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Special

Challenges and prospects for activating a circular economy in the context of sustainable waste management in Algeria

Retos e perspectivas para activar unha economía circular no contexto da xestión sostible de residuos en Alxeria

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Abstract

The article deals with the problem of waste management in Algeria. It aims to analyze the various policies undertaken by the government in order to be able to respond to the principles of sustainable development and the circular economy from the perspective of sustainable and integrated waste management. The analyses carried out show that the first waste management strategies in Algeria were highly reactive and constituted a response to the exponential increase in waste. It is only since the year 2016 that the National Strategy for Integrated Waste Management has constituted an attempt at regulating this sector via a circular approach of profitability and sustainability.

Keywords: Sustainable Development; Circular Economy; Waste Management; Waste Recovery; Recycling.

Resumo

O artigo aborda a problemática da xestión de residuos en Alxeria. O seu obxectivo é analizar as distintas políticas emprendidas polo goberno para poder responder os principios do desenvolvemento sostible e da economía circular desde a perspectiva dunha xestión sostible e integrada dos residuos. As análises realizadas mostran que as primeiras estratexias de xestión de residuos en Alxeria foron moi reactivas e constituíron unha resposta ao aumento exponencial dos residuos. Só a partir do ano 2016 a Estratexia Nacional de Xestión Integrada de Residuos constituíu un intento de regular este sector a través dun enfoque circular de rendibilidade e sustentabilidade.

Palabras chave: Desenvolvemento Sostible; Economía Circular; Xestión de Residuos; Valorización de Residuos; Reciclaxe.

JEL: Q01; Q32; Q42; Q53.

1. INTRODUCTION

Environmental damage is considered one of the most serious problems that threatens present and future generations (Aknin et al, 2002). Hence, in the Brundtland report, published in 1987, the concept of sustainable development (SD) was explained as the international community's awareness of environmental problems. However, the economic model, being of linear dominance, justified by global economic and demographic growth, has led to the exacerbation of environmental damage. It is acknowledged that in order to satisfy consumer demand, economic and political dimensions take precedence in developmental policies over environmental concerns.

Moreover, the conclusions of the Rio 1992 conference on the environment and development highlighted the failure of developmental policies with their linear predispositions causing the deterioration of the environment on a planetary scale. Therefore, it is of extreme urgency to undertake the trajectory of sustainable development recommending that economic and social development refrain from exhausting the available natural resources so as to guarantee environmental sustainability for future generations. With this in mind, several concepts aimed at promoting a new model ensuring the preservation of the environment, natural resources, and sustainable development have been proposed. The circular economy (CE) is at the heart of this new model.

This new paradigm, advocating the 3 Rs, "reduce, recycle and reuse", aims to minimize the extraction of raw materials by extending the life of existing resources (Neves & Marques, 2022). In other words, the CE intends to keep them active for as long as possible in the economic circuit. Recycling is presented as the way to "reuse" products that have reached the end of their life in the production process and therefore "reduce" the extraction of raw materials. Although, in theory, the CE is not only limited to the recycling of waste which constitutes the last loop of the reusing process (Collard, 2020), the three principles are considered fundamental in saving recycle items (Manickam & Duraisamy, 2019).

Thus, by putting waste under the spotlight, it has attracted the attention of economic actors and public authorities. The objective of this campaign is precisely to provide alternatives to overcome the degradation caused by the modern world, characterized by consumerism, which generates huge quantities of waste from different sources.

Effective waste management, from the CE perspective, aims to ensure resources be reintegrated into the economic circuit. Indeed, in order to allow the implementation of a rational waste recovery policy and improve the performance of the economic system, recycled products must be reintroduced into the production process, hence the imperative of having a productive economic model set in place which would ensure their future and their value (Januel & Hamon, 2022).

To enable this transition, on an empirical level, several organizations and institutions have adopted large-scale energy and environmental policies. The United Nations (UN) has played a decisive role in raising awareness, developing standards, and organizing many environmental conferences. At the regional level, the European Union (EU) is seen as a relevant player in the transition process. Directive 2008/98 /CE, adopted in 2008 in the European Parliament, presents itself as a way forward for optimal resource management in identifying priority sectors and means of financing. Since 2015, several measures have been taken to promote the transition to the CE. At the state level, in developed countries such as Belgium, an action plan for this transition was passed in 2016 after analyzing its economic potential and theoretical gains by 2030 (Collard, 2020).

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Based on this knowledge, the objective of this article is to find out about how the principles of the CE allow new strategies to be implemented aimed precisely at efficient waste management, taking into account the particular situations of each country.

We focus on Algeria for the field of our study, an interesting choice since, like several developing countries, various mechanisms and policies have been put in place with a view to combating environmental degradation, thus ensuring this economic and ecological transition. Since the 1980s, the country has ratified several international environmental protection conventions[1] . Regarding waste management, since 2001, several laws and regulations have been created and human and financial resources have been supported (Djemaci, 2012). The first law on waste management of 2001, 01-19, constitutes the reference framework, integrating the universal principles of sustainable waste management, and was the starting point for the development of the National Municipal Solid Waste Management Program (NMSWP). Subsequently, the National Strategy for Integrated Waste Management for 2035 (NSIWM-2035), whose target was to strengthen waste recovery at a recycling rate of 30%, was signed. Tax instruments with an environmental orientation can constitute one of the essential factors in the transition to the CE and sustainability (Pérez et al, 2023). In Algeria, other decrees were promulgated to establish a relevant legal and fiscal framework for eco-taxes. In terms of financing, spending on waste management increased from 0.06% of GDP in 2002 ($56.76 billion) to 0.03% in 2016 ($159 billion) (Ministry of the Environment and Renewable Energies, 2018b). However, it is important to point out that these figures are below the minimum expenditures required to reduce the cost of environmental degradation due to waste, which has been increasing constantly, at 0.2% of GDP in 1999, reaching 0.7% in 2011. From an operational point of view, burial is the first method of waste treatment in Algeria; from 2002 to 2016, 172 waste treatment facilities, divided between technical landfill sites and controlled landfills, were put into operation (Tolba et al, 2020).

However, it has been noted that despite the efforts made by the public authorities to integrate the principles of the CE, Algeria, with its considerable economic, environmental and social potential, is still struggling to truly implement a recycling policy or manage the waste that is generated efficiently. The unrealized recycling potential represents 0.25% (USD 412 million) of GDP in 2015 (National Waste Agency, 2016) while the the amount of household waste which is recycled is less than 7% (Ministry of the Environment and Renewable Energies, 2018). The public character shows predominance in the waste management sector in Algeria with 95% state financing (National Waste Agency, 2020). The country, which exports 97% of its hydrocarbons and imports almost all the products it uses, lacks a diversified economy and a consistent production structure that would allow products to be reused and reintegrated into the economic circuit.

Thus, this paper firstly seeks to analyze the inadequacies of former waste management programs, then to examine how relevant the strategy which began in 2016 is (the NSIWM-2035) in introducing new instruments allowing sustainable and integrated waste management by absorbing the CE's principles. To do this, we start from the beginning, as shown by the figures put forward in this introduction, where the NMSWP and the NSWMP did not yield convincing results for economic, social or environmental aspects. Our hypothesis states that the NSIWM-2035 could unleash an economic potential and bring improvements to the waste management sector in Algeria that could allow it to go beyond the purely reactive and linear situation.

[1] International Plant Protection Convention, The United Nations Framework Convention on Climate Change, and the United Nations Convention to Combat Desertification, among others.

This article is organized in six parts: the introduction explains the context, objective and outline of the study; the second part comprises the literature review to illustrate the degree of the relationships and the interdependence between the concepts of sustainable development, the circular economy and waste; the methodology of the article and the data sources are the subjects of the third part; we present our results and discuss them in the following two parts; the last part contains the conclusions, the recommendations, and the prospects for future research.

2. LITERATURE REVIEW

The literature review used for this article focuses on highlighting the principle of the CE in the context of waste management. Thus, the first task is to concentrate on the concept of sustainable development by analyzing how it emerged as well as its principles to identify its degree of interdependence with the CE and seek to demonstrate this sustainability. After stressing the importance of integrating this CE into sustainability, it would be useful to finally incorporate sustainable and integrated waste management into the framework of the CE.

2.1 SD and the CE: Common roots between the two concepts

Although on a conceptual level, for Velenturf and Purnell (2021), the relationship between the CE and SD remains relatively weak and limited as they have stated that the proposals and solutions of the CE do not systematically lead to compliance with the recommended principles of SD[2] , it could still have significant potential for sustainability. Indeed, arguments have been put forward on this topic, in particular by Barrett and Scott (2012) and Giampietro and Funtowicz (2020), who have argued that the negative effects of a production system, with regard to the CE, could manifest themselves if global systemic measures are not taken to simply avoid the displacement of a negative externality from one part of the system to another. It is due to this that Geissdoerfer et al. (2017) advocated strengthening the relationship between the two concepts, clearly defining how the CE would contribute to sustainability.

If SD and the CE are similar to each other in their evolutionary nature, the literature on environmental policies in the 1970s shows that the two concepts: share the same roots, the CE being seen as an expression of sustainability, meaning that it would not be useful to seek to define the relationship between them (Velenturf & Purnell, 2021). However, it is necessary to question the degree of interdependence between these two concepts, such as whether the establishment of a CE automatically leads to SD, whether the CE constitutes an element and a tool of SD or even whether this interdependence actually exists.

SD dates back to the 1960s, when the risks of economic development on the environment were highlighted. The first authors to take an interest in this problem, (Ehrlich and Holdren (1971); Ehrlich and Holdren (1972) and Commoner et al. (1971) had already tried to provide proposals and solutions within the framework of the IPWT[3] model, such as the establishment of environmental regulations, innovation and technology in production systems. Going further into detail, the Club of Rome, based on the framework of the Meadows report (1972),

[2] Taking into account the economic, social and environmental dimensions.

[3] The IPWT formula (environmental impact (I) = population (P) x wealth (W) x technologies (T)) was used to estimate the environmental impacts of economic growth, by multiplying population growth by wealth and by technological change.

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emphasized that there could not be continuous growth without harming the environment. The conclusions of this report noted that due to population growth, the demand for resources and the pollution generated would rise, causing the system to collapse in the next 100 years if measures were not taken

Since the 1970s, in the wake of these studies, a panoply of conferences, initiated by the United Nations (UN), have been held. Moreover, the Brundtland report (WCED, 1987), not being part of the radical approach of limiting growth, introduced the concept of SD, highlighting the international community's awareness of environmental problems and showing the inability of society and technology to properly manage environmental resources to reduce the negative effects of human activity (Velenturf & Purnell, 2021). If the report defined SD as "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change [were] made consistent with future as well as present needs (WCED, 1987, p.18)," this concept was officially recognized in 1992 within the framework of the Rio Summit, whose conclusions confirmed the failure of developmental policies with a linear tendency around the world and the deterioration of the environment (Dahan & Aykut, 2012). Agenda 21, intended as an action plan and product of the Rio conference, aimed to encourage local governments to adopt their contextualized local agendas.

In the Millennium Development Goals devised by the UN in 2001, the majority of the goals were oriented towards child health, education and prevention of disease transmission while less attention was paid to environmental sustainability (Lomazzi et al, 2014). The 2030 Agenda, or the Sustainable Development Goals (SDGs), drawn up as part of the UN's SD Summit in 2015, constituted the reaffirmation of the objectives set by Agenda 21. In total, 17 of them, grouping the economic, the environmental and the social, were taken on board.

As for the CE, its principles emerged as part of resource management research that dates back to well before SD (Velenturf & Purnell, 2021). Indeed, the issue of waste management, although it has become more complex since the industrial revolution that had begun in the 1760s, has always been an integral part of the formation of cities (Lieder & Rashid, 2016). Regarding the management of natural resources, the physiocrats[4] had already made their contribution by then on how important nature was as an unequivocal source of value and wealth (Patterson, 1998), hence why setting up an industry should not undermine this. These principles were incorporated into the framework of the "industrial symbiosis" of the 1930s, which suggested the mutualization of the means of production for the components of a territory's economic system. In recent years, the CE has become part of the currents of the environmental economy which, thanks to the establishment of short supply chain, in particular at the territorial scale, could constitute an essential SD tool (Gallaud & Laperche, 2016).

2.2. The necessity of sustainability in the CE

The CE has been defined by a considerable number of researchers and practitioners according to the objectives set and current trends. The only common denominator in all their definitions is the effort to make better use of resources. In actuality, on global, national and local scales, more and more natural resources are becoming depleted while the associated carbon emissions continue to accelerate, and waste and pollution continues to accumulate. From a practical point of view, the logic of the CE consists of minimizing the exploitation of

[4] The first physiocratic school being founded by François Quesnay (1694-1774)

resources and maximizing the prevention of waste (Velenturf & Purnell, 2017). Several authors (e.g., Kirchherr et al. [2017] and Ghisellini et al. [2016]) have emphasized that the CE contains the three economic, environmental and social dimensions of SD, which makes the principle of sustainability the main argument for implementing a CE. However, for Geissdoerfer et al. (2017), in the CE, economic issues are at the forefront and, therefore, less attention is paid to environmental and social dimensions.

As a consequence, various CE processes have shown resources being overexploited and the environment being degraded rather than automatic sustainability. Green Alliance (2019) establishes three CE models: the first, promoting the production of energy from waste by destroying existing materials, undoubtedly does not contain principles of sustainability and circularity due to the fact that it generates harmful consequences for the environment and is not part of a logic of circularity of and reuse; the second perception is not aimed at destruction but at the recovery and reuse of materials through recycling; this technique requires changes in Europe where the products will be designed for recycling, and innovations in sorting and waste collection will be made. Although this procedure has been approved, it has limitations, whether it be due to the recycled products degrading slowly, or the increasing energy demand and costs involved. As for the last model, admitting the low durability of the other processes, is oriented towards design adaptation, or, in other words, the techniques of waste prevention and reuse, repair and reconditioning of products. Recycling is the last resort in this model, which also has its limitations, albeit not environmental, but implementational, because it requires changes in production and consumption as well as coordination and collaboration between several parts.

That said, in order to correctly integrate the objective of sustainability into the CE and bring it in line with the principles of SD, more explicit processes need to be adopted, associating environmental limits, social equity and economic objectives with a long-term view to covering intergenerational equity. This can be achieved by swiftly integrating sustainability where the economy becomes a means of reorganizing society and the environment, rather than it being considered as a means in itself (Velenturf & Purnell, 2021).

2.3. In favour of sustainable waste management

Sustainable and integrated waste management is central to the activation of a CE as it is designed to combat the production-consumption-throw away society. Waste has long been considered a cost, with burial of waste as the typical solution (Awasthi et al, 2021) but this type of treatment has proven to be ineffective. Therefore, in order to achieve sustainability, an integrated approach must be sought (Wichitsathian et al., 2004); this should firstly be based on a range of collection and treatment options being used including waste prevention, recycling, energy recovery and rational landfill; secondly, it would require the active involvement of stakeholders, in this case the waste generators comprising households and producers, waste processors, and the relevant regulatory bodies; finally, linkages between the industrial production system and that of waste management would be needed in order to take into account the recyclability of products at the end of their useful life (Kurian, 2006).

3. METHODOLOGY, DOCUMENTATION AND DATA SOURCE

The methodology of this article firstly focuses on the collection of literature related to the CE and SD, mainly drawing on recent articles (less than 5 years old) published in specialized journals. The figures provided by various international and national institutions constitute

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our second source. These have been collected precisely in order to draw up an inventory of the waste situation at different levels.

It appears that the universal values and principles of SD and the CE are implemented in different ways from one country to another. Indeed, socio-economic, environmental and cultural contexts must be taken into account when developing strategies to respond better to the most pressing issues (Komiyama & Takeuchi, 2006).

Thus, with regard to the choice of country for our field study, Algeria is an interesting one for several reasons: firstly, it is a developing country characterized by strong demographic growth, accelerated urbanization and diversified economic activities that mainly focus on services. Nevertheless, these aspects are the direct cause of waste growth. In addition, Algeria, a country whose economy is mostly dependent on hydrocarbon exports could lead to income decreases if the prices of these hydrocarbons internationally, fall below the extraction costs, urgently needs to seek alternative sources of income instead of depending on fossil fuel exports. The CE could pave the way for the creation of new green, inclusive and sustainable jobs (OEDC, 2021).

In order to answer our question about whether there is a sustainable CE in the context of waste management in Algeria, our approach firstly consists of collecting the various texts and regulations governing the waste sector in Algeria and analyzing how aligned they are with the principles of sustainable CE. Next, the central work of this article is based on a comparison between the first waste management programs, in particular the NMSWP and the NSWMP, on the one hand, and the new NIWM-2035, on the other hand.

The first two programs were developed within the framework of Law 01-19 of 2001 to constitute an emergency response to the proliferation of waste; as for the new NSIWM-2035, it is the fruit of a collaboration between several parties. Indeed, this strategy is part of a support program for a sectoral environmental policy overseen by the Ministry of the Environment and Renewable Energy and supported by the European Union. Its implementation was entrusted to an international design studio involving GIZ INTERNATIONAL SERVICES[5] and EY BUILDING A BETTER WORKING WORLD[6] , which may suggest certain rigidity in the strategy due to the fact that stakeholders who are at the heart of the waste management problem in Algeria, among others local authorities, are not directly integrated in its development.

The analysis method firstly involves developing an inventory and a record of the evolution of the waste situation in Algeria while seeking to eliminate the shortfalls and losses suffered by the sector in terms of the absence of recovery strategies, in particular compost and recycling. Secondly, an analysis is carried out of the contributions for the NSIWM -2035 strategy when it comes to the integration of the CE's principles. Thus, in this strategy, the four scenarios envisaged are examined, efficiency, profitability and financial empowerment of the sector, and growth in the proportion of composted or recycled waste to 30%.

[5] The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is a provider of international cooperation services for sustainable development, which operates worldwide.

[6] EY BUILDING A BETTER WORKING WORLD is a British financial consulting and audit firm whose objective is to create a better working environment internationally.

4. RESULTS OF SUSTAINABLE WASTE MANAGEMENT AND ITS RELATIONSHIP WITH THE CE

Since the 2000s, faced with the proliferation of waste due to demographic and economic growth, Algeria has reacted most notably by setting up various legal instruments and developing the first operational strategies, including the NMSWP and the NSWMP, to ensure the collection and burial of waste. Having to deal with the linear vision of waste management, where recovery and recycling are marginalized in the absence of economic and legal incentive instruments, there is a need to adopt a new vision based on the principles of the CE which begins with effective, sustainable and integrated waste management by minimizing environmental risks while creating an economic sector generating income. The NSIWM-2035 is at the heart of these changes. The objective of this strategy is to stop financing the waste sector, in particular, the investment expenditures by the State, and to achieve a financial balance in terms of revenues and expenditures by introducing new incentives and taxes.

4.1. Demographic data and consumer behavior

Algeria has experienced strong population growth estimated at 45 million inhabitants in 2022, which could reach 50 million by 2050 (National Statistics Office 2022). This demographic growth as well as the development of urbanization and economic activities have led to an increase in the number of generators and the quantity of waste. In 2017, the annual average of waste generated per inhabitant per day amounted to 0.8 kg in urban areas and 0.65 kg in rural areas, with an annual growth rate of household and similar waste (HSW) of 3% (Kratbi, 2017). With this in mind, we can assume that population growth and the urban phenomenon are in direct and positive correlation with the rise in waste. As such, the World Bank (2022) has estimated that with population growth and accelerated urbanization, annual waste production will go up by 73% compared to 2020 levels to reach 3.88 billion tons in 2050. In the same vein, as Chen (2018) has clearly demonstrated, urbanization also leads to changes in consumer behavior and consequently the amount of household waste produced. The following points show the changes recorded in the composition of HSW in Algeria in recent years.

4.2. Waste production in Algeria

According to the report on the state of waste management in Algeria (National Waste Agency, 2020), the total amount of HSW produced in 2020 totaled 13.5 million tons, 90% of which represented household waste. Assimilated waste, resulting from economic and administrative activities including industry, commerce, services and administrations, made up 10%. In order to keep the increase in waste as low as possible, different scenarios have been drawn up within the framework of the NIWM-2035. Thus, the quantity of HSW will reach 23 million tons in 2035 in the case of Business As Usual (BAU). If the strategy is implemented, by introducing various measures such as prevention and financial incentives, it will be limited to 20.5 million tons with a recycling rate that could be as high as 25% to 30%.

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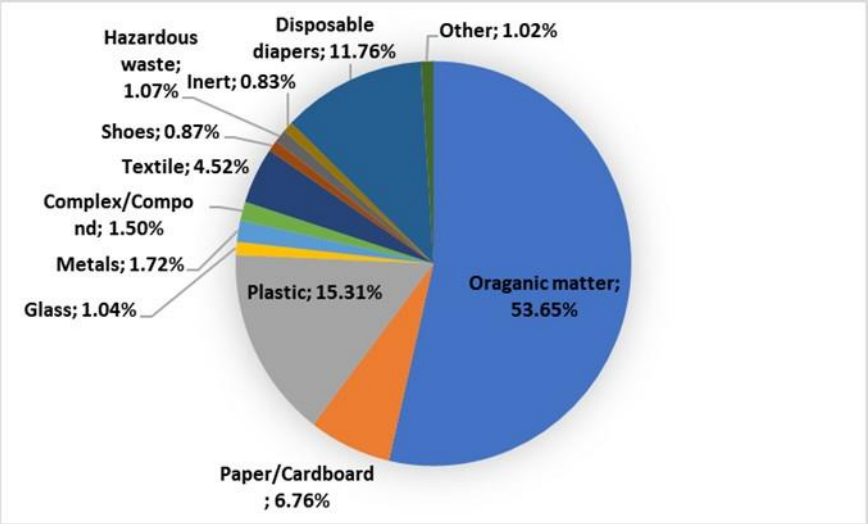
4.2.1. Composition of HSW: potential oriented towards composting

As regards the structure of HSW, a characterization study was undertaken by the National Waste Agency in 2014 with the objective of determining the most appropriate valorization technique. During this period, organic waste was first, at 54.40%, hence the recommendation for organic recovery. Recycling was in second place for the plastic, paper, glass and metals proportion which represented 30%. Finally, energy recovery of the materials for health care percentage was 12%. This data was updated in 2019 in order to identify the most appropriate treatment channels that could be used as a projection for the next 10 years. Figure 1 gives an overview of the composition of HSW in 2019.

Figure 1. Composition of household waste and similar in 2019



Source: National Waste Agency, 2020

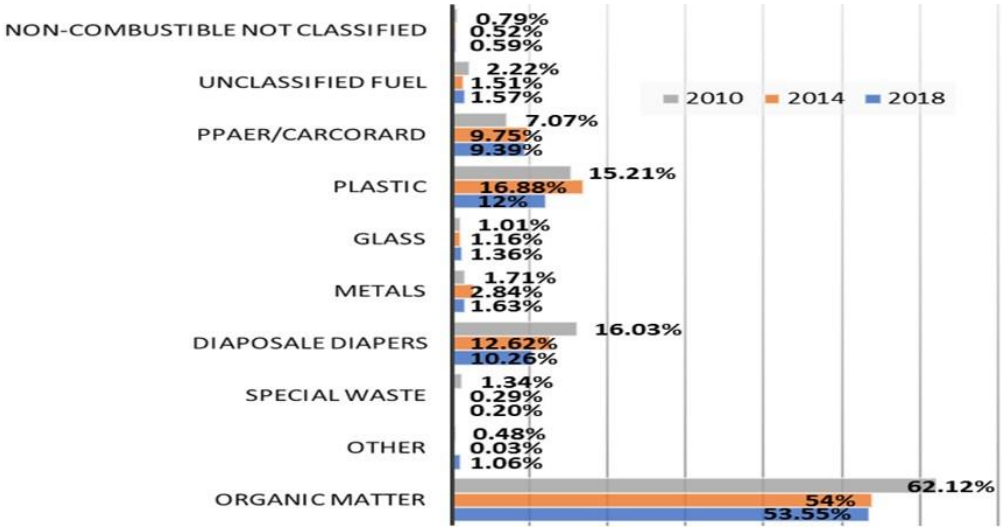
Likewise, the characterization of HSW in 2019 highlighted the significant potential of the composting sector with the predominance of organic waste. Plastic and paper recycling was also a significant investment sector, as seen by the amount generated (15.31% and 6.76%, respectively). Unfortunately, it was noted in the same year that waste recovery, recycling in particular, did not register a rise since the rate of recycled waste represented only 7%.

4.2.2. Changes in the composition of HSW

Regarding the transformation and change of the composition of HSW between 2010 and 2019, it should be noted that the proportion of organic waste dropped from 62.12% to 53.65% between those years. As already discussed above, this was due to population growth and urbanization. Likewise, an increase in birthrate led to a rise in the figure for disposable diapers, from 10.26% to 16.03%. Specific techniques for the treatment of these types of waste should be developed because the materials used are neither combustible nor decomposable. The development of the collectors who informally activate in the waste sector, specializing in paper and cardboard waste recovery from households and at waste drop-off points, has caused the rate to fall from 7.07% in 2019 to 9.75% in 2010. The same was observed for the proportion of plastic. Ferrous metals were also recovered at the source, which explains why

they were practically absent at the technical landfill center level, at 1.71% in 2019 compared to 2.84% in 2014. (National Waste Agency, 2020).

Figure 2. Change in composition of HSW between 2010 and 2018



Source: National Waste Agency, 2020

4.2.3. State of HSW recovery and its potential

In order to assess the potential of composting and recycling for HSW, research was conducted in 2017 in the NSIWM-2035. The study considered the volume composted and recycled in 2016, the potential of compost and recyclable materials included in the composition of HSW provided by the National Waste Agency and the calculation of the deposit price based on market prices. The international prices of compost and recyclables were also taken into account.

For composting, it was considered that the real value of the produce was the result of their competitiveness compared to the market price as well as its differentiation where the compost produced was certified and 100% organic. In this sense, it was noted that the international price of organic compost amounted to 100 US dollars/ton and the cost of compost recovery was not even half this amount, valued at 5580 DZD (Algerian dinars)/ton. For recycling, the study adopted the average prices provided by the German Society for International Cooperation (GIZ) and the National Waste Agency in 2017. Several other factors were also taken into account to determine the prices such as composition and source. Table 1 gives the average prices for recyclable waste.

Table 1. Average prices for recyclable waste

Waste		Average price (DZD/ton)
Plastic all combined		**32,000**
Paper and cardboard		**9,000**
Glass		**3,713**
Ferrous and non-ferrous metals		**13,600**

Source: Cross-checking data from the Ministry of the Environment and Renewable Energies, 2018. NSIWM, p. 49.

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Thus, in order to establish the situation of the achievable potential for composting and recycling of HSW, several databases were cross-checked. For market cost, the average for the data provided by GIZ and the National Waste Agency was taken into account. The production costs and the recovery rate were determined based on Chamieh et al (2016) whose body of work focused on economic instruments to encourage recycling in Lebanon. The site "alibaba.com" provided the prices of compost and recyclables internationally for valorization. A recovery ratio was calculated for each category of waste comprising the assimilated household waste. Table 2 shows the potential of composting and recycling.

Table 2. Potential of composting and recycling

R = International price/ ((market cost + production cost)*technical recovery rate)

Category	Market cost (DZD/ton)	Production cost (DZD/ton)	International valuation price (DZD/ton)	Recovery rate (%)	Ratio
Compost	1500	2220	5580	45	3.0
Plastic	32000	179955	184735	58	0.9
Paper	9000	62942	136264	75	1.9
Glass	3713	18637	78343	85	3.5
Metal	13600	43915	458453	85	8

Source: Cross-checking data from the Ministry of the Environment and Renewable Energies, 2018. NSIWM

Table 2 shows that the cost of plastic recovery was higher than its international price since the ratio was 0.9, due to not having the right means available to recycle it or valorize it which requires both significant investments and quantities of plastic to allow economies of scale to be realized in the long term. In actual fact, compacted plastic materials were exported to China for recycling (Ministry of the Environment, 2017), so to remedy this, the NSIWM-2035 has recommended an alternative for recycling plastic waste, namely the production of Fuel Derived from Waste (FDW) which would be used in cement and metallurgy furnaces. In order to verify how profitable it could be, the calorific value of the fixed-term contract should be compared with that of coal and petroleum-derived fuels. The study has shown that the FDW has a noteworthy economic value when compared to other petroleum products with a ratio of 1.6 against coal and 2.4 against Petcoke, which is used in metallurgy and cement. However, the use of this fixed-term contract would require considerable investments in power plants in order to adapt the material to this type of fuel. For this to happen, measures to export this alternative energy should be contemplated.

Compost and other recyclable household waste yield international price/production cost ratios of more than one, as well as a positive ratio of up to 8 for metal. Opening and closing exports of ferrous and non-ferrous metals within the framework of several laws of engagement constitutes a paradox and an obstacle to developing its potential and recycling efficiency. Article 84 of the 2007 Finance Law established specifications to allow for the export of waste, including metals. Subsequently, Article 75 of the 2014 Engagement Law announced that the export of scrap ferrous and non-ferrous metal, including lead, as well as used batteries, would be suspended. In July 2021, the Minister of Commerce announced that the export of products from recycled metal waste would be reopened. Even more recently, in March 2022, the President of the Republic ordered the suspension of all metal export operations once again.

4.3. Quality of legal and institutional regulation

Although several authors have identified local territories as relevant levels of activation for CEs (Niang et al, 2020), effective and sustainable waste management cannot be developed without a legal-institutional framework that allows the role of each actor to be identified, in particular the integration of the private sector and civil society so as to pool and coordinate their efforts. The implementation of an effective waste management strategy, with a view to the environment, can be carried out within a regulatory and institutional framework integrating, economic incentives, environmental and social legislation, and import and export guidelines, as well as coordination measures between the various actors at local and national levels in order to respond correctly to the strategy.

To this end, concerned about the growing proliferation of waste, and in order to develop an effective, sustainable and efficient waste policy, Algeria has introduced a range of regulatory and institutional measures. Here, several government actors are involved in waste management: at the central level, responsibility for the global policy and the national integrated management plan has been placed on the Ministry of the Environment and Renewable Energies, replacing the Ministry of Water Resources and the Environment which itself was the result of a merger of two ministries in 2016. It should be noted, however, that the skills dedicated to it remain insufficient in terms of operationalizing and executing the national waste management strategy which are under the control of the Ministry of the Interior and local authorities since its implementation is at the municipal and regional levels. Likewise, Various structures have adopted the status of Public Establishment of an Industrial and Commercial nature (PEIC), dedicated specifically to waste management and linked to the Ministry of Water Resources and the Environment. PEICs ensure that local and regional authorities in particular are well coordinated, although they suffer in terms of the methods of implementation made available to them.

At the local level, in accordance with Law 01-19, waste management is the responsibility of local authorities, in particular the municipality and the region. Although the announcement went under the radar, the municipal and regional codes address environmental issues in different articles. In order to effectively manage waste at the local level, regional and municipal PEICs can also be created. However, according to the National Waste Agency's report (2020), most municipalities must supervise the collection and treatment of waste directly. These structures are also put under the supervision of the Wali (prefect).

It also constitutes an essential step towards achieving the strategic objectives of the NSIWM by 2035, which consists, though not exclusively, of recovering 30% of household waste, improving sorting waste, and encouraging the private sector to invest in treatment infrastructures.

4.4. Financing of the waste recovery strategy in Algeria

Since 2001, Algeria has had a policy in force based on operational programs dedicated to waste management in order to provide the waste sector with financial, material and human resources. However, the issue of its financial autonomy arose during the first few years of their implementation. It is clear that in order to achieve profitability and efficiency objectives, expenses must be rationalized, which is why the NSIWM-2035 has been mapped out.

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4.4.1. Waste management as part of the NMSWP and NSWMP 2002-2016

Between 2002 and 2016, the total expenditure of the waste management strategy reached 88.1 billion DZD (the Ministry of the Environment and Renewable Energies, 2017). It has been noted that the financing consisted mainly of the contribution of the central government of up to 95% while the local authorities, which nevertheless ensured the coverage of the operations, only contributed toward 0.4% of the total expenses. Moreover, the majority of these expenses were directed toward investment in the construction of controlled landfills amounting to 67.4 billion DZD and in technical landfill centers to the value of 36.8 billion DZD. The expenses To perform the master plans for household waste and special waste only 0.4% of the total budget was set aside (the Ministry of the Environment and Renewable Energies, 2018). This shows that the strategy undertaken by the Algerian state during this period was oriented more toward waste burial.

Table 3. Distribution of waste management expenses for the period 2002-2016

Source	Expenditure in billions of DZD
Central government and special programs	84.04
Various funds	1
Local government	0.4
External financing	2.5
Total	88.1

Source: Ministry of the Environment and Renewable Energies, 2018

Given that the first waste management programs were reactive, they did not either control the amount of waste produced, nor did they increase the amount of waste recovered, causing other plans to be devised within the framework of the NSIWM-2035.

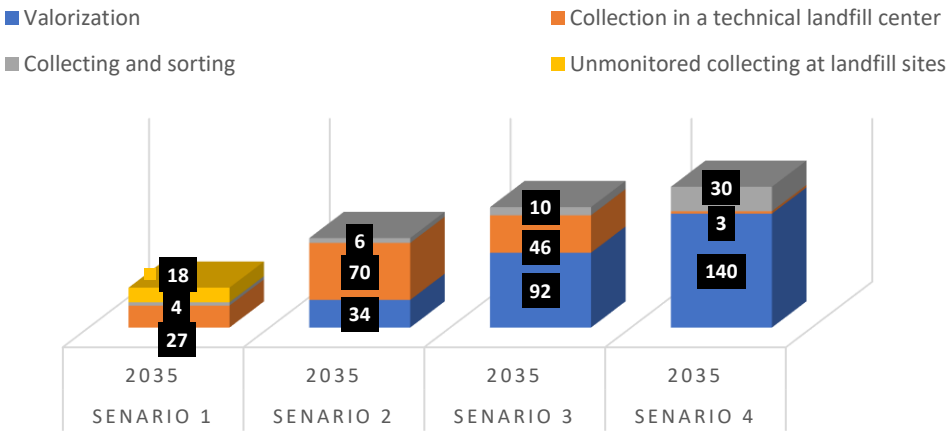
4.4.2. Strategies aimed at valorizing and empowering the sector

The economic and financial analysis of the NSIWM-2035 aims to financially balance the HSW sector and to analyze its expenses and revenues. It also proposes investment options, management, the valorization of composting and recycling, and the recovery of the sector's costs by 2035. Doumani (2017) highlighted an estimate and a financial simulation (Appendix 1) by making projections on the waste situation by 2035 in different scenarios:

- Firstly, it is important to determine a basic scenario by not making changes to the current situation;
- Next, three other scenarios should be discarded by modifying the tax rates and the valuation rates in order to determine the difference between investment and revenue.
- Finally, it is necessary to go for the scenario that will make it possible for the gap to be narrowed between the investment made and the revenue received.

This strategy seeks to be in line with the CE's principles since it is based on those of the 3 Rs, discussed previously. Figure 3 informs us about the simulations used in each scenario.

Figure 3. Investment cost for each scenario of the NSIWM -2035 (billions of DZD)



Source: Doumani (2017), p.71.

From Figure 3, we can see that the investment costs for integrated waste management vary in each scenario. Scenarios 2 to 4 envisage the eradication of traditional landfills. The investment costs for waste recovery increase from scenario 2 to 4, at 34, 92 and 140 billion DZD, respectively. The breakdown of the financing in each scenario has been calculated on the basis of the Tax for the Removal of Household Waste (TRHW) and the income from the recovery of compost and recycling. It has also been assumed that the government will guarantee coverage in the event of a deficit via incentives and subsidies from new regulations.

This study shows that the first three scenarios have deficits and are, therefore, not viable. On the other hand, the fourth scenario should constitute a viable way of financing the HSW sector only if the TRHW is raised to 1% of household income with a recovery rate of 41.12%. Indeed, the current and recalculated rate of the TRHW does not allow there to be effective management of HSW. A tax of 1% of household income is recommended in developing countries in order to cover the costs of collection and cleaning. Moreover, the integration of the polluter-pays principle in Algeria could bring the waste tax up and exceed the alternative of 1% of households, to be able to cover the HSW management chain (MERE, 2018b).

Indeed, if a TRHW of 1% of household income were to be adopted, it would be means-tested and it would have raised up to 26.9 billion DZD in 2035, considering a recovery rate of 80%. Thus, as shown in the table below, 66% of the TRHW would be deducted from households for the 6th to 10th categories[7] , namely the middle to the wealthy classes. In addition, this increase in the TRHW would be carried out gradually, at a rate of 0.5% of household income for the first 5 categories and at 1% for the 6th to 10th categories to raise more equity. This amount would thus be increased to 48.6 billion DZD if households and companies were considered, with a recovery of 80%.

[7] The TRHW raised from each income bracket is the same for the first 5 categories (at a rate of 1,000 DZD considered per household) and the 6th to 10th categories (at a rate of 1,500 DZD considered per household) denote a flat-rate tax instead of a means-tested one.

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Table 4. Current and alternative TRHW rates for households, with 100% recovery

Household income bracket	Current household rate, with 100% recovery		Alternative rate: 1% of household income, with 100% recovery	
	Current rate considered (DZD/household)	Total DZD (in billions)	Alternative rate considered (DZD/household)	Total DZD (in billions)
Category 1	1,000	0.7	3,214	2.3
Category 2	1,000	0.7	4,113	3.0
Category 3	1,000	0.7	4,625	3.4
Category 4	1,000	0.7	5,127	3.7
Category 5	1,000	0.7	5,609	4.1
Category 6	1,500	1.1	6,115	4.5
Category 7	1,500	1.1	6,763	4.9
Category 8	1,500	1.1	7,522	5.5
Category 9	1,500	1.1	8,900	6.5
Category 10	1,500	1.1	14,716	10.7
TOTAL		9.1		48.6

Source: Doumani (2017), p. 45.

With regard to composting and recycling, the revenues could total 38 billion DZD, which would be below the amount calculated in the fourth scenario compared to the investment costs for the recovery. In order to reduce the differences between investment and income, Doumani (2017) recommended the recovery of all types of waste, even outside the technical landfill center, the in-depth analysis of the amount and facilitation of the collection and coverage TRHW and the need for electricity to be produced in the centers.

5. DISCUSSION

The results of this study demonstrate that, in the long-run, waste recovery could mean an increase in the sector's revenues if compostable and recyclable products are transformed, as long as their quality meets international standards. It is also essential that the prices of these recycled products are compared with international prices in order to establish efficiency ratios. In our case, the latter show margins of 0.9 for plastic but up to 1.5 times for plastic if it is converted into fuel, 2 times for paper, 3 times for compost, 3.5 times for glass, and 8 times for metals. However, several other parameters must be taken into account, in particular the quality of the valorization of compostable and recyclable products as well as the quantity of them, which require know-how of valorization and sorting at the source. On the other hand, it is important to point out that these crucial steps are struggling to be implemented in Algeria since they take a long time to put into practice. Moreover, as the experience of cities such as San Francisco demonstrates, recycling rates of 40% and 70% have only been able to be achieved after 4 and 8 years, respectively, with strict monitoring of the strategy's implementation (Doumani, 2017).

To achieve the objectives of the NSIWM-2035 and financially empower the waste sector in Algeria, the current TRHW recovery rate is not enough to cover even the transport costs; therefore, increasing it to 1% of household income is essential. In addition, the procedures and techniques of composting and recycling can have negative consequences for the

environment if the standards of transformations in the units are not taken into account in accordance with SDG 13.

A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was prepared by Doumani (2017) on the overall state of the waste sector, in order to help define the integrated waste management strategy. Indeed, it emerged from this analysis that the strategic framework of the NSIWM-2035 was in the development phase and that there were signs of political will for it to be implemented. It was also noted that the potential for recycling and compost constitutes an opportunity for Algeria, in terms of cost reduction, job creation, and a positive impact on the environment.

It should be recognized, however, that weaknesses and threats outweigh strengths and opportunities. In terms of weaknesses, it is not easy to develop a specific taxation system for waste. Likewise, the recovery rate of TRHW remains low, for both HSW and special waste. Besides this, the regulatory, institutional, organizational and incentive frameworks are out of step with the support structures that should encourage manufacturers to comply with the regulations. As a result, the private sector remains marginalized in the areas of collection, landfill and processing. The waste sector is also dominated by the informal sector, which is often difficult to identify and control. Furthermore, awareness-raising and communication have also been sidelined removed from the national strategy. There are threats of an exogenous nature linked to the various international and regional shocks that could hinder foreign investment flows in the context of waste. The 51/49 rule established by the Algerian government with its protectionist vision and its rule stating that foreign financing and loans must not be relied upon to assist Algeria in its waste sector reforms turns companies and international institutions away. The authorities responsible for the NSIWM-2035's entry into force could also notice only slight impact since the elaboration of this strategy has marginalized them.

6. CONCLUSIONS AND RECOMMENDATIONS

The CE, as a response to the linear capitalist production model in the ecological sense, has important opportunities economically, socially and environmentally. By operationalizing the CE's foundations, which are based on the non-dominance of the economic dimension, they would be perfectly aligned with the principles and paradigms of sustainable development. A CE cannot be implemented and activated without minimizing resources in the first place, based on the promotion of positive consumption habits. The recovery of waste, in particular through recycling, comes last in the circular loop once it has exhausted the reuse and repair stages.

Algeria, like any country at breaking point with a waste crisis, caused by demographic, economic and urbanistic change, has taken several measures to try to handle the situation. In this body of research, we analyzed the Algerian strategy's degree of applicability as well as its relevance and coherence to the universal principles of sustainable waste management within the CE's framework. It appears that the Algerian waste management policy is reactive, bearing in mind that the country had not shown any willingness to protect the environment or activate a CE that could meet the SDGs until 2016. Owing to the limited scope of the operational strategies NMSWP and NSWMP, among others, which only focused on collection and the burial of waste, the lack of effort made was clear to see. The NSIWM, set up in 2017 and observable to 2035, is intended to be a way to introduce new techniques for recycling and sustainable waste management. However, this strategy is still in a transitional period as of

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2023 (having begun in 2018), the objective of which is to establish an inventory of current waste management.

Several other factors, particularly of an institutional, legal and economic nature, have hindered the activation of a CE from the perspective of sustainable waste management in Algeria. Similarly, stakeholders' tasks and responsibilities have not been clearly defined in the regulations. The various decrees drawn up are not always aligned with the law of 2001, notably in the case of the continuous halting and resuming of ferrous and non-ferrous metal exports. The regulations, most of which are oriented towards HSW, do not offer any encouragement for sorting at the source, separate collections or appropriate perks such as exemptions or subsidies, which would further reduce the economic value of waste. The private sector is also almost absent in the development of programs (NMSWP, NSWMP). However, the second period of operationalization of the NSIWM (2023-2030) plans to bring the private sector into the waste market and finally, it is only towards the anchoring period (2030-2035) that the government aims to attribute the primary role to the private sector.

Thus, for waste recovery to be considered as raw material that could replace imported materials and for it to be incorporated in the manufacturing process, compost and recycling are essential. However, the valorization carried out by the public sector for technical landfill centers is not enough to allow for the non-involvement of the private sector, which always remains marginalized due to their not being given incentives or offered risk insurance.

The NSIWM-2035, prepared with SDGs in mind, could present opportunities that will make it possible for the principles of integrated and sustainable waste management to be reconsidered within the framework of the CE. To formulate and implement this strategy, the involvement of all stakeholders is essential, including households, and both the public and the private sector. In order to make the sector profitable and financially balanced, it is essential to increase the rate of collections and tax, particularly the TRHW, as well as the recovery of recyclables and compost. At the cultural level though, it could take several years to materialize, as a change in habits at schools, in households and at companies is necessary.

Finally, it should be said that the way that the waste management strategy is organized and financed presents operational constraints. It is mainly organized at the local level by the communities which are paradoxically devoid of any autonomy or financial contribution. It would be more appropriate to adopt an institutional and legal approach that took into account the transition to the CE while granting the private sector and green entrepreneurship the operating mechanisms. If that were the case, the authorities would only assume the role of regulator and controller, specifically by offering incentives and tax relief.

AUTHOR CONTRIBUTION

Conceptualization, MH and BA; data curation, MH; Formal analysis, MH; Methodology, MH and BA; Writing – Original Draft Preparation, MH and BA; software MH, writing-revision and editing, MH. All authors reviewed and agreed to the published version of the manuscript.

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Appendix

Annex 1: The four scenarios of the national integrated waste management strategy 2017-2035

Scenario	Investment	Income	Deficit coverage
Scenario 1: BAU Investment: C1%-R7% Financing: Current TRHW, Compost income and Recycling	- Collect at 82%	TRHW at 25%, 50% et 80%	Subsidies, incentives, calibration and the introduction of eco-taxes
	- C1%-R7%	Sale C and R Gross	
	Residual landfill 31%		
Scenario 2: Investment: C15%-R15% Financing: recalculated TRHW and revenues from semi-finished products	Bring the collection to 100%	TRHW recalculated at 25%, 50% and 80%	
	C15%-R15%	Sale compost/semi-finished materials	
	Residual landfill	Electricity production	
Scenario 3: Investment: C25%-R25% Financing: recalculated TRHW and revenues from semi-finished products	Bring the collection to 100%	TRHW recalculated 25%, 50% and 80%	
	C25%-R25%	Sale of compost-recycling	
	Residual landfill	Electricity production	
Scenario 4: SDGs Investment: R50%-C25% Financing: increased TRHW and income from semi-finished products	Bring the collection to 100%	TRHW increased to 25%, 50% and 80%	
	C50%-R25% and transformation into semi-finished materials and calculation of the reduction of the carbon footprint	Sale of compost/semi-finished recycled materials	
	Residual landfill	Electricity production	
Parallel activities			
Scenarios 2 to 4	Execute the master plans	Government	
Scenarios 2 to 4	Rehabilitating uncontrolled landfills	Government	

Source: Doumani (2017). Annex VI: Economic and financial analysis of the NSIWM -2035. P65