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Quantitative Study to Assess the Socio-Economic and Environmental Impacts of Implementing the Extended Producer Responsibility (EPR) System for Packaging: Case Study in Morocco

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Abstract

Extended Producer Responsibility (EPR) is an approach to environmental policy that requires producers to assume full responsibility for the costs of managing their products and packaging throughout their useful life. In Morocco, municipalities assume financial and operational responsibility for collecting and eliminating all household and similar waste at considerable expense. In this respect, integrating an EPR system in the Moroccan context, allowing a transfer of responsibility from municipalities to producers is strongly recommended. In this context, the specific research objective is to conduct a quantitative study to assess the socioeconomic and environmental impacts of implementing an EPR system for packaging in the Moroccan context. To accomplish this, the methodology entails estimating the amount of packaging waste generated and the recycled amount based on current recycling ratios. Then, the socioeconomic and environmental impacts are estimated by comparing the business-as-usual scenario (without EPR) and the EPR scenario with improved recycling rates. The implementation of the EPR system allows improving considerably the recycling rates of plastic, cardboard, glass, and metals from 25%, 20%, 14%, and 46% to 50%, 75%, 70%, and 60%, respectively. The estimated amount of household packaging waste (HPW) is about 1,16 million tons/year. The finding results are very encouraging, showing an economic saving of about 482 MDh/year. This saving is mainly related to the avoided cost of landfilling and the loss of revenue resulting from the recyclable material. Therefore, the economic savings exceed 455 Dhs /ton of recyclable HPW, with 2,894 jobs created nationwide. Since the EPR system will simultaneously reduce GHG emissions and prevent ecosystem degradation, it could provide an environmental saving of 196,4 million Dhs. These results underline promising prospects for integrating the EPR system into the transition to more sustainable, responsible, and efficient waste management.

Keywords: Environmental impact, packaging waste, recycling, socioeconomic impact, extended producer responsibility, circular economy

1. Introduction

Evolving consumption and production patterns, linked to population growth, result in a considerable quantity of diversified products on the market. This trend towards consumption, or even over-consumption, generates post-consumer waste proportionally to the number of products involved. In Morocco, the quantity of household and similar waste (HSW) is highly increasing. The total amount of waste estimated at 7 million tons will increase significantly to reach 9,4 million tons by 2030 (MEVAC & eci, 2019; *SINEDD*, n.d.). This amount covers a wide range of products, materials, and resources as shown in the characterization campaigns carried out at the national level(GIZ, 2017; Kitane et al., 2015), and the packaging waste, mostly made from plastic, glass, cardboard, and metals, represents the main non-organic household waste fraction. This fraction comes under considerable pressure on the environment, notably through soil and water contamination, atmospheric pollution, and, eventually, the emission of greenhouse gases (GHG) (Jirou et al., 2014). On a national scale, the waste sector contributes significantly to GHG emissions, a contribution of 4921 Gg CO_2-eq in 2016, accounting for 5,7% of global emissions (eci, 2019). Besides, the cost of environmental degradation due to waste has reached 12.6 million $EU, i.e.,106 MDhs in 2012, accounting for 0,2% of GDP in Greater Rabat and 0,013% of the national GDP of Morocco in 2012. It includes mainly the cost of cleaning up uncollected waste as well as the collection cost (Arif & Doumani, 2014).

In response to these pressures, municipalities provide HSW collection and disposal services, mainly via technical landfills. Ultimately, municipalities are financially and operationally responsible for this communal service, following Organic Law n°113-14. This responsibility entails substantial financial capacities, which vary based on the specific characteristics of each agglomeration in terms of tonnage and perimeter and treatment/recovery infrastructures stipulated in the management contract. Experience gathered from waste management service providers indicates that the respective costs of collection and transport, sorting of recyclable fractions, and landfilling are approximately 300,170 and 150 Dh/t, respectively. In the current situation, those responsible for putting "product packaging" systems on the market are not in a position to take on the management of post-consumer waste from these systems. This is done by the public sector, particularly local authorities, according to a traditional model in which resources are extracted, processed, distributed, consumed, and finally disposed of (linear economy). Thus, the concept of the circular economy has been introduced to encourage further efficient use of resources, mitigate the effects of climate change, and prevent pollution. It is an economic model that promotes more efficient use of resources by applying three guiding principles: "reduce," "reuse," and "recycle" to create a circular value chain with a minimal impact on the environment.

At this point, a paradigm shift based on transferring the management cost responsibility to producers/importers over the product's entire life cycle is necessary: Extended Producer Responsibility (EPR) concept (Cf. Figure 1). The EPR is an environmental policy approach based on the obligation of producers to assume full responsibility for their products and packaging, both during their useful life (e.g. by stipulating compliance with certain health and safety standards) and during the end-of-life phase, i.e. once these products and packaging become waste (GmbH et al., 2018; Lifset et al., 2023; Maitre-Ekern, 2021; Nahman, 2010). EPR is based on the "polluter pays" principle, according to which those responsible for placing packaging products on the market are made responsible for ensuring the prevention and management of waste from these products at end-of-life (Compagnoni, 2022; Joltreau, 2022). It is a pathway that encourages them to modify their product materials to be easily reused and recycled (Allen-Taylor, 2022). However, in this approach, producers will have to set up a reliable "organization" with the requisite skills and stable funding to ensure the

efficient transformation of waste into resources, and to work towards the promotion of the industry's rational transition from a linear to a circular economy (Renaud & Quertamp, 2020). Since the launch of Germany's first EPR system for packaging waste in 1991, over 400 EPR systems have been identified internationally, covering a wide range of waste products, as shown in Figure 2 (OECD, 2016). This extended responsibility makes a significant contribution to increasing the recycling rate, which not only generates considerable revenue in terms of the recoverable fractions marketing as secondary raw materials and creating jobs and a parallel economy, but also reduces ongoing collection/processing capacities by local authorities and, above all, contributes to the non-degradation of the environment. Ultimately, EPR acts: i) Upstream, via an eco-design for the manufacturing of recycled products, integrating recyclables and minimizing the introduction of virgin substances; ii) Downstream through efficient selective collection (i.e., towards the recovery of all waste put on the market, and the promotion of technologies able to convert these wastes into quality resources (Cf. Figure 3). In concrete terms, it is crucial to establish specific, measurable, and achievable collection, sorting, and recycling targets for a given timeframe and specific waste. These targets must also be scalable and updated over time. The sorting-collection-recycling rates set in Germany are illustrated in Table 1.

To sum up, the EPR system should be simple, clear, transparent, and well-structured. The government should set the framework/minimum requirements for the EPR systems, and support and enforce the correct implementation of the schemes. Producer responsibility organizations (PROs) must be officially recognized and permitted by the national government (mwe, 2013). The success of the EPR depends mainly on the issues related to the implementation of the concept. These would require constant monitoring of the effectiveness of regulations, especially in developing countries where the systems are vulnerable due to the informal sector. Setting up the targets and monitoring the upstream financial and physical activities are also fundamental for the success of EPR. Besides, imposing a penalty on producers would not only force them to assume their obligation but would have a trickle-down effect on the downstream section (Gupt & Sahay, 2015).

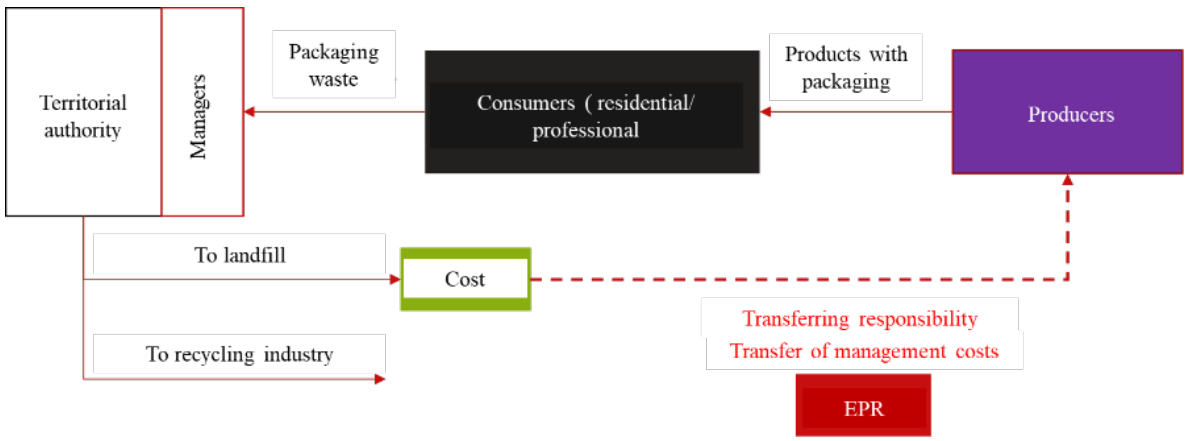

Figure 1:EPR system illustration

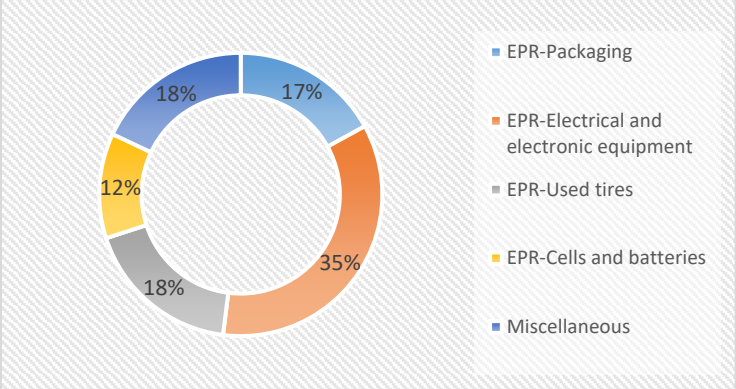

Figure 2: EPR systems related to waste types (OECD 2023)

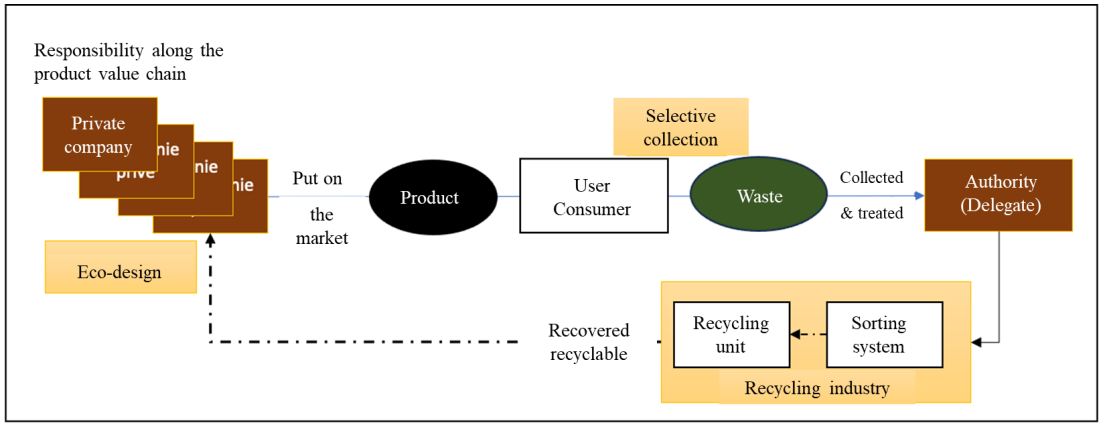

Figure 3: Components of packaging EPR system

Table 1. Collection - Sorting - Recycling quotas set 1993-1995 in Germany (Bünemann et al., 2020)

Packaging waste	**Rate**		
	Collecting	Sorting	Recycling
Glass	60%	70%	42%
Aluminium	30%	60%	18%
Paper & Cardboard	30%	60%	18%
Plastic	30%	30%	9%

Morocco faces significant waste management challenges, including rapid urbanization, population growth, and increasing waste generation. These challenges have strained the country's existing waste management infrastructure, leading to issues such as inadequate waste collection, limited recycling facilities, and the proliferation of illegal dumping sites. In response to these challenges, Morocco has been developing its EPR policy framework. The development of EPR in Morocco is still in its early stages, but the government has made significant strides in recent years. Efforts include drafting legislation and engaging stakeholders. The goal is to establish a comprehensive EPR policy that can address the country's waste management challenges while also contributing to the achievement of the SDGs.

The EPR concept is part of a legislative draft amending and supplementing Law 28-00 on waste management and disposal. The proposal essentially aims to implement Article 8 of Framework Law 99-12 on the National Charter for the Environment and Sustainable Development, which provides for the updating of the legislative framework relating to waste, to reinforce aspects linked to the integration of the EPR approach. This legal draft has been drawn up to anchor and establish the principle of EPR, which makes producers and importers

of products responsible for the recovery of waste resulting from their products, to manage them in a rational way (Banque Mondiale, 2022). "Producers and importers are responsible for managing the waste resulting from the products they manufacture or import at all stages in the life cycle of these products, including the post-use phase." Article 3 of the draft amendment to Law 28.00. Municipalities or communal groupings are also required to apply this law (Article 19). At the regulatory level, it is not specified whether responsibility is to be assumed individually or collectively. Article 4.1 stipulates that producers and importers are required to manage the waste either individually or collectively, within the framework of systems that include legal, institutional, technical, financial, social, and awareness-raising aspects. A regulatory text will specify the list of products subject to the principle of extended responsibility, as well as the terms and conditions of application of this article. They must also implement a hierarchy in the treatment of waste, which requires prioritizing the reduction of its production, then its reuse, then its recycling, then its use as a source of organic substance and energy, and then its elimination (article 4.2). While progress has been made, challenges remain, including the need for stronger regulatory frameworks, better coordination among stakeholders, and increased investment in waste management infrastructure. However, with continued efforts, Morocco is on the path to creating a more sustainable waste management system through the implementation of EPR policies.

Given that the packaging fraction (HPW) constitutes the majority fraction of HSW, the present work aims to conduct a quantitative study of the economic, environmental, and social impact related to the integration of the EPR-packaging system compared with the business as usual (BAU) reference scenario (i.e., without the EPR system), considering the overall HSW deposit in Morocco.

A comprehensive literature review shows that the EPR-packaging system has been successfully implemented through European terms of Directive targets and has contributed to packaging waste reduction and increased recycling activities (Cahill et al., 2011; Lorang et al., 2022). In this regard, it is important to highlight the successful experiences of this EPR system in several countries, namely: France, Germany, Belgium, and Slovakia, as well as those under development in MENA countries (Tunisia). In Belgium, 200 million euros (€17/capita) have been raised through eco-contributions from industry, and around 90% of all household packaging in Belgium has been collected and recycled by 2021 (CITEO, 2022). A total of 15.000 people are employed in packaging sorting and recycling. In Germany, the implementation of the EPR-packaging system has provided a significant increase in the recovery rate of packaging materials (material recycling and energy recovery) from 37.3% to 94.3% between 1991 and 2017. Approximately 290.000 people work in the waste management and secondary raw materials sector (not only in packaging) (GmbH et al., 2018). In Slovakia, the EPR policy provided for the disposal of almost 290.000 tons of waste in 2011, generating a benefit of around 2 million euros (average disposal cost of 7 euros/ton) (Naturpark, n.d.). In Tunisia, the system has provided 1.500 jobs and 30 microenterprises (Arditi & Bonnet, 2018). In Spain and Portugal, the analysis carried out by Rubio et al. (2019) shows that the implementation of the EPR policies has had a positive impact throughout the years on both countries. Besides, Canada has already implemented EPR packaging in five provinces (e.g., British Columbia, Saskatchewan, Manitoba, Ontario, and Québec), which showed significant success. Another EPR system is under development. Concretely, EPR implementation in Nova Scotia highlighted significant economic benefits of around 14–17 million Canadian dollars for municipalities (Diggle & Walker, 2020).

To date, the previous studies have not focused on a quantitative assessment of the impact of an EPR system for packaging. In this context, the research presented in this paper seeks to bridge this gap in the literature. Assessing the socio-economic and environmental impacts of implementing packaging EPR is crucial for several reasons. Evaluating the economic impact

allows for a clear understanding of the costs involved in implementing EPR. Assessing financial benefits allows for identifying potential cost savings and economic benefits, such as job creation in the recycling sector, reduction in municipal waste management expenses, and growth opportunities in the green economy. This facilitates the promotion of long-term sustainability by making a tangible contribution toward achieving the Sustainable Development Goals (SDGs). This is by promoting responsible consumption and production patterns (SDG 12) and ensuring sustainable cities and communities (SDG 11). Such accurate assessments provide policymakers with the necessary data to make informed decisions. Therefore, guarantee the effectiveness and efficiency of policies.

The methodology deployed is divided into four key stages. The first stage consists of estimating the amount of packaging waste generated, based on the total amount of household and similar waste in Morocco. In the second stage, the quantity of packaging recycled will be determined based on current recycling rates for each packaging fraction (plastic, cardboard, glass, and metals). The third step consists of estimating the reference cost and producer fees. The reference cost represents the total cost of waste management, including collection, sorting, and technical landfill of the fraction that has not been recycled. The producer fees represent the eco-contribution paid by obligated companies when they introduce a product to the market. In the final stage, the socio-economic and environmental impact will be estimated by comparing the scenario (BAU without EPR) considering the current recycling rates and the scenario (EPR) with improved recycling rates.

2. Materials and Methods

2.1. Estimation of the Reference Tonnage

Experiments carried out on the characterization of HSW have shown that the fraction corresponding to packaging is the largest part of the inert fraction (i.e., non-organic) (GIZ, 2017; MEVAC & eci, 2019). Packaging includes several materials: plastic in its various forms, metal in the form of steel or aluminum, glass, and, in particular, cardboard associated with beverages or other packaging uses. Figure 4 shows the distribution of packaging waste by material (MEVAC & eci, 2019). The amount of household inert waste is estimated at 1,35 million tonnes in 2019 according to (MEVAC & eci, 2019) distributed over the 4 types of waste (plastic, cardboard, glass, and metal) as shown in Table 2. As a result, the quantity of packaging waste (QHPW) can be deduced for the 4 types of waste (BENJILALI & ZENASNI, 2020) according to Equation 1. This quantity represents the reference tonnage of packaging waste.

$$Q_{HPW} = Q_{HIW}.F_P \quad (1)$$

Q_{HPW} : Amount of household packaging waste (t/year)
Q_{HIW} : Amount of household inert waste (t/year)
F_P : Packaging fraction in waste (%)

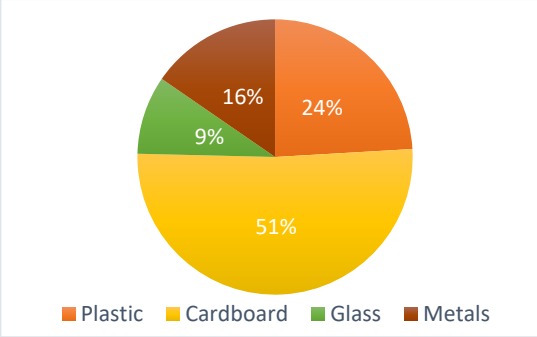

Figure 4: Distribution of packaging waste by material

Table 2. Distribution of the inert fraction of waste

	Material	HIW (t/an)	% Packaging
Packaging waste	Plastic	464.317	60%
	Cardboard	593.639	100%
	Glass	118.727	90%
	Metal[1]	178.092	100%
	Total	1.354.775	

2.2. Estimation of the Amount of Recycled Packaging Waste

It should be noted that the circularity of HPW is close to 100%, except for plastic, which is at 65% (Dalberg, 2019). It is also worth highlighting that the results of the national household waste recovery program (PNDM, n.d) in terms of recycling rates at the national level provide a basis for reflection in defining the applicable thresholds. Table 3 below illustrates the recyclable HPW potential and the recycling rate practiced for each type of waste considered in the present study (MEVAC & eci, 2019; BENJILALI & ZENASNI, 2020). Thus, the amount of recycled packaging can be determined according to Equation 2.

$$Q_{RP} = Q_{HPW}.P_r.\tau \quad (2)$$

Q_{RP} : Amount of recycled packaging waste (t/year)
P_r : Recyclable HPW potential (%)
τ : Recyling ratio (%)

Table 3. Potential recyclable packaging waste and national recycling rates

	Plastic	Cardboard	Glass	Metals
% Recyclable HPW potential	65%	100%	100%	100%
Recyling ratio	25%	20%	14%	46%

2.3. Estimation of the Reference Cost and Producer Royalties

The reference cost represents the total cost of waste management, including collection, sorting, and landfilling of the non-recycled fraction. In this regard, experiences gained from waste management service providers indicate the average costs (Cf. Table 4) (GIZ, 2017; PNDM, n.d). The total reference cost is determined according to Equations 3 and 5 in Dh and per ton (Dh/t), respectively. The non-recycled quantity (sorting refusal) is estimated using Equation 4.

$$C_r = 300.Q_{HPW} + 170.Q_{HPW} + 150.Q_{NR} \quad (3)$$

[1] Metal accounts for 67% of steel-based packaging and 33% of aluminum-based packaging.

$$Q_{NR} = Q_{HPW} - Q_{RP} \quad (4)$$

$$C_u = {}^{C_r}/_{Q_{HPW}} \quad (5)$$

With:
C_r : Reference cost (Dh/year)
Q_{NR} : Quantity of non-recycled waste(t/year)
C_u: Unit cost (Dh/t)

Table 4. Average costs for collecting, sorting and recycling waste (GIZ, 2017; PNDM, n.d)

Collecting and transport average cost	300 Dh/t
Sorting average cost	170 Dh/t
Landfill cost	150 Dh/t

It is also required to estimate the revenue generated by the sale of recyclable packaging fractions by type of material, based on the applicable sales prices Rabat sorting center shown in Table 5 (PNDM, n.d). A weighted average cost was calculated for the metal fraction, considering a composition of 33% Aluminum and 67% Steel, as shown in Table 6. Thus, sales revenues are determined according to Equation 6 for each packaging fraction. Total sales revenue is expressed according to Equation 7. Under an EPR system, obligated companies pay a fee (Eco contribution) when introducing a product into the market. This fee is generally assessed based on the quantity and type of material introduced and partially covers the financial capacity required to collect, sort, and recycle the post-consumer waste related to the product in question (Tumu et al., 2023). In general, 80% of the net costs incurred by the municipality are covered. Consequently, the royalties to be covered by the producers (Ro) can be estimated based on the reference cost and sales revenues from the recycled fraction according to Equation 8 (PRO Europe, 2023).

$$R = C_{su} \,.\, Q_{RP} \quad (6)$$

$$R_T = R_P + R_C + R_G + R_M \quad (7)$$

$$Ro = 0{,}8.\,(\,C_r - R_T) \quad (8)$$

With:
R: sales revenues (Dh/year)
C_{su} : sales cost (Dh/t)
R_p : sales revenues for plastic (Dh/year)
R_C : sales revenues for cardboard (Dh/year)
R_G : sales revenues for glass (Dh/year)
R_M : sales revenues for metals (Dh/year)

Table 5. Selling prices for different types of packaging (Rabat sorting center)

	Plastic	**Metals**	**Glass**	**Cardboard**
Selling price Dh/t	2.000	5333	500	800

Table 6. Weighted cost of metal fraction

		Selling price	**% /metals**	**Weighted cost**
Metals	Aluminium	12000	33%	5333
	Steel	2000	67%	

2.4. Assessment of the Economic, Environmental and Social Impact of the EPR

This section provides an assessment of the economic, environmental, and social impact of the implementation of the EPR packaging system, compared to the BAU reference scenario with current recycling rates (without packaging EPR). The two scenarios are well explained in Table 7. The recycling rates considered in the EPR scenario are aligned with the recycling targets set for European Union countries (Olivier, 2023). The annual economic saving (S_{EC}) that can be generated is related to the material savings S_m (i.e., the quantity of recyclable HPW recovered following the integration of the packaging EPR system, expressed in t/year). This material saving generates a very significant financial gain, mainly linked to the avoided cost of landfill (C_L) and the loss of revenue L_R (the amount of recyclables landfilled) (See Equations 9 to 12):

$$S_m = Q_{HPW}.P_r.(\tau_{EPR} - \tau) \quad (9)$$

$$L_R = S_m.C_{su} \quad (10)$$

$$C_L = 150.S_m \quad (11)$$

$$S_{EC} = L_R + C_L \quad (12)$$

Table 7. Recculing rates for the two scenarios (BAU and EPR)

	Recycling rate			
	Plastic	**Cardboard**	**Glass**	**Metals**
Scenario - BAU	25%	20%	14%	46%
Scenario- EPR	50%	75%	70%	60%

In terms of employability, the total number of jobs that could be created following the integration of the EPR-packaging is estimated according to Equation 13, assuming an average annual salary of around 72.000 Dh and a ratio of payroll[2] to sales of 50%.

$$S_E = \frac{50\%.\ L_R}{72000} \quad (13)$$

From an environmental point of view, this study considers that the integration of packaging EPR impacts both i) the mitigation of CO_2 emissions into the atmosphere and ii) adaptation through the prevention of ecosystem degradation (soil, and groundwater...). Table 8 illustrates the emissions avoided for each ton of recycled material (ADEME, 2014; Pascal & Fanny, 2020) and the carbon tax to estimate the annual mitigation cost in Dh/year. The overall degradation cost is determined based on the degradation cost per ton (402 Dh/t) and the material gain (S_m). Thus, the sum of the two savings represents the overall environmental saving (S_{Env}) following the implementation of EPR at the national level.

Table 8. Data for estimating the environmental savings

Mitigation	$teqCO_2$ avoided /t plastic	0,4
	$teqCO_2$ avoided /t glass	0,5
	$teqCO_2$ avoided /t steel	1,8
	$teqCO_2$ avoided /t aluminium	11,1
	Carbone tax (Dh/$teqCO_2$)	253,0
Adapting	Environment degradation cost (Dh/t)(World bank group, 2017)	402

[2] Electricity and diesel costs are the main utilities used to operate the sorting center.

3. Results and Discussions

The amount of inert household waste (HIW) by type of material has been estimated at 1,35 million tonnes(GIZ, 2017; MEVAC & eci, 2019). Consequently, a tonnage of 1,16 million tonnes of packaging waste per year is derived based on the percentage of packaging for each type of material. This quantity represents the reference tonnage for packaging waste. The recycling rates applied and the recyclable potential of packaging waste are used to estimate the quantity of recycled packaging, which is 261.522 t/year (Cf. Table 9). This amount is distributed between cardboard (45%), metals (32%), plastic (17%) and glass (6%).

Table 10 presents a detailed calculation of the reference cost of waste management for each packaging material. This reference cost amounts to 678 million Dhs, with a unit cost of 586 Dhs /ton. Assuming a coverage rate of 80%, PROs should provide municipalities with total financial support of around 36 million Dhs for the management of their waste, with a weighted fee of 31 Dhs /tonne of waste produced.

Table 9. Estimation of the reference tonnage of HPW

	Plastic	Cardboard	Glass	Metal	Total t/year
Household inert fraction Q_{HIW} (t/year)	464.317	593.639	118.727	178.092	1.354.775
% packaging (F_p)	60%	100%	90%	100%	
Household packaging fraction Q_{HPW} (t/year)	278.590	593.639	106.854	178.092	1.157.176
P_r	65%	100%	100%	100%	-
Recyling ratio τ	25%	20%	14%	46%	
Amount of recycled packaging Q_{RP} (t/year)	45.271	118.727,80	15.066,46	82.456,60	261.522,00

Table 10. Detailed calculation of reference cost and producer royalty

		C_U (Dh/t)	HPW (t/year)	Total (MDh)
Reference cost (C_r)	Collection and transport	300	1 157 176	347,15
	Sorting	170	1 157 176	196,72
	Landfilling	150	895 654	134,35
	Total	**586**	-	**678,22**
Sales revenues (R)	Plastic	2 000	45 271	90,54
	Cardboard	800	118 728	94,98
	Glass	500	15 066	7,53
	Metals	5 333	82 457	439,77
	Total	**2 420**	261 522	**632,83**
Royalties (Ro)	Plastic	209	278 590	58,19
	Cardboard	341	593 639	202,36
	Glass	412	106 854	44,08
	Metals	- 1 507	178 092	- 268,31
	Total	**31**	1 157 176	**36,32**

Table 11 below presents a detailed cost-benefit analysis associated with integrating the packaging EPR system compared to the reference scenario (i.e., without packaging EPR). The table shows the recycling rate targets of this packaging EPR for each deployed material, and the impact on material savings and, ultimately, on economic benefits. The results are particularly encouraging, since they indicate a material gain (i.e., the quantity of recyclable

packaging recovered after implementing the packaging EPR system) of around 438.093 t/year. This results in substantial financial savings, primarily associated with the avoided costs of landfill and the loss of revenue from recyclable materials being landfilled, amounting to 482 million dirhams per year. Thus, the weighted economic saving is 455 Dhs /ton of recyclable packaging.

Table 11. Estimated economic savings with/without integration of packaging EPR

	Plastic	**Cardboard**	**Glass**	**Metals**	**Total**
Recyclable Potential (t/year)	181.084	593.639	106.854	178.092	1.059.669
Recyling ratio (without EPR)	**25%**	**20%**	**14%**	**46%**	
Recyling ratio (with EPR)	**50%**	**75%**	**70%**	**50%**	
Material saving S_m (t/ year)	45 271	326 501	59 732	6 589	438 093
Revenue loss L_R (MDh/ year)	91	261	30	35	417
Avoided cost of landfill C_L (MDh/ year)	7	49	9	1	66
Total saving S_{EC} (MDh/ year)	97	310	39	36	482
Total saving (Dh/t)	538	523	363	203	455

Assuming an average annual salary of around 72.000 Dh, and a 50% share of payroll about sales, the total number of jobs created following the integration of EPR-packaging could reach 2.894 (see Table 12).

Table 12. Number of green positions created following the integration of EPR- packaging

Average salary (Dh/year)	**72.000**
payroll /sales	50%
sales (MDh/year)	417
Green jobs	2.894

The recyclable packaging fraction recovered following the implementation of the EPR-packaging system generates considerable environmental benefits, mainly linked to:

- Mitigation: by avoiding the emission of 80.174 teqCO_2 into the atmosphere. This represents an annual saving of 20 MDh;
- Adaptation: by limiting environmental degradation. The annual saving associated with this action amounts to 176 MDh.

This results in a total environmental saving estimated at 196,4 MDh/year (See Table 13).

Table 13. Annual environmental savings linked to waste management under the EPR system

Mitigation	Total teqCO_2 avoided	80.174
	Carbone tax (Dh/teqCO_2)	253,0
	Mitigation cost (MDh/an)	20,3
Adaptation	Environnemental degradation cost Dh/t	402
	Total economic value-TEV (MDh/an)	176
Total (MDh/year)		196,4
Ratio Dh/t $_{HPW}$		185,3

The success of this paradigm shift, based on the transfer of responsibility from local authorities to producers, requires the specification of new roles and responsibilities of all stakeholders in the value chain of a given product (Kamaruddin & Marwan, 2021). The implementation of any EPR system requires close interaction between these actors in a systemic approach and the active participation of all of them, i.e.: Obligated companies (producers/importers), suppliers, distributors and retailers, consumers, community groups and recyclers (Leclerc & Badami, 2023; Ramasubramanian et al., 2023). It should be noted that in an EPR system, obligated companies can manage their sorting/collection/recycling responsibilities individually or transfer them collectively to a third party, a system operator (PRO) (World Bank, 2022). It's a reliable, well-known organizational structure that needs stable funding from the eco-contribution of all obligated companies. It can take two forms private/public or profit/non-profit. Its missions are to register companies subject to the EPR system in a national register under conditions of fair competition; to document the data filed by obligated companies on the quantity and characteristics of products placed on the market (declaration); to collect and manage the eco-contributions paid by obligated companies; to launch, manage and control requests for proposals linked to collection, sorting, recycling either with municipalities or private companies) ; Communicate throughout the value chain to increase the recycling rate by awareness-raising, education, and training; Document and compare the material flow (collection, sorting, and recycling) of waste and ensure that targets are achieved; Monitor and ensure that companies are fulfilling their responsibilities; Document and justify to the public and authorities. It is also necessary for each company registered in an EPR system to declare and provide information on the commercialized products periodically. This declaration covers quantitative aspects (volume, weight, and unit) as well as qualitative aspects in terms of the materials composing these products and specific characteristics such as rigid/flexible, hazardous, recycled/upgraded/non-recycled with/without color, etc (ADBI, 2022). Given the importance of this data, it must be managed either by the PRO or by the government, in a way that preserves confidentiality and transparency. This register must be as complete as possible, i.e. all potentially obliged companies must be registered, with a substantial and dissuasive penalty for non-registration (in Germany, a penalty of 200.000 EUR is imposed for non-registration or incorrect declaration (*The Central Agency Packaging Register (ZSVR)*, n.d.)). The main responsibilities involved in managing the register are: identifying obligated companies, checking compliance by aggregating data and verifying declarations. The register may be managed by a government agency or by the PRO. It is recommended to be managed by the PRO, to facilitate confidentiality and funding. However, the supervision of a government agency remains necessary for inspection, access to information, and contribution to the registration process.

4. Conclusion

A cost-benefit analysis comparing the BAU scenario and the EPR scenario remains an essential requirement for the adoption of EPR. These costs include management costs (collecting, sorting, and recycling), environmental costs linked to environmental degradation, and the loss of revenue resulting from the low recycling rate. This cost-benefit analysis pleads in favor of the adoption of EPR, which ultimately promotes a paradigm shift based on the promotion of eco-design and circularity schemes, i.e., a new job-creating economy. Furthermore, the manufacturing of recyclable products and the implementation of reverse logistics provide the opportunity to promote this secondary raw material as part of a circular economy. It is well known that the cost of this material is lower than the purchase of virgin raw materials. Indeed, EPR has a dual impact on material flows since, on the one hand,

products will be made up of increasingly recyclable materials. On the other hand, they will be directed for collection upstream of the landfill due to the multiplication of reverse logistics promoted by PRO. Thus, each ton avoided generates savings. This reinforcement is based on maximizing the recyclable fraction (circularity) and reducing landfill costs. In addition, increasing the recycling rate has social repercussions in terms of improved lifestyles, as it creates new jobs in the local area. The number of upstream collectors is 2–7 jobs/ton of recyclable material, and the number of sorters at the landfill is one sorter per ton. The implementation of EPR will also help to integrate semi-formal and informal workers in the waste sector and improve their working conditions and livelihoods. It will also result in greater social recognition for those working in the recycling and waste management sectors. From an environmental point of view, introducing an EPR system has a local impact on the total economic value linked to the avoided cost of environmental degradation and a global impact in reducing the global warming potential (GWP).

This study aims to quantify the socio-economic and environmental impact of implementing packaging EPR on a national scale. The annual amount of packaging waste is estimated at 1.16 million tons. The results obtained following the integration of the EPR system are very encouraging since they indicate a material gain of around 445.903 t/year. This saving in recyclable material generates a significant financial saving, mainly linked to the avoided cost of landfilling and the loss of revenue (the quantity of recyclable material that is landfilled), amounting to 482 MDhs/year. This results in a weighted economic saving of 455 DHs/ton of recyclable packaging waste. Considering that this paradigm shift has both a mitigating effect on the amount of CO_2 emitted into the environment and an adaptive effect by preventing the degradation of ecosystems (i.e., soil, groundwater, etc.), the environmental gain associated with the implementation of the EPR-packaging system could reach a total of 196,4 million Dhs. It should also be noted that this will provide 2.894 jobs nationwide.

However, to ensure its success, it should be noted that the implementation of an EPR system requires a participatory approach, involving the various stakeholders: producers, collectors, recyclers, etc., as well as well-defined objectives in advance, to measure the system's success, coupled with the establishment of control mechanisms. This is to ensure that producers comply with regulations (particularly if they decide not to join the system). The roles of local authorities and collectors need to be clearly defined. Municipalities need to be trained to ensure that the system is properly implemented at the local level. Informal waste collectors need to be better integrated into the system. A legal framework needs to be established to ensure that the EPR system is properly structured, particularly in terms of the roles and responsibilities of the various stakeholders involved in the system. Consumers must also contribute to the effort in an appropriate and informed way through awareness-raising campaigns. In this context, policymakers have to address all these concerns:

- Establish a solid legislative framework: Promulgate specific laws and regulations defining producers' obligations, the types of products concerned, and the recycling targets to be achieved.
- Strengthen waste management infrastructures by building and modernizing sorting and recycling centers and developing and improving selective collection systems to facilitate upstream waste sorting.
- Promote innovation and eco-design by offering tax incentives and subsidies for companies investing in the research and development of eco-designed products and recycling technologies. Furthermore, public-private partnerships (PPP) are a way of encouraging the development of innovative waste management solutions.

- Raise awareness among stakeholders by launching awareness campaigns and setting up training programs for stakeholders involved in the waste management chain, including collectors, recyclers, and producers.
- Develop a monitoring and evaluation system to measure EPR progress and adjust policies accordingly.
- Promote international cooperation through exchanges of experience and best practices with other countries that have implemented EPR by participating in international platforms. Cooperation agreements with other countries and international organizations can also be negotiated to obtain technical and financial support.

Future research could usefully investigate the effective implementation approach of the EPR in the Moroccan context: i) Collectively through an eco-organization. Accordingly, a study of the different governance models for managing the eco-organizations responsible for EPR will be necessary; ii) Individually, where each producer is responsible for managing the waste from its products, from collection to recycling. Besides, it may also be beneficial to study the perception and acceptance of EPR by producers, distributors, and other stakeholders. Other specific studies of different industrial sectors (e.g., electronics, and textiles) could be carried out to understand the implications and challenges specific to each sector.

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