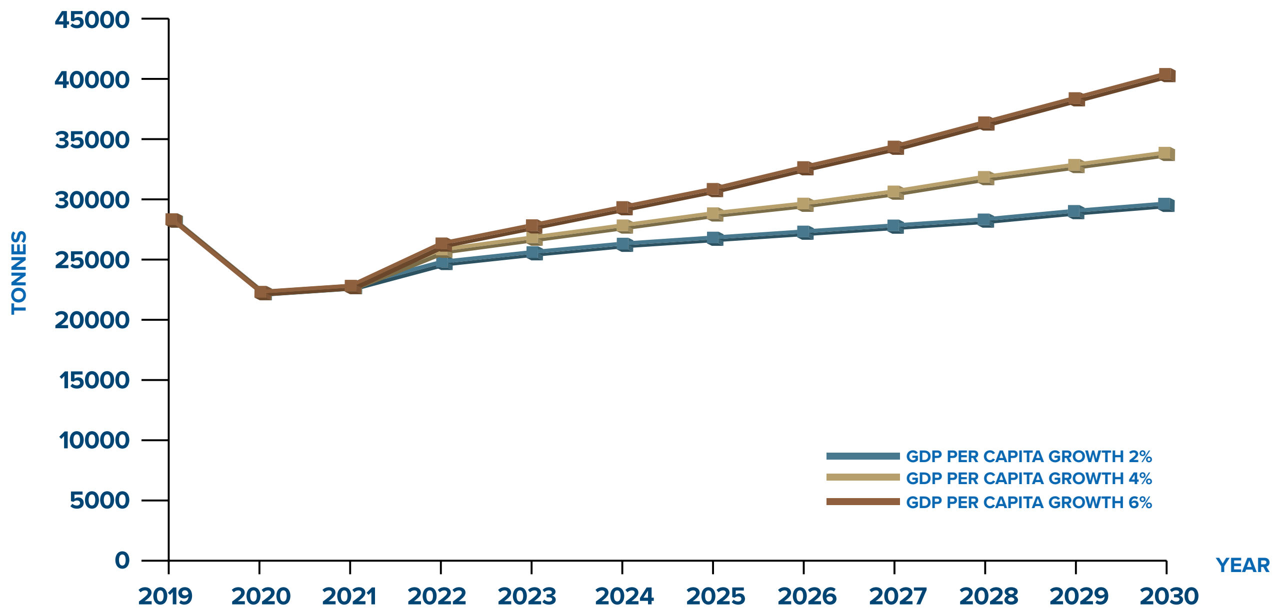
Table 3.3.2 Types of industrial waste for Mauritius

Sector	Types of solid waste	Current management
Food poultry	Organic waste from poultry (including offal, feathers, head, contaminated birds, feet, blood, fat)	Material recovery to produce flour for pet food and landfill
	Carton boxes / paper	Landfill: too dirty to be accepted for recycling
	Plastics	Landfill: too dirty to be accepted for recycling
	Faeces and farm waste	Composted and compost to local market
Food seafood	Organic waste from fish (including whole dead fish, fish bones and fish internal waste)	Landfill
	Fish food packaging (plastics)	Landfill: too dirty to be accepted for recycling
	Salt	Landfill
	Used Oil	Recycling
Food bottling	HDPE	Recycling
	Organic waste including plastics	Landfill
	Carton boxes	Recycling
	Milk powder packaging	Recycling
	Metal drums	Recycling - Reuse
	Scrap metal	Recycling
	Paper	Recycling
	Glass bottles and debris	Recycling - Landfill
Textile and wearing apparel	Yarn and cotton fabric Woollen fluff	Recycling - Landfill
	Obsolete chemicals	Storage - Landfill
	Aluminium plates	Recycling
	Paper to be kept confidential	Landfill
	Plastic toner container	Storage
	General waste (canteen, offices, sweepings)	Landfill
All sectors	Carton boxes / paper	Recycling
	Plastics	Recycling
	Wooden pallets	Recycling
	Exhausted oil	Recycling
	E-waste, Batteries, Lighting equipment	Recycling
	Scrap metals	Recycling

Source: Industrial Waste Assessment 2017

To estimate the different types of wastes at the industry level, the generic equation of the relationship between waste and firms' turnover[22] as reported by the IWA and associated ratios were used. Furthermore, data was also collected on several firms using a questionnaire, specifically designed for this study. Tables 3.3.3 and 3.3.4 (on page 29 and 30) show the types of waste generated by industrial sector. A forecast of the total industrial wastes by the selected industries was made for the period 2021-2030 using the Input-Output (IO) model based on three GDP growth scenarios – 2, 4 and 6 percent. An overview of this method is provided in Appendix A. Figure 3.3 shows the results.

Figure 3.3. Projected quantity of industrial Waste 2021-2030 (tonnes)



Source: Industrial Waste Assessment 2017

In 2019, the quantity of industrial waste disposed at the Mare-Chicose landfill was around 28,500 tonnes; under the 2, 4, and 6 percent growth scenario, this is expected to rise to 29,800 tonnes; 33,700 tonnes; and 40,500 tonnes by 2030.

[22] Wi=1.8E-07TOi where Wi=waste of firm I, TOi=turnover of firm i.

Table 3.3.3 Types of Waste in selected manufacturing industries (%)

Manufacturing sector	Organic wastes	Metal	Plastic	Paper/ Carton	Wood/ pallets	fabric waste	Tins	Tyres	Hazardous waste	fish waste	Salt	E-waste	Metal drums	Aluminium	Other
Fruit, vegetables, oils and fats, grain mill products	73.7	0.0	8.6	8.8	0.0	0.0	0.7	4.8	2.3	0.0	0.0	0.0	0.0	0.0	1.1
Processing of poultry and meat	99.0	0.1	0.3	0.3	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Beverages and bottling	53.0	1.0	3.0	4.0	2.0	2.0	58.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	14.0
Processing of seafood	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	26.0	67.0	4.0	0.0	0.0	1.0
Woven and tufted textile fabrics	22.0	3.0	4.0	2.0	2.0	58.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0
Knitted or crocheted fabrics; wearing apparel	22.0	3.0	4.0	2.0	2.0	58.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0
Paper, printing and recording of media	11.0	0.0	2.0	56.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0	1.0	0.0
Chemicals and pharmaceutical products	22.0	0.0	33.0	7.0	8.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	29.0	0.0	0.0

Source: Industrial Waste Assessment (2017), Surveys conducted during the study

Table 3.3.4 Types of Waste in selected manufacturing industries (tonnes) for 2019

Manufacturing sector	Organic wastes	Metal	Plastic	Paper/ Carton	Wood/ pallets	fabric waste	Tins	Tyres	Hazardous waste	fish waste	Salt	E-waste	Metal drums	Aluminium	Other
Fruit, vegetables, oils and fats, grain mill products	4,950.8	0.0	576.2	593.7	0.0	0.0	45.8	320.0	156.1	0.0	0.0	0.2	0.0	0.0	74.7
Processing of poultry and meat	1,061.0	1.1	3.2	0.0	0.0	7.3	51.1	24.9	0.0	0.0	0.0	0.0	0.0	0.0	80.1
Beverages and bottling	1,376.1	311.6	77.9	441.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	311.6	0.0	77.9
Processing of seafood	0.0	0.0	0.0	23.7	0.0	0.0	0.0	0.0	0.0	307.8	793.2	47.4	0.0	0.0	11.8
Woven and tufted textile fabrics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Knitted or crocheted fabrics; wearing apparel	254.4	33.5	44.6	22.3	22.3	646.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.4
Paper, printing and recording of media	555.3	0.0	101.0	2,827.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,514.5	0.0	50.5	0.0
Chemicals and pharmaceutical products	116.0	0.0	174.0	36.9	42.2	0.0	0.2	0.0	5.3	0.0	0.0	0.0	152.9	0.0	0.2
Total	8,304.6	346.1	976.9	3,948.3	64.5	646.9	53.3	371.1	186.3	307.8	793.2	1,562.0	464.5	50.5	184.5

Source: Estimates

3.4. Hazardous Wastes

Hazardous wastes, as defined in the Environment Protection (Standards for Hazardous Wastes) Regulations 2001, cannot be disposed of along with normal solid waste. These comprise several waste streams such as e-wastes, waste oil, waste lead acid batteries, hazardous healthcare wastes, asbestos wastes and hazardous chemical wastes, among others. The present hazardous waste management system is deficient in terms of data on amounts of hazardous waste being generated, stored and disposed, enforcement of legislations and appropriate treatment/disposal infrastructure[23]. According to the inventory carried out in 2012, the quantity of hazardous wastes generated in 2011 was estimated at 17,000 tonnes, and for 2015 it was forecasted that about 23,000 tonnes would be generated[24]. Medical wastes are incinerated in most public hospitals and some private clinics, and the resultant ash is disposed at the Mare Chicose landfill. In 2016, the volume of HW generated on the island was estimated at around 20,400 tonnes, and included some 9,300 tonnes of e-wastes, 1,725 tonnes of Medical Wastes (MW), and 400 tonnes of Hazardous Chemical Wastes (HCW). Two wastes considered in this report are e-waste and used engine oil.

[23] The setting up of an EWMS (e-waste management system) is in the pipeline. Delays have occurred because of some legal impediments.
[24] Ministry of Environment, Solid Waste Management and Climate Change Minamata Initial Assessment Report 2018

4.

OPPORTUNITIES FOR MATERIAL RECOVERY

Based on the composition of wastes and the projections for the period 2021-2030, this section assesses the scope for material recovery in Mauritius, with the objective to estimate the necessary private investment, the impact on growth and employment. The scope for CE lies to a large extent on the material recovery of household and domestic waste, and to a lesser extent on Industrial Symbiosis of a few types of wastes. The following are identified as forming the components to closing the production consumption material cycle: (1) household biodegradable waste, (2) poultry waste, (3) fish waste, (4) PET, (5) other forms of plastic waste, (6), paper/cardboard waste, (7) glass waste, (8) wood and wooden pallets, (9) textile fabric waste, and (10) used tyres. The two hazardous wastes treated in this report are (11) e-waste and (12) used motor oil.

The Industrial Waste Assessment report (2017)[25] analysed four industries with the potential to develop Industrial Symbiosis for Mauritius, namely: food products (poultry, seafood, beverages and bottling), textile and wearing apparel industries, chemicals and chemical products (including pharmaceutical preparations), and printing and reproduction of recording media). According to the assessment, only the food, and textile and wearing apparel industries generate waste which, in terms of type and amount, could become part of an industrial symbiosis project. These types of waste are: 1. organic waste from the poultry and seafood sub-industries; 2. cotton, wool yarn and fabric from the textile industry; and 3. wooden pallets.

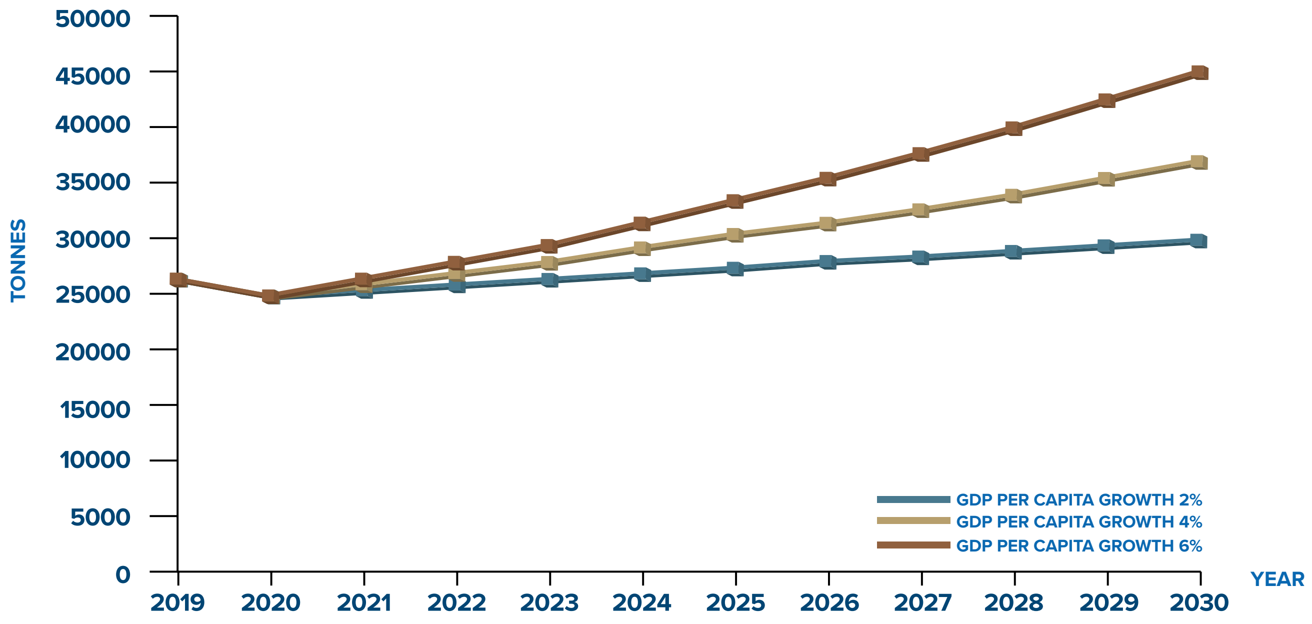
The I-O table provides a detailed picture of the flow of products and resources within a given economy and it is used to estimate output and employment multipliers for specific industries (appendix B, C and D). Impact analysis is the most important use of the multipliers and looks at the effects of a positive or negative change in economic activity. (For example, output and employment multipliers, which account for the total effect across the entire economy).

4.1. Household biodegradable waste

The composition of domestic waste indicates that 54 percent of the wastes disposed by households are biodegradable. If the wastes are separated at source into biodegradable and non-biodegradable wastes, there is a huge potential for composting organic wastes. The benefits include the following: reducing the amount of waste sent to the landfill (which implies longer lifespan of the landfill)[26] by 50 percent; a considerable drop in the emission of methane/greenhouse gases; compost produced would be sold at a much cheaper price compared to chemical fertilizers; lessening the financial burden of farmers; compost would substitute imports of chemical fertilizer, and green jobs would be created through the supply chain. As a result, around 277,500 tonnes could be considered as input in the production system in 2019.

Figure 4.1.1 shows the forecast of organic waste for the period 2021-2030, assuming the unitary elasticity between waste and income.

Figure: 4.1.1. Quantity of organic waste 2019-2030



Source: Industrial Waste Assessment 2017

The organic waste is expected to rise to 317,000 tonnes, 38,400 tonnes and 464,000 tonnes under the 2, 4 and 6 percent scenarios in 2030. The 2025 estimates are respectively 290,000: 319,000, and 350,000 tonnes.

[25] Ibid.
[26] Foolmaun et al. (2011) ibid.

Composting

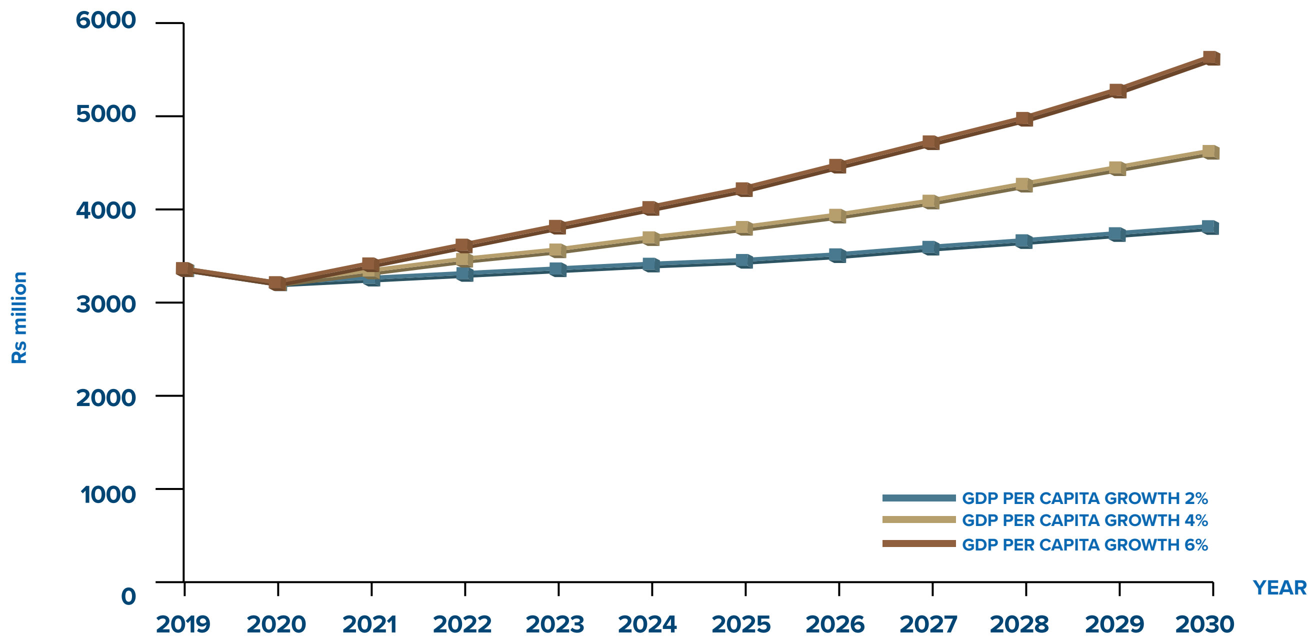
The World Bank (2016)[27] reported that only 8 percent of waste is composted globally, and as low as 1.5 percent in low-income countries. The main reasons include lack of coordinated policies, regulations, and enforcement that support composting across multiple sectors, lack of market demand, unreliable feedstock supply, and unfair competition (synthetic fertilizer subsidies). There is also a high operating cost due to unnecessarily complex technology poorly suited to local market conditions, and poor management of solid waste operations. There is also a need for tipping fees from the municipality and other feedstock suppliers, and compost standards, quality control and certification systems resulting in contaminated compost.

The study by Foolmaun et al. (2011) proposed a composting facility of 50,000 tonnes of biodegradable waste annually to convert 25,000 tonnes of compost. Based on the figures, the investment cost at present would amount to USD 135[28] (approx. Rs 5,500) per tonne and an operating cost of USD 40 (approx. Rs 1,600) per tonne. With a selling price of Rs 1,200 per tonne, there is a probable need for a tipping to make it feasible. This figure is on the lower side since in other countries, the cost is relatively higher. An accurate cost would be USD 400 to USD 600 per tonne and an operating cost USD 60. The World Bank (2016) estimated that around 50 workers are involved for a plant size of 70,000 tonnes (i.e., 0.0007 per tonne) in India, with an operating cost at USD 40 (2016 figure). Similarly, in Brazil, the Ecocitrus composting facility of a capacity of 40,800 tonnes per year employs 25 people (i.e., 0.0006 per tonne).

Figure 4.1.2 below shows the direct gross output if all the organic wastes are converted into compost. This is an optimistic perspective; however, at this stage, this is the most appropriate way to portray the scope of CE.

Assuming 1 tonne of organic waste gives 0.5 tonne of compost, the potential direct gross output will stand at Rs 3.5 billion; Rs 3.8 billion; and Rs 4.2 billion for a GDP growth of 2, 4 and 6 percent by 2025. The realistic scenario of 4 percent gives a direct gross output of Rs 4.6 billion by 2030.

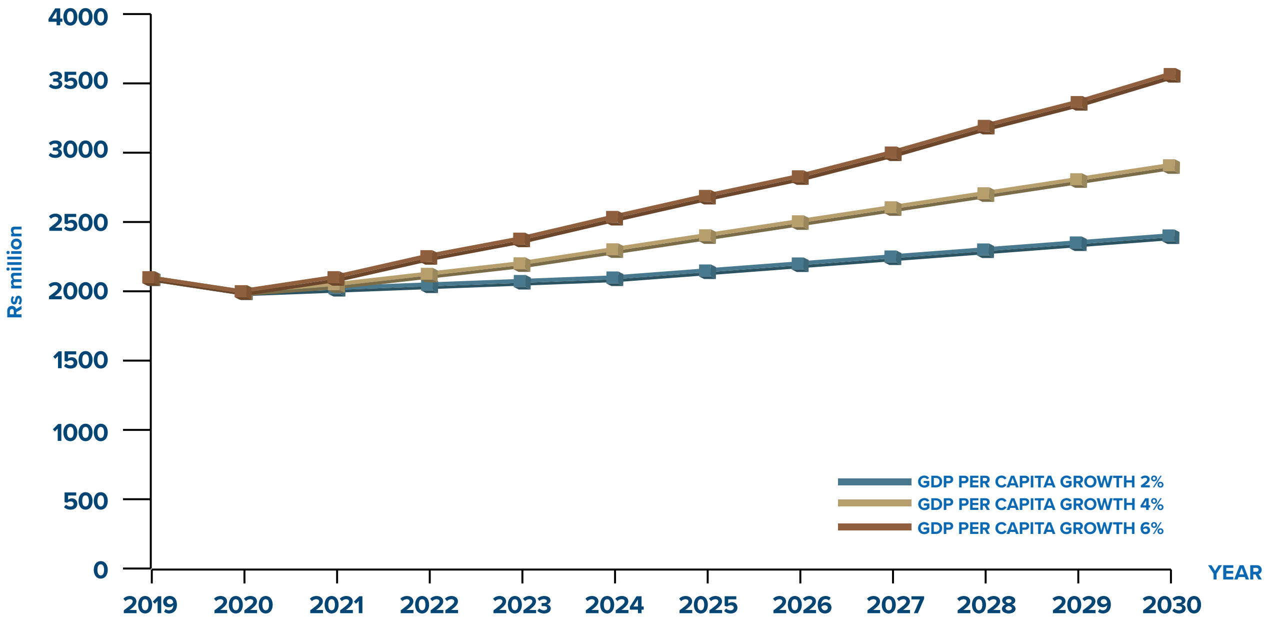
Figure 4.1.2. Direct gross output from composting household biodegradable waste 2021-2030



With an output multiplier of 1.6, the collection, sorting and transfer of waste to the composting plant as well as the uses of intermediate inputs in the composting process will also generate economic activities. Figure 4.1.3 (page 35) shows the indirect gross output that is likely to be generated from composting. It is important to note that currently the transfer of waste to landfill and transfer stations is already part of the economic activity. Around Rs 900m are spent on this activity by the Government. This is already included in the indirect gross output and hence, directing the waste towards composting plants would not create additional activity in this respect. For reference year 2019, the additional economic activity would be around Rs 1.1 billion[29]

[27] World Bank (2016). Sustainable Financing and Policy Models for Municipal Composting. World Bank Group.https://documents1.worldbank.org/curated/en/529431489572977398/pd-f/113487-WP-compostingnoweb-24-PUBLIC.pdf
[28] Compost is currently sold at Rs25 for 2.5kg.
[29] That is, Rs2000m less Rs900m

Figure 4.1.3. Indirect gross output from composting household biodegradable waste 2021-2030



Converting the waste into compostig activity will increase GDP relative to a baseline of no composting by 0.69 percent (table 4.1.1). Depending on the growth scenarion, the investment cost will range from Rs 4.6 billion to Rs 5.6 billion if the capacity is based on the 2025 level and Rs 5.1 billion to Rs 7.4 billion for 2030 capacity.

Table 4.1.1. GDP projection - composting of household biodegradable waste 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	289,962	317,100	5,678	6,210		4,641.2	5,075.6
GDP growth 4%	319,053	383,736	6,252	7,536	0.69%	5,111.4	6,160.5
GDP growth 6%	350,409	464,014	6,872	9,108		5,614.0	7,440.8

Finally, table 4.1.2 provides the direct and indirect employment of a composting strategy. The rise in employment represents 0.1 percent of total employment, relative to a baseline of no composting.

Table 4.1.2. Employment projection- composting of household biodegradable waste 2025-2030

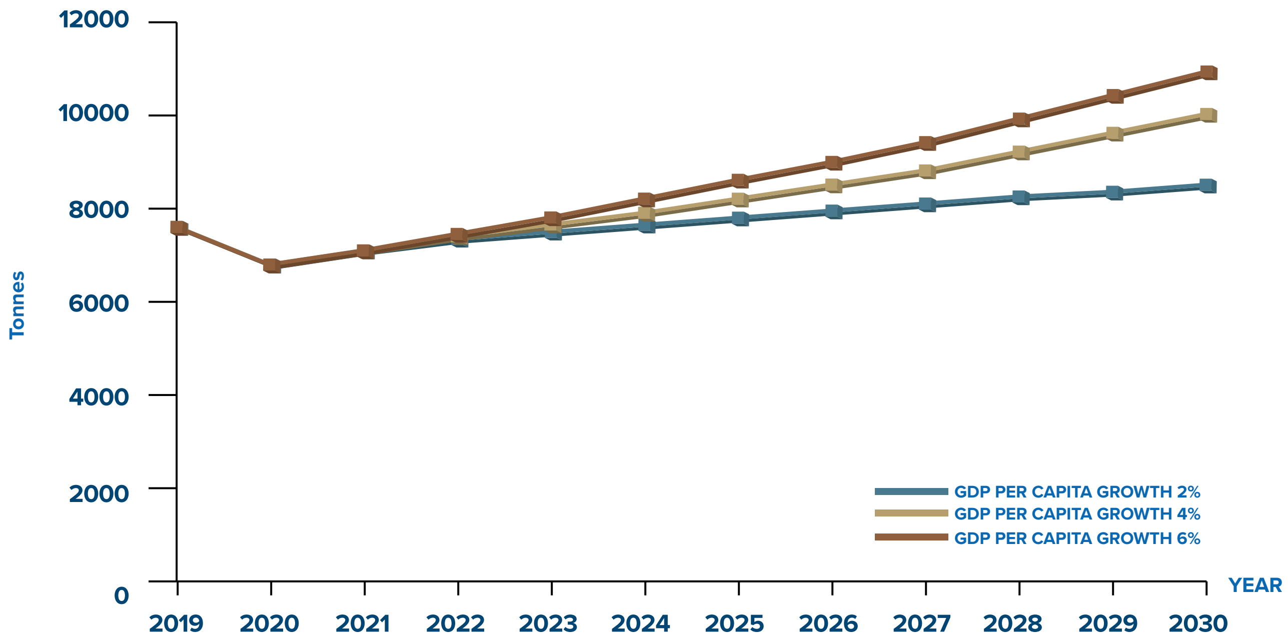
	Direct employment		Indirect employment		Total employment		% increase employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	406	444	957	1,047	1,364	1,491	
GDP growth 4%	447	539	1,054	1,271	1,501	1,810	0.09%
GDP growth 6%	491	651	1,159	1,536	1,650	2,187	

Again, it should be noted that the indirect employment includes the current practice of transferring waste to landfill. These jobs already exist and therefore the additional employment that will created will be less from those shown in table 4.1.2.

4.2. Poultry waste

Poultry waste is one of the wastes which have been proposed for Industrial Symbiosis. The recovery of organic waste for pet food production could be increased by connecting specific firms with those already producing pet food in Mauritius. The estimated total amount of waste stands at 8,238 tonnes; 9,686 tonnes, and 11,255 tonnes for a growth of 2, 4 and 6 percent respectively in 2030. Due to the limited data on the conversion of poultry waste into pet food at the time of this write-up, no estimate can be drawn on its economic impacts.

Figure 4.2.1. Poultry waste



4.3. Fish waste

The Industrial Waste Assessment also reported that there is a possibility of producing omega oil from seafood waste. Discussion is ongoing on this project to conduct the necessary experiment. Further assessments need to be carried out, particularly to verify the future amounts of waste generated.

4.4. Plastic waste

Plastics are categorised by type: (1) polyethylene terephthalate (PET)), (2) high-density polyethylene (HDPE) (bottles, cups, milk jugs), (3) polyvinyl chloride (PVC) (pipes, siding, flooring), (4) low-density polyethylene (LDPE) (plastic bags, six-pack rings, tubing), (5) polypropylene (PP) (auto parts, industrial fibres, food containers), (6) polystyrene (PS) (plastic utensils, cafeteria trays), and (7) other plastics, such as acrylic, nylon, polycarbonate (PC), polyurethanes (PU), and polylactic acid (PLA)[30] . Their percentages are shown in the figure 4.4.1. . Box 4.4.1[31] shows a brief on the recycling of plastic from a recent review by Riccardo Scalenghe.

Box 4.4.1: Types of plastic and recovery

HDPE is characterised by its large density to strength ratio and resistance to many different solvents. Post-consumer plastic waste incorporated in concrete ameliorates the final product, on both a short- and long-term perspective. PVC is not degradable but particularly stable in soil. Polypropylene (PP) is analogous to polyethylene and is a resistant and flexible plastic very similar to HDPE in terms of its properties and structure. In principle, PP is also well suited for recycling, as a recyclate for reuse or remelted directly into new products. In Europe, recycled plastics can generally only be reused for food packaging after an EFSA (European Food Safety Authority) opinion to be reused for food packaging, with higher mechanical properties and thermal resistance. From the point of view of reutilisation, PP fibres can efficiently increase the strength of cement treated clay. Mixing with crushed rock or recycled material from former roads and buildings can result in a material like concrete, asphalt, or mortar composites. Soil reinforced by fibres is a geotechnical engineering technique that has gained consideration because the insertion of synthetic fibres has been demonstrated experimentally to increase the soil shearing behaviour, due to the mobilisation of the tensile strength of fibres at larger deformations. Polystyrene (PS) is resistant to both acids and bases. PS is quite durable and, apparently, unaffected by biodegradation. However, some insects, which have commonly been pests, are able to degrade it within their larval gut. In terms of reuse, bricks obtained by recycled XPS aggregate, instead of mineral sands, obtained good performances.

Plastic type	Recovery
PET	flakes, drying, crystallizing, plasticizing and filtering, then converting in polyester fiber, strapping, and non-food containers, or depolymerized to monomers
HDPE	cascading, downcycling
LDPE	heating, floating, and sinking
PP	melting, extruding, pelletizing
PS	reprocessed granulating and recompressing, extruded to General Purpose Polystyrene pellets
ABS	shredding and blending with virgin ABS

Polyethylene is very easy to recycle, provided it is not bonded with other plastics to form composite materials. Unlike other plastics, PE is often recycled with the same function: canisters become new canisters. Polyethylene terephthalate (PET) is best known as the material used to make disposable and reusable bottles for beverages. However, a lot of other plastic packaging is also made of PET. Many recycling companies still lack the right technologies to sort a wide variety of plastic packaging by type and produce high-quality recyclate that can be used to produce new packaging.

Reference: Scalenghe, R. 2018. Resource or waste? A perspective of plastics degradation in soil with a focus on end-of-life options. Heliyon, e00941.

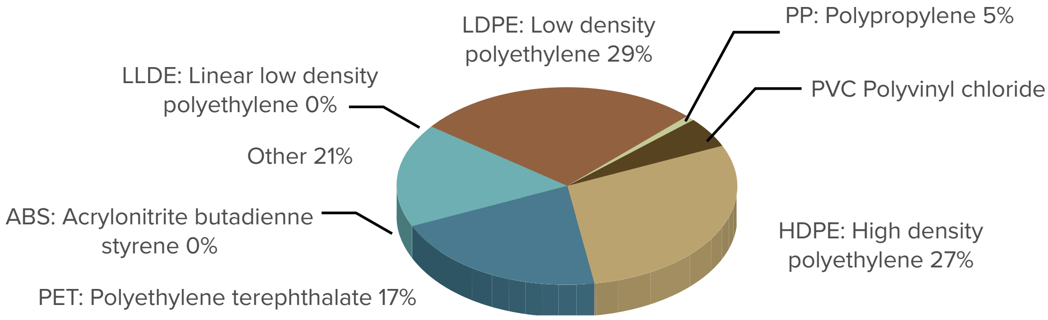
In Mauritius, PET makes 17 percent of total plastic waste from domestic and commercial waste (figure 4.4.1). HDPE and LDPE account for 56 percent. Soft-drinks bottles and some other forms of packaging made with PET typically contain that one type of plastic only, which makes them easy to recycle[32] . Using the projected level of solid waste 2021-2030 and the different category of plastic, table 4.4.1 shows the amount in tonnes which would be generated by the domestic and commercial sector assuming a growth rate of 2, 4 and 6 percent. PET, HDPE and LDPE are the main type of plastic waste generated at household level.

[30] The Society of the Plastics Industry issued the Resin Identification Code (RIC) to make it easier to sort out objects according to their resin type. The symbols used as part of the RIC consisted of arrows that cycle clockwise to form a triangle that encloses a number, where the individual number refers to the type of plastic (STM . ASTM International; West Conshohocken: 2013. Standard Practice for Coding Plastic Manufactured Articles for Resin Identification. ASTM D7611/D7611M-13e1).

[31] L 'Assises De l 'Environment Technical Session 4 Ministry of Environment https://environment.govmu.org/Documents/Assises/Final%20PLASTIC%20AMENDED%20VERSION.%201012.pdf

[32] Scalenghe, R. 2018. Resource or waste? A perspective of plastics degradation in soil with a focus on end-of-life options. Heliyon, e00941.

Figure 4.4.1. Types of Plastic in Domestic and Commercial Waste



Source: Ministry of Environment, Solid Waste Management and Climate Change

Table 4.4.1. Total plastic waste by types 2019-2030 (in tonnes)

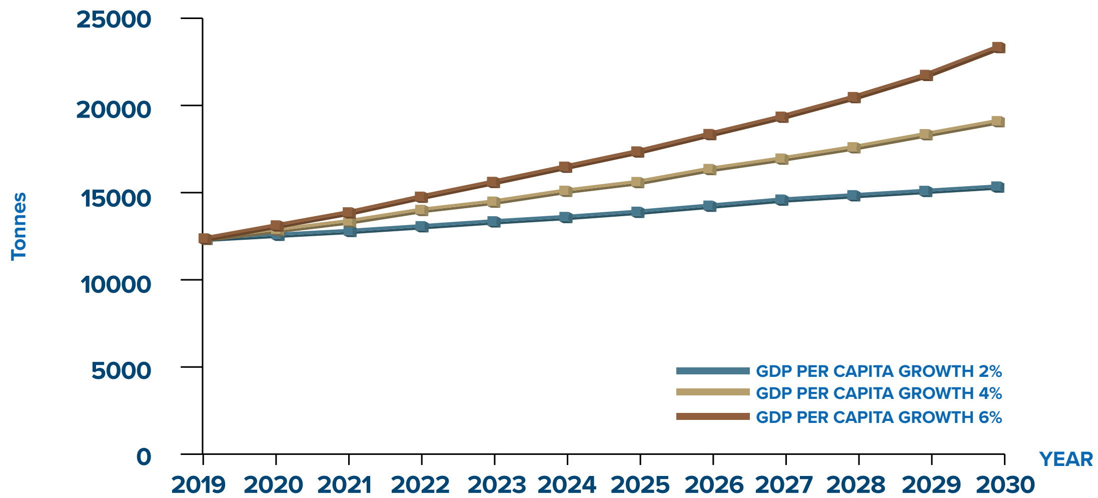
		2%		4%		6%	
Types of Plastic waste	2019	2025	2030	2025	2030	2025	2030
Linear low-density polyethylene	94	95	104	105	126	115	137
Polyethylene terephthalate	12,047	12,266	13,411	13,517	16,285	14,867	17,609
Acrylonitrile butadiene styrene	144	147	160	161	195	178	210
High density polyethylene	19,272	19,623	21,454	21,624	26,052	23,784	28,170
Polystyrene	504	513	561	565	681	622	736
Polypropylene	3,936	4,008	4,382	4,417	5,321	4,858	5,754
Polyvinyl chloride	144	147	160	161	195	178	210
Low density polyethylene	20,948	21,330	23,321	23,505	28,319	25,854	30,621
Total	71,963	73,275	80,113	80,746	97,282	88,814	105,192

Source: Estimates

Under the Environment Protection (PET bottle permit) Regulation, any company bottling any beverage in a PET bottle is responsible for the collection and disposal of the used PET bottles. Prior to this regulation, the only formal disposal route for used PET bottles was by landfilling. There was no separate collection and, consequently, used PET bottles were disposed of commingled with domestic waste. Despite a satisfactory waste collection system in Mauritius, a considerable number of used PET bottles end up around the island. There are around 128 million PET bottles commercialised by the beverage industry annually and around 5,000 tonnes of PET are commercialised[33] . It is estimated around 40 percent (2,000 tonnes) are retrieved and recycled. Household waste composition shows a far higher figure around 12,047 tonnes of PET plastic level.

Data on production and capital costs was collected on existing companies. On average, the investment cost amount to Rs 9,000 per tonne of PET with an operating cost of Rs 30,000 per tonne. Figure 4.4.2 shows the projection for 2021-2030 of PET; with a GDP growth of 2, 4 and 6 percent, the quantity of PET can reach 15,000 tonnes; 19,000 tonnes and 23,000 tonnes respectively in 2030.

Figure 4.4.2. Quantity of PET waste projection 2021-2030 (tonnes)



[33] On average about 25000-30000 bottles to make one tonne of recycled PET

Figure 4.4.3 shows the direct gross output of PET recycling, excluding the current 2,000 tonnes being already in the production system while figure 4.4.4 shows the indirect gross output.

Figure 4.4.3. Direct gross output of recycling PET projection 2021-2030

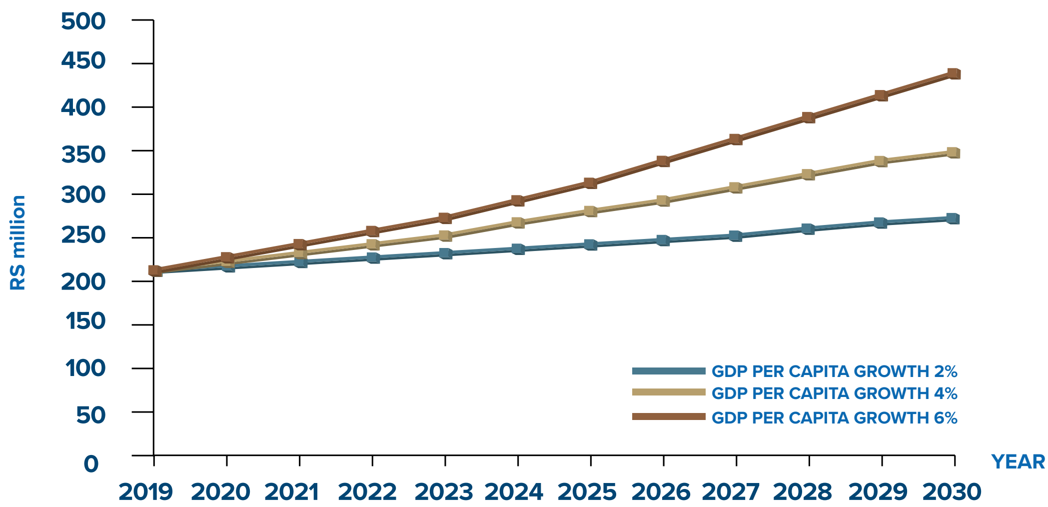


Figure 4.4.4. Indirect gross output of recycling PET projection 2021-2031

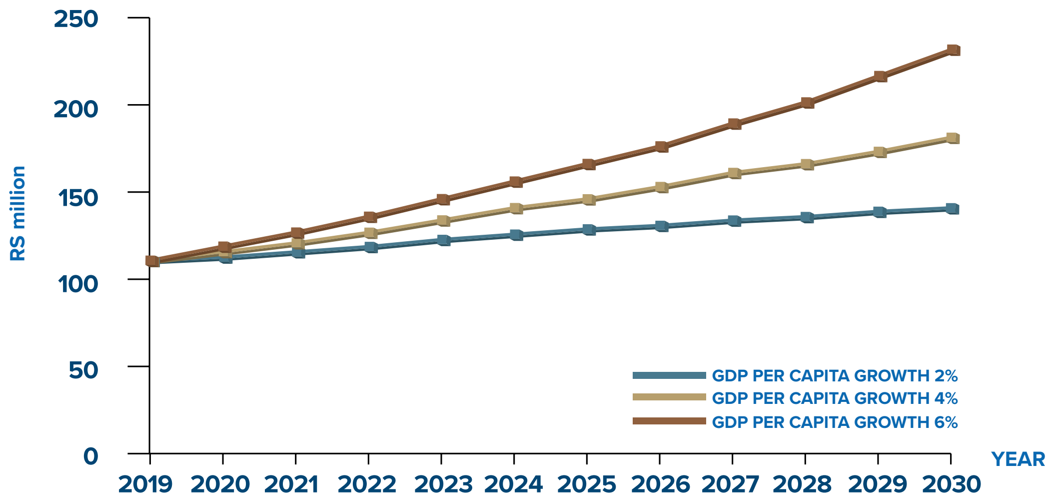


Table 4.4.2. GDP projection recycling PET 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	13,567	14,979	368	413		99.4	111.5
GDP growth 4%	15,243	18,546	422	527	0.04%	113.8	142.2
GDP growth 6%	17,089	22,869	480	664		129.6	179.3

The total investment stands at Rs 99.4 million to Rs 130 million based on 2025 capacity, and Rs 112 million to Rs 180 million on 2030 capacity.

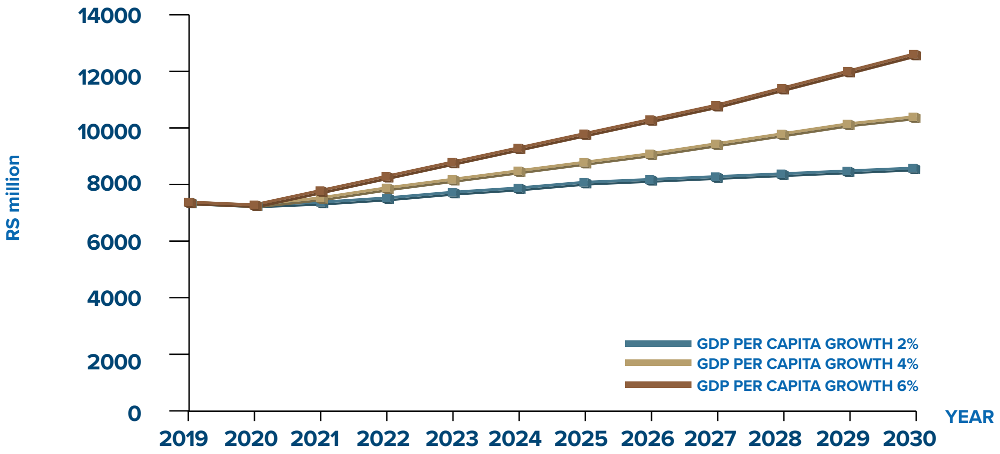
Table 4.4.3. Employment projection recycling PET 2025-2030

	Direct employment		Indirect employment		Total employment		% increase of domestic employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	188	211	44	50	233	261	
GDP growth 4%	216	269	51	64	267	333	0.05%
GDP growth 6%	246	340	58	80	304	420	

4.5. Paper and cardboard

Paper and related products can be recycled several times. In a pre-consumer recycling, materials from manufacturing which do not reach the consumers are recycled. The survey on existing firms shows that the investment cost for recycle paper stands at Rs 1,500 per tonne, with an operating cost of Rs 11,000. The projected quantity of paper and cardboard waste by 2030 will stand at 85,000 tonnes; 102,000 tonnes and 123,000 tonnes by 2030 under the growth scenarios of 2, 4 and 6 percent (table 4.5.1.)

Figure 4.5.1. Quantity of paper waste projection 2021-2030



The direct gross and indirect output are show in figure 4.5.2 and 4.5.3.

Figure 4.5.2. Direct gross output of recycling paper waste projection 2021-2030

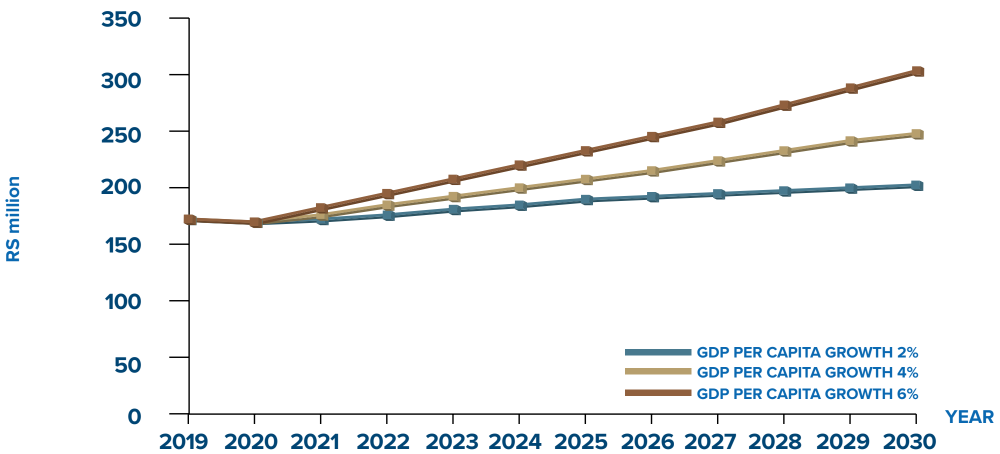


Figure 4.5.3. Indirect gross output of recycling paper waste projection 2021-2031

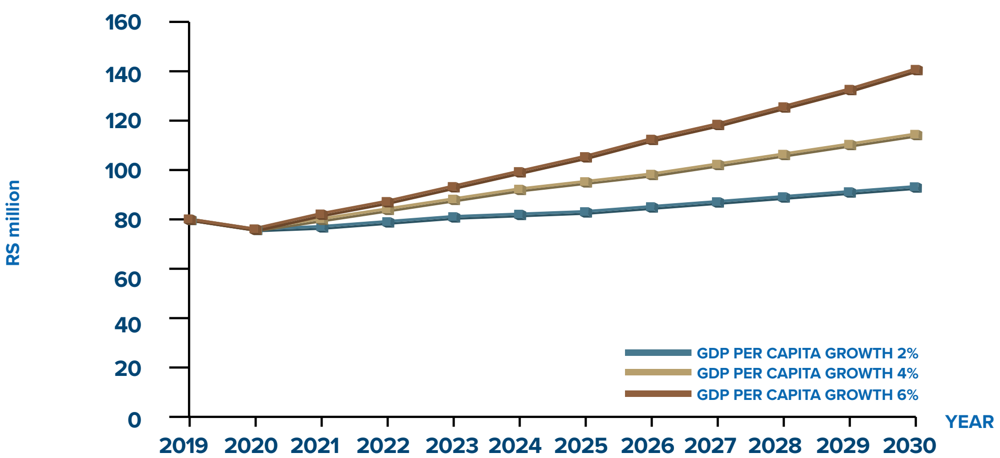


Table 4.5.1. GDP projection -recycling paper waste 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	77,257	84,509	262	288		100.5	110.5
GDP growth 4%	84,953	102,293	289	352	0.03%	111.2	135.4
GDP growth 6%	93,284	123,441	319	428		122.7	164.5

Table 4.5.2. Employment projection -recycling paper waste 2025-2030

	Direct employment		Indirect employment		Total employment		% of domestic employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	137	151	26	29	163	179	
GDP growth 4%	152	184	29	35	180	219	0.03%
GDP growth 6%	167	224	32	42	199	267	

4.6. Glass waste

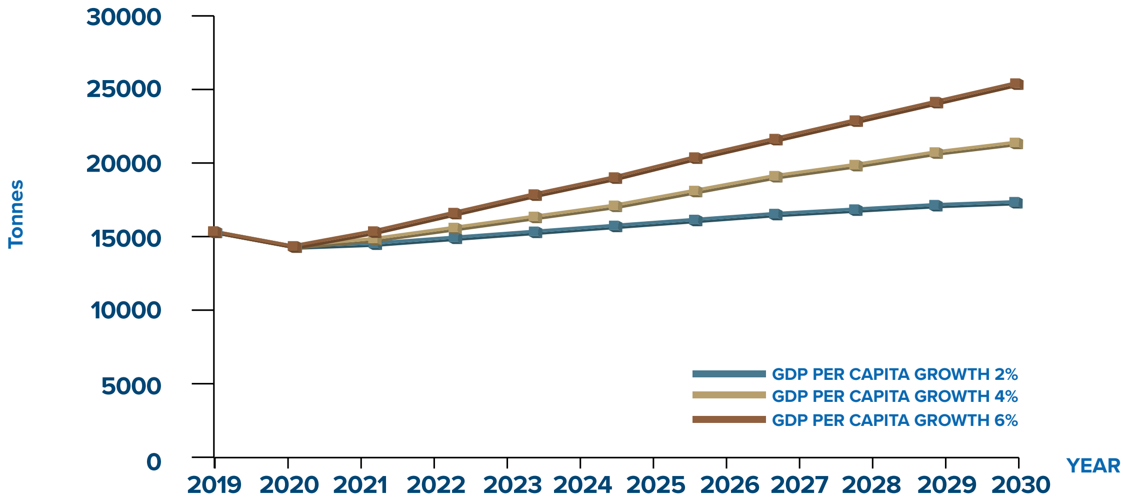
Glass wastes make 3 percent of household and commercial wastes. According to the calculation, the quantity of waste disposed in landfill stands at around 15,400 tonnes. Adding its industrial component could raise this quantity but data are not accurate at industry level. With a unitary elasticity with respect to GDP per capita, by 2030, the quantity can reach a level of 17,000 tonnes; 21,000 tonnes and 25,000 tonnes in related to a GDP growth of 2, 4 and 6 percent, respectively. This would represent a growth by 11.3, 35.2 and 63.5 percent. The increase in glass waste can take different directions with new technologies and development trends. For instance, with the promotion of solar PV panel as a renewable source of energy, there is likely to be solar PV modules that will add to the glass waste in the future[34].

Box 4.6.1: Recycling of glass

Glass is not biodegradable, infinitely recyclable and remains stable for a long period of time. Glass recycling is the process of recycling waste glass into other usable products. When new products are manufactured from glass wastes, they do not lose their qualities and properties. Glass beverage containers are classified according to their color, mainly amber/brown, green, and crystalline. The color of the glass is one of the criteria for classified glass in recycling plants. Other criteria include the presence of inorganic and non-magnetic foreign materials, magnetic metals, and contamination. All glass is eventually crushed while being prepared for recycling. Glass that is crushed and ready to be melted is called cullet. There are two types of cullet: external and internal. Internal cullet is made from defective products that were rejected by a quality control process during glass manufacturing, production offcuts, and transition phases of product changes. External cullet is a waste glass that has been collected and/or reprocessed for recycling. External cullet can be pre- or post-consumer usage. Upcycling represents opportunities for high value products. Thermal shock is the phenomenon of the glass upcycling process. Recycling glass requires separating the glass waste from other refuse. Another problem is that waste glass must be separated by colour (i.e., clear, green, and brown) before it can be reused to make new glass containers. Despite these difficulties, anywhere from 35 to 90 percent of cullet (broken or refuse glass) is currently used in new-glass production, depending on the country.

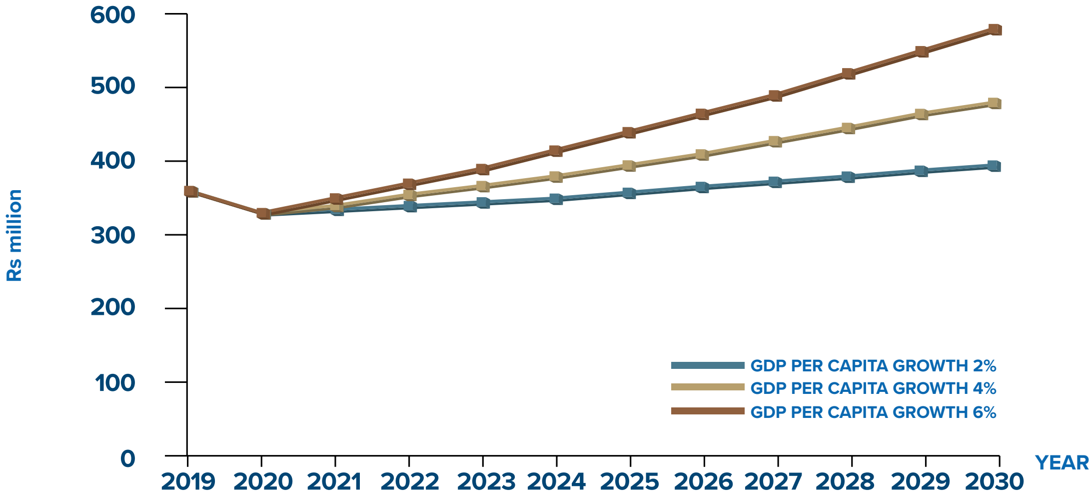
Reference: García Guerrero, J.; Rodríguez Reséndiz, J.; Rodríguez Reséndiz, H.; Álvarez-Alvarado, J.M.; Rodríguez Abreo, O. 2021. Sustainable Glass Recycling Culture-Based on Semi-Automatic Glass Bottle Cutter Prototype. Sustainability, vol. 13, no. 6405. https://doi.org/10.3390/ su13116405

Figure 4.6.1. Quantity of glass waste projection 2021-2030



The current quantity on recycling glass in Mauritius stands at 50 to 70 tonnes for final products, and around 350 tonnes converted into cullet. Data collected by manufacturers show that there is a need for a Rs 4,000 - Rs 5,000 investment in plant and machinery for the recycling per tonne of glass waste into cullet. Using the potential to convert glass waste into cullet, figure 4.6.2 shows the direct gross output that could be generated by the economic activity.

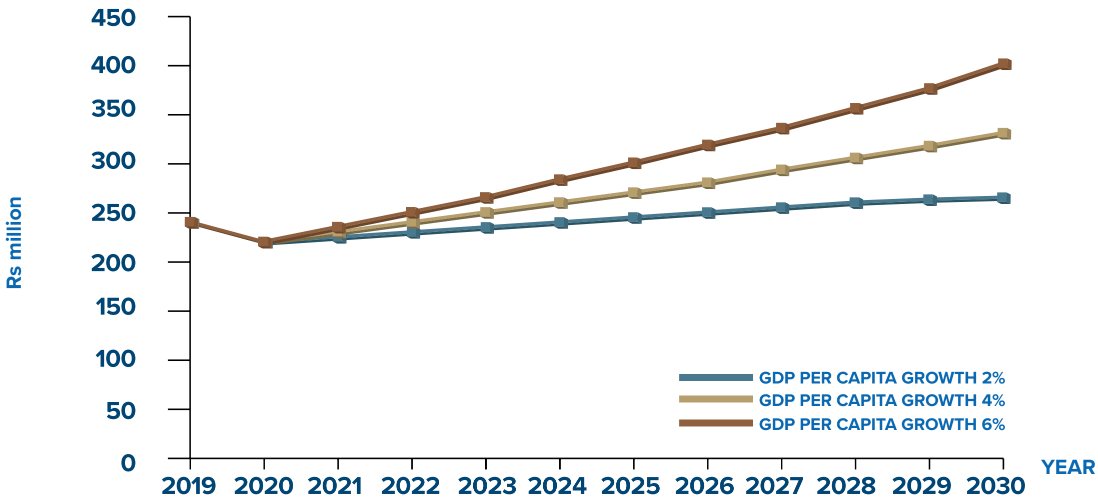
Figure 4.6.2. Gross output of recycling glass waste 2021-2030



If the glass waste was recycled at present, the gross output would stand at Rs 344 million, rising to Rs 351 million; Rs 403 million and Rs 453 million for a GDP growth of 2, 4 and 6 percent by 2025. By 2030, a rise of 12, 36 and 65 percent is forecasted for the different growth scenarios respectively.

The indirect output associated with glass recycling is show below. With an output multiplier of 1.70, the indirect output would amount to Rs 241 million in 2019, rising to Rs 269 million; Rs 328 million, and Rs 400 million for the 2, 4 and 6 percent growth in GDP.

Figure 4.6.3.Indirect gross output of recycling glass waste 2021-2030



The total output impact averages 0.22 percent of GDP, and investment requirement that would meet the 2030 capacity would stand at Rs 73 million to Rs 107 million.

[34] D'Adamo, I., Miliacca, M., Rosa, P. 2017. Economic Feasibility for Recycling of Waste Crystalline Silicon Photovoltaic Modules. Hindawi International Journal of Photoenergy Volume 2017, Article ID 4184676, 6 pages https://doi.org/10.1155/2017/4184676

Table 4.6.1. GDP projection recycling glass waste 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	15,702	17,167	596	653		65.2	71.5
GDP growth 4%	17,303	20,846	659	796	0.07%	72.1	87.1
GDP growth 6%	19,032	25,220	726	966		79.4	105.7

If all the glass was collected, this recycling industry could generate an employment level of around 300-330 directly by 2025, and 150-200 indirectly by 2025. The upcycle of glass waste that is, transforming them into new materials or products with high perceived value, would require an additional 30 percent of investment and would scale up the gross output (direct and indirect) by 30 percent.

Table 4.6.2. Employment projection recycling glass waste 2025-2030

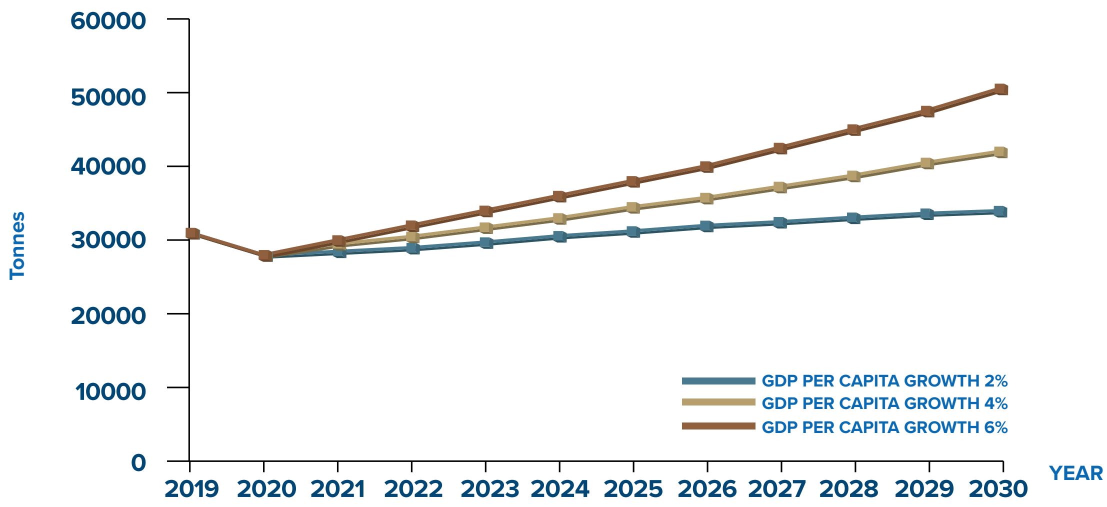
	Direct employment		Indirect employment		Total employment		% of domestic employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	273	299	153	168	426	467	
GDP growth 4%	302	365	169	204	471	569	0.08%
GDP growth 6%	332	443	186	248	519	690	

4.7. Textile waste

Since recent years, textile wastes from industrial production are exported to other countries. The existing companies collect the waste from textile industries, involve in sorting by colours and different grade and eventually the wastes are sent to spinning mills. Remaining waste are used to manufacture needled felt/wadding to be used by mattress manufacturers. Data on existing firms show that an investment of Rs 20,300 per tonne, with an operating cost of Rs 12,000 per tonne, is needed.

The potential of textile waste recycle comes mainly from households and from the commercial sector. Due to the lack of logistic, only industrial textile waste find their way to recycling activities. The current quantity of textile waste dumped in the Mare Chicose Landfill is estimated at 30,800 tonnes. This quantity is expected to rise by 11, 35 and 64 percent by 2030 if GDP grows at 2, 4 and 6 percent respectively (figure 4.7.1).

Figure 4.7.1. Quantity of textile waste projection 2021-2030



Currently, around 2,600 tonnes of textile waste are recycled for exportation. Extrapolating the current activity to the amount generated by the household and commercial sector shows that there is a gross direct output of Rs 550 million that can be generated directly. This is expected to rise to Rs 600 million by 2025 and Rs 800 million by 2030 under a growth scenario of 4 percent. The indirect gross output is shown figure 4.7.3.

Figure 4.7.2. Direct gross output of recycling textile waste projection 2021-2030

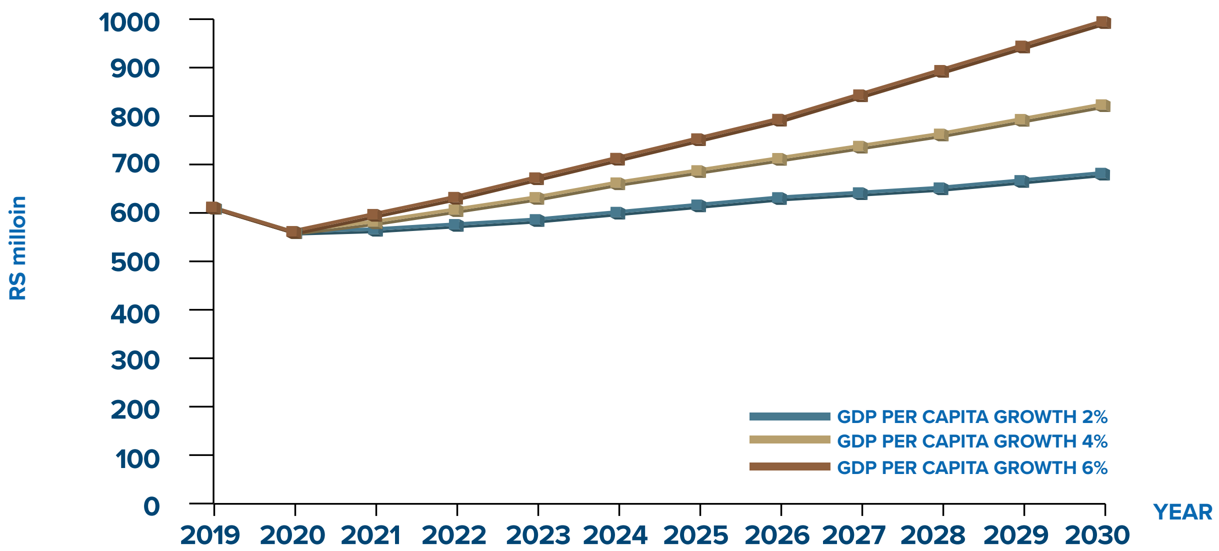


Figure 4.7.3. Indirect gross output of recycling textile waste projection 2021-2030

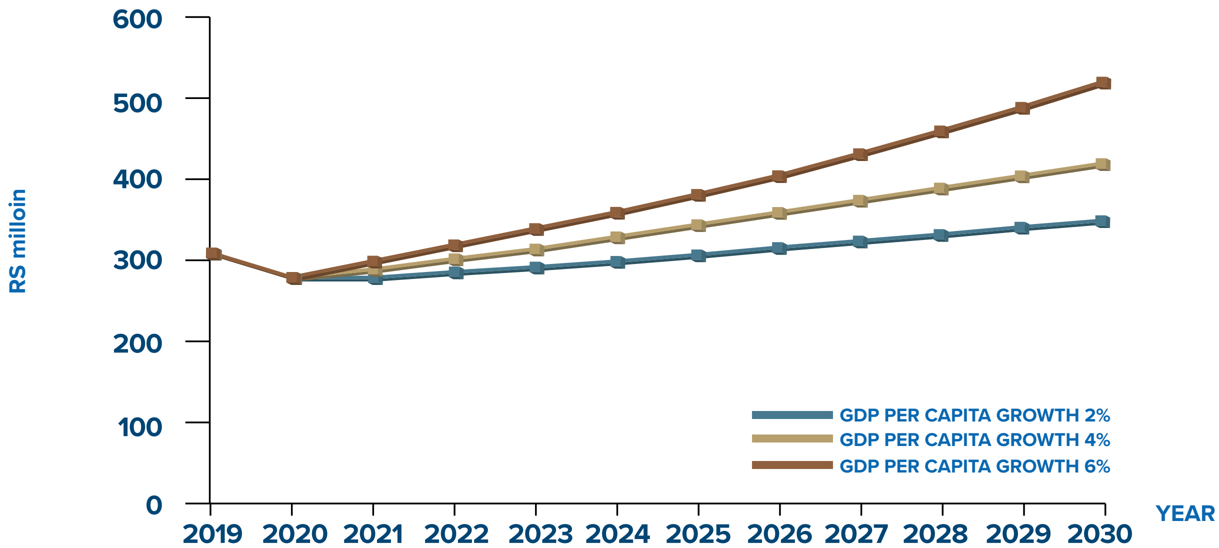


Table 4.7.1. GDP projection - recycling of textile waste 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	31,403	34,334	981	1,081		584	643
GDP growth 4%	34,605	41,692	1,090	1,331	0.10%	671	808
GDP growth 6%	38,063	50,441	1,208	1,629		719	969

Table 4.7.2. Employment projection - recycling of textile waste 2025-2030

	Direct employment		Indirect employment		Total employment		% of domestic employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	435	479	869	957	584	643	
GDP growth 4%	483	590	966	1,179	671	808	0.11%
GDP growth 6%	535	722	1,070	1,443	719	969	

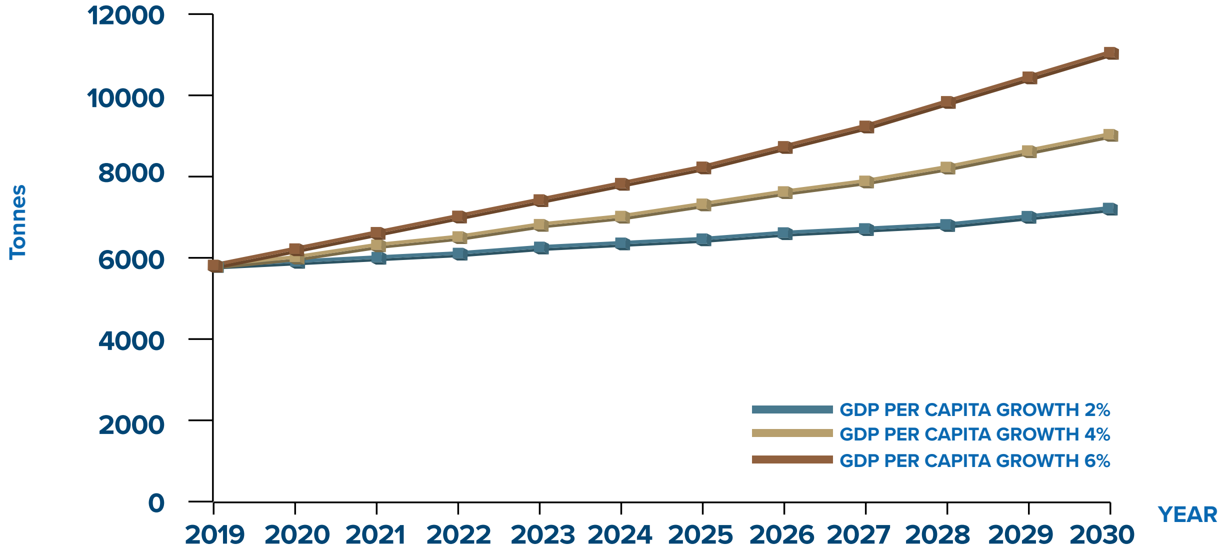
4.8. Used tyres

Used tyres are among the most problematic sources of waste. Manufacturing of tyres is costly and only 30 percent is subject to wear and tear on the road surface. The rest are intact for waste[35]. It is observed that retreading of used tyres is undertaken by four companies. The Government's provision of Rs 2,000 for each tonne of used tyres recycled or exported for recycling initiated some activity in the used tyre sector. However, the quantity of used tyres disposed remains significant. According to the reported recycling figures, 647.7 tonnes were retreaded in 2019. Yet, in 2019, 564 tonnes of rubber tyres landed at the Mare Chicose landfill, and in relation to the number of vehicles in Mauritius this figure represents around 10 percent according to informants. A large quantity is therefore being disposed around the island.

To encourage the recycling of waste tyres, the Government decided that tyre retreading will be classified as a recycling activity in the Budget Speech 2020/21. Moreover, the refund mechanism for exporters and recyclers of waste tyres will be extended to local retreading of tyres. The rate of refund will be Rs 25 per retreaded tyre. It is worth mentioning that new tyres are among the 20 most imported merchandise imports in Mauritius.

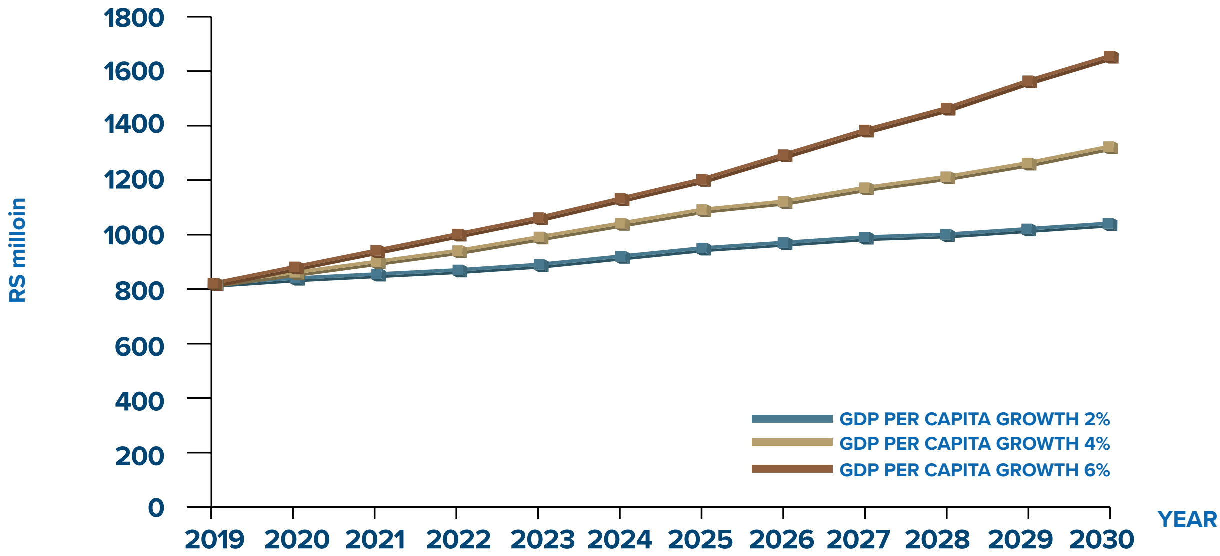
[35] Rekhaye and Jeetah (2014)

Figure 4.8.1 Quantity of used tyres projection 2021-2030



Using the benchmark of 5,640 tonnes of used tyre in 2019, the quantity is expected to rise by 24.5; 53.3 and 89 percent by 2030 with a growth scenario of 2, 4 and 6 percent respectively.

Figure 4.8.2. Direct gross output of retreated tyres 2021-2020



Figures 4.8.2 and 4.8.3 show the direct and indirect output of retreading the total quantity of used tyres projected for the period 2021-2030. With a GDP scenario of 4 percent, the tyre industry can generate almost 1.1 billion in 2025 and 1.3 billion in 2030.

Figure 4.8.3. Indirect gross output of retreated tyres 2021-2030

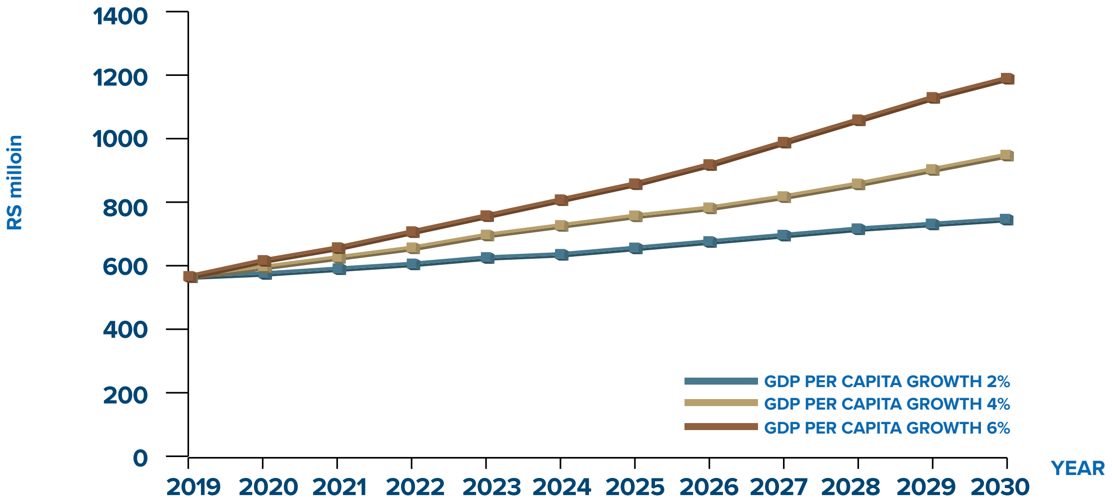


Table 4.8.1. shows that the retreading activity has a potential to increase GDP by 0.6 to 0.7 percent on average, with an investment cost of around Rs 500 million to Rs 750 million

Table 4.8.1. GDP projection - retreaded used tyres 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	6,352	7,013	1,636	1,826		400	447
GDP growth 4%	7,136	8,683	1,861	2,305	0.19%	455	564
GDP growth 6%	8,000	10,706	2,109	2,885		516	706

The tyre retreading activity could also generate 700 to 1000 direct jobs in 2025 and around 800 to 1300 by 2030. The indirect employment is also significant as shown in table 4.8.2.

Table 4.8.2. Employment projection- retreading tyre 2025-2030

	Direct employment		Indirect employment		Total employment		% of domestic employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	729	814	373	416	1,102	1,230	
GDP growth 4%	830	1,027	424	525	1,254	1,53	0.21%
GDP growth 6%	940	1,286	481	658	1,421	1,944	

Retreading is one option for used tyres. They can also be used for recovery for civil engineering applications, material recycling such as steel and energy recovery option such as direct combustion, pyrolysis, and gasification. Rekhaye and Jeetah (2014) analysed the different options – Box 4.8.1. provides major findings.

Box: 4.8.1. Used tyres

The study by Rekhaye and Jeetah (2014) shows the findings of using used tyres for pyrolysis. Pyrolysis provides yield of oil and gaseous products. The main pyrolysis are pyrolytic oil, char, and volatiles. Low temperature and high residence times favour the production of char and tars. When waste tyre is burnt at high temperatures in a limited amount of oxygen, gasification reaction takes place. The Gross Calorific Value (GCV) of coal is 27MJ/kg while waste tyre powder is 35MJ/kg. Oil is the most anticipated products for a process with a GCV of 42.69MJ/kg. Light Pyrolytic Oil gives 41.29MJ/kg. At 450 degree C, 40% carbon black powder takes place and at 450 c, 50% of heavy pyrolytic oil (HPO) was formed. Carbon black powder makes it suitable to be used as fuel or even as a replacement to coal. Shredded tyres could be used as a replacement for coal. The calorific value of waste tyre is 35MJ/kg compared to sub-bituminous coal for Mauritian power plants which is 28MJ.kg and coal at 27MJ/kg. The major issue is CO2 which is higher by 26% compared to coal.

Reference: Rekhaye, A. & Jeetah, P. 2018. Assessing Energy Potential from Waste Tyres in Mauritius by Direct Combustion, Pyrolysis and Gasification The Nexus: Energy, Environment and Climate Change. Pp. 113-126. Ed. Walter Leal Filho and Dinesh Surroop. Springer International Publishing, Switzerland.

In February 2021, the Ministry of Environment, Solid Waste Management and Climate Change (Solid Waste Management Division) invited 'Proposals for Selection' from competent developers or Consortium of developers (partnership or corporate entities) for the setting-up of a Used Tyres Recycling/ Processing Facility in Mauritius. The selected developer would be required to design, finance, build, test, commission, operate and maintain a Recycling/Processing Facility for Used Tyres during a proposed concession period of 10 years. The technology for the proposed Facility shall be of proven type and be robust and durable so that downtime periods arising from breakdown and repairs that cause disruption to the service are kept to a minimum. The main activities are the processing / recycling of Used Tyres and the sale of the recycled materials/ products. As financial incentive, the developer shall be entitled to Rs 2,000 for each tonne of Used Tyres recycled or exported.

4.9. E-waste

E-waste also known as Waste Electrical and Electronic Equipment (WEEE) includes computers, laptops, printers, fax machines and household appliances, such as refrigerators, washing machines, televisions and radios which are intended to be discarded. Consumption of these products has increased massively over the years and this trend is likely to continue in the future. E-wastes broadly consist of ferrous and non-ferrous metals, plastics, glass, printed circuit boards and other items. They contain valuable materials that can be recovered and recycled. The presence of elements therein, like lead, mercury, arsenic, cadmium, selenium, and hexavalent chromium makes them particularly hazardous, and hence are classified as HW. The management of e-wastes comprises identification, segregation, collection, and transportation, transit at Contractors' warehouses and recycling and/or exportation for recycling. There are two categories of plastics in E-waste: thermoplastics which can be melted and remolded into polyethylene (PE), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), and polypropylene (PP); and thermosets which are heat resistant. Heavy metals also form part of the components of e-waste.

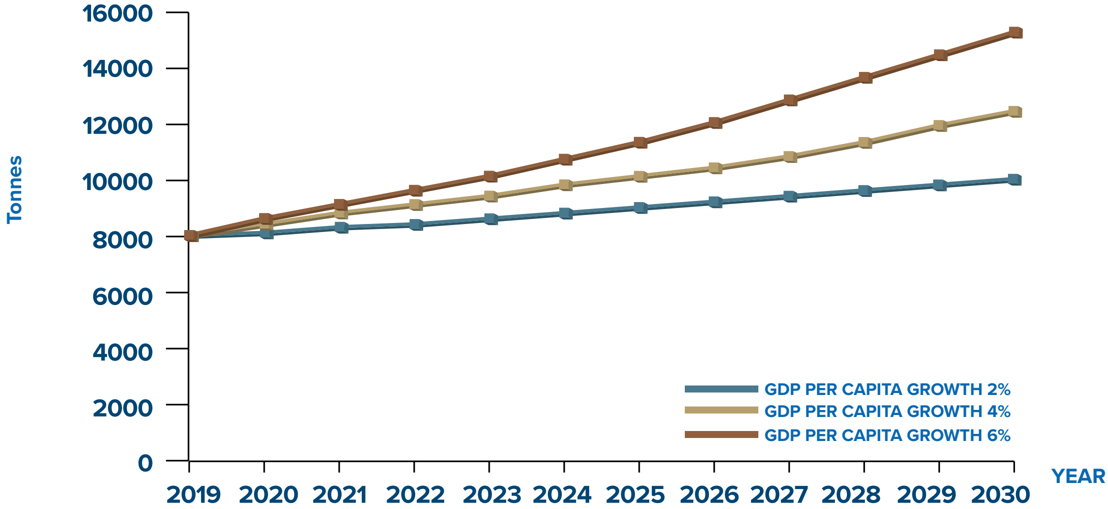
From a study conducted by Kowlesser and Bokhoree in 2008[36], the annual e-waste represented approximately 0.4% of general solid waste that was being disposed. From an analysis of data from Customs Department, Statistics Mauritius, and wholesale and consumer surveys, the study estimated that the amount of such waste was 6,571 tonnes in 2008, but only 1,600 tonnes was disposed in the landfill. This represented 5.5kg per inhabitant in Mauritius 2008. This estimated at 6.2kg in 2011. From a presentation of the Solid Waste Management Division on Extended Producer Responsibility on Electrical & Electronic Equipment, it is reported that around 8,000 tonnes are generated annually, around 6.4kg per capita.

A very low quantity of e-waste is being recycled locally at present (115 tonnes in 2019 from official figures). Using a figure 8000 tonnes, there is thus a huge potential of creating more secondary raw material inputs from the remaining untreated e-waste. This study collected information on recycling activity of enterprises and estimated as investment cost of around Rs 40,000 per tonne of e-waste and an operating cost of Rs 20,000, excluding the imbursement from loan which is already accounted in the capital cost. The gross output is estimated at Rs 45,000 per tonne, but if the repayment of capital expenditure is included, the operating cost is far above the gross output per tonne.

[36] http://greenict.govmu.org/portal/sites/greenict/downloads/Ewaste.pdf

Figure 4.9.1 shows forecasted e-waste by 2030 under the three scenarios; a 24.3, 54 and 90 percent increase is noted for a growth in GDP by 2, 4, and 6 percent respectively.

Figure 4.9.1. Quantity of E-waste projection 2021-2030 (tonnes)



Using the gross output and the amount of e-waste generated annually, with a GDP growth of 2, the direct gross output is estimated at around Rs 400 million in 2025, while a 4 and 6 percent growth in GDP show a figure of Rs 430 million and Rs 500 million respectively. The current business activity which is considered in this analysis includes the de-pollution of end-of-life electronic equipment, pre-treatment of automated recycling, and the recovery of plastic, ferrous and non-ferrous metals for reuse as inputs in the manufacture of other products.

Figure 4.9.2. Direct gross output of recycling E-waste projection 2021-2030

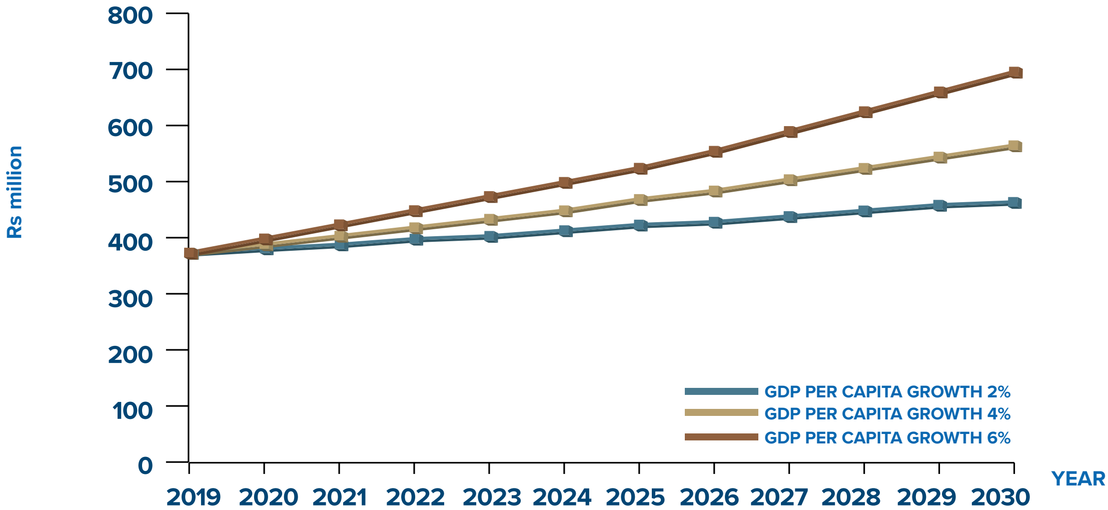


Figure 4.9.3 shows the indirect gross output projection for the period 2021-2030. These activities include the collection service, transport, and segregation, and sorting.

Figure 4.9.3. Indirect gross output of recycling E-waste projection 2021-2030

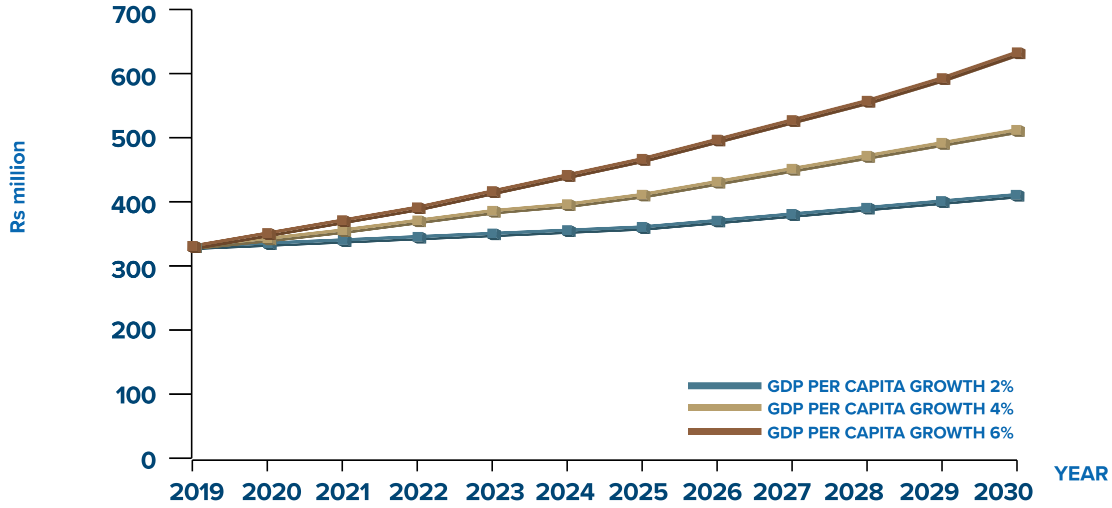


Table 4.9.1 shows the increase in GDP at 0.2 percent if e-waste was recycled into material inputs, and the required investment with the 2030 figure which ranges from Rs 400m to 627m (2021 figures). The total contribution of direct and indirect output is shown in table 4.9.1 The rise in GDP stands at 0.2 percent.

Table 4.9.1. GDP projection recycling E-waste 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	9,009	9,947	774	855		370,6	409,7
GDP growth 4%	10,123	12,316	871	1,061	0.08%	417,0	508,4
GDP growth 6%	11,348	15,186	977	1,311		468,1	627,0

Table 4.9.1 and 4.9.2 show the increase in GDP and employment if the total amount of e-waste was recycled into material inputs.

Table 4.9.2. Employment projection- recycling E-waste 2025-2030

	Direct employment		Indirect employment		Total employment		% of domestic employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	309	342	234	259	544	601	
GDP growth 4%	348	424	264	322	612	746	0.10%
GDP growth 6%	391	524	296	397	687	922	

E-waste is expected to rise in the future due to the increase of technology in the day-to-day lives of the population. Consequently, the development of CE for e-waste is considered as priority. However, interviews with the incumbent in this sector revealed that the biggest obstacle is to secure wastes for recycling. To that end, discussion is on-going for the Extended Producer Responsibility (EPR) which is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility could, in principle, provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals[37]. There is a need for proper incentives as in the case of other type waste. It is highlighted during the discussion with participants that investors are usually at risk of investing when they cannot secure the necessary waste inputs.

4.10. Used engine oil

Given the rising number of vehicles and the level of industrial activities, the disposal of used engine oil haphazardly around the island has strong negative environmental impacts. Used oil attracts a variety of hazardous contaminants when used in engines and transmissions and can potentially contaminate underground water. Mauritius imports tons of engine oil every year but there is currently no formal collection and there is no traceability of where used engine oil goes. Used motor oils are generated because of vehicle maintenance and manufacturers recommend the changing oil every 5,000-10,000 km for most vehicles, every 1,000km for motorcycles and every 300 working hours for construction vehicles[38]. Used motor oil never wears out. It just gets dirty and can be recycled, cleaned, and used again.

There is no accurate estimate on the quantity of used oil that is produced annually. Information from relevant stakeholder reveals a figure of 5,400 tonnes. Assuming a unitary elasticity with respect to income per capita, the projected figures for 2030 stand at 6,200, 7,700 and 9,500 tonnes with a growth scenario of 2, 4 and 6 percent (figure 4.10.1). The forecasted direct gross output stands at Rs 44 million; Rs 63 million and Rs 85 million in 2030, respectively.

Figure 4.10.1. Quantity of used engine oil projection 2021-2030 (tonnes)

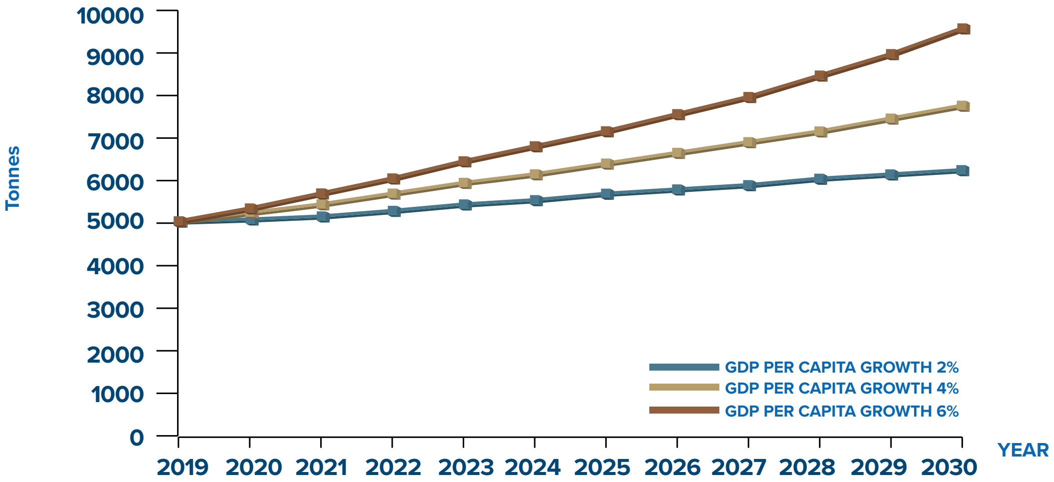
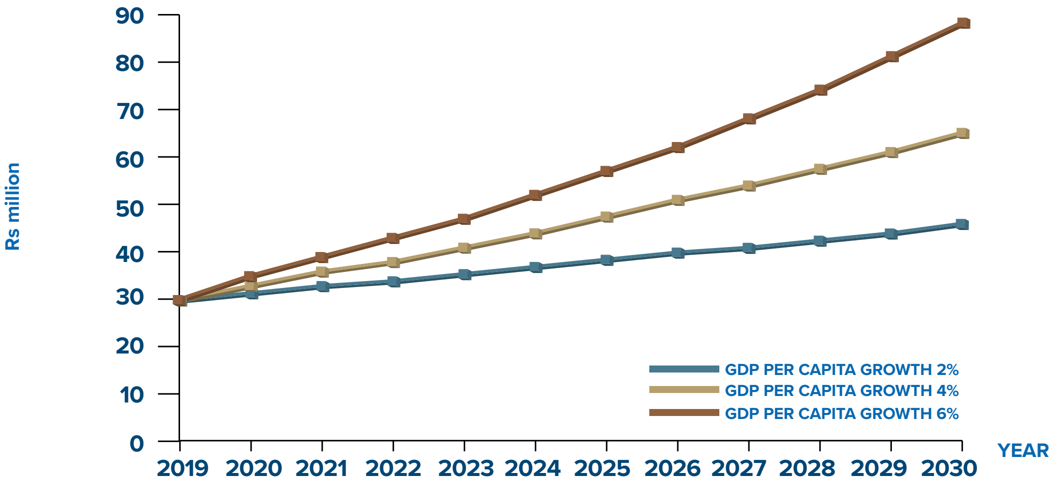


Figure 4.10.2. Direct gross output of recycling used engine oil 2021-2030



[37] OECD.2005. https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?doclanguage=en&cote=env/epoc/wgwpr(2005)6/final

[38] Ministry of Local Government and Outer Islands 2012. Hazardous Waste Inventory Report for Mauritius. The African Institute for the environmentally sound management of hazardous and other waste.

Figure 4.10.3. Indirect gross output of recycling used engine oil 2021-2030

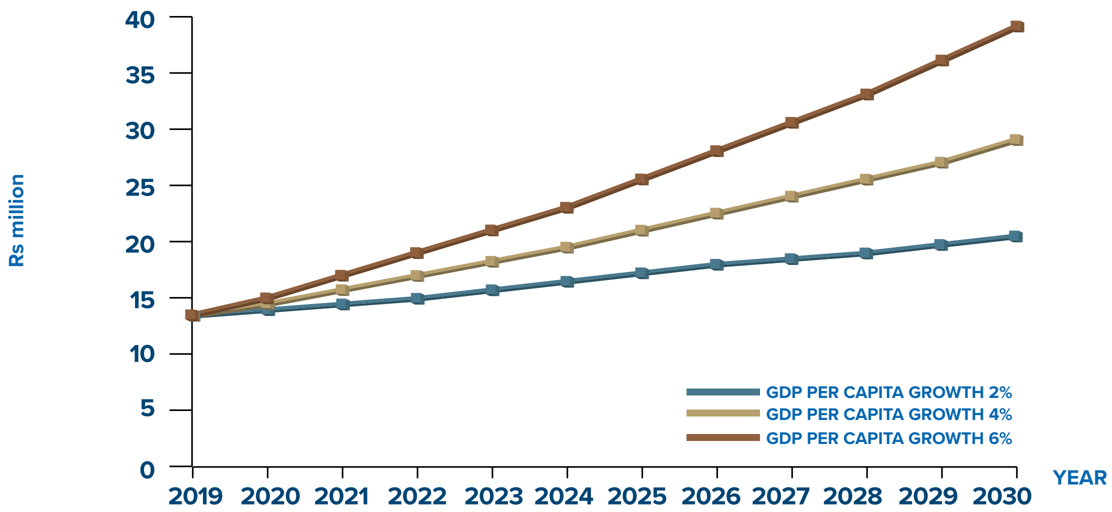


Table 4.10.1 shows that the percentage increase in GDP for used oil recycling activity which stands at 0.01 percent. The percentage increase in employment stands at 0.01 percent.

Table 4.10.1. GDP projection - recycling used engine oil 2025-2030

	Quantity (tonnes)		Total output (Rs million)		% increase in GDP	Investment (Rs Million)	
	2025	2030	2025	2030	Average 2021-2030	2025 capacity	2030 capacity
GDP growth 2%	5,631	6217	53	63		134,7	162,3
GDP growth 4%	6,327	7697	65	90	0.01%	167,4	231,8
GDP growth 6%	7,093	9491	79	123		203,4	316,2

Table 4.10.2. Employment projection recycling used engine oil 2025-2030

	Direct employment		Indirect employment		Total employment		% of domestic employment
	2025	2030	2025	2030	2025	2030	
GDP growth 2%	28	34	32	39	60	73	
GDP growth 4%	35	49	40	56	75	104	0.01%
GDP growth 6%	43	66	49	76	92	143	

5.

CIRCULAR ECONOMY PRIVATE INVESTMENT AND ITS IMPACTS ON GDP AND EMPLOYMENT

5.1. Private investment

The total amount of wastes - excluding used engine oil and e-waste - amounts to 427000 tonnes, representing 83.3 percent of household and commercial waste disposed by the landfilled. Table 5.1 provides a rough estimation of the private investment for each option of treating the wastes. Considering the amount of e-waste and used engine oil, the investment required stands at Rs 6.8 billion, Rs 7.6 billion and Rs 8.4 billion for a growth in GDP of 2, 4 and 6 percent based on 2025 optimal capacity and Rs 7.5 billion, Rs 9.2 billion and Rs 11.2 billion respectively for the 2030 optimal capacity. These estimates exclude scrap metals, plastic LDPE, wood and pellets, among others which could also form part of the CE activities. More importantly, it also excludes the wastes identified for Industrial Symbiosis such as poultry and fish wastes. Adding these wastes could assist to make of Mauritius a Zero-Waste economy (95 percent waste being treated).

Several wastes such as PET, HDPE, and glass are currently treated to produce secondary raw inputs in Mauritius. Data collected indicates that around 30 percent scale of the investment is needed to bring the material inputs into final products. Table 5.1.1 uses this assumption in the estimation.

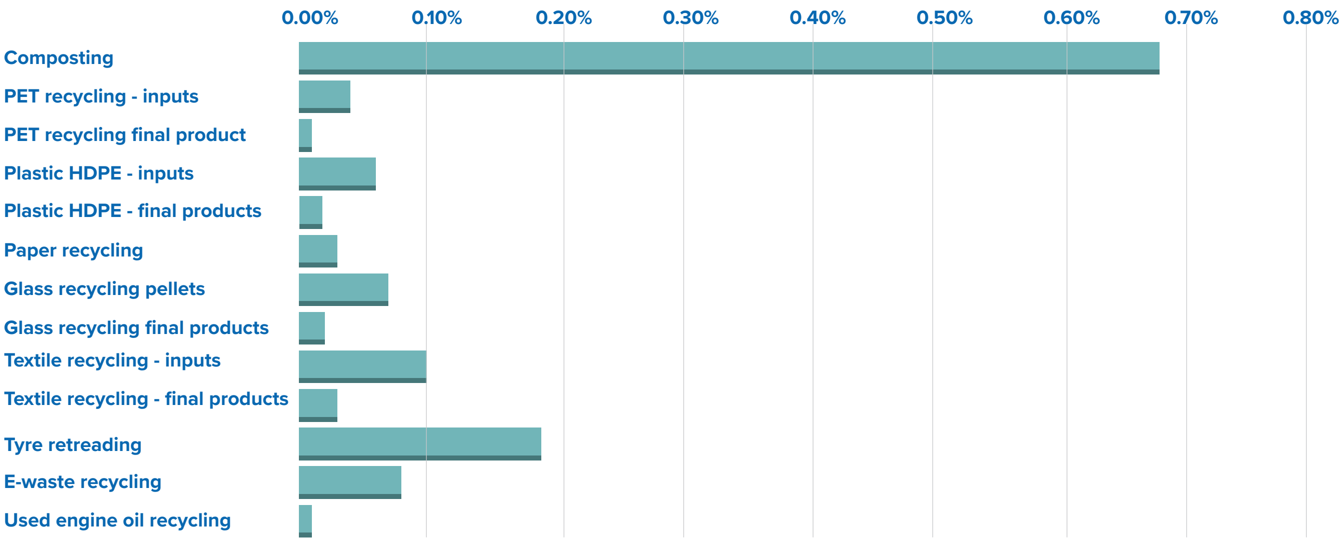
Table 5.1.1. Private investment for CE – selected wastes (Rs million)

	2025			2030		
	GDP growth 2%	GDP growth 4%	GDP growth 6%	GDP growth 2%	GDP growth 4%	GDP growth 6%
Composting	4,641	5,111	5,614	5,076	6,161	7,441
PET recycling - inputs	99	114	130	112	142	179
PET recycling final products	30	34	39	33	43	54
Plastic HDPE - inputs	144	161	180	160	200	221
Plastic HDPE - final products	43	48	54	48	60	66
Paper recycling	101	111	123	111	135	165
Glass recycling pellets	65	72	79	72	87	106
Glass recycling final products	20	22	24	21	26	32
Textile recycling -inputs	584	671	719	643	808	969
Textile recycling - final products	175	201	216	193	242	291
Tyre re-treading	400	455	516	447	564	706
E-waste recycling-inputs	371	417	468	410	508	627
Used engine oil recycling	135	167	203	162	232	316
Total	6,807	7,586	8,365	7,487	9,208	11,172

5.2. Contribution to GDP

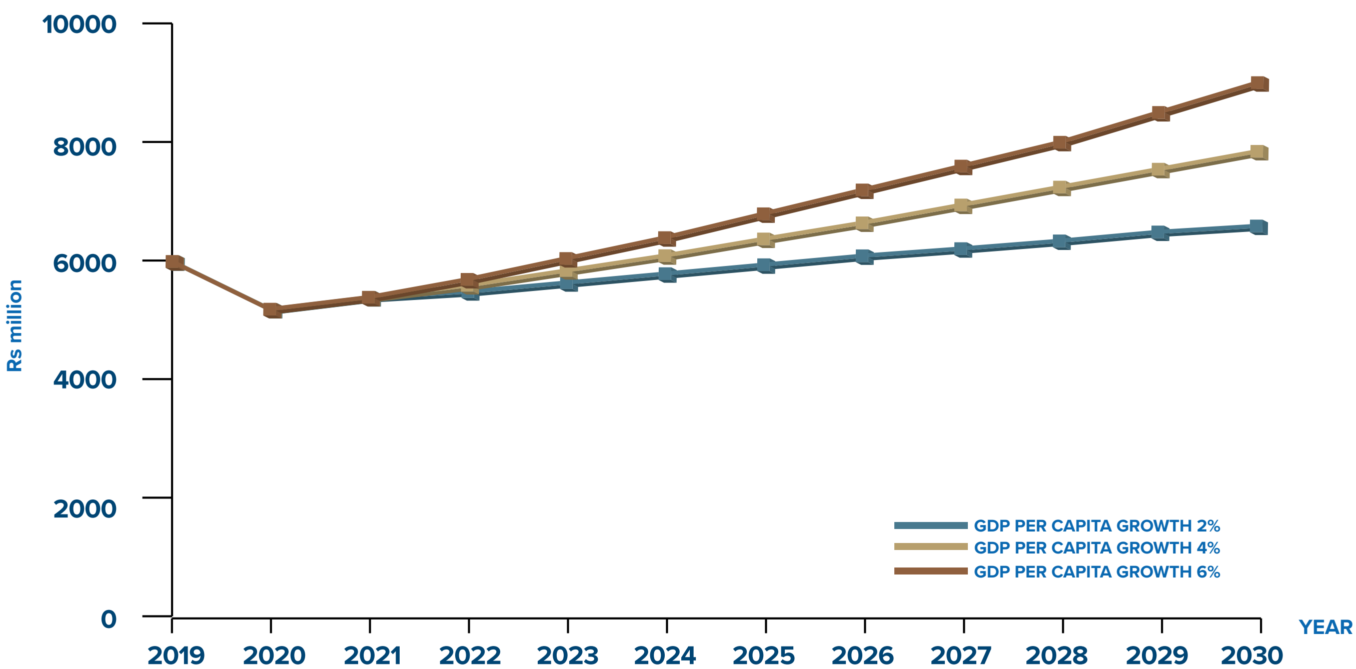
Figure 5.2.1 shows the contribution to GDP annually of the CE activities; Given organic waste forms part of the highest proportion, converting them into compost will increase GDP by 0.66 percent, followed by tyre retreading at 0.19 percent, textile waste to input at 0.10 percent and glass waste to input at 0.07 percent. Turning PET and HDPE into final products would bring an increase of 0.06 percent and 0.08 percent respectively. The total additional contribution at this stage of economic activity stand at 1.32 percent of GDP annually. CE would require around Rs 7.5 billion to Rs 11.2 billion of private investment for almost 83 percent of waste in Mauritius, which will contribute to a gross output of Rs 5.1 billion to Rs 7.7 billion.

Figure 5.2.1 Contribution to GDP – CE activities



Assuming all wastes are converted into either inputs and to some extent output in the economy system, figure 5.2.2 shows an estimation of the magnitude of economic activities: by 2030, the figures stand at Rs 6.1 billion, Rs 7.4 billion and Rs 8.6 billion for a GDP growth of 2, 4 and 6 percent.

Figure 5.2.2. Value added projection of CE activities (direct and indirect output)



5.3. Contribution to Employment

Finally, table 5.3.1 shows the total employment (direct and indirect) which can be created under each GDP growth scenario.

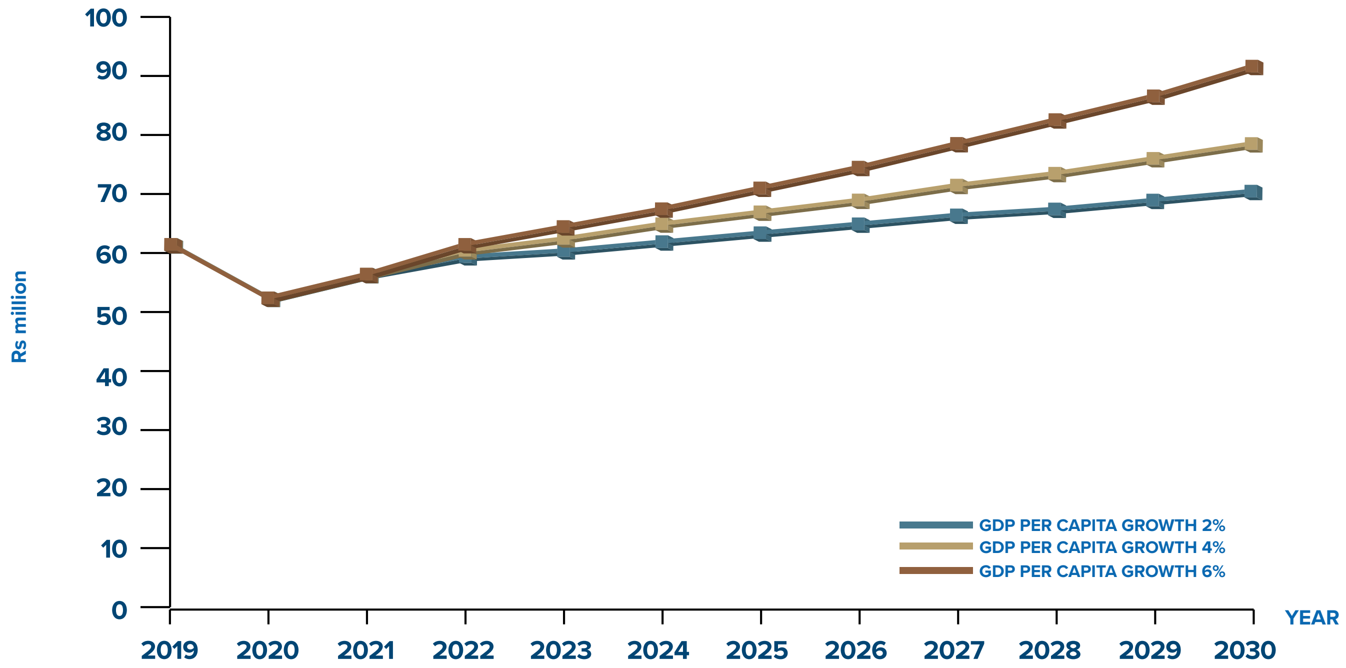
Table 5.3.1. Employment projection in CE

	Direct employment		Indirect employment		Total employment	
	2025	2030	2025	2030	2025	2030
GDP growth 2%	3,503	3,874	2,032	2,251	5,536	6,125
GDP growth 4%	3,925	4,802	2,282	2,798	6,205	7,602
GDP growth 6%	4,378	5,853	2,552	3,411	6,930	9,265

5.4.Operating Cost to manufacturing sector: waste organisation

For the waste to be collected for recycling, it needs to be properly organised and stored. The survey revealed that the cost to an enterprise would be around 0.04 percent of turnover. This gives an indication of the investment and operating cost of Rs 70 million to Rs 90 million annually for manufacturing enterprises to organise their waste in a proper manner.

Figure 5.4.1. Operating cost for waste segregation



6.

SPRINKLER WATER
SUPPLY TO DISTRIBUTION
MANIFOLD
SPRINKLER WATER
SUPPLY
TO QUARANTINE

INVESTING IN RENEWABLE SOURCES OF ENERGY

The analysis could not accurately forecast the proportion of the mixed renewable options by 2025 and 2030. Instead, if by 2025 and 2030 renewable energy will make 30 percent and 60 percent of total electricity production, an attempt is made to estimate the capital and operating cost assuming that several options are each used to produce the entire remaining production considering that at present around 22.2 percent are produced with renewable energy. At the outset, it is essential to forecast the total electricity production for the period 2021-2030. This study assumes a unitary elasticity between electricity consumption and GDP[39].

Figure 6.1. Projection of electricity production 2021-2030.

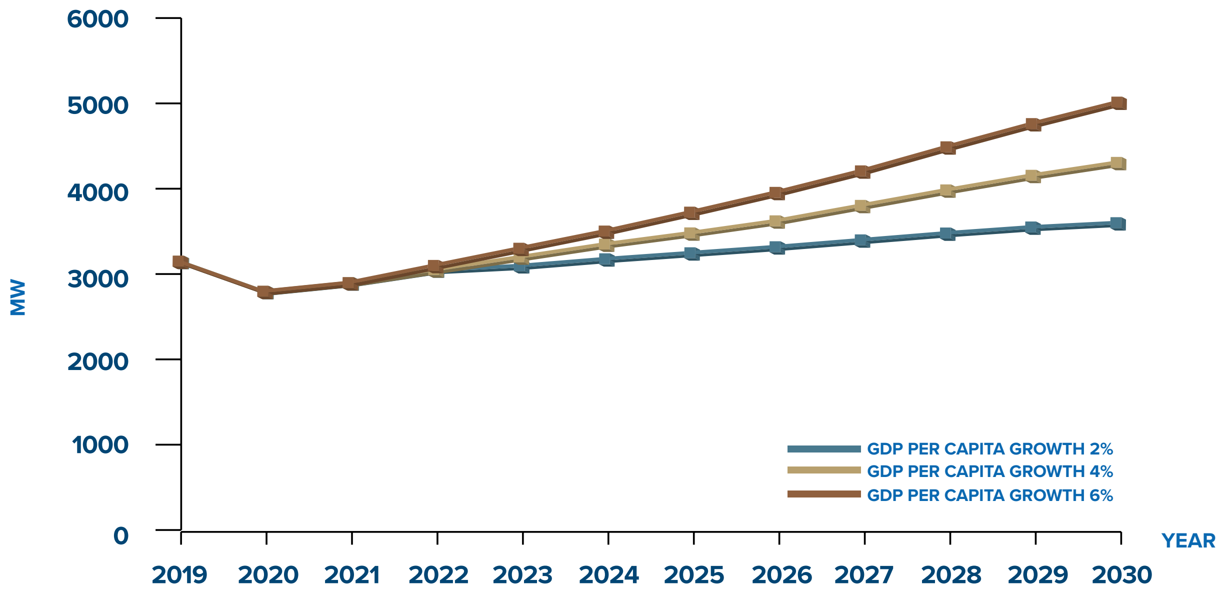


Figure 6.1 shows that by 2025, accounting for a post-COVID-19 recovery phase, electricity production will stand at 3,355 GWh, 3,619 GWh and 3,599 GWh for a GDP growth of 2 percent, 4 percent and 6 percent. This will rise to 3700, 4422 and 5148 by 2030 respectively for the GDP scenarios.

Table 6.1. Capital cost and operating cost of renewable energy options 2025-2030

	GDP growth 2%	GDP growth 4%	GDP growth 6%	GDP growth 2%	GDP growth 4%	GDP growth 6%
Capital cost (Rs billion)	2025	2025	2025	2030	2030	2030
Solar PV SSDG	23.5	29.3	33.7	89.5	15.6	143.3
Solar PV (Utility fixed)	15.8	19.8	22.7	60.3	77.9	96.6
Solar PV (Utility Tracking)	19.4	24.2	27.9	73.9	95.5	118.4
Wind (onshore)	26.6	33.3	38.3	101.5	131.2	162.6
Operating cost (Rs million)	2025	2025	2025	2030	2030	2030
Solar PV SSDG	72	90	104	275	356	441
Solar PV (Utility fixed)	144	180	207	550	711	881
Solar PV (Utility Tracking)	183	229	263	699	902	1119
Wind (onshore)	661	825	949	2519	3254	4033

Table 6.1 shows the investment and operating costs of RE options, in a scenario assuming that 30 percent of electricity is produced from renewable energy sources by 2025 and that this figure will rise to 60 percent in 2030. The unit cost of production is taken from the study conducted by Ryan Shea and Yatin Ramgoolam, in 2019, on the capital and operating costs of various options of renewable energy options in Mauritius[40].

[39] The econometric equation was estimated by Sultan (2018), the long run equation was: lnelectricity=-0.39lnPrice+1.05RealGDP. See Sultan, R. Chapter 9 Tracing the path towards sustainable development in Mauritius through the GDP-CO2 emission nexus.

[40] Shea, R. P., and Ramgoolam, Y. 2019. Applied levelized cost of electricity for energy technologies in a small island developing state: A case study in Mauritius. Renewable Energy, vol. 132, pp. 1415-1424.

7.

AN ASSESSMENT OF THE CONSTRAINTS TO CIRCULAR ECONOMY DEVELOPMENT

The material recovery activities (including recycling) are currently in an infancy phase and are responding to a heterogeneous institutional set up, depending on the sources, types, collection, transfer and disposal of and (more importantly) Government measures towards wastes. Nearly all wastes are collected, transferred and disposed in the landfill. These initiatives respond to Government measures such as the tipping fee of Rs 300 provided to recyclers for waste taken from transfer stations for the purpose of being recycled; Rs 2,000 provided for each tonne of used tyres recycled or being exported for recycling, and 15 per Kg of PET bottles as the incentive for PET bottle recycling. The Government's solid waste management strategy is summarised in box 7.1. As such, Mauritius is at the lowest stage of the 9R framework and waste hierarchy where most wastes are disposed in the landfill (see section 2).

Absence of segregation and organisation

The main cause for the low recycling rate in Mauritius is the limited access of wastes in segregated and unmixed forms, due to low level or no sorting at domestic level. Before wastes can be converted into valuable inputs, they require some organisation: each type of waste need to be stored in a separate manner which will allow the collector to transfer specific wastes to respective recovery/recycling endpoints. With no incentive structure to either households or enterprises, this process is highly inefficient as most generators keep all waste in mixed forms and this requires an additional costly step to separate them at a later stage.

Insufficient wastes for closed loop

It is unanimously pointed out by recyclers that they do not have sufficient raw materials to carry on their business operations while others have ultimately been forced to shut down. There are currently no regulations which prohibit the landfilling of recyclable industrial wastes. From the practices, it can be deduced that with little recycling and composting, it is rather difficult to cope with the current load of industrial wastes.

Segregation at source, at both household and enterprise level is therefore a priority. However, this strategy is far from being effective if the necessary recycling processes are not developed. The main obstacles identified so far at different levels of the value chain can be summed up as: collection and sorting; low customer demand for recycled products; lack of successful circular business models; the challenge of collaborative innovation (cluster approach) among supply chain partners; lack of high-quality recycling materials; and high costs but low economic benefits in short-term, absence of standards, inadequate regulatory framework, weak institutional support, and an absence of a CE mindset as a whole.

Absence of reverse logistic

Reverse logistic strategies are very limited, which means that there are no mechanisms (infrastructures, incentives, etc.) to return products reaching their end of life from consumers to producers. This is the main reason for the disposal of domestic and commercial waste in the landfill.

Box: 7.1. Solid Waste Management Strategy in Mauritius

In order to reduce reliance on the sole landfill and to promote a sustained, healthy and vibrant circular economy, the Ministry of Environment, Solid Waste Management & Climate Change has spearheaded a Consultancy Study, funded by the Agence Française de Développement, on a New Solid Waste Management Strategy and Action Plan for Mauritius with focus on resource recovery and recycling in 2017. After extensive consultations with all stakeholders, a new Solid Waste Management Strategy and Action Plan for the next five years has been developed, which aims at maximising resource recovery and recycling in the short to medium term, while also tapping the energy recovery potential from wastes in the long term. A baseline review, including identification of gaps, of the current solid waste situation has been carried out, after which strategic areas for intervention and actions were recommended, along with specific tasks. The proposed Strategy focuses on five key areas:

- Strategic Area I: “Prevention and Environmentally Responsible Consumption”

Emphasis is laid on the minimisation of the impacts of wastes by reducing the quantities of wastes generated. Concrete actions that can be implemented at low costs and in the short-term include home composting, deposit on post-consumer products, among others. The use of legal instruments and enforcement to discourage bad behaviour and to prohibit non-environmentally friendly products has also been recommended.

- Strategic Area II: “Increase in Resource Recovery”

This Strategic Area proposes ways and means to efficiently recover such resources that are otherwise being wasted by throwing away of recyclables with intrinsic economic value, such as organic matter, waste paper, plastic, glass and metal. Separation of waste at source is viewed to be of paramount importance for this initiative to succeed. The introduction of a systematic segregation and material recovery system for waste generated at, but not limited to, household level, such as wood waste, bulky waste, small hazardous waste, is being recommended, with accompanying legal and financial measures. This will ensure the continuous supply of non-contaminated resources to the recycling industry, reduce the quantity of wastes to be landfilled and stimulates the economy with the creation of new green jobs.

- Strategic Area III: “Adequate Technologies for Energy Recovery”

The setting up of Waste-to-Energy infrastructure can only be envisaged for implementation in the long-term, that is, after successful implementation of resource recovery and recycling projects. Thus, it is proposed that an assessment of the potential of waste-to-energy technologies be carried out in the medium term, as this would not be relevant in the short term.

- Strategic Area IV: “Provision of Adequate Disposal Infrastructure”

It is reckoned that despite all efforts to minimise wastes, to recycle resources and to recover energy, a landfill will still be needed to dispose of residual wastes. This area focuses at short- and medium term on the extension or further optimisation of the existing Mare Chicose landfill, while also considering the eventual option of a new landfill. Strategic Area V: “Information, Education and Communication” Commitment and engagement of all stakeholders are essential in the sustained implementation of the Strategy over the next five years. A lot of focus is thus laid on capacity building of important stakeholders and awareness-raising on new waste practices in general.

Source : Ministry of Environment, Solid Waste Management & Climate Change

Absence of synergies for Industrial Symbiosis

As far as industrial waste is concerned, the scope for Industrial Symbiosis at large scale is limited to textile poultry waste, organic fish waste, and textile waste. Most of industrial waste on plastic, wooden pallet and used oil are already in the supply chain of recycling. There may be opportunities at micro-level and small scale, but there is an absence of synergies among enterprises and other stakeholders, and lack of data on the types of wastes to facilitate discussion. The most common arrangement in the current supply chain of industrial waste is that the generators pay for their disposal. Consequently, any investment/organisation is left on the generators, with hidden cost for the organisation and disposal of wastes. This represents a cost to dispose wastes and effort to convert the same into inputs is left to the recyclers.

Absence of end-of-life strategies

Recycling enterprises treating PET, plastic waste, e-waste, glass waste, among others, manufacture intermediate inputs, and hence the level of upcycle – transforming waste materials in high perceived value - is quasi non-existent. The current waste recycling sector does not work towards a closed loop system where wastes return to the domestic economy, as the waste is exported.

Lack of R&D and product development

Using the wastes as material inputs could also create wide business opportunities. However, there is a need to conduct R&D in product design, undertake technical and economic feasibilities, establish the necessary standards for the inputs produced from wastes and create the necessary market for final products.

Database on waste

The industrial waste audit forms/reports which came into operation as of April 2009 serve as the only tool for managing industrial wastes since there is no database for regulating the inflow and outflow of industrial wastes within the developing island of Mauritius. As of 31 December 2019, there was neither a record on Electrical and Electronic Equipment (EEE) imported, nor a database on the volume generated and recycled. There is a thus a step to create the regular monitoring of the kind of wastes generated. One of the leadership groups recommended as part of a committee - National Circular Economy Task Force (NCET) (section 8) should focus on data collection and dissemination and the codification of waste.

Box: 7.2. Building up a database on CE in Mauritius

If it cannot be measured, it cannot be improved! In the preparation of this report the consultants discovered from the outset that there is a paucity of data on CE – which is to be expected as the concept does not have a national traction so far. Under the Local Government Act of 2013, all recyclers must be registered with the local councils and must submit an annual return. However, these statistics are not collated by Statistics Mauritius and remain at the SWM Department. Furthermore, these figures relate to activities of recyclers solely. A major step in the development of CE would be the systematic collection of data on issues pertaining to CE. Inspiration can be drawn from the Digest of Waste and Resource statistics, UK, which is published since 2015. It is presented as a "publication serving as a compendium of key statistics on waste and resource". It contains sections on:

- Resource, including flows and consumption of raw materials, such as metals and minerals
- Waste generation and sources of waste,
- Destiny of waste, e.g., recycling, incineration
- Waste composition
- Food waste
- Economic characteristics of the sector,
- Waste infrastructure,
- Environmental issues with waste
- Behavioural attitudes to waste
- Waste crime
- EU data on waste

The section of the Digest on Economic characteristics of the waste management sector contains the following data:

1. Gross Value Added (GVA)of the waste management sector as a percentage of the whole economy
2. GVA by waste management sector
3. GVA of waste management sector
4. GVA of repair, re-use and leasing sectors
5. Exports of Refuse-Derived Fuel
6. Employees in the waste sector.

Source : http://www.gov.uk/government/collections/waste-and-recycling-statistics

Uncertainty and risk

Enterprises that are keen to invest in the CE are faced with uncertainty and risk of securing raw materials when investment in machinery and equipment has been undertaken. A major barrier pointed out by key informants is that the process in competing for tenders on a regular basis poses a risk. In case that investment has been made and tenders are not successfully obtained, enterprises would run at a loss. This concern is accentuated by the fact that foreign companies which may have well-defined incentive structure in their country of origin would be more competitive to succeed in their attempts relative to local companies. When wastes are exported, they are not brought back to the domestic economic system and the opportunities to generate wealth and create jobs are limited. A strategy such as 'pioneering status' could play a key role to promote CE activities in Mauritius over a defined period.

Key constraints

Table 7.1 below presents the key constraints mentioned under different categories and suggested tentative change leaders for each category. These can be topics for focus group discussions to come up with implementable recommendations. These Focus Groups should be co-chaired by a representative of the public and private sector respectively. They will report to a National Circular Economy Task Force (NCET). The last section of this report will elaborate on the structure and scope of the proposed committee.

Table 7.1. Constraints of Circular Economy

Categories	Barriers	Change Leaders
Governmental and Regulatory	1. Lack of standardisation 2. Waste management policy incoherence (landfill fees) 3. Obstructive laws and regulations 4. Procurement policies	Ministry of Environment, Mauritius Standard Bureau
Economic and financial	1. Lack of funding to circular business models 2. Environmental cost (externalities) is not considered 3. High upfront investment costs 4. High costs but low economic benefits in short-term 5. Inadequate scale 6. Absence of statistics and indicators for analysis at the national level and KPIs at the firm level	Ministry of Finance, MBA, MRA
Technological	1. Challenges in tracking recycled materials 2. Difficulty in delivering high-quality products made from recovered materials 3. Difficulty in designing reused and recovered products 4. Difficulty in collection and sorting 5. Lack of advanced disruptive technologies	BM/Firms
Societal	1. Lack of trustworthy public information 2. Lack of social awareness 3. Insufficient demand for circular products	Government, BM, NGOs (National CE Committee)
Organisational and managerial	1. Unclear vision about circular economy 2. Hesitant company culture and leadership commitment towards circular economy 3. Organisational structures that result in difficulties for circular economy implementation (silo mentality)	Government, BM
Infrastructural, supply chain and market	1. Lack of high-quality recycling materials 2. The price of recycled materials higher than virgin materials 3. The absence of information exchange system 4. Lack of successful circular business models 5. Challenge of collaborative innovation among supplychain partners	Government, BM

8.

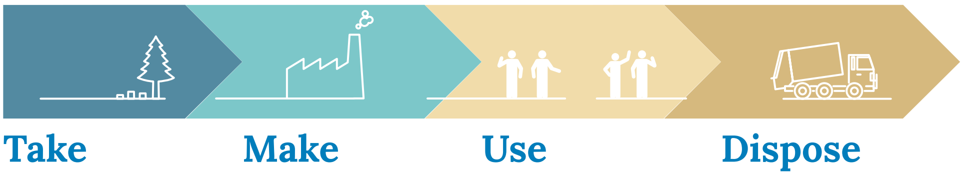
TRANSITIONING TO A CIRCULAR ECONOMY: THE WAY FORWARD

The COVID-19 pandemic has highlighted the vulnerability of small island developing states to external shocks - especially to disruptions in international transport connectivity. Concepts like food security and productive use of imported materials must be revisited. In this context, the circular economy takes a strategic dimension in the path towards greater self-reliance and resilience. Successfully transitioning from a linear to a circular economy would require a change in nationwide behavioural patterns, a change in mindset, and a paradigm shift from linear thinking of "take-make-consume-waste" to value cycles of "maintain-repair-reuse-upgrade-remanufacture-recycle", from cost reduction to value addition.

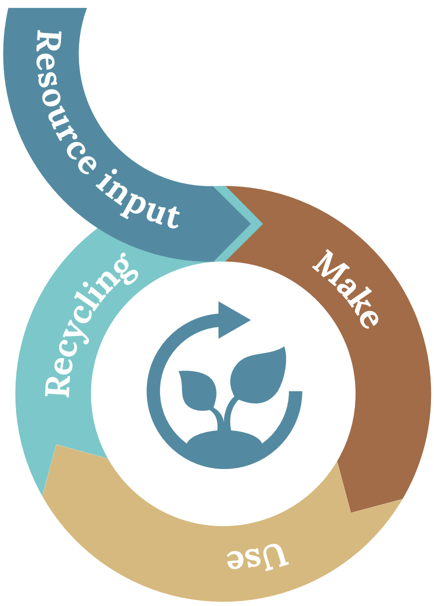
The focus of this report is to assess the state of private sector investment in the circular economy in Mauritius to facilitate post-COVID recovery. CE would require around Rs 7.5 billion to Rs 11.2 billion of private investment for almost 83 percent of waste in Mauritius, which will contribute to a gross output of Rs 5.1 billion to Rs 7.7 billion and value-added of 0.9 percent of GDP annually. It must be pointed out that the first building blocks of a circular economy have already been laid by local entrepreneurs before CE became a buzz word. Over the recent years, there has been a change in business mind-sets towards sustainable operations, and there is more emphasis on resource efficiency.

A circular economy transcends eco-efficient approaches which are primarily concerned with reducing materials used to minimises waste. Eco-efficiency is nonetheless a good start but a start that Mauritius as a country has yet to make. So, it begs the question of whether the current socioeconomic environment is conducive for private investments in a (still non-existent) circular economy. The recent environmental crisis with the Wakashio incident has perhaps helped raise awareness of ecological issues or has at least galvanized stakeholders from all sectors of the economy and civil society, demonstrating that there are many who are concerned by environmental issues.

Linear Economy



Circular Economy



8.1. Exploiting Investment Opportunities: Incentive framework

Although it is not within the remit of this report to look at the incentive framework, yet it important to raise this issue as all respondents bemoaned the absence of incentives. Most are pioneers in the field in Mauritius and wonder why incentives are not made available for CE to take off as was the case for the EPZ and the offshore financial sector. The aim should be to move up the value chain in the CE. There is scope to do so as the CE is in its infancy stage in Mauritius. However, this will require investment and know-how, the adoption of new technologies such as AI (Artificial Intelligence) in existing production processes to minimize waste. Unless incentives are provided, the CE may remain a niche sector instead of a sustainable economic system.

So as not to reinvent the wheel, an adapted version of taxonomy of incentives elaborated by the EU Leadership Group is reproduced below. It must be pointed out that some of these measures are already under consideration by the Government.

Economic Incentive	Increase demand for circular products and services by:	Responsibility
1. Green and Circular Public Procurement	Simple tender criteria to contain mandatory circular performance criteria besides price (green public procurement or GPP)	Central government, local councils, large enterprises
2. Extended Producer Responsibility (EPR) incorporating all external costs in the price of specific product groups	- Incentivising the production and consumption of circular products by modulating EPR fees according to sustainability criteria, which is, in turn, reflected in the higher cost that the producers must bear for end-of-life management of those products that are waste intensive, thus rewarding eco-friendly design choices. - Explore possible taxation schemes, for example on the baseline of virgin resources use (rather than only plastic being not recycled, or single use material) or pollution generated (link to CO2 pricing but not only, for example hazardous substances contents/ hazardous waste generation).	Government should work on the legal framework. BM could initiate a voluntary system of collecting e-waste for example. A Code of conduct could be elaborated by BM.
3. A tax shift from labour to resources	-Adding a high tax on resource-intensive products and services while reducing the taxation of labour -Determine circularity criteria in each product / service / process -Visual circularity labelling mechanism (like the energy efficiency label)	Government with inputs from enterprises
4. No or low VAT for circular products and services	Nudging consumers and businesses towards circular solutions – establish time frame	Government
5. Investigate demand side incentives, beyond GPP	- Voucher schemes for the most vulnerable/less wealthy citizens (to possibly overcome their lack of access to circular services/products) - Levies on advertising, with higher fees for high CO2/high impact products (the benchmark could be established based on PEF average or other type of LCAs) - Mandatory inclusion of sustainable procurement (= in line with GPP criteria) for private businesses having to report on sustainability, and making it a criterion to report on for non-financial reporting - Create a level playing field with public authorities for services that are both public and private: Why should a public-school respect GPP, when a private school could derogate, why should a public hospital comply with GPP, when a private clinic could derogate?	Government

8.2. Multi-stakeholder's Involvement and Ownership

The previous sections have clearly demonstrated that, though there are several private initiatives, these are not sufficient to ensure the development of a sustainable CE. Just wishing for CE to happen is not enough. The barriers/constraints faced by existing operators as well as potential impediments to investment must be understood and acted upon by all stakeholders who will have to act in different roles depending on the context, namely as catalyst or promoters, facilitators, and enablers.

Who are the stakeholders? There are three groups:

1. The public sector, i.e., Central Government, municipal and district councils, and parastatal bodies.
2. The private sector institutions, NGOs, Trade Unions, Consumer groups.
3. The citizens as a source of waste and as consumers.

CE required a shared responsibility among different stakeholders. Consumption patterns would need to be revisited at the individual and household level for change to truly take place. Local entrepreneurs on their part would need to switch to circular material flow whereby they retain value and even re-add value to the supply chain; however, their effort should be met with adequate market demand. The Government (national and local) will need to create the conditions for the development of CE through regulatory and fiscal reforms, infrastructure, infostructure and procurement policies.

Government

The Government has a crucial role to play. As a catalyst or promoter, its role entails, inter alia, developing and garnering support around a strategic CE vision, raising awareness, nurturing a CE culture, establishing clear governance principles, and putting in place a recognition/reward system. As a facilitator, it has primarily a coordination role and acts as a bridge or interface between various stakeholders with a view to ensuring policy coherence and the formation of potential clusters so that economies of scale can be achieved. And its role as enabler relates to factors which are necessary for the growth of CE, namely financing, regulations, standards, capacity building, data, digital technologies and procurement.

Strategies need to be deployed to:

I. Establish a clear vision on CE and policies towards waste management to 2030.
II. Introduce the necessary incentive framework for those involved in CE activities.
III. Reform the waste collection system towards segregation with investment towards the necessary logistic and infrastructure.
IV. Establish necessary logistic such that recyclers secure waste as raw materials in a timely manner.
V. Facilitate industry-university research in product design and development from waste.
VI. Establishing the necessary standards and certification of material recovery from waste (reference is made to the Mauritius Standard Bureau).

Of particular significance at the onset of CE aspirations the Government will have to get on board - especially with respect to sustainable government purchasing decisions to CE advancement. A good start would be for the Government to review its criteria for procurement of waste disposal – contracts which should not be allocated to the lowest bidders but to those who include recycling in their bids. These policies should also seek to present greater scope for Public-Private partnerships in the sector - i.e., collection and sorting can be done by local authorities and sent to private recyclers. If wastes are segregated and collected by the Local Authorities, the institutional arrangement to select private recyclers must be structured in an appropriate manner so that it ensures the optimal investment is made in the CE sector. The criteria could include pioneering status, employment creation, product development, and R&D.

Households

In the CE, the consumers are positioned at the start as well as at the end of the supply of chain. A first step might be to engage more closely with civil society actors to foster greater eco-effectiveness (as opposed to eco-efficiency) in the economy. Accelerating the transition to a circular system necessitates a change in consumer behavior and mindset.

Business community

The interaction with operators revealed that there is a dynamic group of entrepreneurs (passionate pioneers) engaged in CE activities and who believe in the prospects for making CE a game changer. However, a feeling of frustration was also expressed as they were under the impression that there has been a lot of talk (positive) but not much action with regards to incentives, regulations. They believe this may be due to the absence of an interlocutor able to make things happen.

The key player would be those entrepreneurs who would be willing to invest towards making CE a reality. They are likely to bear the biggest risk of the supply chain since survival would require securing markets for the products. This will necessitate innovative ideas in transforming waste to final products. One way is to establish concrete research projects with universities researchers funded by the national institutions, such as the Mauritius Research and Innovative Council, Tertiary Education Commission, among others.

8.3. Policy Framework

While there is no single policy that can promote the complementary processes and interdependencies across sectors and industries, there are overarching policy domains that underpin the CE transition, namely: 1. Research, Design and Development; 2. Purchasing, Standards and Certification; 3. Sustainable consumption; and 4. Materials and Resource Management. There is no need for Mauritius to reinvent the wheel as there are existing CE policy prescriptions that have been detailed in case studies of the EU by CE experts of the region. The EU CE model focuses on the following policy areas: quality standards and norms in production; public procurement; market mechanisms; education and upskilling; promotion; infrastructure; financial incentives; tax relief for circular products; liberalisation of waste trading and its facilitation through virtual platforms; support for eco-industrial parks (clusters are more appropriate in the Mauritian case as an initial step); and labelling related to the quality of re-used and remanufactured products.

8.4. Institutional Arrangements

An institutional framework is required to address issues related to both demand and supply. On the demand side, awareness must be raised about the benefits of CE to ensure that a significant market is developed. On the supply side, a proper chain coordination mechanism is required. It would be recommended to set up (i) a National CE Task Force (NCET) and (ii) a Stakeholder platform. The NCET, as described in box 8.1, will have a pivotal role in coalescing various stakeholders across the CE to ensure that policies are contextualised to best serve the agenda of CE practitioners. They should ensure there is scope for stakeholders from the public, private and third sector to contribute to the policy design process. The body will be key to enabling a participative, bottom-up approach to formulating CE policies and ensuring the effective translation of said policies.

Box: 8.1. National Circular Economy Task Force (NCET)

The NCET will have as its main objectives to promote CE principles; facilitate the acceleration of CE activities and enable the growth of the system, and to act as a channel of communication for different stakeholders to ensure policy coherence. It will also focus on identifying social, economic and cultural barriers to the transition towards a circular economy and contribute towards policy formulation to tackle the identified constraints. The priority action will be to run a national awareness campaign on CE and to elaborate a roadmap. Fundamental to a successful transition towards a circular economy are the commitment and involvement of civil society, businesses, the knowledge community, and public authorities. To this end, the proposed National Circular Economy Task Force (NCET) should comprise representatives from the public and private sectors and civil society as well as academia/professional bodies. It should set up leadership groups for key topics, namely: incentives, regulatory, legal affairs/contracting and chain coordination. The NCET can be co-chaired by the public and private sector. This arrangement was productively used for the APEI project. It could meet every two months while the leadership groups could meet more frequently depending on their respective agenda.

Creating a Stakeholder platform (Infostructure)

Existing institutions and organisational forms cater to linear production and supply chains. The lack of institutional infrastructure in place to foster CE activities, in the form of the legal and regulatory framework and property rights enforcement, presents obvious sets of challenges for local entrepreneurs who must rely on their own resources to deal with legal, regulatory, bureaucratic and technology information gaps. While it may not be necessary to set up a new body, existing support institutions will have to review their operations to take on board some functions required for the promotion of CE. This fundamentally requires action along three vectors: chain coordination, contracting and financial mechanisms.

Chain Coordination Mechanisms

Chain coordination pertains to interaction between different actors in the value chain. The aim is to facilitate inter-firm collaborations to enable cascading activities that loop back into the product's prolonged life cycle. Currently, there is no recognised platform for information sharing or an organisational body to facilitate such interactions between different actors along a sustainable supply chain. In the present business environment, intermediary services seem to be missing; and this has financial implications for CE practitioners who cannot bank on an existing interdependent symbiotic system. For example, one of the local entrepreneurs reported that collection of input materials itself presents challenges due to a lack of education/information on how to handle post-production or post-use waste which ends up getting contaminated before it reaches their factories, thereby increasing their costs. Furthermore, there is no independent intermediary company that collects and sorts out the waste before it reaches them like in other countries. Basically, this coordination can be achieved through a knowledge exchange platform.

Contracting Mechanisms

The second important vector relates to legal contracts and regulatory gaps. It must be pointed out that most of the CE operators are SMEs and often find themselves having to create and self-enforce new rules outside the boundaries of the formal legal framework. For instance, the local small enterprise who needs to procure input material from several other businesses who wish to dispose of their waste have no means of legally ensuring the quality of what they receive. There are no formal contracts that they can use for their business model and must devise their own contractual terms with respective suppliers.

There is also the case of legal loopholes that allow 'illegal' collectors who dispose of the waste of clients through unsustainable methods. These loopholes if not addressed will hinder the aspiration of Mauritius becoming a CE as such leakages would undermine the efforts of private CE enterprises and discourage further investments in recycling activities. Regulatory support is paramount to CE strategies and its absence presents a significant barrier to the foundation of CE strategies and activities.

The present status quo arrangement will need to be revisited to provide a formal legal framework within which CE businesses can operate, as well as assign ownership of material to suppliers and processors in the material flow to foster more efficient metabolisms through greater interdependencies. At its core, a CE requires industrial symbiosis to maximise utility of material flows. For example, in the used-oil-recycling sector, the recycler needs to obtain its inputs from car repair shops, amongst others. The absence of standards and control over the quality of the input material increases the cost to the recycler. The mechanic may not be storing the used lubricated oil in unsatisfactory conditions thus reducing the quantity of inputs (contaminated inputs result in black sludge) and impairing the quality of outputs.

Furthermore, if there was an organisation that could legally certify the end-products quality there would be scope for expanding the market as consumers would feel more confident in using these products. This final product could even be supplied back to the mechanics thereby perfecting the symbiosis between the economic actors in that sector while minimising waste. But who would be willing to invest in R&D to this end considering low regulatory support? And would there be scope for exporting these products given existing trade agreements?

A major building block in the enhancement of CE would, therefore, be the creation of a central information exchange platform. Information exchange is at the nexus of a CE system that is underpinned by interdependencies that connect the upstream and downstream actors in the production chain. To redress some of these concerns, Business Mauritius could step in as a CE accelerating organisation that provides a platform for shared knowledge and set a standard for good practices in waste management to facilitate the task of procuring used input material of satisfactory quality for better value of refurbished product. For this, we would need greater interaction between different actors in the value chain.

The aim of such an information platform would be to collect data on recycled materials flows and share knowledge about circular industry innovation and technologies. Moreover, a platform connecting industrial stakeholders can help the Government establish industry standards and nurture cooperative long-term multilateral partnerships in contracts along the supply chain. Building an information system would also accelerate a demand network through business-to-business and business-to-customer business models. Supply chain networking makes operations more resource-efficient and facilitates coordination across industry-specific stakeholders. Therefore, establishing a knowledge exchange platform should be the first step to setting into motion CE advancing strategies before engaging in large scale investment strategies.

It must be pointed out that at least one enterprise is in the process of setting up a digital platform. This could be leveraged upon, or the BM platform could consist of a network of sector wise platforms. This will have to be investigated further. In the meantime, BM or one of its affiliates could expand its website to have a CE corner where can be made available the findings of the NCET, CE strategies and good practices, an interactive database of suppliers of inputs and technology. It can serve as a virtual marketplace for suppliers and recyclers.

Addressing the legal dimension of the problem would require the intervention of the Government and public authorities. Without a national vision for CE strategies the attempts by local entrepreneurs will continue to fall short of their full capacity. Waste processing will continue to generate second grade products and more waste that cannot be effectively re-fed into the economy to achieve the 'no waste' concept that a CE is built on.

Financial Mechanisms

Securing finances for vanguard business concepts (and by SMEs mostly) is a daunting task in an economy that only considers linear value chains. Accessing finance for end-products that have not entered mainstream production lines puts CE practitioners at a disadvantage. Referring to the difficulties of inter-firm interactions complicates the claim to financial viability as there is limited scope for shared investment prospects between actors along the same value chain. Institutional support may be useful in ensuring not only the availability of finance but also ease of access to finance. There is a need to explore different financing pathways - i.e.: venture capital, leasing, incubators, green financing and preferential procurement.

9.

CONCLUSION

It must be acknowledged that it will take time for CE as an economic system to replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, and to become a significant contributor to national wealth. Both the EPZ and the financial sectors took almost a decade to reach their cruising speed. Whilst there is no doubt about its potential for growth in the coming years, it needs nurturing as it is bound to stagnate in the absence of a proper conducive environment in terms of infrastructure, regulations, standards, incentives, institutional support, market development, and most importantly a strategic vision shared by all stakeholders. It is hoped that this report will be useful to trigger the necessary discussion at the level of the Government, and business community for concrete actions to develop the CE in Mauritius.

APPENDIX A: OUTPUT AND EMPLOYMENT MULTIPLIER – AN INPUT-OUTPUT APPROACH

Suppose x_i represents the output of industry *i*, which can either be sold to consumers as final consumption or be used as 'intermediate inputs' to produce other products or services. The proportion which is consumed by consumers is called 'final demand' and, for simplicity, it is denoted by Y_i. There are also several industries which will use x_i as inputs in their production. The part which is consumed by a particular industry, industry 1 (or which is sold to industry 1) may be represented by x_{i1}; similarly, industry 2 will use x_{i2}, and industry '*n*' will consume x_{in}. Hence, in mathematical terms, industry i output is consumed as follows:

$$x_i = x_{i1} + x_{i2} + \ldots + x_{in} + Y_i \qquad (1)$$

This can be written as follows:

$$x_i = \sum_{j=1}^{n} x_{ij} + Y_i \qquad (2)$$

Each industry (j=1...n) which uses x_i as input is assumed to employ a production technology such that the quantity consumed, x_{ij}, is proportional to that industry 's output[41], x_j, with a technological coefficient a_{ij}. This can be written as:

$$x_{ij} = a_{ij} x_j \qquad (3)$$

Hence, replacing (3) in (2), we have

$$x_i = \sum_{j=1}^{n} a_{ij} x_j + Y_i \qquad (4)$$

Equation 4 is an economy-wide production system involving *n* number of industries. When there is a rise in demand for a product in an industry, output in that industry will rise. This is called the 'direct effect'. It also leads to a rise in demand in inputs used in its production; this in turn, leads to an increase in demand for output in other industries which will generate successive round rises in demand for other products and employment, creating a multiplier effect of input and output requirements. This is referred to as the 'indirect effect'. Equation 4 can be used to estimate the output and employment multiplier effect. Using matrix terminology, equation (4) can be written as:

$$\mathbf{x} = A\mathbf{x} + \mathbf{y} \qquad (5)$$

if A is the technological matrix such as $\begin{bmatrix} a_{11} & a_{12} \ldots a_{1n} \\ a_{21} & a_{22} \ldots a_{2n} \\ .. & \\ a_{n1} & a_{n2} \ldots a_{nn} \end{bmatrix}$, $\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ . \\ x_n \end{bmatrix}$ and $\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ .. \\ y_n \end{bmatrix}$

then Equation (5) can be rearranged as follows:

$$\mathbf{x} = (1-A)^{-1}\mathbf{y} \qquad (6)$$

The elements of $(1-A)^{-1}$ provides the direct and indirect effects on output from a unit change in sectoral final demand in a particular sector. Based on equation (8), the output impact analysis can be calculated:

$$\Delta \mathbf{x} = (1-A)^{-1} \Delta \mathbf{y} \qquad (7)$$

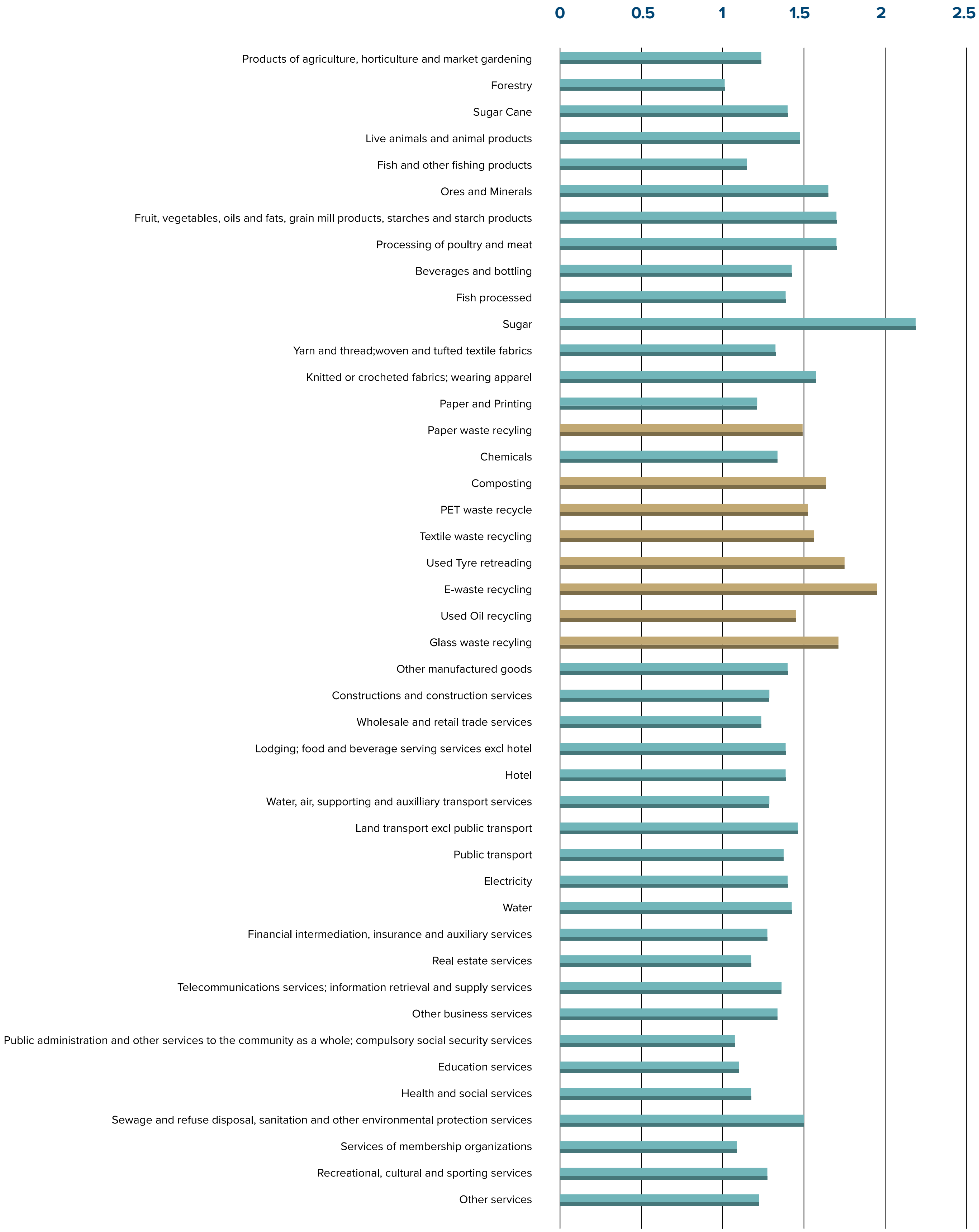
The direct and indirect change in employment potential due to a unit change in a sectoral final demand would be L is vector of employment coefficients. given by:

$$\Delta \mathbf{e} = \mathbf{L}(1-A)^{-1} \Delta \mathbf{y} \qquad (8)$$

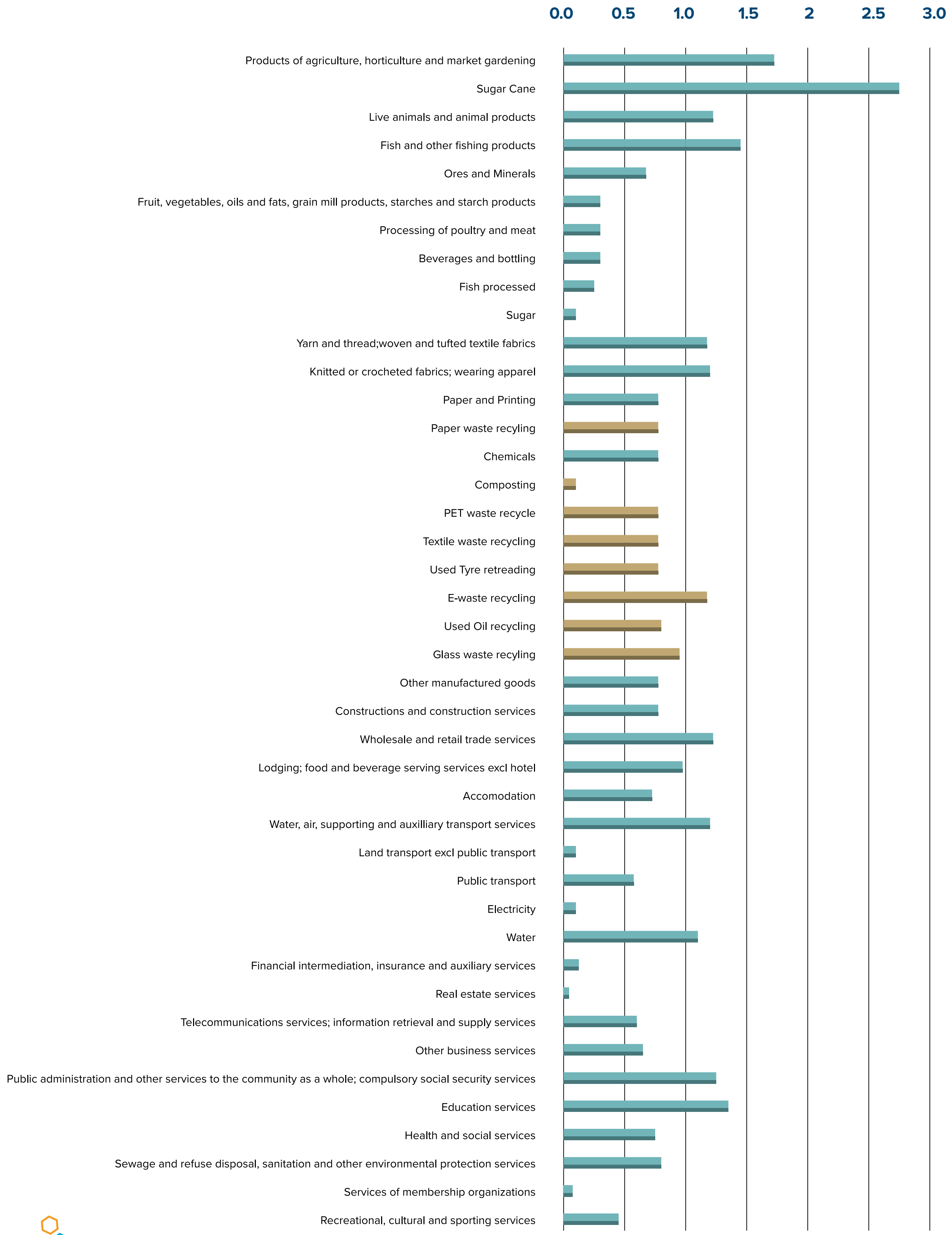
L is vector of employment coefficients

Source: The materials are based on Miller, R., Blair, P. (2009)

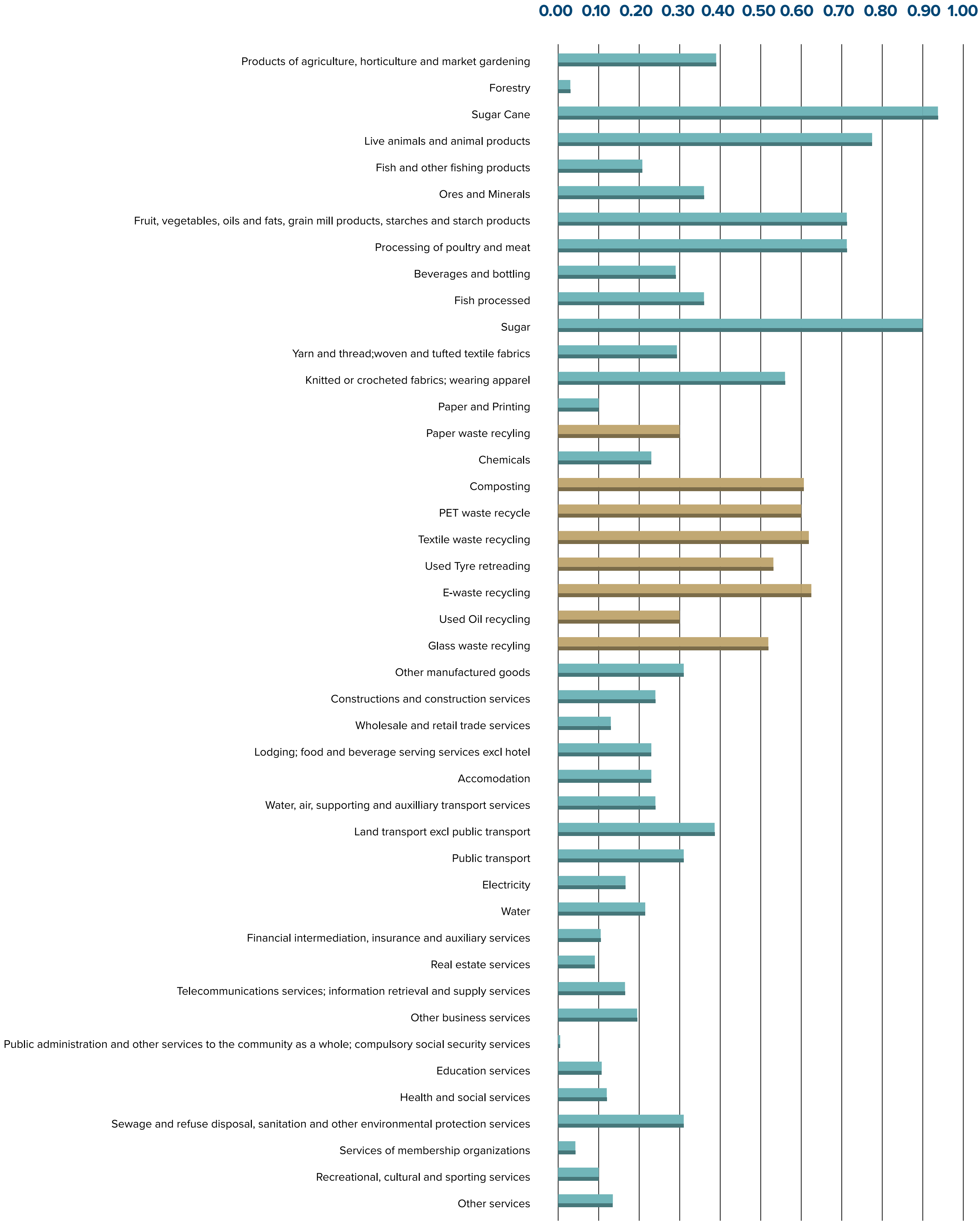
APPENDIX B: OUTPUT MULTIPLIERS



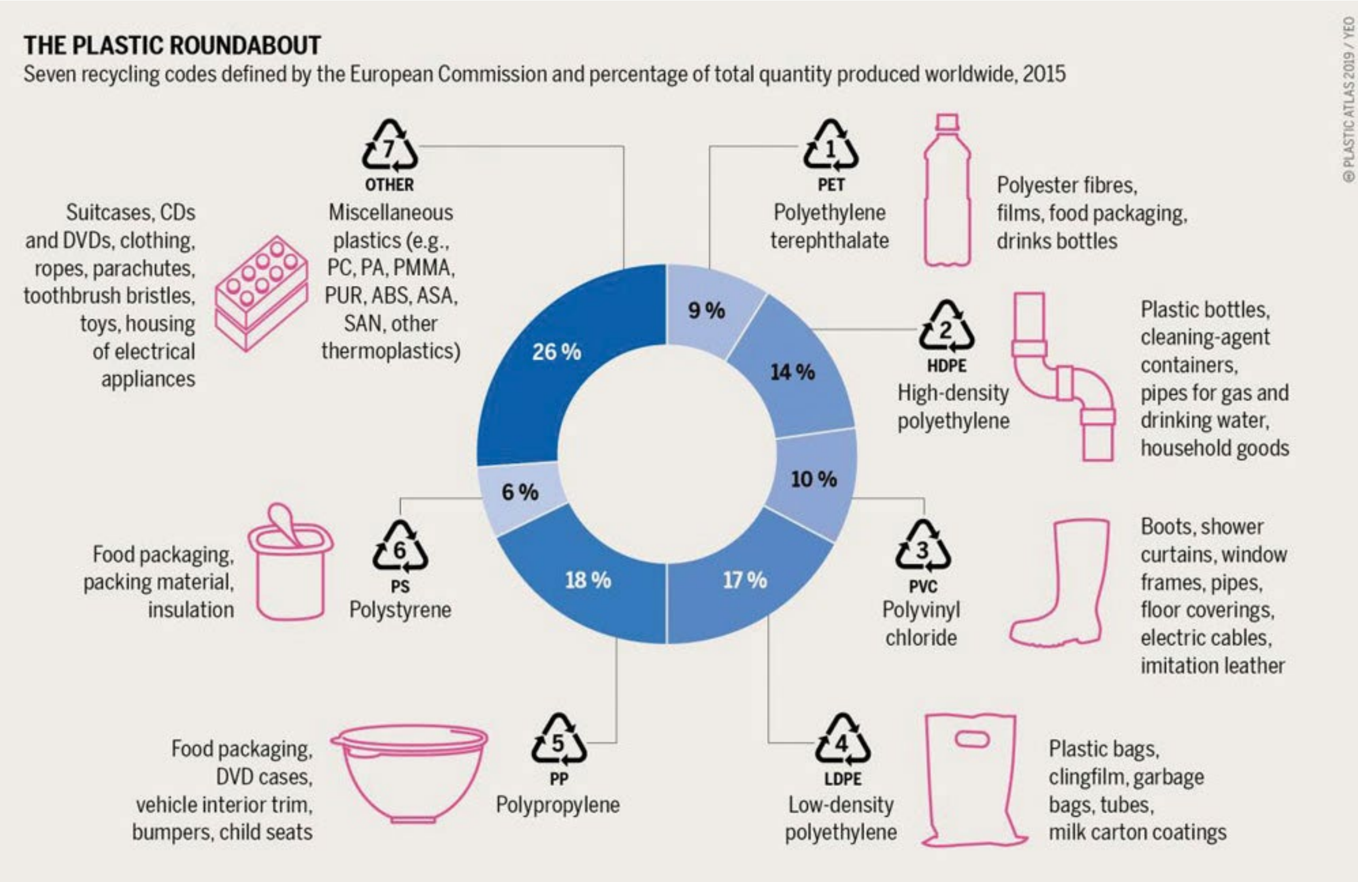
APPENDIX C: DIRECT EMPLOYMENT MULTIPLIERS (PER RS MILLION)



APPENDIX D: INDIRECT EMPLOYMENT MULTIPLIER (PER RS MILLION)



APPENDIX E: DIFFERENT TYPES OF PLASTIC



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