Economic Assessment of a Deposit Refund System (DRS), an Instrument for the Implementation of a Plastics Circular Economy

in Menorca, Spain

Estefania Sanabria Garcia and Leander Raes

GLOBAL MARINE AND POLAR PROGRAMME

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Contents

This IUCN economic brief is based on the dissertation "*Economic assessment of a deposit refund system, an instrument for the implementation of a circular economy solution to reduce plastic waste in Menorca, Spain*", developed in fulfilment of International Master of Science in Sustainable and Innovative Natural Resource Management (SINReM) organized by Ghent University, Uppsala University and TU Freiberg (Sanabria, Raes, & Speelman, 2021).

1. INTRODUCTION

1.1. Background and objective of the study

The ‘Plastic Waste Free Islands – Mediterranean’ (PWFI-Med) project is implemented in Cyprus and Menorca, Spain, by IUCN, the International Union for Conservation of Nature, and funded by the Didier and Martine Primat Foundation. The project aims to provide solutions to tackle plastic leakage from islands, incorporating policy, business operations, and citizens’ ‘behavioural’ changes. PWFI-Med focuses on three sectors of the economy: waste management, fisheries, and tourism. The PWFI-Med project has three main goals: (1) to improve the knowledge and to provide policy recommendation regarding waste generation on the island; (2) to enhance the adoption of plastic leakage reduction measures in the three focal sectors; and (3) to develop a blueprint[1] for the Mediterranean in collaboration with regional bodies. The project is implemented from January 2019 to December 2021.

To support this project, the main objective of this research is to carry out an economic assessment of an instrument to reinforce the implementation of the plastics circular economy (CE) in the waste management sector in Menorca. The focus of the evaluation is a Deposit Return System (DRS) for PET beverage bottles. The aim of the DRS is to increase the quantity and quality of the collection of plastic bottles, increasing their recycling potential and reducing leakage to the Mediterranean. A cost-benefit analysis (CBA) is carried out to identify whether the implementation of the instrument is economically feasible and sustainable over time, thus supporting the decision-making process for the government of Menorca.

1.2. Marine plastic pollution and the plastics circular economy

Plastic waste generation and its leakage into the marine environment is a global problem. Every day an estimated 27,000 tonnes of plastics enter the seas and oceans as leakage. This quantity is expected to double in the next decade (Boucher, et al, 2019; Boucher & Friot, 2017). One of the most threatened marine environments by plastic pollution is the Mediterranean Sea (Campana et al., 2017). Boucher & Billard (2020) estimate the total amount of plastics accumulated in the Mediterranean to be 1.18 million tonnes, with a range of 0.05 to 3.55 million tonnes. The same study estimates that a total of 230,000 tonnes are leaking into the Mediterranean every year, with a range of 150,000 to 610,000 tonnes per year.

Plastics in the marine environment cause ecological and socioeconomic impacts (Boucher et al., 2020; PlasticsEurope & EPRO, 2019). The negative ecological effects can be divided into three types: physical, chemical, and pathogens and vector parasites. The socio-economic impacts can be direct or indirect. Direct economic impacts are the costs related to clean-up activities and the potential loss of income in fishing, aquaculture, tourism and maritime transport (UNEP & GRID-Arendal,

1 A recommended step-wise approach to reduce plastic leakage based on the project results.

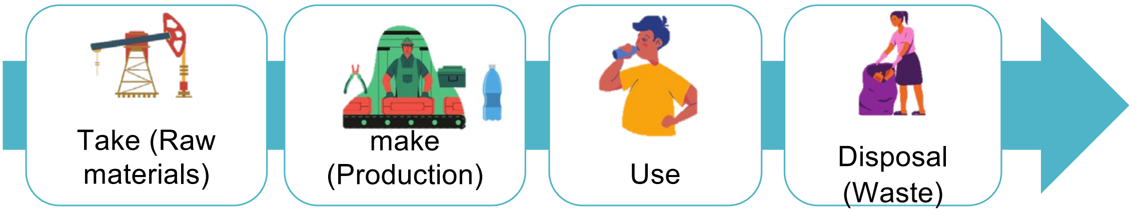

Figure 1: The linear economy model ("take-make-dispose" model). Adapted from the Ellen MacArthur Foundation (EMF, 2020b).

2016; UNEP, Truecost, & PDP, 2014; Viool, Gupta, Petten, & Schalekamp, 2019). Indirect costs are those associated with issues such as public health, the decline in the real estate value of oceanfront properties, and the loss of marine ecosystem functions caused by the loss of species and the degradation of marine ecosystems (Beaumont et al., 2019; UNEP et al., 2014; Viool et al., 2019). If the current economic model of "take-make-dispose" is maintained, these impacts are expected to increase (Boucher et al., 2019; Boucher & Friot, 2017; GESAMP, 2015).

Policy instruments can be implemented to reduce the impacts caused by plastics entering in the marine environment. The adoption and application of such instruments must be based not only on ecological criteria but also on socio-economic factors, ensuring that they not only provide environmental benefits, but are also economically sustainable over time. It is thus necessary to assess the cost and benefits related to the implementation of policy instruments. Cost-benefit analysis (CBA) is a methodology to support decision making (European Commission, 2014). It makes it possible to compare alternatives in economic terms and provide evidence on which one will provide the highest economic benefits.

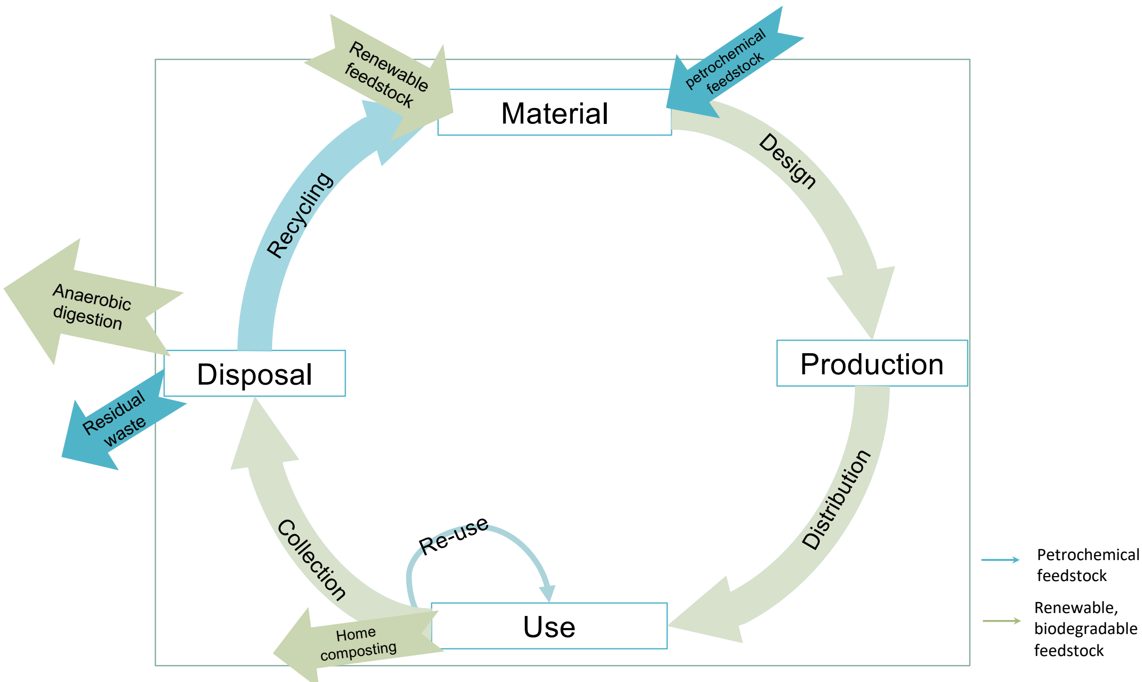

Figure 2: A Plastics circular economy model, based on work by Ellen Macarthur Foundation (EMF, 2020b). The circular economy for plastics starts from the design, ensuring that no materials are lost, no toxins are leaked and that the maximum use is achieved. All products should be designed to fit within a system whether through being reused, recycled, or composted. If applied correctly, the circular economy benefits society, the environment, and the economy.

The Plastics Circular Economy has been promoted by governments, private and public organizations, as a solution to the impacts of plastic pollution (EMF, 2020a; European Commission, 2018). Contrary to the linear economy (Figure 1) in which raw materials are taken, converted into products, used, and disposed (the take-make-dispose model), the model for plastics in the circular economy (Figure 2), promotes the reuse of plastic materials, generates value from waste and avoids sending recoverable plastic to landfills or other disposal mechanisms (PlasticsEurope, 2019).

Three actions are required to achieve the plastics in the CE presented by the Ellen MacArthur Foundation (2020b): (1) elimination of plastics that are not needed when alternatives are available; (2) innovation to ensure the reuse, recyclability and/or degradability of the necessary plastics; and (3) material circulation to maintain its value in the economy, avoiding downcycling. Therefore, the instruments promoting these strategies - separately or in combination - can be viewed as necessary for the transition to a circular economy for plastics.

The conceptual framework is presented in Figure 3. Plastics can enter the ocean as leakages at any stage of life, causing economic impacts (Ryberg, Laurent, & Hauschild, 2018). Through the implementation of circular economy strategies, it is possible to decrease the plastic waste generation and its leakage. Consequently, the economic impacts should diminish.

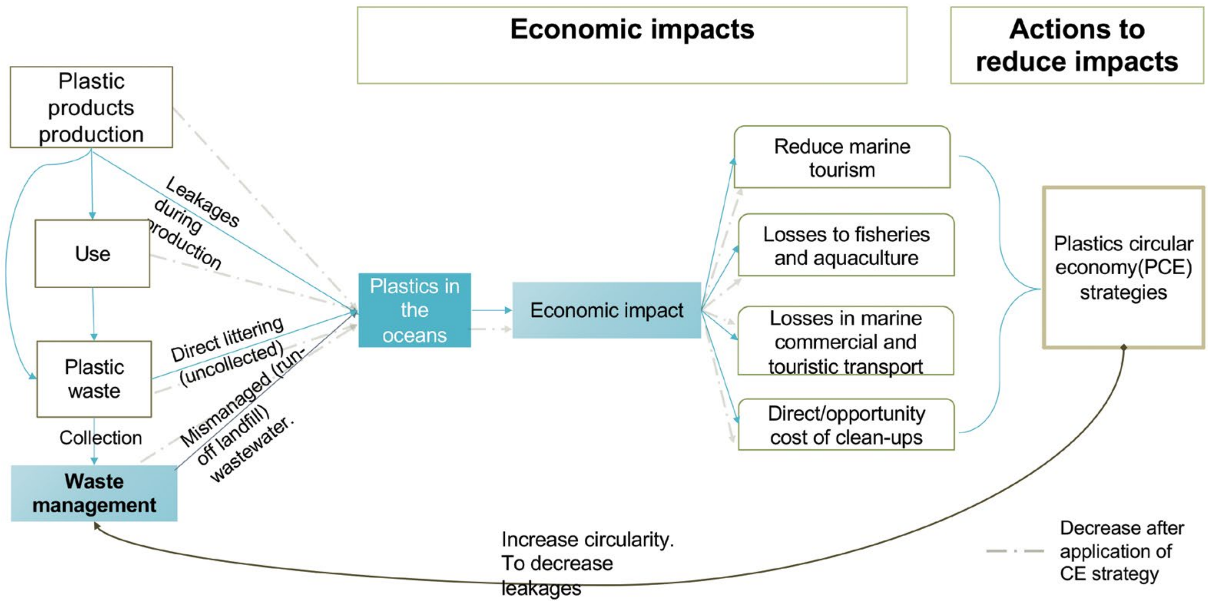

Figure 3. Conceptual framework, the role of plastic circular economy strategies to decrease economic impacts. With the implementation of plastic circular economy strategies, the circularity of plastic will increase, hence, leakages and their consequent impacts will decrease.

1.3. Case study, Menorca

Menorca is part of the Spanish archipelago of the Balearic Islands, located in the Mediterranean Sea (Figure 4). The island was declared a biosphere reserve by UNESCO in 1993. The population in 2020 was 95,641 (OBSAM, 2020). However, during the tourism peak season, the island can host more than 106,000 additional people per day. The island's economy depends mainly on tourism, responsible for more than half of the income (in 2018 the expenditure of tourists in Menorca was 1,388 million euros), followed by agriculture. (European Parliament, 2019; IBESTAT, 2021; Islasbaleares, 2020).

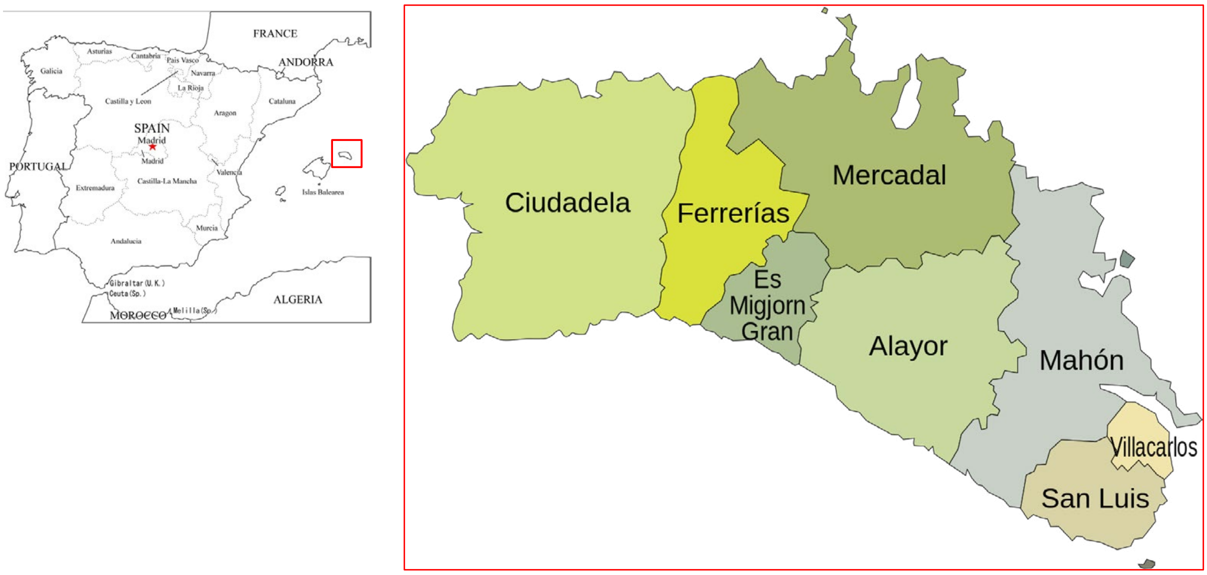

Figure 4: Menorca, Spain, location map.

Currently, the waste collection system in Menorca is based on separation at the source, with public bins in which the residents deposit the waste previously segregated at household level. These bins are identified by a colour system: yellow for light packaging (including plastics), blue for paper and cardboard, green for glass, brown for organic residues, and grey for non-recyclables or rest fraction. The plastic, metallic, cardboard, and paper materials are collected and sent to the island's waste treatment plant, where they are prepared to be dispatched to recycler companies by seaway (Ajuntament de Maó, n.d.; CREMENORCA, 2020).

The '*UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action*' methodology results show that in 2018, 10,220 tonnes of plastic waste were generated on the island. The collection rate of plastic waste was 90% (9,161 tonnes), with only 14% (1,427 tonnes) going to recycling. Ten percent (1,059 tonnes) of plastic waste is not collected through the waste management system at all (IUCN, UNEP, & Quantis-EA, 2020).

In Menorca, plastic marine litter is also present. A recent modelling study shows that in the Balearic Sea, north of Menorca, the concentration of plastic garbage reaches three kg per km^2 (Soto-Navarro et al., 2020). In addition, the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* results for Menorca demonstrate that the island leaks 78 tonnes of plastics per year into the Mediterranean Sea, with PET being the main leaked polymer; packaging and tourism are the main sectors that contribute to leakage (IUCN, UNEP, & Quantis-EA, 2020).

The governing body of the island aims to transition to sustainability with plans such as the '*Action Plan for the Biosphere Reserve of Menorca*', which identifies actions and projects aiming to strengthen and promote Menorca's commitment to sustainable development (CIME- Agencia Reserva de Biosfera Menorca & GOIB, 2019). Additionally, in June 2020, the government approved the new '*Sectoral Master Plan for the Prevention and Management of Non-hazardous Residues in Menorca 2019-2025*' (CIME, 2020a). This new plan considers infrastructure and equipment, as well as new strategies for the management of waste.

The context of Menorca – including its status as a biosphere reserve, the dependence of its economy on tourism, the results of the current plastic waste management system and the sustainability strategy adopted by the government - are reasons to continue adapting and proposing interventions. CE instruments for plastics can play an important role for Menorca, addressing impacts from the source, while supporting the transition towards sustainability (CIME, 2020c).

1.4. Description of deposit refund system (DRS)

After interaction with stakeholder and additional inputs from literature review, a deposit-refund system (DRS) on PET bottles was selected as the instrument to be assessed. This decision was based on three key reasons. First, the DRS was identified as an instrument that enhances the plastics circular economy. Second, an economic analysis of a DRS can contribute to the decision-making process, encouraging or discouraging its implementation by the local Government. Third, the principal polymer and sector hotspots identified in the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* Report for Menorca (IUCN, UNEP, & Quantis-EA, 2020) are addressed with a DRS.

A DRS is a market-based instrument, in which products packed in containers have a reimbursable extra cost (deposit); when the consumers return the containers, this extra cost is refunded (Zhou et al., 2020). This instrument encourages the return of good quality materials that can be put back into the economy through reuse - when returned to the packaging company - or through recycling in the case of single-use containers (Hogg, Fletcher, Elliott, & von Eye, 2010).

Some of the main advantages of a DRS for single-use beverage containers are: the contribution to container collection, an increased recycling rate, and therefore an enhancement of the CE for plastics (European Commission, 2018; Fletcher, Hogg, Eye, & Elliott, 2012; Patorska & Paca, 2019). The increase in social awareness - generated once the consumer becomes accustomed to returning the bottles - can in turn reduce the extent of littering behaviour (European Commission, 2018; Hogg et al., 2010). Moreover, the system has considerable public support (above 80%), with organizations all over Europe, including in Spain, asking for its mandatory implementation (Retorna, 2021; Spasova, 2019; Zero Waste Europe, 2019). Legally regulated DRSs currently operate in ten European countries[2], covering 26% of the continent's population (Patorska & Paca, 2019).

2 The countries with a legally regulated DRS in Europe are Croatia, Denmark, Estonia, Finland, Germany, Iceland, Lithuania, The Netherlands, Norway, and Sweden.

2. METHODOLOGY

This study evaluates the economic profitability of a DRS for PET bottles used for drinks, in Menorca. For this, a CBA was carried out by comparing a scenario without the instrument (the business as usual or BAU scenario) and a scenario with the DRS in place (DRS scenario).

2.1. Cost-benefit analysis (CBA)

CBA is an analytical and management tool applied to guide the implementation of policies (European Commission, 2014). In this study, the costs and benefits of the BAU scenario are compared with those of the DRS scenario, allowing to select the best option in terms of economic benefits.

The object of the CBA is to determine the economic implications of implementing a DRS for the local waste management system (i.e. the costs and benefits for the waste management system are the object of analysis). The reference year for both the BAU and DRS scenarios is 2018.

The first step to analyse the costs and benefits of the BAU and DRS scenarios is to estimate the flow of PET bottles in each of the scenarios. For the BAU scenario, this is done based on the results from the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* Report for Menorca (IUCN, UNEP, & Quantis-EA, 2020), stakeholder interactions, and a literature review to obtain additional data or estimates when direct data are not available. The flow of PET bottles in the DRS scenario also consider data on the application of this instrument, specifically from Europe.

Secondly, the costs, benefits, and net benefit of both scenarios are estimated and then compared. To do so, the benefits and costs are identified (Table 1).

Thirdly, all the benefits, as well as all the costs, are added to obtain the total benefits and costs, respectively. Then, the net benefit is calculated (Equation 1).

$$\text{Net benefit} = \sum \text{benefits} - \sum \text{costs} \qquad (1)$$

A sensitivity test is carried out to identify how the results of the DRS scenario vary when some of the input variables are changed. In this study, this evaluation is performed by modifying the value of particular key assumptions while the other variables remain the same, and then recalculating the costs and benefits with changed variables (European Commission, 2017). The variables modified are: (i) the return rate of bottles to the system from 0% to 100%, and (ii) the volume of the bottles that will enter in the DRS (considering bottles of 500 ml instead of the 1 l previously considered).

Table 1. List of costs and benefits identified for the Business as Usual (BAU) and Deposit Return Scheme (DRS) scenario

	BAU scenario		DRS scenario	
	Phase	**Description**	**Phase**	**Description**
COSTS	Marketing	Not applicable	Marketing	Cost of Extra labelling
	Extra management	Not applicable	Extra management	Cost of Administration
	Operation BAU system	Not applicable	Operation DRS	Cost of reverse vending machine (RVM)
		Not applicable		Cost managing the RVMs by retailer
		Not applicable		Cost per space occupied by the RVMs
		Cost of collection and transport		New cost of transport, collection
		Cost of sorting and conditioning		New cost of conditioning
		Cost of tonnes landfilled		New cost Landfill
BENEFITS	Collection	Not applicable	Collection	Revenue from unclaimed deposit
	Export	Revenue from PET bottles exported	Export	New revenue from tonnes PET exported

3. RESULTS

3.1. The proposed DRS for Menorca.

The proposed DRS for Menorca is presented in Figure 6. This is based on the design of other DRSs operating in Europe[3], and is adapted to the context of the island, considering the operation of the local waste management system, the number of retailers and the fact that there are no bottling companies or producers of PET bottles located in Menorca.

The DRS will be applied to all PET drinking bottles commercialized (sold) on the island, excluding dairy and including containers for juices, water and sodas. The system proposed is automated, utilizing reverse vending machines (RVMs), as the stakeholders[4] identified by Rezero (2020)[5] in Menorca expressed that, according to them, the best option is utilizing the RVM instead of manual collection. RVMs will be installed in hyper- and supermarkets. In Menorca, there are four hypermarkets and 56 supermarkets (CIME, 2018). Following the DRS proposed for Spain, this study considers that 50% of the supermarkets will have one machine, while all four hypermarkets will have three

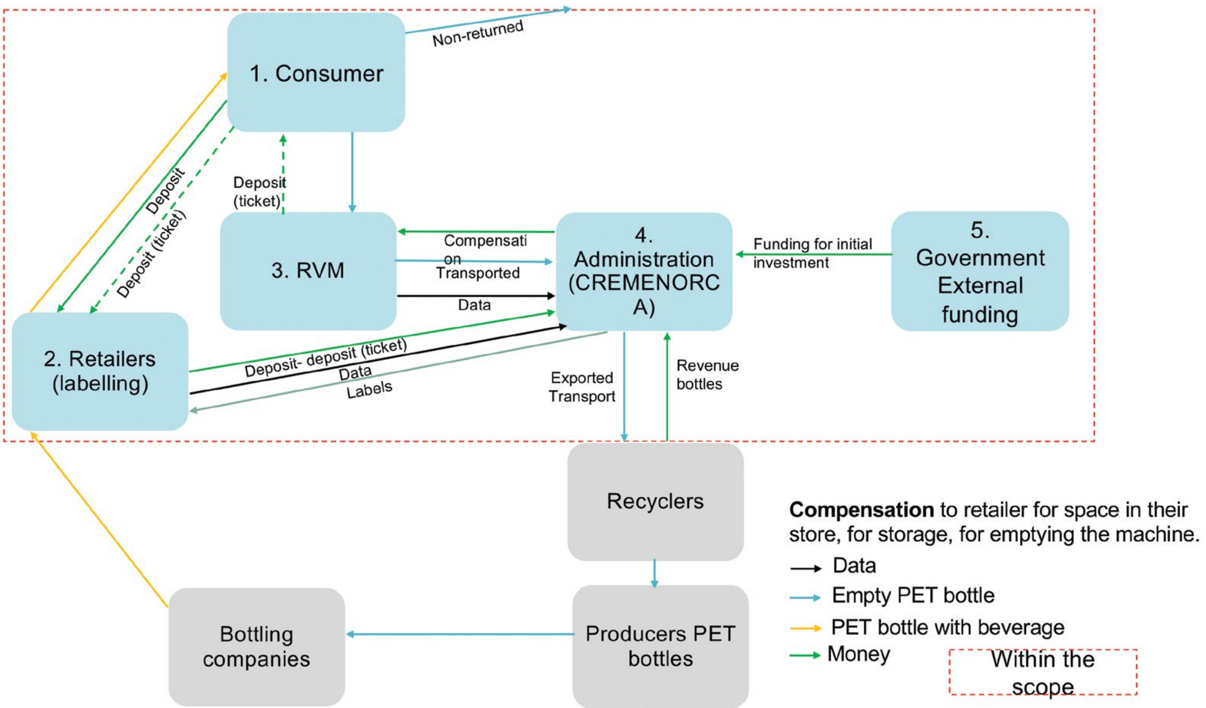

Figure 6. DRS proposed for Menorca.

3 The design of the DRSs in the 10 European countries and their performance is presented in a recent report by Reloop (2020).

4 CREMENORCA, OBSAM, environmental organizations, the city council of the eight municipalities, the Department of Environment and biosphere reserve of Menorca, and the organization for small and medium enterprises (PIME).

5 A plan for the implementation of a return system for beverage containers including cans and plastic bottles, proposed by Rezero (2020).

each (Fletcher et al., 2012). Hence, a total of 40 machines are needed.[6]

Based on the DRS proposed for Spain, a deposit of EUR 0.2 is considered for the baseline DRS scenario (Fletcher et al., 2012). The size of this deposit is also close to the average deposits used in DRSs across Europe, EUR 0.17.[7] One main factor affecting the DRS's results is the amount of deposit selected for the bottles (Fletcher et al., 2012; Hogg et al., 2010). Thus, the return rate is predicted based on the deposit amount by performing a regression analysis. Based on the results, a return rate of 91.5% would be obtained with a deposit of EUR 0.2.

This study assumes that all retailers that commercialize beverages in PET bottles will be registered in the system, and that all PET bottles are of 1 l. This is based on figures from Coca-Cola, which show that from the total of PET bottles that the company puts in the European market, 79% are bottles with volume equal or greater than 1 l (CCEP, 2019).[8]

There are **five principal actors involved in the DRS**, namely: (1) consumers; (2) all retailers on the island; (3) the retailers where RVMs are located; (4) the administration of the DRS, which is the consortium of waste and energy of Menorca (CREMENORCA); and (5) the local government or, in a broader sense, other (external) funding sources.

Since the DRS is designed to cover only the bottles commercialized in Menorca, a labelling system should be implemented on the island to identify the bottles that are part of the system. The label should be printed by the administration, actor (4), and supplied to the retailers, actor (2), upon request. This label could also contain the name of the retailer for further traceability. Retailers would put the adhesive label on the PET bottles in their store.

(1) *Consumers*: They can purchase a beverage in any retail store on the island, giving the deposit to the retailer. Once the consumers return the bottle in one of the RVMs, they obtain a ticket with the deposit on it. This ticket can then be used to buy any product in any grocery store in Menorca.

(2) *All retailers*: Consumers can use the ticket obtained from the RVM to buy products in any grocery store. Given this, retailers must report the data related to the amount of the deposit received when selling bottles, and the deposit (tickets) that they take as payment. The retailer will hand over to the administration the money corresponding to the deposits that are not claimed when the consumers do not return the bottles.

(3) *Retailers in which RVMs are placed*: The machine receives, compacts, and stores the PET bottles. The RVM also prints out the ticket with the amount of deposit on it. Once the RVM's capacity is reached, the retailer will empty it and store the PET bottles before they are collected by the DRS administration.

(4) *The DRS administration*: The administration manages all the data in the system, claims the deposits from the retailers and supplies the labels upon request. It oversees: the operation and maintenance of the RVMs, the collection and transport of the bottles, the preparation (further compaction), and temporal storing of bottles in the waste treatment plant. It also administers the money flows and transferring revenues to cover costs; for example, to retailers where an RVM is placed, compensating them for the place occupied by the RVM and the act of emptying the machine.

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6 This distribution also considers the Menorca results from the UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action Report (IUCN, UNEP, & Quantis-EA, 2020): most of the RVMs will be placed in Mahon and Ciutadella, with 15 and 13 RVMs, respectively. These are hotspots for plastic waste generation. Mahon is the highest contributor to leakages. Alaior and Es Castell are also covered, with two and three RVMs respectively; these are both hotspots for leakage and Alaior has the second lowest collection rate. Ferreires is the municipality with the lowest collection rate; two RVMs are located there. The rest of the RVMs are distributed along the rest of the island considering only the number of supermarkets.

7 The deposit of the DRSs in the 10 European countries are presented in a recent report by Reloop (2020).

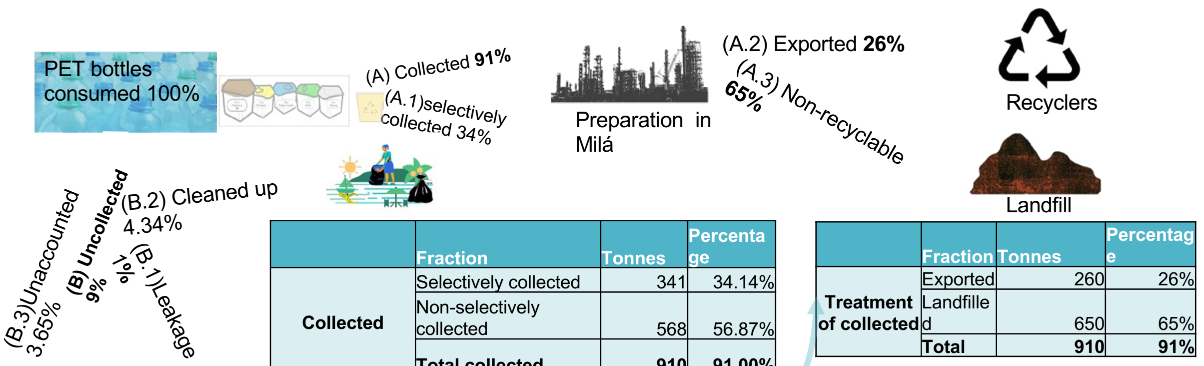
8 This is confirmed by the estimation of total PET bottles collected in Menorca, since the total weight for those materials was 909.6 tonnes and the total amount of units was 22.46 million (Rezero, 2020). Thus, the weight of a single unit would be 0.040kg. This weight coincides with the figure that one tonne of PET bottles is equal to 25,000 units of 1 l (Treevolution, 2018).

(5) ***Local government and/or additional external financing*****:** They provide capital for the initial investment (that is, the acquisition of RVMs and other equipment, such as a label printer). During communication with stakeholders, it was mentioned that capital resources from the "sustainable tourism tax" could potentially be used for DRS testing. This type of government funding could be considered to cover the costs of implementing the DRS. Additionally, potential external financing obtained can also be considered. This could include, for example, financing from conservation organizations such as the Menorca Preservation Fund (MPF), which aims to support local environmental initiatives by raising funds (MEP, 2021).

3.2. Flow of PET bottles in the BAU and in the DRS scenario

The flow of PET bottles in the BAU scenario is shown in Figure 7. There are two main fractions in the PET bottles flow: Fraction A, which is collected in the waste management system, and Fraction B, which is not collected. Part of fraction A is selectively collected in the yellow bins (A.1). After preparation in the waste treatment plant, part of this is send to recyclers (A.2) and another is landfilled (A.3). For fraction B, one part enters the oceans as leakages (B.1), another share is cleaned up from beaches (B.2), and another is not accounted for (B.3)

A report by Rezero (2020) shows that in Menorca 341 tonnes of PET bottles were found in the yellow bins (fraction A.1)[9], and 568 tonnes of PET bottles were found in the grey bins for non-recyclable materials. This accounts for a total of around 910 tonnes. This number is exclusively the collected fraction (fraction A). According to the results from the *UNEP/IUCN National*



	Fraction	Tonnes	Percentage
Collected	Selectively collected	341	34.14%
	Non-selectively collected	568	56.87%
	Total collected	**910**	**91.00%**
Uncollected	Leakage	10	1.00%
	Cleaned up	43	4.34%
	Unaccounted*	36	3.65%
	Total uncollected	**90**	**9.00%**
TOTAL CONSUMED		**999.5**	**100%**

	Fraction	Tonnes	Percentage
Treatment of collected	Exported	260	26%
	Landfilled	650	65%
	Total	**910**	**91%**

*Considered to remain in households, being taken out of the island or enter other environments, no oceans

Figure 7. Flow of PET bottles in the BAU scenario. Original elaboration, based on IUCN, UNEP & Quantis-EA (2020), REZERO (2020), Vlachogianni (2019) and OBSAM (2020)

9 Not all the fraction in the yellow bins (fraction A.1) is send to recyclers. After preparation in Milá, the waste management plant, part of the plastic (81 tonnes) is landfilled because it does not fulfil the conditions to be recycled.

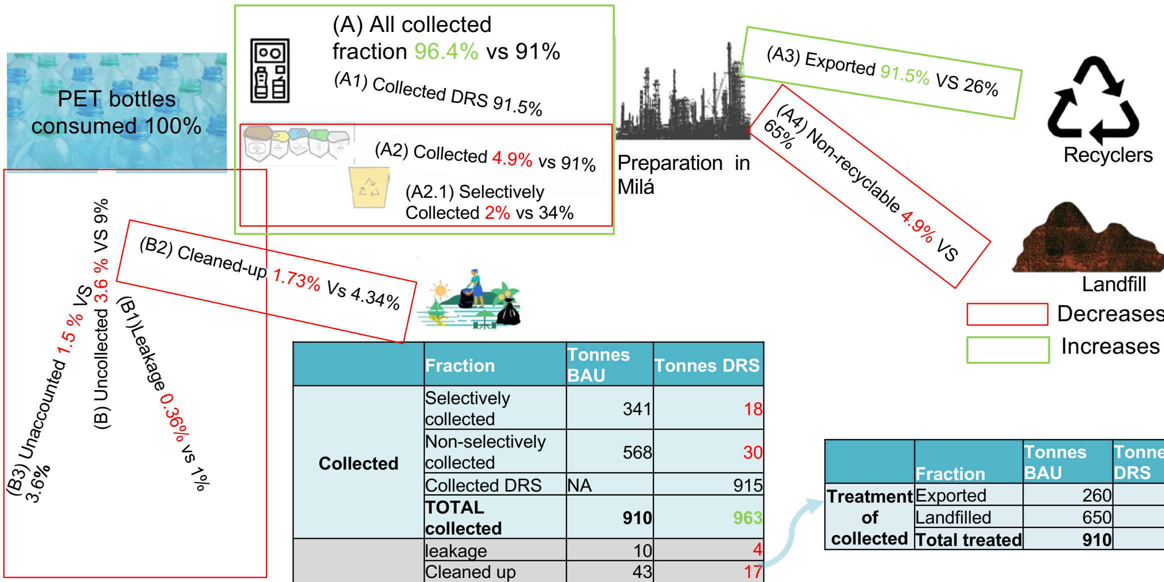
Guidance for Plastic Pollution Hotspotting and Shaping Action Report for Menorca, 91% of the total PET is collected - 26% of which is exported to be recycled (fraction A.2), and 65% is landfilled (fraction A.3). The remaining 9% is not collected through the waste management system (fraction B) (IUCN, UNEP, & Quantis-EA, 2020). Thus, an estimated total of 999.5 tonnes of PET bottles are consumed. This translates to 24,987,500 units of 1 l bottles.[10]

The 9% of bottles, which are not collected through the waste management system (fraction B) corresponds to 90 tonnes. Based on the results from the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* Report for Menorca, 10 tonnes of this (fraction B.1) end up as leakages, entering the marine environment (IUCN, UNEP, & Quantis-EA, 2020).

This study estimates the total number of PET bottles collected during beach clean-ups (fraction B.2) in 2018 as follows. During the clean-ups in Menorca, 617 tonnes of all types of waste was collected (OBSAM, 2020). A survey of marine litter on the Mediterranean islands found that 82% of total waste is plastics (Vlachogianni, 2019). Thus, 506 tonnes of the total waste cleaned-up from beaches in Menorca are plastics. Considering uncollected PET bottles (90 tonnes) and the total of all types of uncollected plastics (1,059 tonnes), 8.5% of uncollected plastic waste corresponds to PET bottles. Therefore, of the total tonnes of plastic cleaned from the beaches in Menorca, 43 tonnes are PET bottles (8.5% of 506 tonnes).

Finally, 36 tonnes are unaccounted for (fraction B.3), either because the bottles are kept in homes (remain in use or are being stored), have been removed from the island, or have ended up in the terrestrial environment, and not on beaches or in the sea.

The expected change in the flow of PET bottles for the DRS scenario compared with the BAU flow is presented in Figure 8. As presented previously, this baseline DRS scenario is based on a deposit of EUR 0.2 and a return rate of 91.5%.



	Fraction	Tonnes BAU	Tonnes DRS
Collected	Selectively collected	341	18
	Non-selectively collected	568	30
	Collected DRS	NA	915
	TOTAL collected	**910**	**963**
Uncollected	leakage	10	4
	Cleaned up	43	17
	Unaccounted	36	15
	Total Uncollected	**90**	**36**
TOTAL CONSUMED		**999.5**	**999.5**

	Fraction	Tonnes BAU	Tonnes DRS
Treatment of collected	Exported	260	915
	Landfilled	650	49
	Total treated	**910**	**963**

Figure 8. Expected flow of PET bottles after implementation of DRS in Menorca, Spain, with a deposit of EUR 0.2.

10 Considering bottles of 1 l with a weight of 0.04 kg, or the figure that 1 tonne of PET bottles is equal to 25,000 of 1 l units (Treevolution, 2018)

The collected fraction (A) will increase due to the fraction that is collected in the DRS (A.1). The fraction collected in the current waste management system (A.2) will decrease as well as what is collected in the yellow bins (A.2.1). The fraction exported to recyclers (A.3) is expected to increase, while the fraction landfilled (A.4) should decrease. The uncollected fraction (B) will decrease; and hence the leaked (B.1), cleaned up (B.2), and the bottles unaccounted for (B.3) will diminish as well.

The total collected fraction of plastic bottles (fraction A) will be 96.4%. This considers the collection rate in the DRS (91.5%) (fraction A.1) and the fraction that will be collected in the regular system (4.9%)[11] (fraction A.2). The bottles found in the yellow bins (fraction A.2.1) will be 2%.[12] From the total collected, the fraction exported to the recyclers (fraction A.3) is expected to be equal to what is collected through DRS.[13] The remaining fraction (4.9%) will go to landfill (fraction A.4). The uncollected (fraction B) will be 3.6%, representing a decrease of 60%. This is based on several studies conducted in different cities and states in Australia and in the Unites States.[14] The reduction in leaked bottles (fraction B.1), those cleaned-up via beach clean-ups (fraction B.2) and those unaccounted for (fraction B.3) are equal to the decrease in the uncollected fraction (60%).

3.3. Costs, benefits, and net benefits of the BAU and DRS scenario.

The costs, benefits, and net benefit of the BAU scenario are compared to the costs and benefits of the DRS scenario. The results are shown in Figure 9.

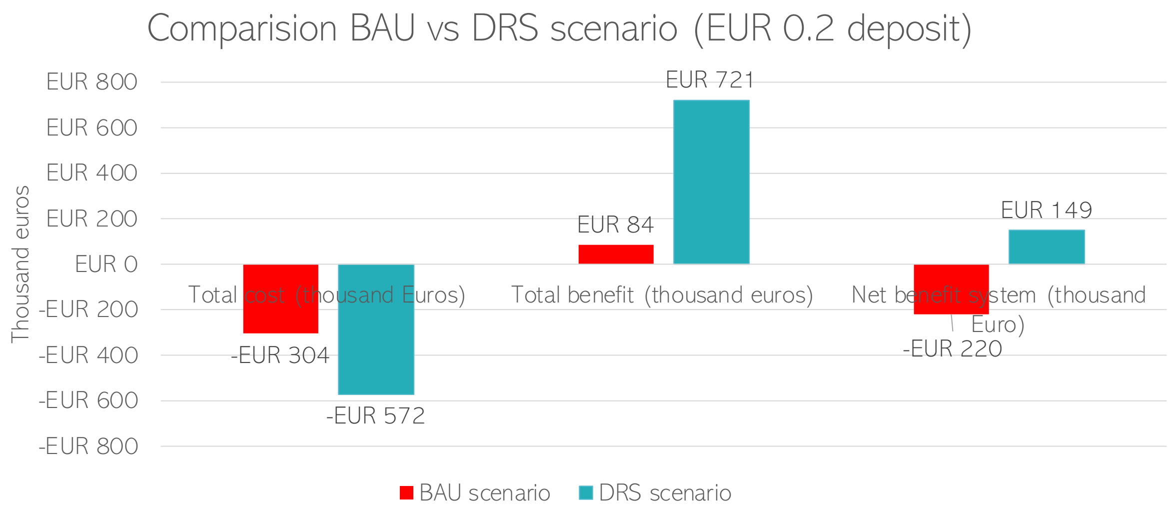


Figure 9. Comparison of cost, benefit, and net benefit of BAU and DRS scenario (with a deposit of EUR 0.2 and return rate of 91.5%).

11 Confirmed by the DRS in The Netherlands, in which 5% of the bottles that are not collected in the DRS are assumed to be collected by the normal system (Spasova, 2019)

12 Estimated based on data for the BAU scenario. In the BAU scenario, 91% of PET bottles are collected through the regular system; from this, 37.5% is selectively collected. Hence, in the DRS scenario, 2% of PET bottles (32.5% of 4.9%) will be found in the yellow bins.

13 Based on data from DRSs in Europe. In Croatia, Iceland, Lithuania, Netherlands and Norway, it was reported that 100% of the PET bottles collected in the DRS are sent to recyclers (Croatian Environment and Nature Agency, 2016; Flöskumóttaka, 2021; Infinitum, 2019; Schneider, Karigl, Reisinger, Oliva, & Süßenbacher, 2011; Spasova, 2019; USAD, 2018)

14 Average results on the reduction in container litter after the implementation of the DRSs in U.S (Maine, Michigan, Oregon, Iowa and New York) and in Australia (New South Wales, Queensland and the Northern Territory) (COEX, 2020; DEC, 2020; Iowa the Policy Project, 1980; NSW EPA, 2018; U.S. GAO, 1990; Waste, Angel, Kelman, & Lazarro, 2013).

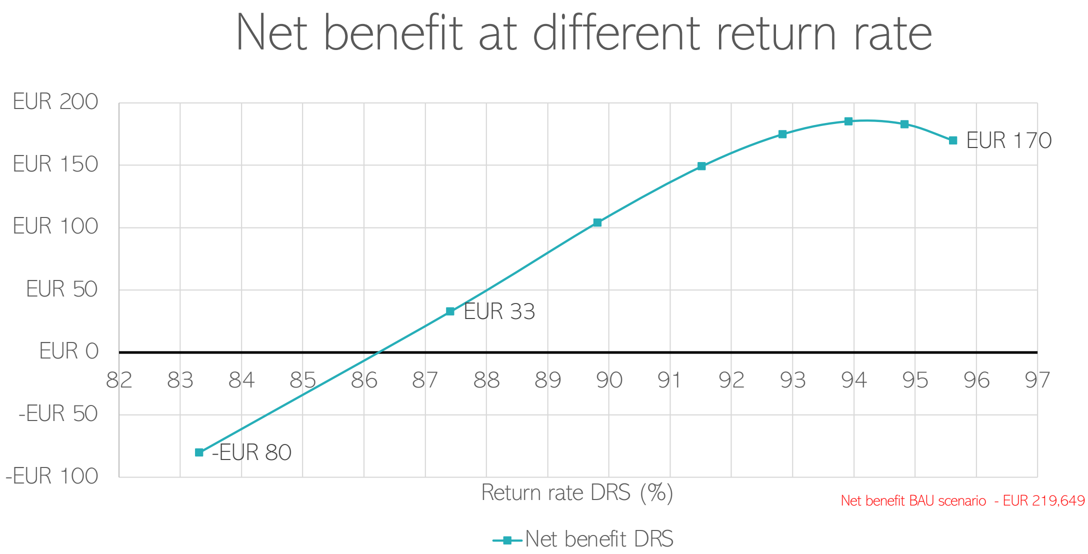


Figure 10. Variation in net benefit at different return rate, varying the deposit from EUR 0.05, and incrementing by EUR 0.05 until it reaches EUR 0.4

The costs, benefits as well as the net benefits are higher for the DRS scenario as compared to the BAU scenario. Despite the costs being 1.88 times higher for the DRS scenario, the total benefits are 8.54 times higher than in the BAU scenario. Furthermore, unlike the BAU scenario, which costs Menorca's government around EUR 220,000 annually, the DRS, if implemented, should generate a profit.

As a next step in this study, the deposit amount was varied from EUR 0.05 to EUR 0.4 to analyse how changes in the deposit rate affect the results of the CBA. The graph of variation of net benefit is presented in Figure 10. In the graph, the BAU scenario is also presented as a specific point, for comparison.

The net benefit increases when the deposit amount and the return rate increase. However, at a deposit of EUR 0.3 and a return rate of 94% there is an inflection point, where net benefits reach a peak and start to decrease. This is caused by the fact that the total benefits of the system depend mainly on the benefit of unclaimed deposit, as shown in Figure 11. When the benefits from unclaimed deposit decrease, the total benefit generated by the system decreases. When increasing the deposit and hence the return rate, the revenue for unclaimed deposits increases due to the higher

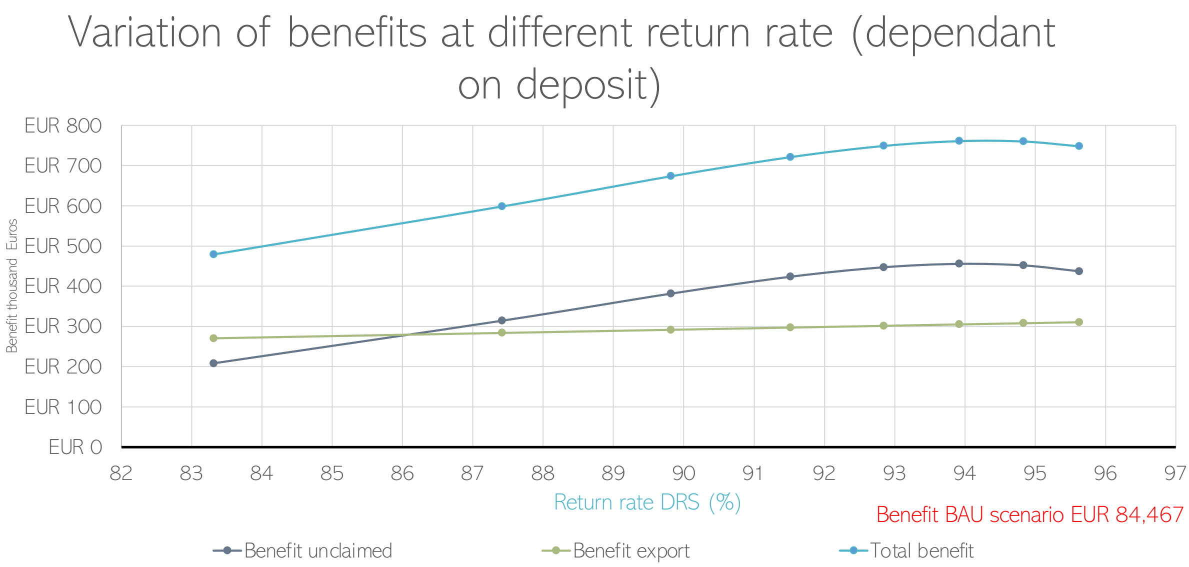


Figure 11. Total benefits and benefits from unclaimed deposit and for exporting PET bottles

deposit amounts, even if the quantity of bottles that are not returned is decreasing (collection rate increasing). However, in the case with a deposit of EUR 0.35 or larger, the number of bottles not being returned (and thus the deposits that are unclaimed) is too small. At this point, the revenue starts to decrease. Figure 10 also shows that the net benefit reaches the break-even point at a return rate of around 86%.

These results show that if the objective is to a self-sufficient system, a return rate higher than 86% is needed; and the deposit of EUR 0.2 falls within the suitable range for a DRS in Menorca. However, maximum profit with a higher return rate is achieved with a deposit amount of EUR 0.3. Even higher deposits would increase return rates more, but with lower net benefits.

3.3.1. Sensitivity analysis

Two sensitivity analysis are carried out with the baseline DRS scenario, using EUR 0.2 as the deposit. Two assumptions are tested by modifying the scenario: (1) the return rate is independent of the deposit amount, and (2) the bottles in the system are 500 ml instead of 1 l, as used previously.

Since it is assumed that the return rate depends on the deposit amount, it is important to estimate how the cost and benefits of the system will vary when that is not the case. For this, the deposit amount is fixed at EUR 0.2, and the return rate is varied starting from 0% to 100%. These results are presented in Figure 12.

Costs increase with a higher rate of return, while benefits and net benefits decrease. At a fixed deposit amount, if the rate of return increases, fewer unclaimed deposits enter the system. This decreases the benefits from this flow, and the net benefits as a result. This illustrates once again the system's financial dependence on not recovering all plastic bottles (to keep the benefits from the unclaimed deposits). In addition, it shows that the financial benefits generated by the export of PET bottles are almost insignificant. Even at a 100% return rate - and considering that all the bottles are sold to recyclers - the benefits of this sale are EUR 324,837, less than the costs generated at this return rate (EUR 591,387). Figure 12 also illustrates that the system is expected to be profitable at any rate of return between 0% and 94%. Therefore, to maintain the DRS scenario with a EUR 0.2 deposit as financially self-sufficient at the current price for plastic bottles to be recycled, the return rate should be less than about 94%. This contradicts the ideal of a circular economy for plastics that aims for 100% collection to increase the circulation of PET bottles and prevent their leakage into the environment.

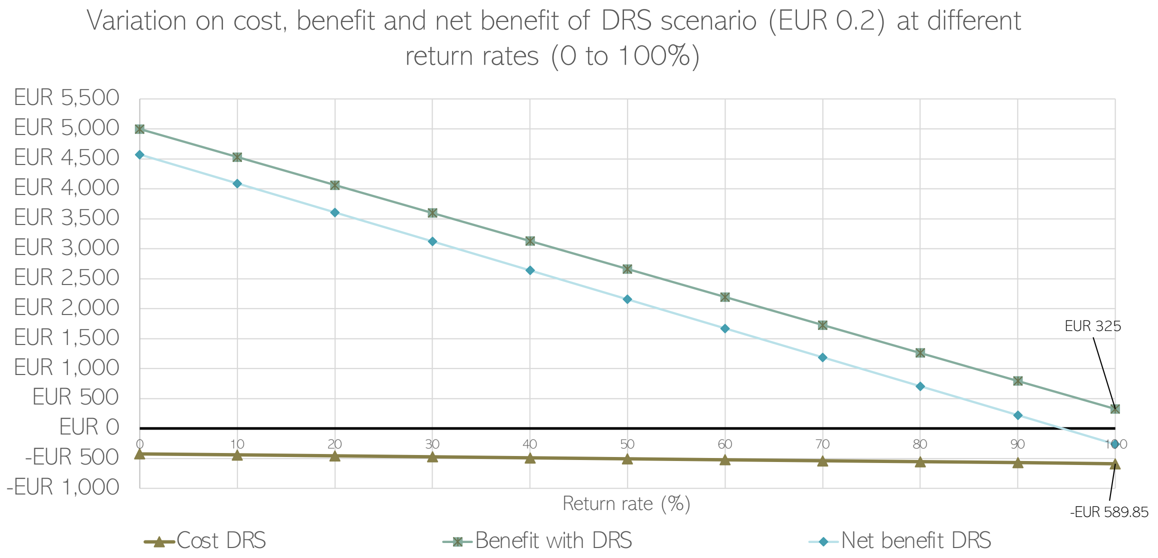


Figure 12. Changes in costs, benefits, and net benefit, variating the return rate, with a fixed deposit of EUR 0.2

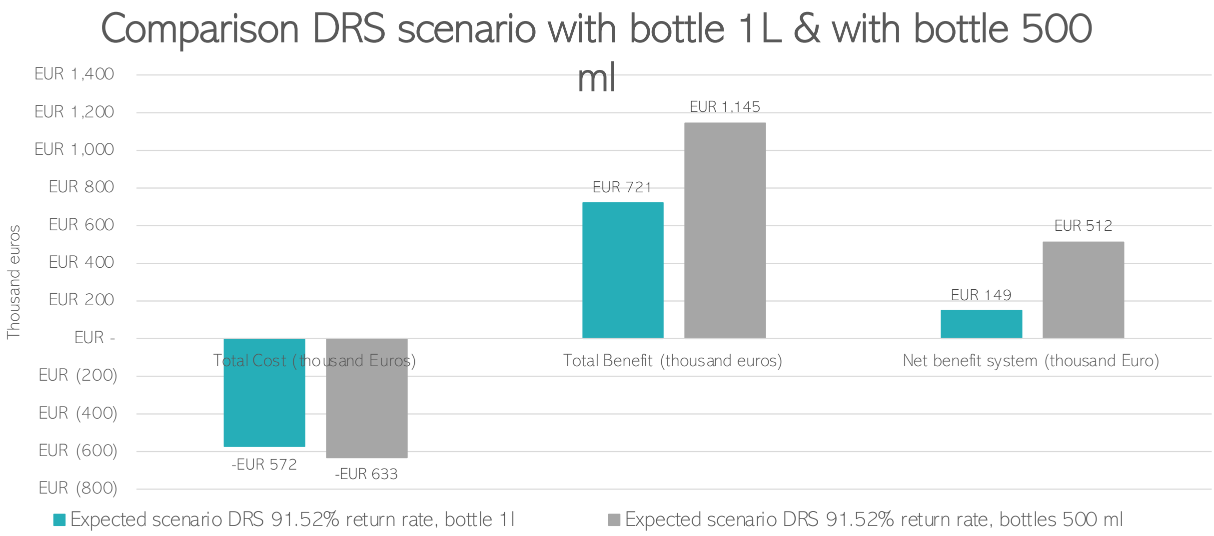


Figure 13. Comparison of costs, benefits, and net benefit of the DRS scenario (with a deposit of EUR 0.2) for bottles of 1 l vs bottles of 500ml.

Redoing the analysis, but using for the model a standard bottle size of 500ml, with a weight of 0.02 kg per unit, the costs, benefits and net benefits are determined and compared with the scenario in which a bottle of 1 l is considered (Treevolution, 2018). The results are shown in Figure 13.

The costs, benefits and net benefits are higher when considering bottles of 500 ml than compared to a scenario with only 1 l bottles. The costs are 1.1 times higher, an increment due to the rise in the labelling cost (increasing from EUR 61,173 to EUR 122,244). This is the only cost that increases since the others are determined by the tonnage of PET bottles and not by the number of units. As for the benefits, these are 1.59 times higher, caused by the increment in the revenue for unclaimed deposits, determined by units of bottles (increasing from EUR 423,754 to EUR 847,508). Finally, the net benefit is 3.43 times higher in the scenario with bottles of 500ml. These results are due to the fact that the same deposit (0.2 EUR) is applied to all bottles, and bottles of lower volume (and lower weight) input more units per tonne into the system.

Changing the deposit from EUR 0.05 to EUR 0.4 for the plastic bottles results in the following costs, benefits, and net benefit. For the net

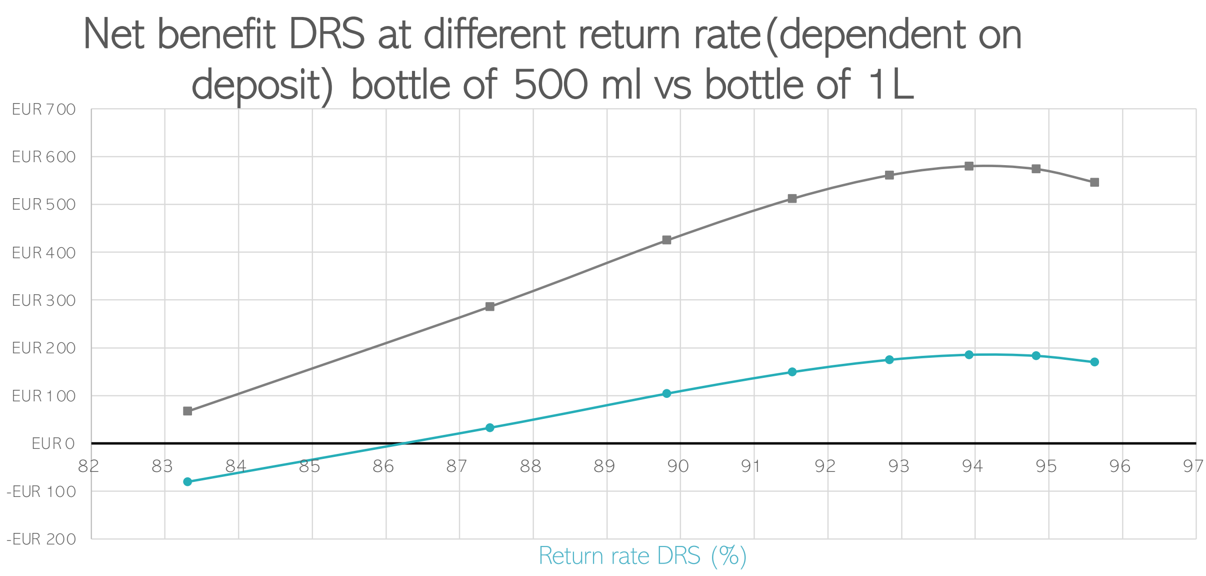


Figure 14. Comparison of net benefit at different return rates (varying deposit amount from EUR 0.05 to 0.4), considering bottles of 500 ml vs bottles of 1 l.

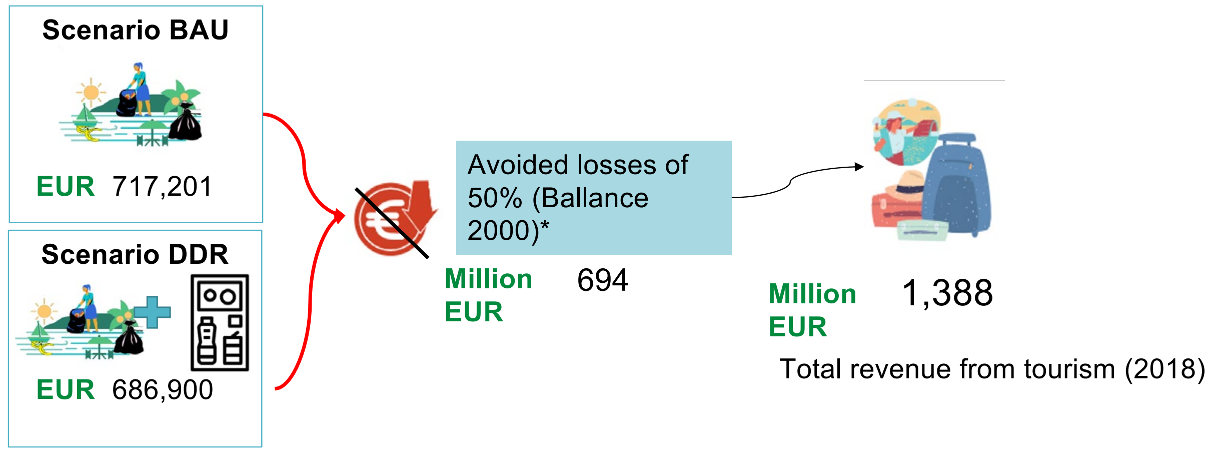
benefit, even with a deposit lower than EUR 0.05 (return rate of 83%), the scenario with a bottle of 500 ml is profitable, while the scenario with a bottle of 1 l reaches the break-even point at a deposit higher than EUR 0.1 (return rate higher than 86%) (Figure 14). The inflection point is the same in both cases. However, the DRS considering 500 ml bottles remains profitable at a higher return rate compared to the DRS that considers 1 l bottles. In practice, bottles of different volumes, including the ones of 500ml, will enter the system.

3.4. Inclusion of beach clean-up costs and benefits for tourism

The yearly cost for beach clean-ups in Menorca is EUR 717,201 (CIME, 2015). As shown in the flow of PET bottles in the BAU scenario, an estimated 43 tonnes of PET bottles are cleaned-up from beaches in Menorca. This is 7% of the total tonnage of litter cleaned-up in 2018 (617 tonnes). Assuming that the cost of the clean-up contract is based on the weight of waste collected, the cost for exclusively cleaning up PET bottles is 7% of the total cost of the contract, EUR 50,501. When implementing the DRS, the fraction of bottles that are expected to end up on beaches is estimated to decrease by 60%. Hence, the cost related to clean-up the PET bottles will decrease by 60 %, saving EUR 30,301. Thus, the new cost of the yearly beach-clean up contract is EUR 686,900.

The benefits of beaches without litter are estimated looking at the economic importance of the tourism sector. Following the UNEP/MAP (2015) study on marine litter in the Mediterranean, the estimated percentage of tourism revenue that would be lost if plastic litter remained on the beaches is based on a study performed in Cape Peninsula by Ballance et al. (2000). According to Ballance et al. (2000), clean-ups are considered to avoid a 50% drop in number of tourists. It is assumed that tourism revenue will decrease in the same proportion as the reduction in the number of tourists. Considering that tourists expended EUR 1,388 million in Menorca in 2018, the total avoided losses are estimated to be EUR 694 million.
In the BAU scenario, these avoided losses are based exclusively on beach clean-ups, which cost EUR 717,201. With the inclusion of the DRS, fewer bottles will have to be cleaned-up from beaches. The potential cost for the tourism industry is thus avoided at a lower investment in clean-ups (EUR 689,900), as shown in Figure 15.

Figure 15. Overflowing trash bin, Menorca, Spain. Photo by Marta Perez Lopez, Coordinator of Plastic Free Menorca www.plasticfreemenorca.org



*Cited in a marine litter assessment in the Mediterranean (UNEP-MAP 2015)
In south Korea the loss in revenue was equivalent to 79-100% of (Jang et al. 2014)

Figure 16. *Estimation of cost on tourism. Original elaboration, based on* Ballance et al.(2000) *and data from beach clean-ups* (OBSAM, 2020).

The cost of clean-ups is added to the cost of the BAU and DRS scenario, EUR 717,201 and EUR 686,900, respectively. Additionally, the benefit i.e., the avoided cost on tourism (Million EUR 694) caused by the clean-ups or by a combination of clean-ups and the DRS, is added to the total benefits. Hence, the net benefit of the BAU and DRS scenario will vary, as shown in Table 2.

The increase in the costs is higher for the BAU scenario than for the DRS scenario; consequently, the net benefits are greater for the DRS scenario. The results show the benefit of implementing a DRS to save on beach clean-up costs in Menorca.

Table 2. Variation in cost, benefit and net benefit when including avoided cost on tourism.

Potential avoided cost on tourism (50% of revenue)	EUR 694,150,000			
	Cost clean-ups (thousand euros)	**Cost** (thousand euros)	**Benefit** (thousand euros)	**Net benefit** (thousand euros)
BAU scenario		304	84	-220
DRS scenario		572	721	149
BAU scenario + clean-ups and externalities	717	1,021	694,234	693,213
DRS scenario + clean-ups and externalities	687	1,259	694,871	693,612

4. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The results show the benefits of implementing a DRS as compared to the current collection system. The flow of PET bottles is estimated to change. First, the fraction collected increases, the fraction sent to recyclers grows and the fraction landfilled diminishes. Thus, the value of the plastic bottles remains in the economy, complying with one factor of "The new plastics economy vision", the circulation of all plastic items (EMF, 2020b, 2020a). Second, the uncollected fraction is reduced; and, therefore, the amount that ends up entering the oceans or beaches decreases. Furthermore, the implementation of a DRS addresses the main polymer and sector hotspots identified in the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* analysis for Menorca (IUCN, UNEP, & Quantis-EA, 2020).

Based on DRS studies, it is assumed that the return rate depends entirely on the deposit amount (Fletcher et al., 2012; Hogg et al., 2010). However, factors such as the population's behaviour (related to environmental awareness and waste separation habits), and the number of returning points (places where the consumer can return the container), can also influence the return rate (Hogg et al., 2010). A survey performed in Spain showed that 90% of the population is in favour of implementing a DRS (Retorna & CECU, 2012).

Under normal extended producer responsibility (EPR) conditions, the producers are the actors in charge of labelling the bottles to recognize them as part of the system. However, this study evaluates a labelling system implemented by the DRS administration and by the retailers solely in Menorca. This means that the original producers are not considered to be involved in this task.

The proposed DRS relies heavily on retailers. Firstly, they oversee the placing of the adhesive labels in the bottles. Secondly, retailers are responsible for transferring the data of the system and the money corresponding to the unclaimed deposit to the administration. In case these tasks are not performed reliably and correctly, the system will not work as expected. Therefore, it is necessary to closely control this step in the DRS process. Given this, it could be suggested to make the registration to the system mandatory for all retailers, and that the name of the store (where the bottle is purchased) be presented on the bottle label.

The CBA results show that the DRS is feasible and could be economically self-sufficient when considering a deposit of EUR 0.2. Despite the higher implementation costs of the DRS scenario, it is profitable. This is contrary to the BAU scenario, which generates a cost for the island's government. However, by varying the deposit amount, this study finds that the optimal deposit, at which the net benefit is at the maximum, is EUR 0.3; it also provides a higher return rate (94% instead of 91.5%). Nevertheless, this study uses a deposit of EUR 0.2 as the baseline DRS scenario given that this is the one proposed in the DRS for Spain; it is also closer to the average deposit in other European DRS's.

The sensitivity analysis conducted in this study shows that the DRS is not economically self-sufficient at a return rate of 100%, which is the ideal outcome for a CE. This shows the financial dependence of the DRS on the unclaimed deposits. The benefits obtained through the sale of PET, post-consumer bottles are rather small in comparison with the benefits obtained from unclaimed deposits. If the system's administrator would decide to stop exporting the PET bottles to the recycler, the system's net benefits would not be highly affected. This is a consequence of the prices of PET-post consumer bottles. According to ICIS et al. (2019), the price of post-consumer, mixed, coloured PET bottles in Europe has varied between EUR 200 to 380 per tonne from 2017 to 2019. Nevertheless, in a plastics circular economy, recycling must be encouraged. Therefore, the financing mechanism could be adjusted. For example, the EPR principle could be applied, making producers pay a certain amount for each bottle that is put on the market. Fletcher et al. (2012) suggests an administration fee of EUR 0.013 per container, in the DRS's for Spain. In this case, the costs of the system, with a deposit of EUR 0.2, will be completely covered at any return rate and not only at a return rate lower than 94%.

Given that the most important source of revenue for the DRS are the unclaimed deposits, the system must be carefully designed, and targets for the collection should be put in place. Thus, the goal will be to reach a high return rate (aiming for the ideal 100%) and not the highest profit. In case the system is designed to obtain profit (by lowering the return rate), the flow of PET bottles in the BAU scenario will remain. Thus, the linear economy model is maintained, neglecting the main objective of the policy, which is to increase the plastics CE, increase collection and recycling, and decrease plastic leakage.

The sensitivity analysis also reveals that with smaller volume bottles (500 ml instead of 1 l), the DRS has a greater potential for profitability at higher return rates. This is because the same deposit amount is applied to both types of bottles. Considering that in practice bottles of different volumes will enter the system, it is expected that the net benefits will vary: increasing with smaller-sized bottles and decreasing with larger ones. If different deposit amounts are applied based on the size of the bottle (i.e. the bigger the bottle, the greater the deposit), the net benefits can remain the same regardless of the type of bottle that enters the system.

By implementing beach clean-ups, losses are avoided in the tourism revenue. With the implementation of a DRS, the bottles that end up on the beaches will decrease. This, in turn, helps to avoid costs for tourism and decreases the investment required in beach clean-ups.

Apart from positive externalities for the tourism industry, there are additional benefits resulting from the implementation of a DRS. Since fewer bottles will be landfilled, the lifespan of the landfill will increase, which results in economic benefits, by extension. For example, in Israel, the cost per occupied landfill space per bottle has been estimated at NIS 0.0055[15] or EUR 0.0014 (Lavee, 2010). Another benefit is the reduction in greenhouse gases. Per tonne of plastic that is recycled, emissions of 1,9tCO2eq are avoided; this due to a reduction of virgin plastic production. (Pew & SYSTEMIQ, 2020).

In addition, the implementation of a DRS should reduce plastic leakage. With fewer bottles leaking into the Mediterranean Sea, the ecological impacts of marine plastic pollution - such as entanglement, ingestion, bioaccumulation, toxicity, and the transport of invasive species - should be diminished (Bhattacharya et al., 2010; Harvey et al., 2020; Ryberg et al., 2018). The reduction in plastic leakage will also decrease the economic impacts of marine plastic pollution, such as costs on marine transport, fisheries and aquaculture (Mouat et al., 2010; Takehama, 1990; UNEP et al., 2014).

The impacts of plastics in marine environments are caused by leakages from all sources flowing into the Mediterranean Sea (Boucher & Billard, 2020). Menorca's plastic leakage is estimated at 78 tonnes/year. This said, the leakages into the Mediterranean come from different sources and not exclusively from Menorca. Plastics leaking into this marine system are estimated at a

15 New Israeli Shekel (NIS)

total of 230,000 tonnes/year (Boucher & Billard, 2020). Therefore, to significantly influence the different ecological and environmental impacts, it is necessary to reduce plastic leakage, not only from Menorca, but also from other sources. Similarly, since plastic leaks are not just PET bottles, strategies involving other types of plastics must also be implemented. While a reduction in plastic leakage is key, it alone will not address the existing plastic stock in the Mediterranean Sea (Boucher & Billard, 2020)

Based on the results of this study, the implementation of a DRS in Menorca is recommended. This instrument will enhance a CE for plastics on the island. Firstly, it would return plastics to the economy, increasing the amount sent to recyclers and thus reducing the production of virgin plastic. Secondly, the implementation of a DRS would reduce the number of plastic bottles that enter the oceans and/or escape into the environment. Given that a DRS is self-sufficient, it can generate economic benefits for the government of Menorca and be used to further actions to increase circularity in the economy.

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