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Assessing of sustainable and integrated waste management in the prefecture of Marrakech, based on the "wasteaware" model.

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Abstract

This article proposes a set of indicators for assessing the integrated and sustainable management of household and similar waste, drawing on UN-Habitat's pioneering work in global solid waste management. The analytical framework divides the urban solid waste management system into two interconnected "triangles": one covering physical aspects such as collection, recycling, and disposal, and the other focusing on governance dimensions, including inclusiveness, financial viability, and the strength of institutions and policies. Using the case of the Marrakech prefecture, with a population of 1,405,373 and an urbanization rate of 74%, the article highlights the evolution of waste management practices, particularly after the establishment of the city's waste disposal and recovery center in 2020. The study identifies both strengths and areas for improvement in the local waste management system, providing a strategic basis for future enhancements. Despite key advancements, challenges such as low recycling rates and informal waste recovery continue to hinder progress towards a circular economy.

Abbreviations: CEV ,Centre d'Elimination et de Valorisation ;CNSS, Caisse Nationale de Sécurité Sociale ;GNI, Gross National Income ;PNVD :Plan National de Valorisation des Déchets ;SNRVD :Stratégie Nationale de Réduction et de Valorisation des Déchets .

Keywords: " wasteaware " model; Household and similar waste ; Integrated Sustainable Waste Management ; Marrakech prefecture.

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1. Introduction

The exponential growth of the human population, coupled with urbanization and industrialization, has resulted in massive waste production (Kanojia & Visvanathan, 2021) . Changing lifestyles and increasing levels of expenditure further exacerbate this problem (Ramachandra et al.,2018; Weng & Fujiwara, 2011). This significant increase in the amount of waste generated (Ma & Hipel,2016) has prompted both developed and developing countries to focus on managing the waste produced (Vergara & Tchobanoglous,2012).

Indeed, the household and similar waste management is transitioning from simple disposal in uncontrolled landfills to sustainable practices such as reuse, recycling ,and reduction (Shekdar, 2009; Agamuthu & Fauziah, 2011; N. Li et al., 2013) as cited in (Ma and Hipel,2016) .Thus, waste management aligned with the principles of the concept of sustainable development must ensure the attainment of both the social and economic objectives of economic agents while minimizing the environmental burden (Khudyakova & Lyaskovskaya,2021).

Consequently, Sustainable waste management is based on four essential principles (Aloueimine, 2006) : the use of optimized technologies to reduce pollutants, the implementation of reuse, recycling, or composting systems, the disposal of waste with consideration for the environment, and the final burial of non-reusable waste. However, the success of waste management depends not only on technical innovation but also on the involvement of all stakeholders (Ma & Hipel, 2016), such as national and local governments, municipalities, NGOs, businesses, and citizens (Guerrero et al., 2013). Educating citizens to reduce waste and installing recycling equipment are crucial measures to decrease overall waste production (Loan et al., 2019).

1.1. Waste management in Morocco

Morocco is a North African country with a remarkably high urbanization rate of 60.3% (HCP, 2014). The annual population growth rate is approximately 1% (World Bank, 2022). As in other developing countries, rapid socio-economic changes have led to production and consumption patterns that often neglect environmental impacts. Consequently, waste generation has significantly increased, from 600,000 tonnes per year in 1960 to over 7.82 million tonnes per year in 2019 (SINEDD, 2020), representing a 13-fold increase. This growth is considerably higher than demographic growth, which only tripled over the same period (REEM, 2020).

Waste management in Morocco began with efforts to improve waste collection while minimizing environmental impacts. These Efforts also include the burial of waste in compliance with international standards and the closure of unauthorized dumps.

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Indeed, the results in terms of collected quantities are very encouraging: by 2020, the rate of professionalized waste collection had reached 96%, representing to 5.3 million tonnes per year, compared to just 44% in 2008. Historically, collected waste was often disposed of in unauthorized dumps, without impact assessments or appropriate treatment. To align with environmental standards, Morocco has implemented a program to rehabilitate and close illegal dumps. To date, 53 such sites have been rehabilitated and closed, with further closures planned in the near future.

Currently, 26 controlled landfills and recovery centers (CEVs) are operational, with the selection of these sites determined through a multi-criteria analysis. Despite these efforts, the proportion of household and similar waste actually recycled in Morocco did not exceed 380,000 tonnes, or 6%, in 2015, while the quantity potentially recyclable is estimated at 1.4 million tonnes (SNRVD, 2019).

1.2. Waste management in Marrakech

The prefecture of Marrakech, covering an area of 2,625 km², is a decentralized territorial entity with legal personality and financial autonomy. It serves as the capital of the Marrakech-Safi region, with an estimated population of 1,428,167 in 2022 (CERED-HCP projection, 2017).

In recent years, the city has experienced significant rural exodus, which has greatly accelerated the urbanization rate, reaching 74% (Ibid.). This dynamic has resulted in an exponential increase in waste generation, estimated at 535,718 tonnes in 2022 (PDPGDMA projection, 2019). Additionally, the composition of this waste has shifted, reflecting changes in the population's lifestyle and the diversity of socio-economic activities.

2. Methods

The Wasteaware indicators offer a comprehensive framework for integrated and sustainable waste management, enabling performance assessment at both municipal and national levels. These well-established indicators are now widely available, addressing the historical lack of global comparative data on waste management (Wilson et al., 2015c).

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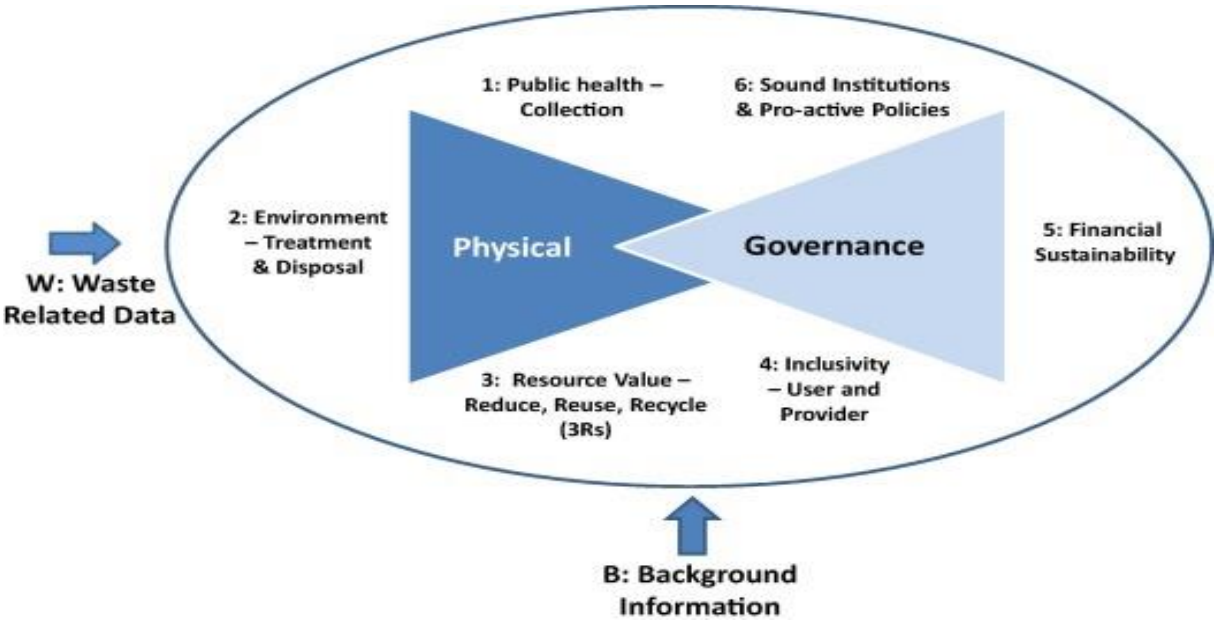
Fig. 1. The Integrated Sustainable Waste Management (ISWM) framework used by the Wasteaware indicator set.



Source: Wilson et al. (2013)

The purpose of the Wasteaware indicators is not to assign a pessimistic score but rather to utilize existing data, without the need for a primary survey, to provide an overview of waste management performance. This approach helps identify strengths and weaknesses, guiding efforts toward a sustainable waste management system (Wilson et al., 2015c).

It is important to note that the scope of these indicators includes all municipal solid waste, covering household waste, similar types, and some commercial waste. However, it generally excludes major industrial waste and construction debris (Scheinberg et al., 2010).

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3. Results and discussion

Table 1 : Wasteaware benchmark indicators for Marrakech prefecture

Category	Indicator	Results
Country		Morocco
City		Marrakech
Background information on the country		
Country level income	World Bank income category	Low
	GNI per capita	3442 US dollars
Population	persons	1 405 373
Waste generation per capita	(tonnes /year)	7,82 Mt/an (in 2019)
Waste related data- City		
Waste per capita	(Kg /day)	1,13 in urban area 0,5 in rural area
Waste composition		
Organic	Percentage	72
Paper	Percentage	14
Plastics	Percentage	7
Glass	Percentage	2
Metals	Percentage	1
Textiles	Percentage	4
Physicals compents		
Public Health- Waste collection	Waste collection coverage	80 % Medium
	Waste captured by the system	65,50% low/Medium
	Quality of the waste collection service	95,83% Medium /High
Environmental control -Waste treatment and disposal	Controlled disposal and treatment	65,50% low/Medium
	Degree of environmental protect ion in the treatment and disposal of waste	90,00% Medium/High
Resource management- reduce, reuse and recycle	Recycling rate	16,3% Low/Medium
	Quality of 3Rs	41.66% Low
Governance factors		
Inclusivity	User inclusivity	66,66% Low/Medium
	Provider inclusivity	100,00% High green
Financial stability	Financial sastainability	40,00% Low
Solid institutions and proactive policies	Adequacy of the national solid waste management framework	91,66% Medium/High
	Local institutional coherence	100,00% High

Key: Indicators assessed into five categories and colour coded

LOW	LOW/ MEDIUM	MEDIUM	MEDIUM/ HIGH	HIGH

Source: Authors

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Table 1 shows that the primary composition of municipal waste in the city of Marrakech is predominantly organic matter (70%), including fruit and vegetable peelings, herbs, and similar materials. Other waste fractions consist of plastics, glass, paper, metals, and textiles (Ouchen, 2018).

The" waste collection service "is rated at a medium level (80%). It is worth noting that the collection rate in both Marrakech and Méchouar-Kasbah municipalities is exceptionally high, reaching 100%, as all neighborhoods are equally served. However, in the rural municipalities of the prefecture, the collection rate varies significantly, ranging from 30% to 77% (PDPGDMA, 2019).

Additionally, a considerable proportion of residual waste in rural municipalities is organic and is recycled as cattle feed or used for manure production. Regarding the "fraction of waste captured" by the system, this accounts for 65.50% of the waste produced (a Low/Medium score), as a significant portion of household and similar waste escapes the system due to recovery by the informal sector and open-air incineration in some rural areas of the prefecture.

The "quality of waste collection service" indicator received a higher average score of 90.00%, due to the following achievements: professionalization of the collection service, eradication of black spots, regular street cleaning, renewal of the collection fleet in line with current technical requirements (e.g., container lifts, compactors), and compliance with health and safety conditions for waste collection personnel (e.g., uniforms, gloves, and boots).

The "controlled treatment and disposal" indicator also showed a Low/Medium score of 65.5%, reflecting the proportion of household waste transported to the disposal and recovery facility (CEV), located in the SAFSAFA douar in the rural municipality of L'MNABHA. Covering an area of approximately 182 hectares, the center is accessible from the town center via National Road N°7, and then via Provincial Road RP 2002, which links the center of KETTARA to SIDI BOUATMANE. Waste is first transported to the transfer center, located at the former HARBIL controlled landfill or the SAADA transfer center, both of which are currently uncontrolled and easily accessible to informal reclaimers.

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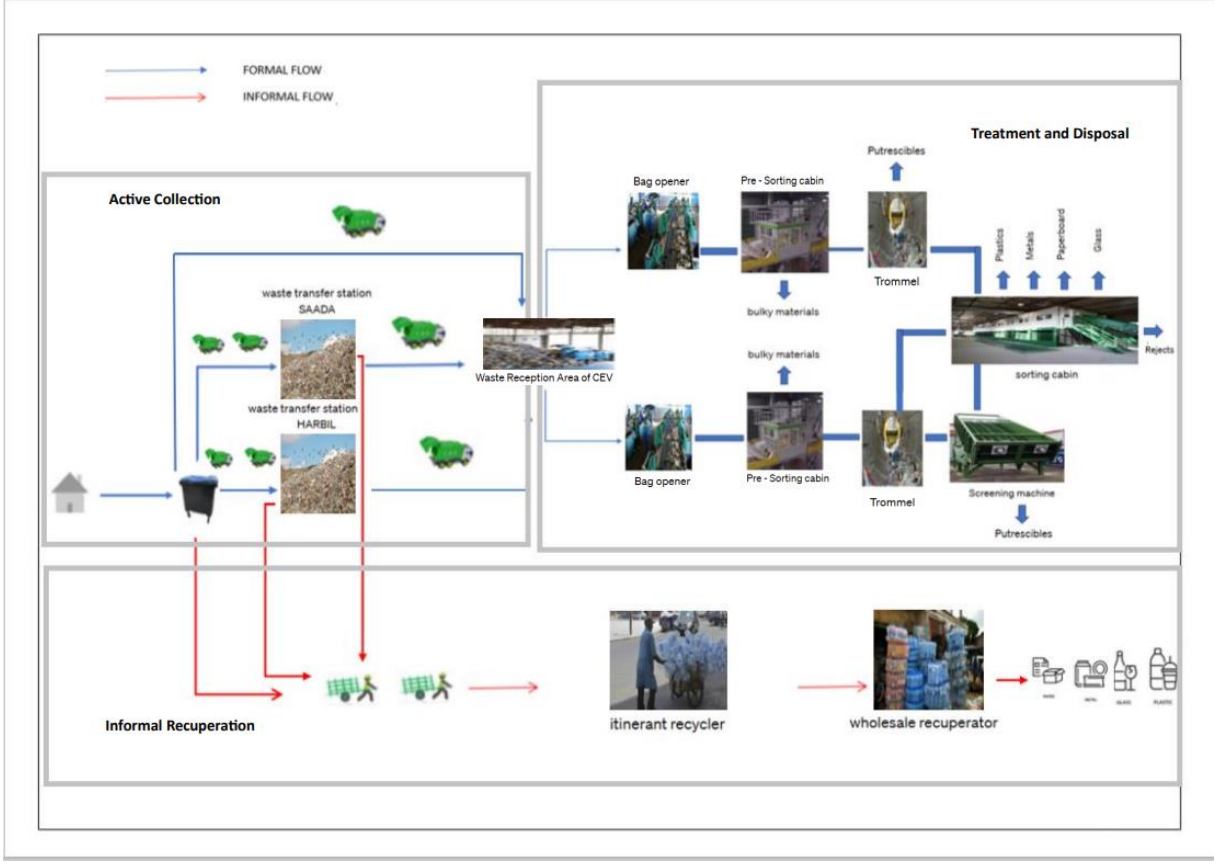
Fig. 2. Household waste process flow diagram of Marrakech prefecture.



Source: Authors

The "degree of environmental protection in waste processing and disposal" indicator received a higher medium score of 90.00%, as the waste processing site is fenced off to prevent waste from flying away and is controlled to restrict access to informal waste collectors. The waste first passes through a weighbridge, then undergoes a sorting process on two nearly identical lines—one mechanical and the other manual—to recover recyclable materials. Only inert and organic waste are landfilled, with leachate being collected but not treated. In fact, the company managing the CEV is a specialized firm, ensuring that its staff wear gloves, boots, overalls, and high-visibility vests, and are registered with the national social security fund (CNSS).

The following indicator concerns the "waste recycling rate": approximately 34.58 tonnes per year of cardboard are recycled at the Marrakech disposal and recovery center (CEV), representing 0.05% of the cardboard produced. It is important to note that no recycled paper is produced, which can be explained by the long residence time of the waste in the transfer center, leading to the deterioration of paper quality due to the humidity of the waste, as well as by the informal recovery.

The recycling rate for plastics is only 2.88%, while the recycling rate for metals is relatively high at 3.37%. This results in an overall recycling rate of 6.3% at the CEV. However, it is

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important to emphasize that the definition of recycling adopted here is based on UN-Habitat's work, which includes a range of public and private activities—both formal and informal—aimed at diverting materials from disposal to recovery for productive use. With an estimated 10% of informal recovery in Morocco (PNDM, 2008), and in the absence of specific data for the prefecture, we will adopt the national figure. Consequently, the overall recycling rate stands at a Low/Medium level, reaching 16.3%.

The "3Rs quality" indicator is rated low, with a score of 41.66%. This is due to the absence of source sorting, the lack of organic matter recovery except for a few voluntary initiatives to feed livestock, and the unhealthy working conditions of informal waste collectors. However, the construction of an Eco-center in the municipality of Méchouar-Kasbah is set to begin soon. This initiative aims to provide legal recognition to the profession of waste collectors, improve their image, and organize their work within the framework of a cooperative or a delegation.

It is important to note that the governance indicators are primarily qualitative. The "user inclusion" indicator scores a low-medium 66.66%, due to the inequity in collection services between urban and rural residents. Some rural municipalities do not manage their waste effectively, while urban areas are fully serviced. Additionally, citizens have the right to file complaints with the municipalities, and they actively participate in the selection of controlled landfill sites through public surveys, as outlined in the waste management master plan. It should also be noted that the delegated companies are required to organize awareness campaigns for citizens.

The "inclusion of service providers" indicator measures the involvement of service providers in the planning and implementation processes, achieving a high score of 100% because the city of Marrakech has delegated the cleaning service to the private sector. This service is divided in to two different lots :

- The cleaning of public spaces, as well as the collection and disposal of household and similar waste at the disposal and recovery center (CEV), which is entrusted to two delegated companies.
- The disposal and recovery of household and similar waste is delegated to a third specialized company.

In addition, a transparent call for tenders was launched for these waste management contracts, with the delegates committing, in their specifications, to carrying out a diagnosis of the informal activities on the landfill site. This is to submit a plan for the supervision and integration of informal reclaimers.

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The "financial stability" indicator is rated low at 45% due to the following shortcomings: Waste management accounts are not open to the public, and the operating costs of treatment sites are extremely high. In addition, the tax collection rate is quite low, as the municipality services tax collected is not solely dedicated to waste management but also covers all services provided by the municipality (e.g., public lighting, maintenance, etc.).

The final indicator measures the extent of regulatory practices and the organizational strength of Municipal Solid Waste Management (MSWM) in the city. This indicator achieves relatively better results due to the following achievements:

At national level

In December 2006, Law 28-00 on solid waste management was promulgated in Morocco, focusing on the prevention of the harmful effects of waste on human health, fauna, flora, water, air, soil, ecosystems, sites, landscapes, and the environment in general. The implementation of this law was reinforced by several decrees and joint rulings.

In 2008, the National Household Waste Program was established by the Ministry of the Interior and the Department of the Environment to address shortcomings in the management of the household waste sector. Spanning a period of 15 years and supported by the World Bank.

The aim of this program is to provide financial support to local authorities in various areas, such as the development of their household and similar waste management master plans, the construction and operation of controlled landfill sites, the rehabilitation of former illegal landfill sites, the professionalization of household and similar waste collection and cleaning activities, and the enhancement of the skills of managers and technicians working in the field of household and similar waste management (PNDM, 2008).

Secondly, the implementation of the National Waste Valorization Program (PNVD) and the National Strategy for the Reduction and Valorization of Household Waste (SNRVD) aims to advance the operationalization of waste treatment and accelerate the transition to a circular economy at the territorial level by promoting the growth of valorization channels that foster the creation of green jobs.

Since 2015, the promulgation of Law No. 77-15, which prohibits the manufacture of non-degradable plastic bags, has been in effect. In response, a pilot project for ecological bags (canvas bags) was launched in 13 cities in partnership with local authorities and environmental associations, offering a sustainable alternative to plastic bags.

It is important to note that several national institutions are responsible for implementing waste management policy in Morocco:

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- **The Ministry of the Interior**: This ministry supports and coordinates plans and programs related to hygiene, sanitation, and solid waste. The Directorate General of Local Authorities (DGCT) plays a supervisory role, providing essential technical and financial support to local authorities, particularly communes.
- **The Ministry of Energy Transition and Sustainable Development**: This ministry plans and coordinates initiatives in the waste management sector through the Department of Sustainable Development.
- **The Economic, Social and Environmental Council**: This institution acts as an advisor to the government, the House of Representatives, and the House of Councilors, with a particular focus on environmental issues.

At local level

The Organic Law N°113-14 grants municipalities the authority to create and manage local public services, including the collection, transportation, landfilling, and treatment of household and similar waste. In the case of Marrakech, on November 19, 2019, the municipality elected the board of the "Grand Marrakech" inter-communal cooperation establishment, which includes the fifteen municipalities of the Marrakech prefecture, some municipalities of Al Haouz, and the municipality of Sidi Bouatman. This establishment manages the delegated management contract signed between the Commune of Marrakech and the ECOMED MARRAKECH company. This establishment can help reduce costs (Bel and Costas, 2006; Bel and Mur, 2009; Bel et al., 2014; Dijkgraaf and Gradus, 2013; Struk and Bakoš, 2021; Zafra-Gómez et al., 2013) and improve efficiency through economies of scale, including information, negotiation, monitoring, and agency costs (Feiock, 2007) in (Hefetz et al.,2012).

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Conclusion

in this article, we identify the strengths and weaknesses of household and similar waste management in Marrakech and propose the establishment of an autonomous institutional framework dedicated to waste management, in the form of a national agency. This would ensure sustainable governance and leverage the knowledge and expertise Morocco has gained in this field.

Given the predominance of organic matter in the composition of household and similar waste, we recommend the introduction of a dual-stream collection system for such waste. Additionally, the installation of biological treatment centers, such as composting or methanization, should be considered to reduce and limit the polluting potential of waste. It is relevant to note that the low percentage of metals.

It is crucial to minimize the residence time of household and similar waste in the transfer center to prevent any deterioration in the quality of recyclable materials, mainly due to the high moisture content of the waste, which is estimated at 65%.

We insist on the need for waste management laws that are more repressive than incentive-based, with the obligation to set up a monitoring body to ensure that these laws are applied. In parallel, an ongoing educational program aimed at the general public is recommended to encourage citizens to engage in sorting at source and avoid bad practices. But also, the introduction of a tax dedicated to the management of household and similar waste to assist municipalities in financing the costs associated with waste management.

It is essential to include informal reclaimers in the household and similar waste management system to ensure optimum efficiency in waste recovery, benefiting from their skills and in-depth local knowledge of waste management. This integration will also encourage the creation of green jobs, improving their working conditions while ensuring adequate social protection.

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References

Aloueimine, S. (2006). Méthodologie de caractérisation des déchets ménagers à Nouakchott (Mauritanie) : Contribution à la gestion des déchets et outils d'aide à la décision.

Centre d'Etudes et de Recherches Démographiques (CERED). Haut -commissariat au plan, (2017).Projections de la population des populations des régions et des provinces 2014-2030.

Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. Waste management, 33(1), 220-232

HCP, 2014. Morocco Population Census - Marrakesh.

Hefetz, Amir & Warner, Mildred & Vigoda-Gadot, Eran. (2012). Privatization and Intermunicipal Contracting: The US Local Government Experience 1992–2007. Environment and Planning C: Government and Policy. 30. 10.1068/c11166.

Kanojia, A., & Visvanathan, C. (2021). Assessment of Urban solid waste Management Systems for Industry 4.0 technology interventions and the Circular Economy. Waste Management &Research,39(11),1414-1426.

Khudyakova, T. & Lyaskovskaya, E. (2021). Improving the Sustainability of Regional Development in the Context of Waste Management. Sustainability. 13. 1755. 10.3390/su13041755.

Loan, L. T. T., Takahashi, Y., Nomura, H., & Yabe, M. (2019). Modeling home composting behavior toward sustainable municipal organic waste management at the source in developing countries. Resources, Conservation and Recycling, 140, 65-71. https://doi.org/10.1016/j.resconrec.2018.08.016

Ma,J., & Hipel ,K.W.(2016) .Exploring social dimensions of municipal solid waste management around the globe -A systematic literature review .Waste Management ,56,3-12.

Ministère de la Transition Energétique et du Développement Durable, Département du développement durable, (2020) .4ième Rapport sur l'Etat de l'Environnement du Maroc.

Ministère de la transition énergétique et du développement durable, Système d'Information National de l'Environnement et du Développement durable (SINEDD). Available online : https://sine.environnement.gov.ma/

Ouchen, A., 2018. Waste management in the city of Marrakech : strategy, opportunities and constraints.: [La gestion des déchets au niveau de la ville de Marrakech: stratégie, opportunités et contraintes.]. AfriWaste Workshop, 7 November 2018, Marrakech, Morocco.

Préfecture de Marrakech, 2019.Plan Directeur Préfectoral de gestion des déchets ménagers et assimilés de la préfecture de Marrakech.

African Scientific Journal
ISSN : 2658-9311
Vol : 03, Numéro 27, Décembre 2024

Ramachandra, T.V., Hariharan, B., Kulkarni, G., & Han, S.S. (2018). Municipal solid waste: Generation, composition and GHG emissions in Bangalore, India. Renewable & Sustainable Energy Reviews,82,1122-1136.

Royaume Du Maroc, 2006. Loi n°28-00 relative à la gestion des déchets et à leur élimination : loi 28-00, 17 pp.

Scheinberg, A., Wilson, D.C., Rodic, L., 2010. Solid Waste Management in the World's Cities: Water and Sanitation in the World's Cities 2010. Earthscan on behalf of UN-HABITAT, London.

Secrétariat d'Etat auprès du Ministre de l'Energie, des Mines et du Développement Durable ,(2019). Rapport de synthèse de la Stratégie Nationale de Réduction et de Valorisation des déchets

Stretz, J., & Olez, B.(2015b). "wasteaware" Benchmark indicators for integrated sustainable waste Management in cities. Waste Management,35,329-342.

Vergara,S.E., & Tchobanoglous, G.,(2012),Municipal Solid Waste and the Environment: A Global Perspective .Annual Review of Environment and Resources,Vol.37,pp.277-309

Weng, Y. C., & Fujiwara, T. (2011). Examining the effectiveness of Municipal solid waste Management Systems: An Integrated Cost–benefit analysis perspective with a financial cost modeling in Taiwan. Waste Management ,31(6),1393-1406.

Wilson, D.C., Rodic, L., Cowing, M.J., Velis, C. A., Whiteman, A., Scheinberg, A., Vilches, R., Masterson, D., Stretz, J., & Olez, B.(2015c). "Wasteaware" Benchmark Indicators for Integrated Sustainable Waste Management in cities. Waste Management,35,329-342.

Wilson, David & Velis, Costas & Rodic-Wiersma, Ljiljana. (2013). Integrated sustainable waste management in developing countries. Proceedings of the ICE - Waste and Resource Management. 166. 52 –68. 10.1680/warm.12.00005.

World Bank Data for Morocco 2022. Available online: http://data.Worldbank.org/country/morocco