IWAR

TECHNISCHE UNIVERSITÄT DARMSTADT

Promoting Circular Economy in Cities of the Global South through Assessment of Waste Management Systems: The Case of Marrakech (Morocco)

vom Fachbereich Bau- und Umweltingenieurwissenschaften
der Technischen Universität Darmstadt

zur Erlangung des akademischen Grades
Doktor-Ingenieur (Dr.-Ing.)

DISSERTATION

von

Alessio Campitelli, M.Sc.
aus Darmstadt

Erstgutachterin: Prof. Dr. rer. nat. Liselotte Schebek

Zweitgutachterin: Prof. Dr.-Ing. Anke Bockreis

Darmstadt 2022

Campitelli, Alessio: Promoting Circular Economy in Cities of the Global South through Assessment of Waste Management Systems: The Case of Marrakech (Morocco).

Dissertationsort: Darmstadt, Technische Universität Darmstadt

Veröffentlichungsjahr der Dissertation auf TUprints: 2022

Tag der Einreichung: 19.04.2022

Tag der mündlichen Prüfung: 21.06.2022

[…] dirt is matter out of place” (Douglas, 1966)

Danksagung

Als ich mich nach meinem Umweltingenieurstudium dazu entschlossen hatte zu promovieren, war mir nicht bewusst, was es genau bedeutet eine Doktorarbeit zu schreiben. Wenn ich nun über diese Zeit nachdenke, dann erinnere ich mich an einige Tiefpunkte in dieser Phase, die es mir erschwert haben meinem Ziel der Promotion näher zu kommen. Oft habe ich mich von diesen Tiefpunkten demotivieren lassen und manchmal kam auch der Gedanke bei mir auf dieses Ziel nicht weiter zu verfolgen. Aber diese Tiefpunkte konnte ich glücklicherweise überwinden, wegen der vielen schönen Momente, die die Promotionsphase mit sich brachte. Hierzu haben bedeutende Erfolgserlebnisse und Motivationshochs wesentlich dazu beigetragen. Die nächsten Zeilen möchte ich all denjenigen Personen widmen, die mir vor und in dieser Phase geholfen und mich unterstützt haben mein Promotionsziel zu erreichen.

An erster Stelle möchte ich meiner Erstgutachterin Prof. Liselotte Schebek danken, dass Sie mich in Ihr Team aufgenommen haben und mich in dieser Phase als Mentorin begleitet und immer unterstützt haben. Danke für Ihr Vertrauen! Ihnen und meiner Zweitgutachterin Prof. Anke Bockreis möchte ich für die Zeit danken, die Sie beide in die Betreuung meiner Arbeit investiert haben und für Ihre Rückmeldungen.

Des Weiteren möchte ich Jan Kannengießer danken, dass du mir durch die Projekte „Trans4Biotec“ und „Biotec2Future“ die Möglichkeit gegeben hast meine Expertise in Bezug auf Kreislauf- und Abfallwirtschaft sowie Entwicklungszusammenarbeit auszubauen und, dass du mich in meinen Vorhaben unterstützt und begleitet hast. Danke auch an die Projektpartner Prof. Naaila Ouazzani, Prof. Mostafa Stitou, Prof. Theodore Djeni, Lamia Saadoun, Soufia Oumena, Franck Orlando Yebouet, Akeyt Koffi, Youssef Aoulad El Hadj Ali und Redouane Rifki für eure Unterstützung.

Ein riesen Dankeschön geht auch an das gesamte SuR Kollegium. Besonders möchte ich euch: Oumaima Aryoug, Christian Dierks, Tabea Hagedorn, Jorge Cristóbal Garcia, Michael Gottschling, Almut Güldemund, Susanne Hanesch, Steffi Weyand, Jürgen Wilke, Julia Zeulner sowie Regina Berlinger und Alba Sanchez für eure Unterstützung, eure Zeit und euer Feedback danken.

Hinzu möchte ich noch allen Personen danken, die mich direkt oder indirekt dazu motiviert haben im Bereich der Abfall- und Kreislaufwirtschaft zu promovieren: Prof. Johannes Jager, Dr. Marina Franke, Dr. Wolfgang Pfaff-Simoneit, Prof. Martin Kranert, Tobias Berger und Fr. Marion Hübner.

Zu guter Letzt möchte ich meiner gesamten Familie und meinen Freunden danke sagen. Danke, dass ihr für mich da gewesen seid und ich mich immer auf euch verlassen kann.

Infine, vorrei ringraziare tutta la mia famiglia, specialmente mia moglie, mio figlio, i miei genitori, mio fratello e il mio cane Sammy. Grazie per essermi sempre stato vicino, per aver creduto in me e per avermi sostenuto in tutti questi anni. Senza di voi non ce l'avrei mai fatta.

Grazie!

Zusammenfassung

Ein funktionierendes Abfallwirtschaftssystem (AWS) ist unabdingbar für eine gute Lebensqualität, eine saubere Umwelt und die Schonung natürlicher Ressourcen. Allerdings kann die Qualität des AWS von Land zu Land stark variieren. Viele Länder des globalen Südens wie bspw. in Afrika haben kein funktionierendes AWS. Die Gründe hierfür sind vielfältig (wie z.B. fehlender politischer Wille, Mangel an finanziellen Ressourcen, Armut). Abfälle werden in diesen Ländern überwiegend in Form einer linearen Abfallwirtschaft nach Entstehung auf Müllkippen oder Deponien entsorgt oder sogar offen verbrannt. Jedoch unternehmen einige Länder Anstrengungen, um eine Kreislaufwirtschaft (Circular Economy, CE), die im Gegensatz zur linearen Abfallwirtschaft eine Schließung von Kreisläufen durch bspw. Recycling beabsichtigt, in ihrem Land zu fördern.

Ziel dieser Arbeit ist es, eine Methode zu entwickeln, die es ermöglicht den CE Zustand von urbanen AWS v.a. im Kontext des Globalen Südens zu bewerten. Diese Methode soll dazu beitragen, CE-Potenziale strukturiert zu identifizieren, indem bestehende Rahmenbedingungen bewertet und basierend darauf konkrete Maßnahmen abgeleitet werden. Hierfür wurde ein 5-stufiges Bewertungskonzept (waste management system – development stage concept, WMS-DSC) entwickelt. Während Stufe 1 ein AWS ohne grundlegende abfallwirtschaftliche Elemente darstellt, repräsentiert Stufe 5 eine funktionierende CE.

Marokko, als Beispiel für ein Land des Globalen Südens, hat in der Vergangenheit bereits Strategien und Programme ins Leben gerufen, um ihre Abfallwirtschaft auf einen besseren Standard zu bringen und eine Grundlage für eine CE zu schaffen. Jedoch ist nicht klar, ob die aktuellen Anstrengungen ausreichen werden, um zukünftig eine CE zu etablieren. Mithilfe des WMC-DSC soll dies bewertet werden können. Das WMS-DSC wurde am Beispiel der marokkanischen Stadt Marrakesch erprobt und damit einhergehend validiert.

Die Ergebnisse der WMS-DSC Analyse zeigen, dass in Marrakesch die Entwicklungsstufen je nach Systemkomponente zwischen Stufe 1 und Stufe 4 variieren können, wobei die Stufe 2 und Stufe 3 bei den Komponenten Governance, Sektor und Markt sowie Abfallbeseitigung vorherrschen. Die am wenigsten entwickelten Komponenten sind die des Abfallrecyclings und der Energierückgewinnung. Die Ergebnisse zeigen, dass Marrakesch noch weit von einer funktionierenden CE entfernt ist. Jedoch ist ebenfalls ersichtlich, dass bestimmte Komponenten (z.B. Governance, Abfallbeseitigung) in der Vergangenheit stärker von der Politik gefördert wurden als bspw. das Abfallrecycling. Zudem konnten anhand der Ergebnisse des WMS-DSC konkrete Verbesserungspotenziale für diverse Systemkomponenten (z.B. Abfallsammlung, Abfallrecycling, Abfallvermeidung) identifiziert werden.

Auf Grundlage dieser Ergebnisse wurden in einem weiteren Schritt Maßnahmen zur Förderung einer CE in Marrakesch abgeleitet. Insgesamt wurden 33 Maßnahmen identifiziert, welche in vier Cluster eingeteilt wurden. Die Cluster umfassen dabei die Erhöhung der Sammelquote und getrennte Abfallsammlung (Cluster A), die Optimierung der Kontrolle, Regulierung, Überwachung und Bewertung des AWS (Cluster B), die Förderung der Kreislaufschließung in Marrakesch (Cluster C) und die Förderung der Zusammenarbeit zwischen Forschung, Unternehmen und Gesellschaft (Cluster D).

Die ganzheitliche Betrachtung des AWSs und die starke Vernetzung des Systems mit anderen Subkomponenten und Stakeholdern (z.B. Ministerien, Institutionen, Unternehmen, Märkte, etc.) führen dazu, dass nicht alle Maßnahmen direkt für die Stadt Marrakesch bestimmt sind, sondern auch übergeordnete Ebenen (z.B. national, regional) sowie die Unternehmensebene

ansprechen. Die Maßnahmen dieser Arbeit können direkt in abfallbezogene Aktionspläne, Masterpläne oder Abfallwirtschaftspläne auf kommunaler sowie übergeordneter Ebene integriert werden.

Insgesamt konnte anhand der Fallstudie das WMS-DSC validiert und dessen Mehrwert für die Analyse der AWS in Städten des Globalen Südens demonstriert werden, indem die verschiedenen Facetten des AWS von Marrakesch bewertet, Verbesserungspotenziale identifiziert und konkrete Handlungsempfehlungen abgeleitet wurden.

Abstract

A functioning waste management system (WMS) is essential for a good quality of life, a clean environment and the conservation of natural resources. However, the WMS quality can vary widely from country to country. Many countries of the Global South do not have a functioning WMS. The reasons for this are manifold (e.g., lack of political will, lack of financial resources, poverty). In these countries, generated waste is mainly managed in a linear way, means discarded in open dumps or landfills or even openly burned. However, some countries are making efforts to promote a circular economy (CE) in their respective territories, which, in contrast to linear waste management, aims to close loops through recycling.

The aim of this work is to develop a method to assess the CE status of urban WMSs, especially in the context of the Global South. This method should help to identify CE potentials in a structured manner by evaluating existing framework conditions and, based on this, deriving concrete recommendations for action. To achieve this, an assessment tool (WMS – development stage concept, WMS-DSC) was developed. It is based on five development stages with stage 1 representing a WMS with the absence of essential waste management (WM) elements and stage 5 exemplifying a functioning CE.

Morocco, as a Global South country, has already launched strategies and programs in the past to bring their WM to a better standard and establish a basis for a CE. However, it is not clear whether current efforts will be sufficient to establish a CE in the future. With the aid of the WMS-DSC, this will be assessable. The WMS-DSC was tested and validated using the Moroccan city of Marrakech as an example.

The results of the WMS-DSC analysis show that, depending on the system components, the development stages of Marrakech vary from stage 1 to stage 4, with stage 2 and stage 3 being dominant for the following components: governance, sector and market, and waste disposal. The least developed components are waste recycling and energy recovery. The results show that Marrakech is still far from establishing a functioning CE. However, the different categorizations show that certain components (e.g., governance and waste disposal) were promoted in the past by politics more than others (e.g., waste recycling). In addition, it becomes clear what additional work is needed for numerous system components (e.g., waste recycling, waste collection, and waste prevention).

Based on these results, measures were derived in a subsequent step to promote a CE in Marrakech. All in all, 33 measures were identified and categorized into four clusters. These clusters comprise the increase of the collection rate and the separate collection of waste (cluster A), improve the control, regulation, monitoring and assessment of WMS (cluster B), promote the closing of the loop in Marrakech (cluster C) and encourage the cooperation between research, companies and society (cluster E).

The holistic view of the WMS and the strong interconnection between the system and other system subcomponents and stakeholders (e.g., ministries, administration, companies, market) mean that not all measures are directly intended for the city of Marrakech, but some address higher levels (e.g., national and regional) as well as the company level. The results from this work can be directly integrated into WM related action plans, master plans or WM plans at the municipal level as well as at higher levels.

In conclusion, the case study validated the WMS-DSC and demonstrated its added value for WMS analysis in cities of the Global South by assessing the various facets of Marrakech's WMS, identifying areas for improvement, and deriving specific recommendations for action.

Contents

List of Figures

List of Tables

List of Abbreviations

C&D	Construction and demolition
CE	Circular economy
CEV	Disposal and recovery center (Centre d'élimination et de valorisation)
CMUR	Circular material use rate
comp.	Company
CT	Collection and transport
DEA	Data envelopment analysis
DR	Diversion rate
DRE	Regional Environmental Department (Direction régionale de l'environnement)
DTT	Distance-to-target
EoL	End-of-life
EPR	Extended producer responsibility
ER	Energy recovery
EU	European Union
G	Governance
GHG	Greenhouse gas
HI	High-income
IMANOR	Moroccan Institute of Standardization
ISO	International Organization for Standardization
LCA	Life cycle assessment
LI	Low income
LMI	Lower-middle income
LMIC	Low and middle income countries
MCDM	Multi-criteria decision making
MSW	Municipal solid waste
MTEDD	Moroccan Ministry of Energy Transition and Sustainable Development
mun.	Municipal
nat.	National
OECD	Organization for Economic Co-operation and Development
PNDM	National Program of Household and Similar Waste (Programme National des Gestion des Déchets Ménagers et Assimilés)
PNVD	National Program for the Recovery of Waste (Programme National de Valorisation des Déchets)
PPP	Public private partnership
PR	Prevention and reuse
RDF	Refuse-derived fuels
reg.	Regional
SIREDD	Regional Information System on the Environment and Sustainable Development (Système d'Information Régional sur l'Environnement et le développement durable)
SM	Sector and market
SNDD	National Strategy for Sustainable Development 2030 (Stratégie nationale de développement durable 2030)
SNRVD	National Waste Reduction and Recovery Strategy (Stratégie Nationale de Réduction et de Valorisation des Déchets)
UMI	Upper-middle income
UN SDG	United Nations sustainable development goal
WD	Waste disposal
WM	Waste management
WMS-DSC	WMS development stage concept
WMSs	Waste management systems
WR	Waste recycling
ZWI	Zero-Waste-Index

1. Introduction and goal of the research

1.1. Motivation

Globally, the performance of waste management systems[1] (WMS) varies widely. There are well-developed systems that provide almost universal waste collection and safe waste disposal in sanitary landfills or in waste incineration plants equipped with flue gas cleaning to reduce emissions into the environment. In some cases, a good recycling system is available, with high-tech sorting and recovery technologies designed to close the loops.

In contrast, there are also WMSs that are still under development or are being reconstructed, for example in conflict regions. These WMSs often have to deal with manifold problems, such as a lack of comprehensive waste collection and environmentally hazardous waste disposal in open dumps or through open burning (Figure 1). Also, an unsophisticated legal situation and a lack of capacity in politics and administration to organize a regulated, economically efficient and functioning WMS are critical challenges (Kaza et al., 2018; UNEP, 2015). The sum of these practices, especially the inappropriate disposal of non-hazardous and hazardous wastes, has big negative impacts on human health; they can cause diseases (cholera, dengue fever, etc.) and, consequently, the outbreak of epidemics. Also, such practices have huge negative effects on the environment and can damage ecosystems (Giusti, 2009; UNEP, 2015). This is particularly the case for countries in the Global South, which includes many low and middle income countries (LMIC) or developing countries (Dados and Connell, 2012).

For both terms, Global South and Global North, there is no uniform and common definition, but rather conceptual views of the South-North division of the world are concealed. One concept, assigns the former third world or developing countries from Africa, Latin America and Asia to the Global South, which are underdeveloped, live in poverty and, whose power on supranational level (e.g., United Nations) is limited (Schneider, 2017). In contrast, Lopez (2007) includes in the Global South all people, who are socially and politically disadvantaged e.g., by neoliberal policies. For this, the geographical understanding is disrupted, as these people can also be located in countries of the Global North (Lopez, 2007). A third conceptualization, interprets the Global South as a metaphorical and relational concept, whereas lines can be drawn between a powerful North and a dependent South (e.g., Northern and Southern United States, Northern and Southern Italy) (Schneider, 2017; Sparke, 2007). In this study, the Global South is used to describe disadvantaged or underprivileged countries of the globalized world in a value-free way and to avoid the categorization in developed countries and developing countries, which constitutes a hierarchy. For this, all countries dealing with big structural problems, especially regarding waste management (WM), can be considered as countries of the Global South e.g., LMIC as well as high income countries as the Seychelles, which despite their high income level have to deal with several problems in WM (Cristóbal et al., 2021; Kannengießer, 2017).

[1] "A waste management system (WMS) is a system-relevant infrastructure system that has the function of collecting, treating (including sorting) and disposing all types of generated waste. Activities that promote waste prevention and reuse or concern trading and broking of waste or secondary raw materials are also part of the system as well as components regarding all governance (e.g. public authorities, laws, regulations), technical (e.g. treatment technologies), and organizational (e.g. infrastructure, collecting services) aspects and other resources (e.g. qualified labor, financial resources, natural resources) required for this function." Campitelli et al. (2022b).

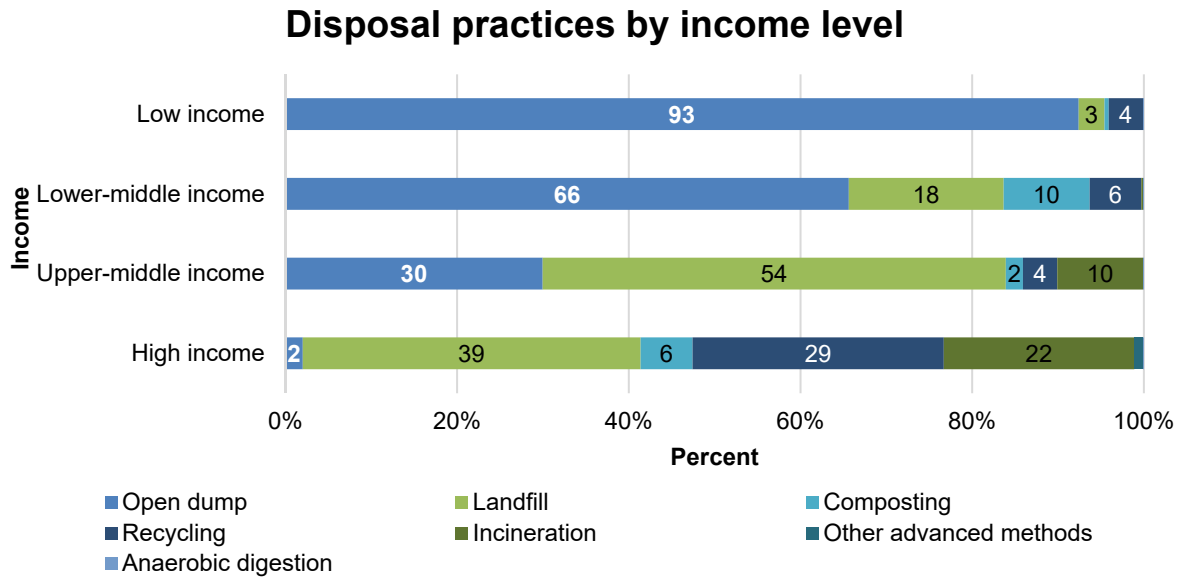


Figure 1: Disposal practices by income level adapted from Kaza et al. (2018)

WM is not only primarily responsible for the disposal of waste, but it is also meant to reduce the environmental impacts of human activities and avoid health risks. The Global Waste Management Outlook even describes WM to be a fundamental human right (UNEP, 2015).

A well-functioning WMS is therefore a central element for a good quality of life, a clean environment and the conservation of natural resources. However, the functionality or "quality" of WMSs differs from country to country. There are different reasons why WM does not really exist or is inefficient in countries of the Global South. One problem is that a WMS is a complex system that needs structured organizations, basic technical infrastructures as well as control and monitoring bodies. Hence, good governance and financial resources are crucial in building up a WMS and to cover all the associated costs. (Kaza et al., 2018; UNEP, 2015)

Public interest and political will are drivers to initiate the process of building up a WMS (UNEP, 2015). Many countries around the world are aware of these problems; therefore, for decades, there have been different efforts worldwide, with the help of countries of the Global North and international funding institutions, to minimize health risks and environmental pollution emanating from WM (Lerpiniere et al., 2014; World Bank, 2020b).

In the past, numerous projects by international funding institutions tried to build up a sound WMS in such countries, firstly, by implementing technologies from countries of the Global North (Lerpiniere et al., 2014) and, secondly, by building up infrastructure, without focusing on the operation (Marshall and Farahbakhsh, 2013). Different examples show that this approach did not work, and the projects failed due to the fact that implemented technologies ceased to operate after project end or after the financial support stopped (Filho et al., 2016; Pfaff-Simoneit, 2012; Wilson, 2007). Recently, the funding strategy changed to funding of more capacity building and skills projects to create basic organizational structures in national and local governments or fundamental waste collection systems. More funding was granted to projects that considered a holistic view of the WMS and not only a pure funding of technologies (Lerpiniere et al., 2014). Although some countries have made progress in introducing waste legislation and national waste strategies, there are still many gaps and problems concerning their enforcement (Kaza et al., 2018). This is facilitated among others by prevalent corruption and lack of reliable control mechanisms. Moreover, challenges such as urban growth and poverty hinder the sound implementation of WMSs (UNEP, 2015).

Global problems, such as climate change, resource depletion, pollution of the oceans, have led some countries of the Global North, as the European Union (European Commission, 2020), Japan (METI, 2020) and the United States of America (EPA, 2021), to start transforming their linear WM more and more into a Circular Economy (CE). The basic idea behind a CE is to reduce waste and its negative impacts to a minimum and keep materials and products in the economic cycle for as long as possible (Korhonen et al., 2018). CE is a chance to change the economic system and the society in a way that makes them more sustainable. This means being more resource efficient and, in the best case, climate neutral, implying a positive effect on economic prosperity and social equity (Kirchherr et al., 2017). This change is also the big challenge of CE, "[…] to design a pathway for inclusive growth that enables the economy to flourish, whilst staying within the planet's ecological capacity […]" (Wit de et al., 2020, p. 31). In addition, CE can positively support the achievement of several sustainable development goals (SDGs) of the United Nations (UN) (Rodríguez-Antón et al., 2021). According to Rodić and Wilson (2017), 12 of the 17 SDGs are linked to WM and, thus, to CE.

Many countries, for example European countries, expect large potentials from the concept of CE in terms of prosperity, job creation, economic growth, increase of competitiveness and potential carbon neutrality. The European Commission states that CE is the goal to strive for in the future (European Commission, 2020). However, such a fundamental transformation of the economy cannot happen instantly, since it is not a matter of implementing small, self-contained individual solutions, but of changing an entire system. The transformation of the WMS has a direct impact on the society and the economy and is also influenced by them during the transformation process (Grießhammer and Brohmann, 2015), thus constituting an iterative process. Accordingly, such a societal transformation would be a long process that involves huge investments (Grießhammer and Brohmann, 2015).

However, countries in the Global South are also interested in the concept of CE. In Africa alone, 12 countries, e.g., Tunisia, Egypt, Rwanda, Morocco, Nigeria and South Africa, have policies to promote a CE and exploit its benefits (Rademaekers et al., 2020). In addition, the European Commission also supports countries of the Global South in their development towards a CE, which is also defined in the European Green Deal (European Commission, 2019). Besides countries, municipalities have an essential function as they ultimately contribute in achieving national WM and CE goals and in realizing the exploitation of CE potentials. These CE potentials can be exploited with the support of the EU through financing or planning of CE projects (Diaco et al., 2020). Hence, the municipal level shall not be neglected in the CE debate.

This prompts the question, whether the transformation of cities in the Global South towards a CE is feasible if the CE concept of the EU is taken as a model. This question is difficult to answer because there is no real example so far.

Grießhammer and Brohmann (2015) state that the visions and guiding principles of the CE can be a driver for transformation, as they describe promising alternatives to the current system. But, the study also emphasizes that if they are formulated in a diffuse and unspecific way, they are more likely to hinder the transformation process. Clear descriptions are needed to make the visions imaginable, which enables linking them to one's own experiences and makes them more convincing to promote the transformation. (Grießhammer and Brohmann, 2015)

The CE goals included in the European Circular Economy Action Plan (European Commission, 2020) are in parts very specific, but they are difficult to implement, if the needed infrastructures and capacities are lacking. Consequently, a direct adoption of the visions by countries of the

Global South is rather difficult to achieve. However, the system perspective could help to achieve the transformation. It is necessary to consider the system as a whole, including the relevant subsystems, in order to identify starting points for initiating the transformation process.

In order to analyze WMSs in a systems perspective, diverse challenges exist. WMSs are complex infrastructure systems (Campitelli et al., 2022b). The general characteristics of infrastructure systems are that they are long-living, capital-intensive, and highly regulated with a distinct network character due to the diverse dependencies and linkages of the individual subsystems, within and outside the system (Markard, 2011). Thus, assessing the status quo of systems – in this case a WMS – is essential in implementing measures that initiate or achieve the transformation. Methods taking into account the WMS as an infrastructure system is a clear research gap (Campitelli and Schebek, 2020).

There are different methods of assessing WMSs, such as life cycle approaches, multi-criteria decision tools and benchmarking methods (Allesch and Brunner, 2014; Campitelli and Schebek, 2020). However, the suitability of methods varies, depending on the objective of the study. Consequently, choosing the right method is very important, also with regard to the case study under investigation. For example, lack of waste-relevant data and information, which often applies in cities in the Global South, make a reliable assessment more difficult (Zurbrügg et al., 2014). Despite the poor data situation, an assessment of the WMS situation must be made in order to derive improvement measures to promote further development. This is not possible with current assessment methods, which is another important research gap (Campitelli et al., 2022b; Campitelli and Schebek, 2020).

1.2. Research questions and goal of the study

The aspects and research gaps mentioned before lead to the following main research question:

How can WMSs of cities in the Global South and their transition towards a CE be assessed and optimization potentials be identified?

To answer this question, it was first necessary to evaluate assessment methods in regard to their suitability for the assessment of WMS in the Global South. Therefore, the following sub-research question was defined:

1. *Which methods are suitable for the WMS assessment in countries of the Global South?*

Second, an approach for the general assessment of WMSs and their transition to a CE needs to be developed, taking into account the results from sub-research question 1. Thus, the second sub-research question is:

2. *How can WMSs and their transition towards a CE be assessed?*

In order to validate the approach resulting from sub-research question 2, a case study was performed on the WMS of the Moroccan city of Marrakech, as an example of a city of the Global South. This posed the following sub-research questions:

3. *What is the actual WMS performance of the Moroccan city Marrakech?*
4. *Which measures are needed to achieve a transition towards a CE in Marrakech?*

Consequently, the goal of this study is to develop a methodology that enables the assessment of WMSs of cities in the Global South in order to identify fields for improvement, and derive specific recommendations for action to move the WMS towards a CE.

1.3. Research methodology

The above mentioned sub-research questions are related to three publications, which are part of this cumulative dissertation.

Paper 1: Campitelli, A.; Schebek, L. (2020): How is the performance of waste management systems assessed globally? A systematic review. J. Cleaner Prod., 272, 122986, doi:10.1016/j.jclepro.2020.122986.

Paper 2: Campitelli, A.; Kannengießer, J.; Schebek, L. (2022): Approach to Assess the Performance of Waste Management Systems towards a Circular Economy: Waste Management System Development Stage Concept (WMS-DSC). MethodsX, 9, 101634, doi:10.1016/j.mex.2022.101634.

Paper 3: Campitelli, A.; Aryoug, O.; Ouazzani, N.; Bockreis, A. and Schebek, L. (2022): Assessing the Performance of a Waste Management System towards a Circular Economy in the Global South: The Case of Marrakech. → *Status: under review*

The research questions are investigated based on the evaluation of various literature, current reports and research articles as well as the information gained from expert interviews. For sub-research question 1, a systematic review analyzing methodological approaches used to assess the performance of WMS has been carried out (Paper 1). Based on these results, a benchmarking approach for the general assessment of WMSs and their transition to a CE has been developed to answer sub-research question 2 (Paper 2). To proof the concept, the developed approach has been applied on the city of Marrakech, as an example of a city of the Global South. The current WMS of Marrakech has been analyzed and optimization potentials for a CE transition have been identified. Hereby, the sub-research questions 3 and 4 were examined (Paper 3). The detailed description of the research methodology is described in the respective papers as well as in chapter 2.1, 2.2, and 2.3.

The assignment of the publications to the corresponding sub-research questions and the affiliation to the main research question are visualized in Figure 2.

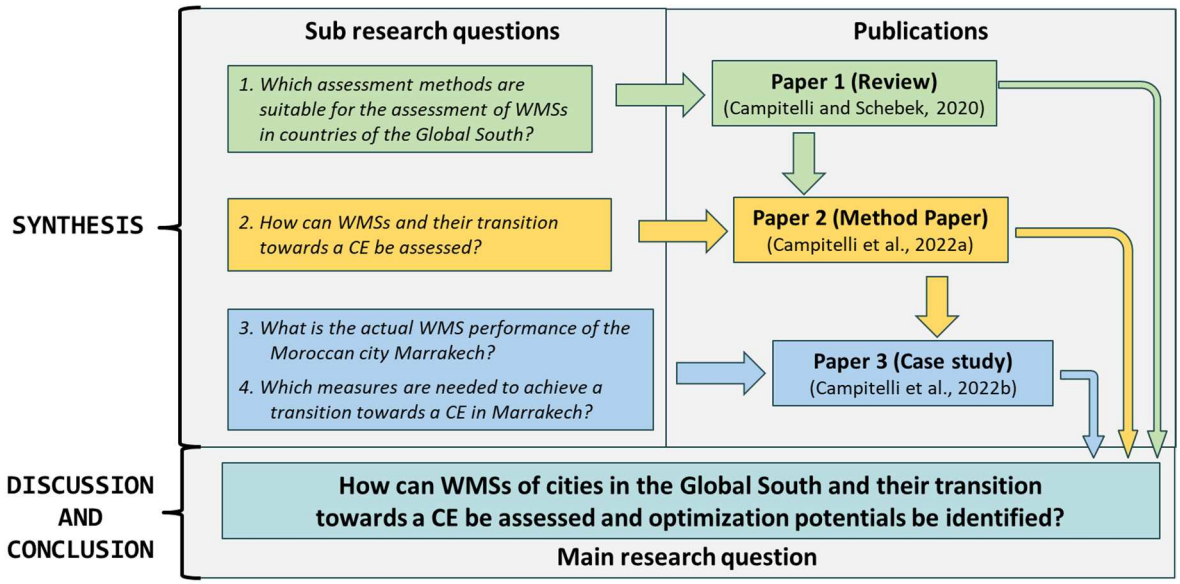


Figure 2: Framework of the dissertation including the synthesis, discussion and conclusion

1.4. Case study selection

Due to the fact that this study is focusing on countries of the Global South and therefore, lack of data is an obvious problem for assessment, to validate the methodology, the Moroccan city Marrakech has been chosen as a case study.

Marrakech is the fourth largest Moroccan city and the capital of the Marrakech-Safi region (HCP, 2014). Beyond this, Morocco is an interesting case study, as on the one hand, it stands for an example of a Global South country and on the other hand, it is a country that has been strongly supported by the EU in the past, especially by Germany (among others through the German Society for International Cooperation - GIZ) (Monnerjahn, 2019). In Morocco, many efforts have been made to improve the Moroccan WMS in order to reduce its environmental impact (Diaco et al., 2020). Policies have also been taken from the European area for guidance. Even though aspects of a CE are addressed in Moroccan policies and strategies, CE is still in its infancy. (Diaco et al., 2020) In a rather short period of time, Morocco has undergone a remarkable industrial and infrastructural evolution, which poses new challenges regarding WM. The increasing industrialization and urbanization has led to a rise in waste volumes (e.g., household, industrial, and construction and demolition (C&D) wastes), whose disposal mainly takes place by means of landfilling (Monnerjahn, 2019). Moreover, the recycling rates of waste are very low due to the absence of segregation at source and sorting as well as treatment plants. In this context, waste collectors (informal sector) plays a significant role, since they take part in the collection and sorting of waste for recycling. In Morocco, CE potentials are estimated to be very high, as the existing system is not yet designed for reuse and recycling (Diaco et al., 2020).

The selection of Marrakech as a case study is also motivated by existing contacts at the University Cady Ayyad in Marrakech in the context of two research and teaching projects[2] on which the author worked on during his dissertation phase. These contacts made it possible to obtain relevant data for the analysis. Moreover, the associated research stays in Marrakech provided a good insight into the Moroccan metropolis and enabled the gaining of WM related experience about the city of Marrakech, which both helped to conduct the analysis of the city.

1.5. Outline

Chapter 1 gives a brief introduction in the research topic, describes the motivation and the goal of the study. In addition, the research question, the associated sub-research questions are presented, the overall research methodology and the structure of the study are described. The synthesis of the publications and the direct connections to the sub-research questions are discussed in chapter 2. Chapter 3 provides a summarized discussion of the results from chapter 2 and answers the main research question. Furthermore, identified limitations are critically discussed and a conclusion is given.

[2] The projects are Trans4Biotec: "Know-how transfer in waste management for the development of new biotechnology applications in developing countries" and Biotec2Future: "Development of a Master Studies Programme 'Environmental Biotechnology Engineering' for Ivory Coast & Morocco".

2. Synthesis

This chapter is divided into the respective sub-research questions. These questions are answered using the findings from the three publications, which are part of this cumulative dissertation. The most important findings are summarized and the connections between them and the sub-research questions are highlighted in this chapter.

2.1. Which methods are suitable for WMS assessment in countries of the Global South?

As mentioned in the introduction, countries that do not already have a well-developed WMS would face more difficulties in building it up and transforming it to a CE. To change the system, its assessment is fundamental. Plenty of methods exists for doing this (Allesch and Brunner, 2014; Finnveden et al., 2007; Karmperis et al., 2013; Pires et al., 2011; Zurbrügg et al., 2014). However, not all are suitable for countries of the Global South as well as for decision makers, who are the most relevant stakeholder group in this context, because they are mainly designed for academic purpose (Zurbrügg et al., 2014). In order to investigate the suitability of methods for WMS assessment, a systematic literature review of 366 peer-reviewed articles assessing the WMSs of cities or countries and focusing on MSW published before May 2019 was performed (Campitelli and Schebek, 2020). For this, the PRISMA guidelines (Liberati et al., 2009; Moher et al., 2015) were taken into consideration. The scope of the systematic review was to 1) identify existing correlations between country income group and different considered issues (e.g., used assessment methods, investigated WMS components) that indicate possible future trends, 2) categorize assessment methods concerning the suitability for decision makers and country income groups and, based on this, 3) determine the evolution of WMS assessment for different country categories since the 1980s.

For this systematic review, three databases (Web of Science, ScienceDirect and Technik und Management) as well as snowballing were used to identify relevant articles. The detailed description of the systematic review methodology and the detailed results can be found in Campitelli and Schebek (2020).

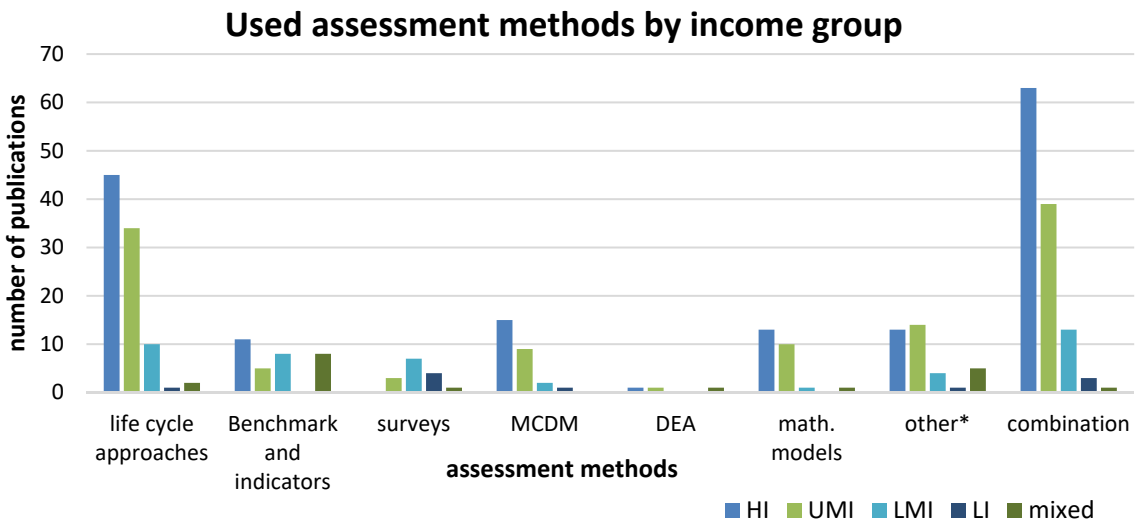
While in the review all income groups (high income – HI, upper-middle income – UMI, lower-middle income – LMI and low income – LI) were analyzed, in this chapter the focus will be on the results involving countries of the Global South (means LI and LMI countries).

To decide, whether a method is suitable to assess WMSs in cities or countries of the Global South, the method shall meet specific requirements. Therefore, a suitable method shall:

i) …be able to assess all relevant WMS components, such as governance, waste market, collection and transport, waste disposal, energy recovery, waste recycling, and prevention and reuse,
ii) …work also with lack of relevant waste data and information and
iii) …be practicable for decision makers.

Considering the first point, only four studies assessed all WMS components concurrently. Whereas Fuldauer et al. (2019) used performance indicators in combination with scenario and decision-making analysis, Zaman (2014) applied the Zero Waste Index (ZWI) for WMS assessment of Adelaide, Australia, combining it with a survey to identify relevant areas for WM strategies in future. Arushanyan et al. (2017) used SWEA (Swedish Waste Management Environmental), a model based on an LCA approach, to analyze the environmental impacts of several Swedish policy instruments. Al-Khatib et al. (2007) investigated the current state of WMSs in seven Palestinian districts, conducting surveys to define trends and problems.

For WMS assessment, several methods have been identified (Figure 3). To guarantee a concise overview, these methods are clustered into eight categories (i.e., life cycle approach, benchmark and indicators, surveys, multi-criteria decision making (MCDM), data-envelopment analysis (DEA), mathematical models, other[3] and the combination of different methods).



For other* see footnote 3.

Figure 3: Used methods classified by income group (Campitelli and Schebek, 2020)

All assessment methods require specific types of data as metrics (e.g., population, waste composition, recycling rates, landfill rates and number of waste pickers) or literal descriptions (e.g., service quality and level of awareness). The depth of detail and the type of data required for their application can vary, depending on the investigated aspects and system components. Quantitative data is mostly needed for the assessment of environmental, economic as well as technical aspects using metrics from impact assessment (e.g., GHG-emissions and resource depletion), financial data (e.g., costs, revenues), various rates (collection or recycling rates, etc.) or efficiency indicators (Halkos and Petrou, 2019; Kaufman et al., 2010; Yang et al., 2018) as well as indices (Yadav and Samadder, 2018a; Zaman and Lehmann, 2013). However, qualitative data is usually used to assess organizational, governance and social aspects. The generation of this non-numerical data is done by utilizing methods such as structured interviews or group discussions (Dangi et al., 2017; Kassahun and Birara, 2018; Lalitha and Fernando, 2019).

Some methods, for example mathematical modeling, MCDM, DEA and life cycle approaches, need a significant amount of robust data for calculation to guarantee valid results. The use of this methods has a positive effect as they can go more into detail regarding WMS assessment than other methods, for example the use of benchmarking tools. Life cycle approaches need specific data, which are often not available in countries where data collection is lacking (Zurbrügg et al., 2014). Therefore, these methods are mainly used to evaluate WMSs in HI and UMI countries. However, twelve studies applied LCA for LMI countries (Batool and Chuadhry, 2009; Islam and Moniruzzaman, 2019; Majeed et al., 2018; Menikpura et al., 2012;

[3] Methods categorized as “other” are methods such as energy, exergy, emergy, economic and policy analyses as well as material or substance flow analysis, greenhouse gas analysis, rapid impact assessment and strategic environmental assessment.

Nguyen Phuc Thanh and Matsui, 2013; Ogundipe and Jimoh, 2015; Rana et al., 2019; Sharma and Chandel, 2017; Singh and Basak, 2018; Syeda et al., 2017; Wang et al., 2018; Yadav and Samadder, 2018b). Only three studies examined the WMSs in LI countries using LCA (Oyoo et al., 2014) and MCDM (Kapepula et al., 2007; Makarichi et al., 2018). When LI or LMI countries use data-rich methods, the validity of the results must be viewed critically. In the case of LCA, it is possible that for assessing WMSs, data from HI countries (e.g., from databases) are used and many assumptions have to be made to calculate the environmental impacts. Subsequently, uncertainties cannot be avoided (Finnveden et al., 2007). Consequently, the validity of the calculated results and the representativeness are not guaranteed. The more the need for detailed data, the less applicable a method is for countries in which waste-relevant data are not systematically collected or access is not provided due to certain issues, e.g., uncooperative institutions or companies.

In contrast, surveys and interviews are more appropriate methods for such conditions because they generate data. Surveys, interviews and waste analyses have been found in 15 studies, which investigated WMSs of mostly LI or LMI countries, due to the lack of data (see Figure 3).

Benchmarking tools and indicators are generally user-friendly with the goal to simplify the assessment and give a first overview. The needed data for assessment can be quantitative or qualitative. For this reason, these assessment methods are suitable for all country types and for decision makers.

For the comparison of different case studies, performance indicators for benchmarking (e.g., wasteaware benchmark indicators (Wilson et al., 2012)) or composite indicators (e.g., ZWI (Zaman, 2014)) and LCA, DEA and other mathematical models are frequently used.

In order to ensure a clear overview, the identified methods are categorized into three clusters regarding the needed data and the suitability for specific users and country groups (Table 1).

Table 1: Methods cluster (Campitelli and Schebek, 2020)

Type	Included methods	Characteristics	Suitable for…
Type A: “Data generating methods”	Surveys, interviews, waste analysis or field investigations	Generation of quantitative or/and qualitative data.	• Academics; • all country categories, but mostly used in LI and LMI countries
Type B: “Simple assessment methods”	Benchmarking and performance indicators	Mostly simplified assessment methods, which need quantitative and/or qualitative data.	• Academics and mostly decision makers; • all country categories
Type C: “Complex assessment methods”	System analysis methods, such as life cycle approaches, mathematical models, MCDM, DEA and their combinations.	They need good and reliable data records for in-depth analysis. Usually, they are very complex, but also simplifications of such methods for non-academic purposes exist.	• Academics and partly decision makers; • mostly used in HI or UMI countries

Since the 1980s, many new methodologies have been developed for WMS assessment (focusing on MSW). While 137 of the reviewed studies published new methods, tools, frameworks or innovative combinations of already existing methods, the remaining 229 studies assessed WMSs by applying existing methods. Only a part of the newly developed methods addresses waste planners and other decision makers, who are the main target group that needs these tools the most. The major part of innovative methods is still designed for academic purpose and often with the goal to inform decision makers about the assessment results, which underlines the findings of Zurbrügg et al. (2014).

There are many assessment methods with limited applicability for LI and LMI countries, mostly due to the high amount of data needed, which cannot be provided (Figure 4). Therefore, it is essential that a database is created to enhance WMSs in these countries. Surveys, structured interviews as well as field investigations are methods that can generate missing qualitative and quantitative data. Especially for countries without relevant waste data, due to lack of related statistical records (e.g., waste amount and waste composition), these methods are suitable. However, type A methods are scientific methods that are not suitable for direct decision makers.

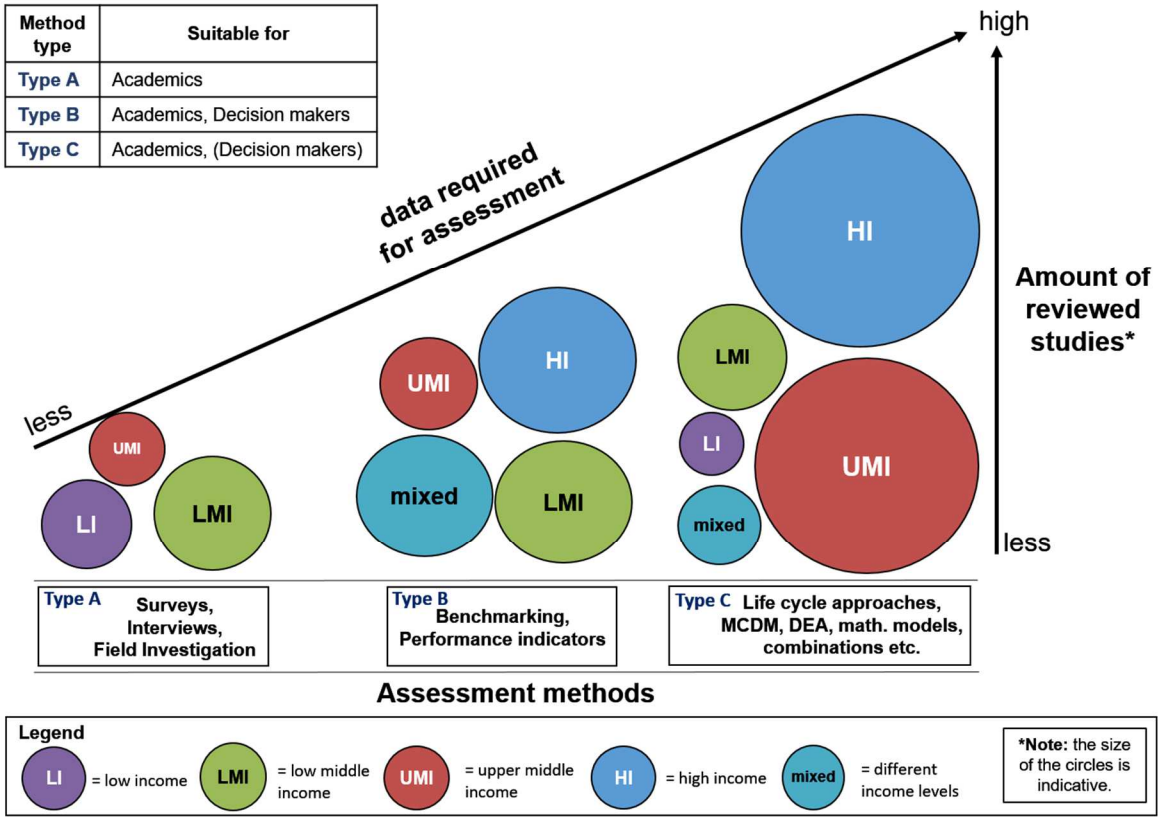


Figure 4: Used methods as per needed data and income group (Campitelli and Schebek, 2020)

Interim conclusion

Considering the findings presented above, the following conclusions can be drawn for countries in the Global South regarding the suitability of WMS assessment methods.

When studying WMSs, it is important to consider prevalent conditions when selecting methods, especially regarding data availability and data robustness. The future challenges for researchers and decision makers will be mainly data scarcity. Drawing reliable and consistent recommendations for action or making fundamental decisions will be significantly affected by this. This circumstance may hinder progress as well as the transformation of WMSs to CE. Due to the fact that the poor data situation cannot be solved instantly, it is necessary to develop or adapt methods that facilitate the evaluation of WMSs and increase the validity of the results despite the poor data situation.

Benchmarking is a suitable method to meet exactly such challenges, as it does not only exclusively require quantitative data but also works with qualitative data; therefore, it can be applied in case of poor data availability. Moreover, benchmarking can be used to compare different systems, is often designed to be suitable also for non-academic personnel and can be potentially used by countries of the Global South.

Furthermore, it must also be ensured that all WMS components are analyzed to a necessary depth considering the existing interdependencies between the system components. Such a holistic system analysis, which takes into account all relevant WMS components, can avoid the formulation of measures that either contradict each other or promote certain components while causing disadvantages to others. Moreover, the holistic system analysis is required in the context of the CE transformation of WMSs.

2.2. How can WMSs and their transition towards a CE be assessed?

In this subchapter, a novel holistic approach to assess the performance of WMSs and their transition towards a CE (Campitelli et al., 2022b) is presented. From the previous subchapter, the following findings have influenced the conceptual design of the approach:

1) Benchmarking is most appropriate for WMS assessment in countries of the Global South because it can work with quantitative data and in case of poor data availability also with qualitative data.
2) Few studies analyzed all relevant WMS components and none of them did an in-depth analysis of the individual WMS components and their interdependencies.

Based on these two findings, a WMS assessment method called WMS development stage concept (WMS-DSC) has been developed. The idea behind the WMS-DSC and the use instructions are described in the following.

2.2.1. WMS development stage concept (WMS-DSC)

The WMS-DSC can be used to i) assess the status quo of a WMS and, based on this identify possible measures for implementation, ii) analyze whether relevant system conditions to implement a specific measure are met, iii) monitor the progress of a WMS, and iv) compare WMSs of different cities.

The WMS-DSC is primarily designed to assess the WMSs of cities and municipalities, but the structure of the concept enables also the assessment of WMSs on the regional and national scales. However, it must be noted that doing this clearly reduces the holistic character as some criteria only apply to the municipal level. The WMS-DSC can generally be used for all WMSs (urban and rural) and is adaptable to countries of the Global South and the Global North. The concept is primarily focused on MSW. The WMS-DSC can be used by practitioners and decision makers, who are familiar with the WMS under study.

The concept consists of five development stages. While stage 1 describes the absence of or a very immature and malfunctioning WMS, stage 5 stands for a fully implemented CE. Every development stage represents a hypothetical scenario. By equating the highest stage with the objectives that have evolved globally for a sustainable CE, this concept can be used to identify the targets and most suitable steps for an individual WMS to move towards a future best practice CE. The WMS categorization into development stages enables the clear identification of symptoms and causes of possible waste mismanagement and potential measures for improvement. Regardless of the motivation for using the concept, recommendations for action can be derived based on the assessment results and the scenario descriptions.

Recently, new benchmarking methods have been published that assess WMSs by defining WM development ranges as sorts of maturity levels (Fatimah et al., 2020) or development bands (Whiteman et al., 2021). Both methods see CE as the final achievable level of WM development. While the approach by Fatimah et al. (2020) focuses more on the analysis of an industry 4.0-based smart CE, the framework of Whiteman et al. (2021) was developed to be mainly applied in LMIC to promote the WMS development towards a CE. UN-Habitat (2021) also developed the Waste Wise Cities Tool, which consists of guidelines on how cities should collect waste related data with the aim of reducing data gaps.

Furthermore, it also includes control levels (“ladders”) for different WMS components (collection, disposal, recycling and recovery). This is a diagnostic tool for WMS performance

assessment in cities all over the world, but it is mainly meant to support cities of the Global South, where lack of data is a crucial problem.

All benchmarking methods stated above can be used for rapid assessment of the WMS performance or for specific parts of a WMS, but they are limited in terms of an in-depth and holistic analysis of the whole WMS performance. Therefore, holistic approaches for WMS assessment are still rare or are usually presented in a simplified way such that the level of detail and completeness is reduced (Campitelli and Schebek, 2020). Often, WMS components regarding governance, waste sector and market as well as prevention and reuse are missing or are underrepresented in the assessment.

The WMS-DSC enables an in-depth analysis of the WMS performance for cities and goes further regarding the level of detail and the investigated WMS components in comparison with the three approaches mentioned before.

The structuring based on development stages has already been applied in other application areas, e.g., by the European Commission for capacity building (European Commission, 2011). In the context of WM, the German Ministry of Environment defined five technological development stages, starting from the extensive uncontrolled dumping and ending with the status of a CE (BMUB, 2016). Striegel (2015) described ten fields of action subdivided into five development stages to support LMIC in establishing WMSs (Striegel, 2015).

In contrast to other benchmarking methods, the WMS-DSC approach goes further and comprises the following novel features:

- A WMS is characterized precisely by components and system boundaries.
- Every development stage is worked out as a detailed hypothetical scenario for all relevant WMS components (Table 2), including different dimensions such as governance, economic, social, organizational, environmental and technical aspects (Campitelli and Schebek, 2020).
- The performance assessment is expanded by the distance-to-target (DTT) concept, which is a widely used method in LCA to assess the actual state of a specific issue and relate it to the desired state (target). The distance to the target is normally expressed by a specific value (Castellani et al., 2016). However, the integration of DTT in WMS assessment concepts is still missing. By integrating the DTT concept, it is possible to estimate the quantitative or qualitative distance to a higher development stage, which in this paper is expressed by pre-defined stages.
- Based on the analysis results, measures to improve the WMS can directly be identified by the WMS-DSC user considering the measures of the respective higher stage.
- Interactions between the different WMS (sub)components are visible: firstly, this enables a better understanding of the complex system of WM; secondly, it helps to identify possible causes of waste mismanagement.

Table 2: Description of the WMS components (Campitelli et al., 2022b)

WMS components	Description
Governance "G"	All measures that are needed to manage, control and regulate WM at the municipal, regional or national level. For example, laws, regulations, policy and financial instruments, waste plans, programs, concepts, authorities, and other supervisory bodies, institutions, or WM services. This component is divided into 16 subcomponents assigned to four groups: • **Legislation and other policies (G.1 – G.6):** Duties and targets; laws, regulations and agreements; nomenclature; national WM; regional WM; and municipal WM • **Administration and monitoring (G.7 – G.11):** Control mechanisms; authorization and public participation; quality standards and threshold value; data collection; reporting and evaluation • **Education and research (G.12 – G.14):** Education; research; awareness building • **Occupational safety, health and environmental protection (G.15 – G.16):** Occupational health and safety measures; environmental protection measures
Sector and market "SM"	All market activities and aspects concerning WM (including recycling markets, import and export of waste, employment); the structuring of the WM sector (including public and private company structures); the integration of the informal sector; financial funding of WM activities and waste projects; trading and broking of waste products or secondary raw materials and fuels. This component is divided into seven subcomponents: • **Sector and Market (SM.1 – SM.7):** Sector development; jobs; informal sector; WMS structure and organization; financial funding; enterprises; recycling market
Collection and transport "CT"	Measures such as the collection of waste systems (e.g., door-to-door), separation at source of different waste types (MSW; hazardous waste, C&D, etc.), and their transportation and storage (e.g., transfer stations) are included here. Also, aspects concerning service providers, collection efficiencies and collection rates are included. This component is divided into eight subcomponents: • **Collection and transport (CT.1 – CT.8):** Waste collection; service provider; collection rates; separate collection; collection of recyclables; waste transport; transfer stations; collection of hazardous wastes
Waste disposal "WD"	All measures and aspects regarding the disposal of waste (open dumping, open burning, landfilling, and other means of disposal), the different qualities of landfilling, and leachate and landfill gas management are included. This component is divided into five subcomponents: • **Waste disposal (WD.1 – WD.5)** Waste disposal; operational measures; leachate water management; landfill gas management; other means of disposal
Energy recovery "ER"	Aspects and measures of plants that use waste as a fuel (like the controlled incineration of waste to produce thermal or electrical energy), co-incineration and the conversion of refuse-derived fuels (RDFs) into energy as a substitute for fossil fuels are described here. This component is divided into three subcomponents: • **Energy recovery (ER.1 – ER.3)** Thermal disposal and energy recovery; incineration plants; energy and raw material recovery
Waste recycling "WR"	Measures to recycle different wastes, such as composting, fermentation, sorting and other recycling plants (especially material recycling), are described here as well as recycling rates, diversion rates (DR) and the circular material use rate (CMUR). This component is divided into eight subcomponents: • **Waste recycling (WR.1 – WR.8)** Waste recycling; composting, fermentation, sorting and recycling plants; RDFs; recycling of construction and demolition waste; recycling rates; DR and CMUR
Prevention and reuse "PR"	Measures to prevent waste and promote reuse activities as well as innovative business models, such as sharing and repairing and efforts of companies regarding the optimization of processes and products (product design), are included here. It also comprises indicators such as waste generation and Zero-Waste-Index (ZWI). This component is divided into six subcomponents: • **Prevention and reuse (PR.1 – PR.6)** Prevention; circular business and usage models; product design; process optimization and operational disposal strategies; waste generation; ZWI

The WMS-DSC approach consists of a matrix, which frames five development stages for seven WMS components. The general structure of the matrix is shown in Table 3. The single stages are described in the following chapter.

Table 3: Overview of the structure of the WMS-DSC matrix (Campitelli et al., 2022b)

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Governance					
Sector and market					
Collection and transport					
Waste disposal					
Energy recovery					
Waste recycling					
Prevention and reuse					

2.2.2. Five stages to reach a CE

The five stages, based on the defined development stages of the German Ministry of Environment (BMUB, 2016) have been extensively revised and linked to WM driver(s) (Wilson, 2007) and main target(s), enabling a clear mapping of the individual stages. The detailed descriptions of all stages are presented as follows:

1st Stage: "Absence or lack of essential elements of waste management"

Driver: Removal of waste

Main target: Collection and removal of waste from housing areas

The main driver and target for this stage is the removal of any kind of waste. The waste is not sorted at source and is discarded on uncontrolled dumping sites or openly burned. The legal situation is very weak, and there are almost no control mechanisms. Lack of responsibilities and unclear structures lead to unregulated, unreliable, ineffective, and expensive waste collection and disposal activities. There is no or only little waste-related data or statistics. The informal sector is an essential part of the WM as it operates in waste collection and sorting of recyclables. Occupational safety, health protection, and climate and environmental protection measures are almost non-existent.

2nd Stage: "Reliable collection and improved landfill sites"

New driver: Protection of human health

Main targets: Stop of uncontrolled dumping and open burning

In this stage, the protection of humans from the health hazards associated with improper disposal of wastes is becoming more important. The main target of this stage is to stop uncontrolled dumping and open burning and to move towards a controlled disposal of waste. Also, the legal situation is getting more stringent and specific; responsibilities are defined, and control bodies have been implemented. Waste related data collection is introduced to evaluate the actual WM state on the municipal, regional, or even national scale. Waste concepts, plans, and programs are becoming more important to make existing WM more transparent and create disposal security. Waste collection has been further expanded, but has not been widely established (especially in rural areas). The financing of WM is getting more stable. Simple recycling plants (e.g., composting plants) are implemented. WM offers great employment potential, but there is a lack of qualified personnel. Health security in the waste sector, urban hygiene, and conditions in the informal sector have been improved. Recycling markets are expanding.

3rd Stage: "Separate collection and sorting"

New driver: Environmental and climate protection

Main targets: Reduction of landfill volume and its emissions

This stage is predominantly characterized by the driver "environmental and climate protection". The reduction of emissions from landfills and its volume are the main targets of this stage. Waste segregation at source, higher collection rates, and the increased use of sorting facilities are the basis of high-quality sorting. Waste collection services are becoming more efficient. Additionally, due to stricter regulations concerning the disposal of waste in sanitary landfills, energy recovery, anaerobic digestion and the use of waste as RDF are considered relevant alternatives of waste treatment. Sales markets emerge for the use of RDF and other recycling products. Regulations on the monitoring of emissions released from waste treatment plants have been implemented to reduce emissions from WM. The informal sector has been completely formalized through the formation of responsible umbrella organizations or interest groups or by their integration into private sector enterprises. Extended producer responsibility (EPR) is introduced to make distributors and manufacturers more accountable for their products after becoming waste. This may lead to a possible formation of dual systems or other take-back concepts as well as efforts in ecological product design. Also, more jobs are being created in the WM sector regarding the construction and operation of treatment plants. An intensified use of automation can lead to higher occupational health and safety in the waste sector. Initiatives and programs to strengthen the environmental awareness regarding waste are conducted.

4th Stage: "Expansion of the recycling industry"

New driver: Resource value of waste

Main target: Increased use of waste as a resource

First, efforts are made to close material loops not only on a national scale but also on a company scale (including industrial symbiosis). Therefore, material recycling of waste becomes a matter of growing relevance. The main driver of this stage is the effective use of waste as a valuable resource. The primary target is to expand the use of waste as a resource to produce secondary raw materials. The sector is expanding and its importance in the context of resource policy is rising. WM planning is integrated into resource and energy efficiency concepts.

Modern and high-end technologies are used to produce mono fractions with a high quality or to treat wastes properly, in an environmentally friendly and resource-efficient manner. Recovery of fuels from waste through waste-to-energy plants (incineration, fermentation plants, etc.) are alternatives to material recycling. Landfilling of inert and pre-treated waste is still practiced, but landfilling rates of MSW are decreasing. Waste prevention is getting more important.

WM services are more often delegated to private providers or to WM associations as well as public private partnerships (PPP). Competition in the waste sector is growing. Qualified personnel, especially in the development, planning, construction, and operation of advanced technologies, are strongly requested.

5th Stage: "Circular economy – waste as a resource"

New driver: Conserve natural resources

Main target: Avoid waste and increase resource efficiency

Conserving natural resources is the essential driver of this stage. This stage describes visions of the future, considering a successful implementation of a CE. The concept of the CE (including circular bioeconomy) is intended as a fundamental concept of resource management and is put into practice. Objectives such as waste prevention, substitution of fossil resources with bio-based alternatives, and enhancing resource efficiency are pursued to a significant extent. The recirculation of waste materials into the material cycle can be verified by very high recycling rates. The transparent data situation in the field of production and WM in combination with a more extensive use of digitalization enables a more efficient and resource-saving economy. The reuse of products and the prevention of waste result in an ongoing trend towards more innovative business models, such as leasing, sharing, and low-packaging trade, which gain a high social standing and are actively used by large proportions of the society and enterprises. The quality of recyclates and their quantitative availability are publicly monitored and reported, so that secondary materials are systematically and extensively used in industry to minimize supply risks and to remain competitive. The practical application of CE makes a significant contribution to a resource-efficient and low-carbon economy, which can be clearly monitored by the respective sustainability indicators.

The descriptions of stage 1 to stage 4 are mainly leaned on WM developments in the European area, but developments in LMIC are also taken into account, mostly in the descriptions of stage 1 to stage 3. As mentioned before, the final stage 5 describes a fictional best-case scenario of a well-functioning CE. Therefore, even if a city of a HI country has a good performance (e.g., stage 4) in the subcomponents of governance, at the same time, it may have a weak performance in component prevention and reuse. For cities of the Global South, it works in the same way. They may have good performances regarding waste generation but have great optimization potentials regarding waste disposal. This concept allows the rewarding of aspects that are good or successful in a WMS with a higher stage assignment.

When using the concept, it should be noted that the financial barriers for cities in the Global South are greater than those of cities in the Global North, so funding, e.g., from development banks or international alliances, is required. Regarding the CE visions that are described in stage 5, the WM costs may rise with increasing stage. This surely depends on the stages that are targeted (e.g., stage 3 or stage 5) and what infrastructures are already in place. Consequently, implementing certain technologies may not yet be an option for specific cities in the Global South. However, it is definitely important to know the potentials on which the city can build on. It should be highlighted that the vision of a CE does not only mean technological change but also societal change. Subsequently, it may take a considerable amount of time, depending on the country, until stage 5 is achieved. It is also important to mention that the concept is independent of time, i.e. the stages of the individual components do not necessarily have to be reached at the same time, since components may be dependent on one another. It must be emphasized that, from a systemic point of view, governance must be seen as the foundation, collection and transport as well as sector and market as the first build up level and the other components as the second build up level concerning their dependencies (Figure 5).

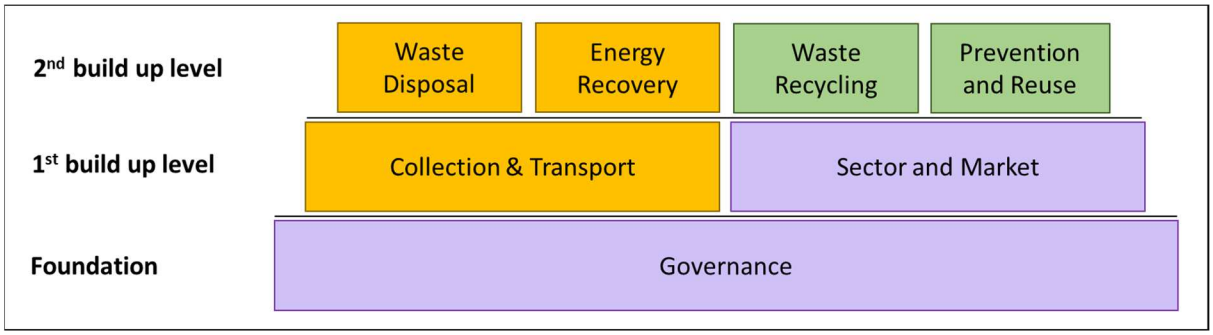


Figure 5: Dependencies between the different WMS components

2.2.3. WMS-DSC use instructions

Intended users of the WMS-DSC are practitioners, decision makers and academic personal, who are familiar with the WMS under study. To use the WMS-DSC, the following six steps should be applied (Figure 6).

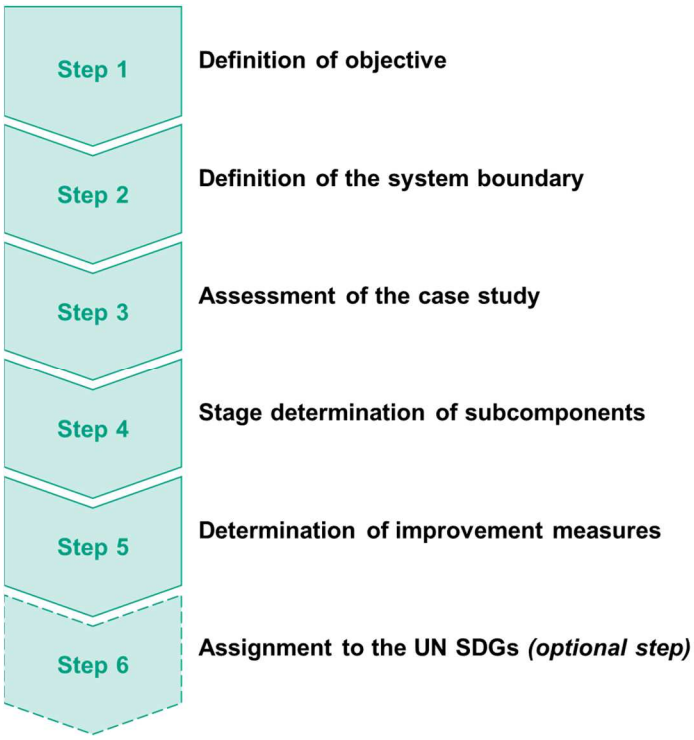


Figure 6: Six steps to use the WMS-DSC

<u>Step 1:</u> Definition of objective

In step 1, the objective(s) of the investigation is/are defined:

i) Assessment of the actual WMS state and identification of suitable measures to introduce, based on the actual WMS conditions
ii) Assessment of existing preconditions to implement specific measures (target state)
iii) Monitoring of progress (<u>Condition</u>: Assessment has been done before, e.g., 5 years ago)
iv) Comparison of different WMSs

Independent of the chosen objective, improvement measures can be derived based on the assessment results.

<u>Step 2:</u> Definition of the system boundary

In general, when assessing systems, it is of particular relevance to define the boundaries in which the system to be assessed is located. Depending on the chosen assessment objective (see step 1), the system boundary can vary. The modular design of the WMS-DSC makes it possible to examine a specific WMS component (e.g., governance only) or political scale (e.g., national level only), but it has to be taken into account that this limits the holistic nature of the concept.

In the detailed WMS-DSC (Appendix I), the subcomponents and their criteria follow a clear structure, which is presented in Figure 7. The structure is illustrated by the example of the subcomponent G.8 (Figure 7A) and its criterion G.8.2.1 (Figure 7B).

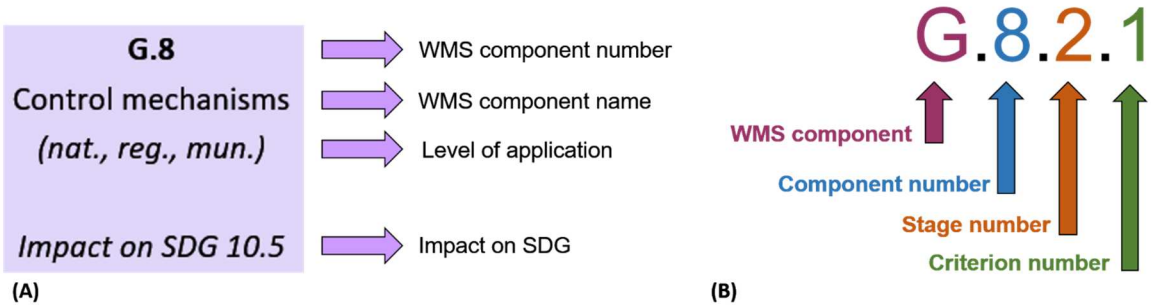


Figure 7: Subcomponent structure (A); criteria coding (B) (Campitelli et al., 2022b)

Beside the WMS component number and name, the level of application and, if applicable, the impact on the SDG's are mentioned for every subcomponent (Figure 7A). In the WMS-DSC, four levels of application have been identified: national (nat.), regional (reg.), municipal (mun.), and company (comp.). These four levels will support the user in assessing a single criterion. They should make it easier for the user to find the respective information to assess the criterion. For example, there are subcomponents that can be found only at the national level, such as national legislation; similarly, waste collection is mostly applied at the municipal level. Moreover, there are some criteria that can be present at multiple political levels in parallel, such as stakeholder cooperation and environmental protection measures.

In addition to the level of application, the level of influence must also be mentioned here, which differs from the level of application. The level of influence means that a criterion whose level of application is national is also directly influencing the underlying political levels. For example, the data or information needed to assess G.2. (laws, regulations and agreements) can be found at the national level, but they directly impact regional and municipal waste policies and legislative frameworks.

As mentioned before, the WMS-DSC is designed to assess the WMS at the municipal level, but also regional and national WMSs can be assessed as well as WMS in the context of companies. If objective (iv) (see step 1) is chosen, then more case studies have to be selected.

Depending on the selected objective(s) (step 1), it may be necessary to assess all WMS components (e.g., objective i) or only specific components (e.g., objective ii). Therefore, if objective (i) is selected, then it is recommended that all seven WMS components are assessed. If objective (ii) is chosen, then the implementation measure must be defined at this point. Furthermore, the needed preconditions have to be marked in the WMS-DSC to define the "target state". For example, if the conditions for the implementation of a composting plant is to be examined, it may not be necessary to assess the WMS components regarding energy recovery.

<u>Step 3:</u> Assessment of the case study

When assessing a WMS for the first time, it makes sense to assess stage 1 vertically, i.e. all seven components from top to bottom. After stage 1 has been fully assessed, from stage 2 onwards, it is recommended to assess the components horizontally, i.e. from left to right.

In the Excel checklist (Appendix II), the user can choose in the dropdown list if the single criterion is m = met, pm = partially met, nm = not met, or na = not available[4].

[4] "Not available" is chosen if the geographical circumstances do not enable it (e.g. WD.5.1, waste burning or dumping on high seas and coastal waters would be redundant if the case study is not near a high sea or coast), if energy recovery (incineration) is not desired by the city/nation and will not be promoted, or if no data is available (e.g. missing recycling rates).

If certain data (e.g., recycling rates, indices) are only available at the national level and not at the municipal level, the national data can be used, but this must be indicated in the assessment to increase transparency and traceability.

The criteria are as far as possible formulated in a positive way. Conversely, in the best case, all criteria in stage 1 are ticked as "not met", and from stage 2 onwards, they are ticked as "met". In general, if a stage 2 criterion is ticked, then, where applicable, the corresponding counterpart in stage 1 should be ticked as “not met”.

Some subcomponents’ criteria are underlined. The underlined criteria represent important milestones that are essential to build up a WMS or even a CE. At the end of the assessment, these milestones help to identify essential recommendations for action.

Moreover, some criteria need conditions that are not included in the same subcomponent. If this is the case, the required criteria are added in brackets; see the following example: “SM.4.3.2: Companies specialized in waste recycling/disposal need a specific certification (G.8.3.3) to work in WM”. The required certification is defined in the WMS component G.8.3.3 (“Introduction of regulated and recognized certification of specialized WM companies”). This means that if the system boundary is set in a way to include only specific WMS components, it is necessary for this case to include the interactions (dependencies), which are part of an excluded WMS component.

<u>Step 4:</u> Stage determination of subcomponents

An exact determination of the stage of a subcomponent is possible, when all characteristics of the stage are ticked. Therefore, for a subcomponent to be fully in stage 3, all criteria of stage 3 have to be met; otherwise, it is only partly in stage 3. In order to provide a consistent visualization of the results table (see Figure 8), users are advised to do the following:

If the criteria of a stage-related subcomponent:

...are completely "met", then the fields are marked dark blue.

...are completely "not met", then the fields are white.

...all other combinations are interpreted as "partly met" and are marked with light blue.

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Collection and transport	CT.1 Waste collection					
	CT.2 Service provider					
	CT.3 Collection rates					
	CT.4 Separate collection					
	CT.5 Collection of recyclables					
	CT.6 Waste transport					
	CT.7 Transfer stations					
	CT.8 Collection of hazardous wastes					

Figure 8: Exemplified presentation of the results for CT (Campitelli et al., 2022b)

If a subcomponent’s criteria are met at different stages, then an exact determination is not possible. In this case, the range has to be mentioned (e.g., “CT.3 is in the range of stage 1 to stage 4”). If a WMS component extends over several stages, this shows that a development of the WMS component is ongoing. Only the criteria that are "met" are considered to define the stages and, finally, the range.

However, this assessment can also be useful to identify additional criteria that are necessary to move to the next stage. Considering the DTT principle, in this case, the distance is determined by the stages, and the main target is to achieve stage 5, which is the best-case scenario. If objective (ii) is investigated, then the target is equal to the implementation measure (see step 2).

Subcomponents are not always described consistently in all stages. In some cases, certain criteria are only present at stage 2 or higher (e.g., G.2.3.5) or only go up to stage 2 as a maximum (e.g., G.4.2.1 and G.4.2.2). This means that not every subcomponent can necessarily reach stage 1 or stage 5.

Step 5: Determination of improvement measures

Depending on the objective selected in step 1, different result types can be generated. They may be very detailed, involving the identification of specific measures for further implementation (e.g., introduction of separation at source), or more abstract, such as the identification of possible WM activity fields (e.g., promoting material recycling). Depending on the assessment, a large number of measures may result. In order to maintain a clear overview, dividing the measures into clusters is recommended. These clusters may be subcomponent-related. But due to the existing interdependencies between the different subcomponents, it would also make sense to cluster measures that are topic-related (e.g., "Promote recycling", “Ensure area-wide collection", "Ensure disposal security") or aligned to the SDGs.

Furthermore, if different cities or municipalities in a country are assessed, similarities and differences can be identified from the respective city-specific results. An upscaling of the city related WMS conditions at the national level can be realized if the case studies examined are representative of the country. This analysis permits the drawing of conclusions regarding whether the WM in a country is evolving homogeneously or whether a big diversity has been identified. Finally, by equating stage 5 to a functioning CE, with this concept, the CE potential can be estimated and measures derived on how to exploit the existing potentials.

Step 6: Assignment to the UN SDGs *(optional step)*

Step 6 is an optional step that can be taken if an assessment of the WMS concerning the SDGs is desired. In the detailed assessment concept (Appendix I), the corresponding SDGs (see example in Figure 7A) have been assigned to the respective subcomponents where possible.

Interim conclusion

The WMS-DSC meets two requirements: 1) to represent the extensive complex system of WM as holistically as possible and 2) to present it as simply as possible, so that it can also be used by non-experts who, however, have a good knowledge of the WMS under study. Since the concept consists mostly of qualitative criteria, an unequivocal selection is not always possible, because it allows a considerable amount of room for interpretation by the WMS-DSC user. This must be taken into account for every assessed case.

The categorization of WMSs into development stages enables the detection of symptoms and causes of waste mismanagement and potential measures for improvement. Furthermore, it identifies how the WMS, for example in a city, is structured and how the performance of the WMS is evolving. Therefore, the WMS-DSC can be used by decision makers, such as local actors, for self-assessment to detect essential WMS activity fields. This can also happen in cooperation with development partners (e.g., sponsors such as the World Bank), for example to identify the next WMS improvement steps. However, the final introduction of future measures for this sector requires experts in the field of WM, who are responsible for designing the measure(s) implementation as well as verifying the financial affordability for future implementation. Therefore, the concept can support cities to identify necessary measures and better describe the desired future steps in WM development. In particular, when countries in the Global South have similar CE goals and visions as the EU, the WMS-DSC can be a supportive tool for defining CE goals.

Also, the concept may be used by development banks and other funding agencies to identify funding targets and milestones of projects as well as to review them after approval.

In summary, the WMS-DSC provides a comprehensive concept, displaying the most relevant but certainly not all existing interactions between the various criteria. But where possible, the relevant interactions have been interlinked throughout the concept. However, it has no claim to completeness, because of the high complexity of the system and the rapid development in this area.

Due to the fact that the WMS-DSC method enables an in-depth analysis of the WMS and CE performance of a city, it could also be applied after the usage of the rapid assessment approaches of Fatimah et al. (2020), Whiteman et al. (2021) and UN-Habitat (2021) to get the big picture of the WMS performance.

2.3. What is the actual WMS performance of the Moroccan city Marrakech?

The next subchapter describes the use of the WMS-DSC to assess the WMS performance of Marrakech (Morocco) to proof the WMS-DSC (Campitelli et al., 2022a). Firstly, the case study of Marrakech is presented as well as the system boundary and the data acquisition for the analysis. Secondly, the analysis results (Appendix II and Table 5) are presented based on the structure of the WMS-DSC, including all components. In the results, only a selection of the analyzed subcomponents is presented as well as the stage classification. The detailed analysis results can be found in Campitelli et al. (2022a) and also in Appendix II.

2.3.1. Description of the case study: Marrakech (Morocco)

According to the World Bank income classification, Morocco is classified as an LMIC (World Bank, 2020a). Tourism, agriculture and manufacturing are important sectors of the Moroccan economy. In 2018, Morocco's GDP per capita reached 3,361.22 US dollars, and the economic growth is estimated at 1.7% (World Bank, 2020a). The prefecture[5] of Marrakech is the 4th biggest city of the kingdom of Morocco and the capital of the Marrakech-Safi region. Besides the prefecture of Marrakech, seven provinces belong to the region, which in the last census of 2014 had a population of 4,520,569 inhabitants. The city of Marrakech had 928,850 inhabitants (HCP, 2014). Projections by the United Nations indicate that the population in Marrakech will rise to about 1,270,000 by 2035 (UN, 2018). In the prefecture of Marrakech, 379,277 tons (SIREDD, 2022a) of MSW were generated in 2015. The largest share of the MSW is organic waste, which accounts for 72% (Ouchen, 2018).

System boundary:

The system under study is the WMS of the prefecture of Marrakech (Morocco). The particularity of some components (e.g., G and SM) means that the analysis of the WMS does not refer exclusively to the city of Marrakech, but also to higher levels, such as regional (Marrakech-Safi region) and, especially, national level (Morocco). Through the top-down connection, decisions at higher levels can directly affect the practice at the municipal level.

Data acquisition

A wide variety of data sources were used to perform the analysis. Besides scientific literature, information mainly from reports, official government documents (e.g., programs and legal texts) and daily newspaper articles was used. Furthermore, relevant websites (e.g., of companies) were scanned to provide suitable examples, and an interview with Redouane Rifki, a plant operator of the disposal and recovery center “CEV” (Centre d’élimination et de valorisation) in Marrakech, was conducted in 2021. All results, the rationale and the used references are presented in Appendix II.

[5] A prefecture is an administrative division in Morocco.

Table 4: Results for Marrakech for G and SM (Campitelli et al., 2022a)

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Governance	G.1 Duties and targets					
	G.2 Laws, Regulations and Agreements					
	G.3 Nomenclature					
	G.4 National level WM					
	G.5 Regional level WM					
	G.6 Municipal level WM					
	G.7 Stakeholder cooperation					
	G.8 Control mechanisms					
	G.9 Authorization and public participation					
	G.10 Quality standards and threshold values					
	G.11 Data collection, reporting and evaluation					
	G.12 Education					
	G.13 Research					
	G.14 Awareness building					
	G.15 Occupational health and safety					
	G.16 Environmental protection					
Sector and Market	SM.1 Sector development					
	SM.2 Jobs					
	SM.3 Informal sector					
	SM.4 WM system structure and organization					
	SM.5 Financial funding					
	SM.6 Enterprises					
	SM.7 Recycling market					

	Subcomponent is met
	Subcomponent is partly met
	Subcomponent is not met or data is not available

Table 5: Results for Marrakech for CT, WD, ER, WR and PR (Campitelli et al., 2022a)

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Collection and transport	CT.1 Waste collection					
	CT.2 Service provider					
	CT.3 Collection rates					
	CT.4 Separate collection					
	CT.5 Collection of recyclables					
	CT.6 Waste transport					
	CT.7 Transfer stations					
	CT.8 Collection of hazardous wastes					
Waste disposal	WD.1 Waste disposal					
	WD.2 Operational measures					
	WD.3 Leachate water management					
	WD.4 Landfill gas management					
	WD.5 Other means of disposal					
Energy recovery	ER.1 Thermal disposal and energy recovery					
	ER.2 Incineration plants					
	ER.3 Energy and raw material recovery					
Waste recycling	WR.1 Waste recycling					
	WR.2 Composting					
	WR.3 Fermentation					
	WR.4 Sorting and recycling plants					
	WR.5 Refuse derived fuel					
	WR.6 Recycling of construction and demolition waste					
	WR.7 Recycling rates					
	WR.8 Diversion rate and Circular material use rate					
Prevention and reuse	PR.1 Prevention					
	PR.2 Circular business and usage models					
	PR.3 Product design					
	PR.4 Process optimization and operational disposal strategies					
	PR.5 Waste generation					
	PR.6 Zero-waste index					

2.3.2. Governance: Stage 2 to stage 3

G.1: Duties and targets; G.2: Laws, Regulations and Agreements

Waste in Morocco is an important emission sector, which has been declared a national priority (Climate Chance, 2020). A legal basis for WM is the waste act (Law 28-00). Moreover, seven other laws and dahirs (King's decrees) are present as well as 11 orders and nine other regulations that have a direct relation with waste. In 2014, with Law 99-12, Morocco introduced an ecological tax on plastic articles, and in 2015, with Law 77-15, the country banned plastic bags. Other laws regarding the management of C&D waste are in preparation. Actually, there are no national policies about EPR (Rademaekers et al., 2020). The 5-stage waste hierarchy is also not anchored in the waste law (Law 28-00).

G.4: National level WM

Different national programs and strategies related to waste are in place, such as the National Program of Household and Similar Waste (PNDM), which is a 40 billion dirhams (~ 3.8 billion Euro) investment program that was launched in 2008 and ends in 2023 (Climate Chance, 2020). Its objectives are to achieve higher collection rates (90%), construct controlled landfills and recycling centers in 100% of urban communities and rehabilitate or close all existing dumpsites by 2020. Moreover, it also aims to professionalize and develop the waste and recycling sector to achieve recycling rates of 20%, by considering training and awareness campaigns for chain actors (Amounas, 2020).

The National Strategy for Sustainable Development 2030 (SNDD) represents the foundation to implement a green economy in Morocco by 2030 (Royame du Maroc, 2017). This strategy recognizes WM and recovery as important aspects of the green industrial sector to invest in; further, it aims to improve the recycling rates for certain waste types, such as municipal and agricultural wastes and wastewater (Climate Chance, 2020).

The National Program for the Recovery of Waste (PNVD) was launched to promote an integrated and sustainable WM in Morocco by taking into consideration the concept of CE. It is targeted at minimizing the impacts of industrial activities, reducing waste to save natural resources and creating green jobs by promoting investments in recycling and waste recovery (including the informal sector) (Ghariani, 2020). In this regard, the former Ministry of Energy, Mines and Environment[6] published the national waste reduction and recovery strategy (SNVRD) in 2019 (GIZ, 2019). The SNVRD determines targets and constitutes different measures and tools to foster CE at the national level (Diaco et al., 2020).

According to Rademaekers et al. (2020, p. 13), Morocco is working on a roadmap towards CE within the framework of a green economy plan, which is not published, yet. Even though CE aspects are integrated into the PNVD and SNVRD, CE is not yet the main target of the waste law (Law 28-00).

In regard to its public institutions, Morocco is well-positioned. At the national level, the MTEDD is mainly responsible for WM. It elaborates the national strategy of sustainable development and participates in the development, implementation, monitoring and evaluation of national environmental programs (such as PNVD, PNDM and SNRVD) (MTEDD, 2022).

[6] Now Moroccan Ministry of Energy Transition and Sustainable Development – MTEDD.

G.5: Regional level WM; G.6: Municipal level WM

At the regional level, the Regional Directorate of Environment in Marrakech-Safi region, which is one of the deconcentrated services of the MTEDD, is responsible for WM issues (SIREDD, 2022b). At the municipal level, the management, disposal and recovery of household and similar wastes was entrusted in 2020 to an intercommunal cooperation ("Grand Marrakech") (mapecology, 2020). By law, prefectural or regional master plans for WM (Dahir n° 1-06-153 Article 12) as well as regional master plans for the management of non-hazardous industrial, medical and pharmaceutical, agricultural and inert wastes (Decree 2-09-683 and Arréte 3413-11) should exist, but they could not be found online.

G.8: Control mechanisms

Environmental control (including waste issues) is the responsibility of the Moroccan state and the environmental police (Law 99-12 Art. 35). This responsibility is assigned to the Secretariat of State in charge of Sustainable Development by Decree 2-14-758 of 2014 and the Directorate of Control, Environmental Assessment and Legal Affairs. The mission of this directorate is to ensure the application of legislation and regulations in environmental matters by regularly carrying out controls and inspections. At the regional level, the Environmental Impact Assessment and Monitoring Service, which is subordinate to the Regional Environmental Department (DRE) of Marrakech-Safi, is responsible for carrying out environmental inspections and control operations. Hence, the basic conditions are met regarding the monitoring of WM activities and identifying violations of rules, but the frequency of controls and their effectiveness could not be determined. IMANOR (Moroccan Institute of Standardization) certifies conformity to standards and normative reference systems in industries (e.g., ISO 14001, ISO 9001, ISO 50001) and is a member of the International Organization for Standardization (ISO) group (IMANOR, 2022).

G.11: Data collection, reporting and evaluation

The Regional Information System on Environment and Sustainable Development (SIREDD), which is the operational entity of DRE, provides alphanumeric and cartographic data and information concerning environmental topics, such as waste and biodiversity. Such information system exists in all Moroccan regions and is uniform, but it is not clear how the data is used at the national level. Concerning waste data, the SIREDD of Marrakech-Safi has a waste related database with nearly 30 indicators concerning waste and leachate generation, collection, recycling and disposal rates for MSW, agricultural, industrial hazardous, medical and pharmaceutical wastes. Also, indicators such as the number of treatment plants, illegal dumps, active landfills, rehabilitated and closed landfills, as well as transfer centers are available. Out of these indicators, only ten contain data, and they are predominantly not up-to-date. The various provinces of the Marrakech-Safi region are mapped, but not continuously for all regions and for a long period of time, leading to great data gaps. (SIREDD, 2022a)

G.14: Awareness building

Morocco has taken actions to improve recycling and WM over the last decade. Alongside these efforts, the authorities are also trying to change the behavior of the population and to raise awareness concerning waste, e.g., through the PNDM and specific campaigns. In this regard, many actions have been taken to raise awareness about WM and CE, such as the creation of the Association of Educators of Life and Earth Sciences of Morocco (AESVT Maroc), which is a non-profit organization pushing educational projects promoting sustainable development. But more efforts are needed to stimulate sorting at source and recycling. This becomes

unavoidable when the waste collection system in Marrakech enables sorting at source with more than one bin.

Classification results for the component G

Based on the foregoing, it can be stated that for the city of Marrakech and higher levels, G can be considered to be in stage 2 to stage 3. However, stage 1 to stage 4 are partially met for specific subcomponents (Table 4).

2.3.3. Sector and market: Stage 2 to stage 3

This component refers to the city of Marrakech, higher levels as well as company level.

SM.1: Sector development

Waste is an important issue not only for the institutions but also for other stakeholders. The Coalition for the Recovery of Waste (COVAD) was created in April 2016, bringing together stakeholders from the private sector, civil society and government bodies to promote CE in WM on the national and international scales (Diaco et al., 2020). Therefore, stakeholder dialogues and an exchange addressing WM and CE challenges exist.

SM.2: Jobs; SM.3: Informal sector

In Marrakech, an Ecocenter is planned, which besides recycling and recovery of waste, aims to ensure the legal recognition of the profession of waste collectors and structure their work within a cooperative framework to encourage the creation of micro-enterprises in the field of recycling. With its construction, new jobs in the recycling sector in Marrakech are expected (Ouchagour, 2021). The informal workers play an important role in the waste sector, and they are organized as small communities, but until now, there is no official association that represents their interests.

SM.4: WMS structure and organization

The current Moroccan WMS is a linear economy, which could be changed in future through a paradigm change to achieve a CE. For this reason, a structural change is necessary. This means dividing tasks (e.g., PPP) and unifying competences to surmount the challenges (EcoActu, 2019). Therefore, the integration and cooperation of public and private actors is important. Law 86-12 (2015) regulates the PPP activities in Morocco, but in 2020, a new law (46-18) was promulgated, which amends and supplements law 86-12. Numerous changes have been made to increase PPP in Morocco (MEF, 2020). Presently, due to the missing EPR, there is no established system that ensures the fulfillment of disposal and recycling obligations of manufacturers, retailers and distributors in Morocco.

SM.5: Financial funding

The funding of WM projects is crucial, especially for countries in the Global South. The German Development Bank and the World Bank have provided assistance to Morocco in establishing a viable financing system to develop the PNDM. More funding opportunities (e.g., regarding environmental policy and sector programs) were listed by Diaco et al. (2020), including Industrial Depollution Fund, National Environment Fund, Clean Development Mechanism, Morocco Capital Carbon Fund and the Energy Development Fund.

SM.6: Enterprises

At the local level, audits are carried out to receive the final certificate regarding Environmental Management System (ISO 14001), Occupational Health & Safety Management System (ISO 45001) and Energy Management System (ISO 50001). The city council of Marrakech was the first African city to receive an ISO 14001 certificate, back in 2007. For this reason, the city of Marrakech drafted a report on the state of the environment of the city and conducted surveys on the environmental perception of the population and the environmental sensitivity of municipal employees; the city also carried out some training workshops (Daddi et al., 2011). In Morocco, 196, 142 and 2 certificates were assigned to companies in 2020 for ISO 14001, ISO 45001, and ISO 50001, respectively (ISO, 2021). The results show that in comparison to energy, environmental and occupational health & safety certificates are more in the focus of Moroccan companies, and there is a basic awareness regarding environmental issues (including waste).

Labeling exists for specific products and substances (hazardous substances). The Moroccan Standard NM 03.2.100 presents the classification, packaging and labeling for hazardous products. Additionally, Law 24.09 is related to the safety of products and services; it refers mostly to hazardous products and disposal handling (Law 24.09. Art. 9). Decree n° 2-12-502 implements Law 24.09; Art. 1 defines the requirements for products and product categories in terms of safety (e.g., composition, use, maintenance, reuse, recycling).

SM.7: Recycling market

Overall, the recycling market is not clearly structured. However, the plastic recycling sector in the informal sector of Morocco is highly structured (GIZ, 2019). Moreover, Morocco has introduced export licenses for specific recyclables (e.g., wastepaper and PET bottles) to ensure waste supply for national recycling industries (Diaco et al., 2020).

The import of hazardous waste is prohibited by Law 28-00, Art. 42. Import and export of hazardous waste has to be authorized by the authorities responsible for sustainable development. In Decree 2- 17-587, the criteria and procedures for granting such authorizations are defined (Morocco-export.com, 2019). Concerning the import of combustible waste, MTEDD is responsible for the authorization (e.g., tires, a waste-to-energy source) (Salamy Bebila, 2020).

Classification results for the component SM

The results for this component are in stage 2 and stage 3; also, stage 1 to stage 4 is partially met for specific subcomponents (Table 4).

2.3.4. Collection and transport: Stage 1 to stage 2

Compared to the last two components, this analysis refers predominantly to the municipal level.

CT.1: Waste collection; CT.2: Service provider

The collection of MSW is mostly done by the formal sector, namely the companies Arma and Mecomar (Yahya, 2021). Nonetheless, the informal sector plays a significant role in waste collection in Marrakech. They are relevant in filling the collection gaps, e.g., in rural areas, and in collecting recyclables (plastics, metals, glass, etc.) separately. The open access to transfer stations enables the picking out of recyclables from the collected waste, which means that less recyclables end up in the CEV waste sorting center (Rifki, 2021). The collection is done using uniform aboveground systems as well as placing waste in bags or boxes in front of the door (especially in the Djemaa el-Fna).

CT.3: Collection rates

Regarding the city of Marrakech, no specific updated collection rates for the urban area could be found. According to the State Secretariat for Water and Environment (Hafidi, 2015), the collection rate in 2005 for the agglomeration of Marrakech was about 85%. The national goal in accordance with the PNDM is to achieve a collection rate of 90% by 2020. Marrakech city has the highest MSW collection rate in the Marrakech-Safi region with 100% (Rifki, 2021; SIREDD, 2022a). The rates for the other provinces are between 35% and 80% (SIREDD, 2022a). For rural areas, no specific collection rate is available.

CT.4: Separate collection; CT.5: Collection of recyclables

In Marrakech, there is no segregation at source, so, all types of waste are collected in one bin; consequently, collection rates for recyclables are not available. A model project to implement segregation at source is planned in one district of Marrakech. Municipal and assimilated wastes from commerce and industry are also collected (Rifki, 2021).

CT.6: Waste transport

Collection trucks of the formal collection firms are modern and equipped with automation and compactors. Moreover, there are plans to double the collection capacity by increasing the number of vehicles and staff, using GPS technology to monitor the collection performance, introducing feedback systems and raising the awareness of citizens regarding cleanliness of the city (Yahya, 2021). Due to the contracting of new companies (in 2021), it can be assumed that not all measures have been implemented at the time of the analysis. However, these announcements show that the city of Marrakech is investing in cleanliness and urban hygiene by strengthening waste collection.

CT.7: Transfer stations

Two transfer stations exist in Marrakech for waste transfer from small to bigger trucks. Currently, they are open to the public. There are plans to increase the amount of equipment, restrict access to the public and integrate equipment for waste transfer (Rifki, 2021).

Classification results for the component CT

The results of the analysis show that CT can be classified into stage 1 and stage 2, whereas aspects of stage 3, stage 4 and stage 5 have been partly met (Table 5).

2.3.5. Waste disposal: Stages 2 to stage 3

WD.1: Waste disposal

Since 2015, the generated household and assimilated wastes of Marrakech are disposed centrally in the controlled El Mnabha landfill, which is located 42 km from Marrakech. This landfill has replaced the old uncontrolled Al Azzouzia landfill, which was closed in 2016 after rehabilitation due to existing environmental and sanitary risks (Saadoun et al., 2021). El Mnabha landfill is part of the waste CEV elimination and recycling center in Marrakech, which is operated by Ecomed. Due to the introduction of landfill classes, the disposal of liquid and hazardous wastes is prohibited on El Mnabha landfill, which is dedicated solely to non-hazardous household and assimilated wastes (landfill class 1), but the discharge of waste with hazardous contents cannot completely be prevented.

As already noted in 2.3.4, an area-wide waste collection is not yet a reality for the rural areas in Marrakech. Due to the lack of data, it is also difficult to say which parts of this gap is covered by the informal sector. Open burning and wild dumping of waste are possible ways by which the citizens discard their wastes. C&D waste is mainly dumped openly (Rifki, 2021).

WD.2: Operational measures

Before disposing the waste, it gets registered and weighted (Rifki, 2021). The disposed waste types are documented and the waste data (amount of disposed waste and waste type) are forwarded to the municipality, but the statistics are not being published so far. The disposed waste is compacted and covered daily with soil.

WD.3: Leachate water management; WD.4: Landfill gas management

The active El Mnabha landfill is equipped with a basin to collect the generated leachate. The leachate is not further treated, but the construction of leachate treatment units (physical-chemical, biological treatment and ultrafiltration) in future is planned. CEV will probably start the first leachate treatment unit in 2022. At present, the remaining leachate is evaporated like in the old Al Azzouzia landfill. The biogas from the active landfill is flared. Surface and groundwater monitoring is done twice a year. Next to the landfill, there is a sorting plant on the site, where the waste is mainly manually sorted into diverse fractions (Rifki, 2021). The idea behind this project is to valorize waste and minimize landfilled waste.

Classification results for the component WD

The component WD is mainly met in stage 2 to stage 3. Some aspects are also partly met in stage 1 to stage 3 (Table 5).

2.3.6. Energy recovery: Stage 1

ER.1: Thermal disposal and energy recovery; ER.2: Incineration plants; ER.3: Energy and raw material recovery

Currently, Marrakech does not have any incineration plants for thermal or energetic recovery of waste. During the city's analysis, no information could be found on whether waste-to-energy facilities are planned or prospectively desired. Some essential criteria for the implementation of a waste incineration plant are in place, such as the systematic collection of waste and the presence of controlled landfills. It is unclear whether qualified staff for the operation of all processes of an incineration plant are available. Due to the high organic fraction of the waste of Marrakech, it is not certain if the heating value of at least 7 MJ/kg is met (Rand et al., 2000). Therefore, more detailed and current analyses concerning waste composition and characteristics would be appropriate. However, other energy recovery options are conceivable, in terms of RDFs, which could be pursued further. But for this purpose, more effort regarding the sorting of plastic waste is necessary to ensure that these valuable waste materials are valorized instead of landfilled. Nevertheless, there is a cement plant in Marrakech that also co-incinerates waste. Among other things, old tires or RDF are used for co-incineration. The CEV could be a good RDF supplier for the cement plant once the intended RDF plant is realized.

Classification results for the component ER

For this component, ER.1 is partly in stage 2, and the subcomponents ER.2 and ER.3 are in stage 1 (Table 5).

2.3.7. Waste recycling: Stage 1

WR.1: Waste recycling

The collection of recyclables from households and the picking of recyclables in transfer stations are done by the informal sector. Marrakech has a sorting facility (CEV), which was completed in 2017, officially inaugurated in 2019 (MMEME, 2019) and started their work in 2020 (Rifki, 2021).

WR.2: Composting; WR.3: Fermentation; WR.5: Refuse derived fuel

Currently, organic waste is mainly landfilled, composted at home or used to feed animals. Ecomed, the operator of the CEV, plans to construct a composting unit to pre-treat the incoming waste before landfilling for emission reduction (e.g., methane). Moreover, an RDF unit to produce RDF, which could be sold to the cement plant located near the landfill (Rifki, 2021), is planned. A fermentation plant is not available in Marrakech.

WR.4: Sorting and recycling plants

The sorting center of the CEV consists of two conveyors, each with a throughput of 400 tons per day (Rifki, 2021). In addition to a bag opener, there are also drum screens and magnet separators as well as several stations for manual sorting of specific types of waste. The waste fractions, including plastics, metals, aluminum and glass, are sorted out. Plastics and metals are compacted in baling presses. However, the amount of recyclables in the incoming waste is very low, as they are often already picked out by the informal sector (Rifki, 2021). As already mentioned in 2.3.3 in SM.2 an Ecocenter is planned to recycle and recover waste (Ouchagour, 2021).

WR.7: Recycling rates

Estimated recycling rates for the region of Marrakech-Safi exist from 2015 (GIZ, 2019). A stage attribution of these estimates gives the following result: Most recycling rates are in stage 2, the rate for plastics in stage 3 and for metals in stage 4 (GIZ, 2019). But since the methodology for calculating this data was not comprehensible, it was not included in the evaluation. E-waste is disposed on the landfill or not recycled appropriately. Most of the electronic devices are repaired and reused (Rifki, 2021). For C&D waste, no specific data were available.

WR.8: Diversion rate and Circular material use rate

Due to the fact that the informal sector predominantly recycles the waste, there are no reliable and robust recycling rates or other data for relevant calculations for the city of Marrakech, such as the diversion rates (DR) and the circular material use rate (CMUR).

Classification results for the component WR

The majority of the subcomponents can be assigned to stage 1; however, for WR.4 (sorting and recycling facilities) and WR.6 (recycling of C&D waste), stage 2 is partly met (Table 5).

2.3.8. Prevention and reuse: Stage 1 to stage 4

PR.1: Prevention

Based on Law 77-15 and Decree n° 2-16-174, Morocco has banned the manufacturing, trade and sale of plastic bags. Regulations are being tightened to remove existing gray areas in the law to ban illegal selling and distribution of plastic bags altogether (Mbaye, 2020). Concrete goals regarding waste avoidance (e.g., food waste) do not currently exist.

PR.2: Circular business and usage models

Repair, especially in African countries, is a very widespread practice (Rademaekers et al., 2020). The use of repair services instead of rebuying, especially for electronic products, furniture and textiles, is common in Marrakech as well as the use of spare parts. In Morocco, there are several spare parts online markets (especially for cars), like moulpieces.ma, monauto.ma, mister-auto.ma, etc. In 2022, a new website named Okato will be launched for the selling of general second-hand spare parts in Morocco (Okato, 2021). Besides repair, carpooling is also offered by the carpool service in Morocco Pip Pip Yalah, which is also usable in Marrakech; however, a specific car-sharing system could not be found for Marrakech.

PR.3: Product design

In Morocco, there are no mandatory deposit systems for products (e.g., packaging and batteries). A voluntary deposit system for PET bottles is provided by Marjan and Carrefour (Label Vie), which are supermarket chains. Marjan, for instance, introduced a deposit system for plastic bottles in different supermarkets in 2021 and plans to expand it in future due to good customer feedback (seariousbusiness.com, 2021).

With Law 22-16, the manufacturing and marketing of non-degradable bags was prohibited, and the application of the eco-tax on plastic products brought some companies in Morocco to consider the recyclability of their products in the product design phase (GIZ, 2019; WWF, 2019). Moreover, as mentioned in 2.3.3, numerous companies are awarded the ISO 14001 certificate regarding environmental management. There are companies in Marrakech that are taking into consideration end-of-life (EoL) issues in their processes, such as packaging manufacturer UCC Paul Lagache and tea producer Siti Tea. These examples show that a basic awareness concerning waste and EoL issues is present in the context of companies.

PR.5: Waste generation

Concerning waste generation rates, Morocco is at a high stage. According to Diaco et al. (2020), the urban population of Morocco generates around 0.76 kg of waste per capita per day, and the rural population generates 0.30 kg per capita per day. Compared to the rest of the world, this represents a small waste generation rate (Kaza et al., 2018), which results in a classification of stage 4. This shows that, in principle, there is a foundation for waste PR; this must be used to prevent countries like Morocco from developing in the same way as highly industrialized countries, which often have high waste production rates (Kaza et al., 2018). According to the WWF report of 2019, Morocco produces large quantities of plastic and is facing some challenges in the aspect of WM. Out of the 0.55 MT/year of plastic waste generated in 2016, only 0.04 kT of plastic were recycled and reintegrated into the production lines as secondary material (WWF, 2019). This includes innovative composite materials as well. This shows that the EoL management is not prominent yet.

PR.6: Zero-waste index

As indicated by Zaman and Swapan (2016), the ZWI for most African nations is extremely low and is assessed to be under 0.05 for Morocco. Furthermore, the substitution rate of virgin raw materials by recovered waste (e.g., via recycling) is very low (Zaman and Swapan, 2016). Besides waste PR, increasing the recycling rates is an essential factor to raise the ZWI. In the context of recycling, there is still much to be done both in Marrakech and Morocco.

Classification results for the component PR

After the analysis of PR, the results show various stage attributions of the single subcomponents. While PR.1 and PR.6 are in stage 1, PR.2 to PR.4 are in stage 2; PR.5 can be attributed to stage 4 (Table 5). Considering the partly met stages, attributions to stage 1, stage 3 and stage 4 can be made.

Interim conclusion

The analysis results show the varying classification of the stages. The components ER and WR are both classified in stage 1. For WR, a slight development towards the next stage can be assumed due to the planned activities (e.g. expansion measures in CEV, construction of new recycling plant in Marrakech, etc.). The components CT and PR are mainly in stage 2 but also assigned to stage 1 (CT.4, CT.5, PR.1 and PR.6); in addition, stage 4 is achieved for PR.5 regarding waste generation. For CT and PR, more effort to achieve higher stages can be seen in the results. According to the WMS-DSC results, the components G, SM and WD can be classified in stage 2 to stage 3 with a trend towards stage 4.

Regarding G, it can be said that Morocco is very active in defining the legal framework for WM and already has a good basis. A great potential for improvement is also seen in the implementation. WM laws and regulations exist, but they have numerous gaps that need to be closed in order to establish a CE, for example by implementing measures or instruments that promote recycling (e.g. EPR and regulations on secondary raw materials). There are also indications of some activities with regard to a CE, but certain instruments (such as SIREED) still have to be established so that a more precise statement on the state of the WM can be made. Furthermore, there is great movement in regard to WM in the city of Marrakech through the planned measures to improve waste collection (Yahya, 2021), new foundations, such as intercommunal cooperation ("Grand Marrakech") (mapecology, 2020), and the opening or planning of additional sorting and recycling facilities.

Since the stages of the case study is in the lower to middle range, it does not make so much sense to specifically have stage 5 as the primary goal. This would limit the feasibility of the measures and rather lead to an overwhelming challenge. In order to increase the feasibility of the measures, certain stages were chosen by the author depending on the analyzed component state. For example, for WR, it is important to get out of stage 1 first. For CT and WD, the goal should be to get every subcomponent at least to stage 3 to encourage the trend towards stage 4 or even 5.

2.4. Which measures are needed to achieve the transition towards a CE in Marrakech?

Based on the analysis results of the WMS-DSC in the previous subchapter 2.3, recommendations for actions (Table 6) to promote the transition towards a CE in Marrakech have been derived. The derivation of the measures was done by identifying the missing milestones (underlined criteria, see Appendix I) and considering the criteria of the higher envisaged stages. According to Campitelli et al.'s (2022) method, four thematic clusters containing 33 measures were identified to improve the WMS primarily for the city of Marrakech and move towards a CE:

Cluster A: Increase collection rate and separate collection of waste

Cluster B: Improve control, regulation, monitoring and assessment

Cluster C: Promote closing the loop in Marrakech

Cluster D: Encourage cooperation between research, companies and society

Table 6 gives a short overview of the four clusters and the related 33 measures, including the levels of application, the states of priority, the preconditions to implement the measure and the SDG's assignment. Most of the measures are aimed directly at the city of Marrakech (n. 20). However, there are also measures that have to be implemented at the national (n. 20), regional (n. 16) or company (n. 7) level. Of all measures, 13 have been classified[7] as essential and 25 as relevant. It is important to mention that some measures contain essential aspects and relevant aspects, such as M4, M6 and M7.1. As can be seen in Table 6, most of the derived measures of the clusters A, B and C have a direct as well as an indirect impact on the SDGs 11 "(Make cities and human settlements inclusive, safe, resilient and sustainable") and 12 ("Ensure sustainable consumption and production patterns"). Moreover, the measures directly or indirectly contribute to meeting the SDGs 3 ("Ensure healthy lives and promote well-being for all at all ages"), 4 ("Ensure inclusive and equitable education and promote lifelong learning opportunities for all"), 6 ("Ensure available and sustainable management of water and sanitation for all"), 8 ("Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all"), and 9 ("Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"). The detailed descriptions of the single measures are available in Appendix III.

These measures can be incorporated into action plans and development programs of the city of Marrakech or at higher levels (e.g., regional or national). Also, development organizations could use these measures as basis to develop concrete projects to meet the SDGs. Other Moroccan municipalities or cities with similar conditions can also adopt some of the measures for their own cities due to the fact that some measures are universal.

[7] Essential measures are those that are declared as milestones in the WMS-DSC tool (underlined aspects). All other measures can be classified as relevant. These milestones form the basis for building a WMS, which in turn is relevant for setting up a CE. It is also possible to classify measures as "optional" if, for example, various alternatives to a measure are developed or even if they are currently not relevant in the mid-term, but could become more significant in the long term.

Table 6: Overview of 33 CE promoting measures (adopted from Campitelli et al., 2022a)

Recommendations for action			Level of application				State of priority		Conditions	(in)direct impact on SDG
Cluster	Measure coding	Measure title	National	Regional	Municipal	Company	Essential	Relevant		
A	M1	Prescribe a mandatory separate collection for waste from households and businesses by law	x				x			11 and 12
	M2	Introduce separate collection at municipal level			x		x		M1	
	M3	Introduce decentralized drop-off bins for other types of residual wastes			x			x		
	M4	Increase the collection rate in rural areas and introduce its recording			x		x	x		
	M5	Increase the efficiency of transfer stations		x	x			x		
	M6	Standardize waste related data collection procedures	x	x	x		x	x		12
B	M7.1	Enhance the regulatory WM framework concerning CE aspects	x				x	x		8 and 12
	M7.2	Include the 5-stage waste hierarchy in the waste law	x				x			
	M7.3	Include the extended producer responsibility in the waste law	x				x			
	M8	Prescribe a mandatory systematic pretreatment for wastes before disposal	x				x			11
	M9	Extend WM laws, plans and concepts at the regional and municipal levels concerning CE aspects		x	x		x			6, 8, 11 and 12
	M10	Set and review waste targets	x	x	x			x		12
	M11	Ratify other WM related international agreements	x					x		
	M12	Update of the waste nomenclature	x					x		
	M13	Introduce a state-approved certification for WM companies	x					x		
	M14	Define emission limits for landfills and quality standards for secondary materials	x				x			11
	M15	Implement clear and uniform collection, disposal and recycling rates	x				x			12
	M16	Improve working conditions for the informal sector		x	x			x		3 and 8
	M17	Increase transparency of trading structures for wastes and recyclables	x					x		12
	M18	Offer insurances against caused environmental damages for companies				x		x		11
	M19	Determine sites for a safe disposal of disaster waste		x	x			x		
C	M20	Install a composting unit in the CEV and increase its treatment capacities		x	x		x			11 and 12
	M21	Install a leachate treatment process in the CEV		x	x			x		6 and 11
	M22	Prepare favorable conditions for future sale of compost	x		x			x	M2 & M20	9 and 12
	M23	Enhance quality and quantity of sorted recyclables for high quality recycling			x	x		x	M2, M5 & M14	
	M24	Strengthen and digitize the secondary resource market	x	x		x		x		
	M25	Provide a budget to promote WM and CE activities	x	x	x		x			11 and 12
	M26	Intensify the integration of WM and CE aspects in companies and their company evaluation				x		x		8 and 9
	M27	Integrate construction and demolition waste recycling in the WMS	x		x	x		x		11 and 12
	M28	Incorporate a recycling center for e-waste in the WMS		x	x			x		
D	M29	Establish stakeholder platforms to foster exchange regarding CE	x	x	x	x		x		8
	M30	Integrate WM and CE aspects in educational programs of schools			x	x		x		4
	M31	Promote interdisciplinary research in WM and CE projects	x		x			x		9
	M32	Increase cooperation between universities, WM and recycling companies	x		x	x	x	x		4, 8 and 9
	M33	Launch programs to train specialized personnel for the waste and recycling sector			x	x		x		

Interim conclusion

In summary, it is evident that Marrakech is making progress with regard to CE. However, most of the activities are focused on the implementation of fundamental infrastructures related to waste collection and landfilling, while the technical and legal recycling infrastructure is still in its infancy. If Marrakech as well as Morocco want to achieve a CE, certain milestones (see measures in Table 6 and Appendix III) have to be reached.

If the recommended actions are successfully implemented, apart from ER, all other components would be at least in stage 2. Solely, the component ER would remain in stage 1 as incineration is not necessary in Marrakech, but co-incineration would still be of interest. Therefore, the components CT, WD and WR could then be categorized in stages 2 to 3 and G, SM and PR in 2 to 4, which would be a good basis for further expanding the CE in Marrakech.

The derived measures have a direct or at least indirect impact on achieving the SDGs 3, 4, 6, 8, 9, 11 and 12. The SDGs, which are mostly impacted from the measures are the goals 11 and 12, because of their direct relation to WM.

Concerning the WM, Marrakech is in a transition phase. While, several measures to improve waste collection, waste disposal and increase recycling are planned, there are still major deficits in recycling, waste segregation and the consideration of other waste streams, such as C&D waste. A transition towards a CE can only work if the basics (e.g. essential measures in Table 6) are implemented at the municipal and higher levels. Marrakech needs to address several initiatives in parallel in order to successfully achieve this transition. The potential in Marrakech is considered to be great, but this transition can still take several years to decades. The advantages and strengths of the city, like the low waste generation rate, can be a good motivator to move towards a CE society. The derived recommendations for action can help to promote the transition towards a CE in Marrakech.

3. Discussion and conclusion

How can WMSs of cities in the Global South and their transition towards a CE be assessed and optimization potentials be identified?

To answer the main research question of this dissertation, four sub-research questions (see p. 14) were defined. The most important findings of **sub-research question 1** (see 2.1) are:

1) Benchmarking is most appropriate for WMS assessment in countries of the Global South because it can work with quantitative data and in case of poor data availability also with qualitative data.
2) Few WMS studies analyzed all relevant WMS components and none of them did an in-depth analysis of the individual WMS components and their interdependencies.

Influenced by these two findings, the outcome of **sub-research question 2** is the WMS-DSC (see 2.2). The WMS-DSC meets two requirements: 1) to represent the extensive complex system of WM as holistically as possible and 2) to present it as simply as possible, so that the concept can also be used by non-experts, who however should have a good knowledge of the WMS under study. Regarding the first requirement, all relevant WMS components, including G, SM, CT, WD, ER, WR and PR are taken into account for the in-depth analysis. To meet the second requirement, the WMS-DSC was designed as a benchmarking tool based on five development stages; whereas stage 1 represents a WMS lacking the essential WM elements, stage 5 is equivalent to a functioning CE. Every development stage is worked out as a detailed hypothetical scenario for all relevant WMS components, including different dimensions, such as governance, economic, social, organizational, environmental and technical aspects.

The opportunities of the WMS-DSC are multifold. It can be used by practitioners or decision makers familiar with the WMS under study i) to assess the actual WMS state; ii) to analyze whether the system conditions are met for the introduction of specific measures, iii) to monitor the progress of a WMS and iv) to compare different WMSs. This concept enables practitioners to identify weaknesses represented as symptoms. Furthermore, existing strengths of the WMS are visible and can further motivate the improvement.

With respect to **sub-research question 3**, the WMS-DSC was applied on Marrakech (Morocco), as a case study. This case study served as a proof of concept for the WMS-DSC, which was successfully validated. The actual WMS state of Marrakech was analyzed to identify the CE progress in the city (see 2.3). The results showed that depending on the system components, the development stages vary from stage 1 to stage 4, with stages 2 and stage 3 being dominant for the components: G, SM and WD. The components CT and PR are mainly in stage 2, but also assigned to stage 1. The subcomponent PR.5 (waste generation) is the only one that has achieved stage 4. The least developed components are WR and ER. The results show that Marrakech is still far from a functioning CE. However, the different categorizations show that certain components (e.g., G and WD) were promoted more than other (e.g., ER and WR).

Based on these results and to answer **sub-research question 4**, measures were derived in a subsequent step for the promotion of CE in the city of Marrakech. 33 measures categorized into four clusters (Cluster A: Increase collection rate and separate collection of waste; Cluster B: Improve control, regulation, monitoring and assessment; Cluster C: Promote closing the loop in Marrakech; Cluster D: Encourage cooperation between research, companies and society) are the final result of the WMS analysis.

The holistic view of the WMS and the strong interconnection of the system with other system components (national government, ministries, institutions, administration, companies, markets, etc.) mean that not all measures are directly intended for the city of Marrakech, but some address higher levels (e.g., national, regional) as well as the company level. The results from this work can be directly integrated into WM related action plans, master plans or WM plans at the municipal level and also at higher levels. Moreover, some measures are universal and can be adopted by other Moroccan municipalities as well as other cities outside Morocco with similar conditions.

3.1. Limitations of the study

However, the concept also has some limitations, which are critically discussed as follows.

Limitation 1: Analyses require data. Obtaining data for analysis can be challenging, depending on the subject of the study. In the study of Marrakech and higher levels (Marrakech-Safi region and Morocco), it was noticeable that there are some data in the area of WM, but the existing statistics portal, which collects waste-relevant data, has large gaps and is not yet fully developed. Information and data were predominantly obtained from reports, online newspaper articles and interviews and are referenced in the analysis document. Furthermore, Moroccan project partners assisted in data and information gathering to overcome the existing language barriers (Arabic and French). Therefore, the used data or information is mainly not from peer reviewed papers, which is a limitation factor in terms of the accuracy of the data. Since the accuracy of the data could not always be guaranteed, all sources utilized for the WMS analysis were cited (Appendix II) to ensure traceability of the data as well as reproducibility.

Limitation 2: Missing data and lack of information is often a great limitation for the assessment and, above all, a relevant factor regarding the uncertainty of the results. Uncertainties also complicate decision support for decision makers. These limitations were reduced by including lack of data as an assignable aspect for some subcomponents in stage 1. Thus, depending on the subcomponents, missing data or lack of information could be assigned directly to stage 1. If information was relevant for higher stages, then "not available" could also be selected, which is equivalent to "not met". Due to this fact, it was nevertheless possible to generate results. Consequently, this means that missing information leads to a lower categorization and vice versa a good data situation is important for a successful CE implementation. This allows to make decision, even with existing uncertainties.

Limitation 3: In addition, the investigated aspects can be misinterpreted and the use of qualitative data offer room for interpretation by the WMS-DSC user. Consequently, both can have an impact on the stage assignment and lead to the fact that an unequivocal stage selection is not always possible. In order to reduce the potential for misinterpretation, the investigated aspects have been described in detail, and additionally, a glossary has been provided defining relevant WM terminologies. However, the limitation caused by the necessity of using qualitative data is unavoidable.

Limitation 4: Although the WMS-DSC provides a comprehensive concept displaying the most relevant interactions between the various (sub-)components, it certainly does not include all existing interactions. Therefore, where possible, the relevant interactions have been interlinked throughout the concept. Nevertheless, it has no claim to completeness because of the high complexity of the system and the rapid development in this area. This must be taken into account for every assessed case.

Limitation 5: Although the concept is designed to be used in theory by practitioners, it has so far only been applied by academic staff or by master's and PhD students. A basic WM knowledge or at least a good knowledge of the WMS under study is recommended before using the WMS-DSC; this applies to both academics and practitioners. The knowledge is necessary to reduce possible errors (see Limitation 3). However, the design of the concept took into account that sufficient information regarding the method is available to perform the analyses (e.g., detailed descriptions of the method, glossary, case study example "Marrakech"). In this regard, a possible challenge that practitioners could face is to identify possible linkages between the derived measures after the analysis. As mentioned in limitation 4, obvious interactions between different subcomponents are already linked in the WMS-DSC, but this is not assured for all derived measures due to the complexity of the WMS. By applying the WMS-DSC for Marrakech, the potential users have an example on how the derived measures can look like and how they can be linked with each other.

3.2. Conclusion

The case study showed that it is possible to make stage classifications through the WMS-DSC even when some data and information is lacking. The case study not only validated the WMS-DSC, but also showed that the concept can be used for cities and countries in the Global South to perform an in-depth analysis with a benchmarking tool. In addition, it shows that through the specific definition of the individual stages and the existing stage descriptions, improvement measures can be derived in a simplified manner. These are decisive advantages over other methods, which supports the use of the WMS-DSC for WMS analysis in countries of the Global South. As stated by Grießhammer and Brohmann (2015), clear descriptions of visions, can promote transformation processes. With the clear stage descriptions, especially for the higher stages 4 and 5, the WMS-DSC can have a beneficial effect on the promotion of the CE transition due to the fact that the visions are more imaginable.

In addition, to WM analysis, the categorization approach can also be used for educational purposes in universities to facilitate the understanding of WMSs and the existing interconnections between the various WMS components. This provides a valuable opportunity to raise awareness regarding WM. Moreover, this method has already been applied by a German master's student for the Seychelles. Besides Marrakech, three other Moroccan cases (Tétouan, Settat and El Jadida) are currently analyzed by three Moroccan students within the framework of their master's theses, as part of the project Biotec2Future.

Finally, it can be said that the WMS-DSC is meant to assess WMSs of cities in the Global South and identify optimization potentials for moving towards a well-functioning CE. Furthermore, the concept can be used as a supporting tool that helps to increase sustainability in WM and, consequently, to realize the SDGs (especially SDG 11 and SDG 12).

4. References

Al-Khatib, I.A., Arafat, H.A., Basheer, T., Shawahneh, H., Salahat, A., Eid, J., Ali, W., 2007. Trends and problems of solid waste management in developing countries: A case study in seven Palestinian districts. Waste Manage. 27 (12), 1910–1919.

Allesch, A., Brunner, P.H., 2014. Assessment methods for solid waste management: A literature review: [Review Article]. Waste Manage. Res. Vol. 32 (6), 461–473.

Amounas, M., 2020. Programme National des Déchets Ménagers, 6 pp. Accessed 16 July 2021.

Arushanyan, Y., Bjorklund, A., Eriksson, O., Finnveden, G., Soderman, M.L., Sundqvist, J.-O., Stenmarck, A., 2017. Environmental Assessment of Possible Future Waste Management Scenarios. Energies 10 (2).

Batool, S.A., Chuadhry, M.N., 2009. The impact of municipal solid waste treatment methods on greenhouse gas emissions in Lahore, Pakistan. Waste Manage. 29 (1), 63–69.

Bilitewski, B., Wagner, J., Reichenbach, J., 2018. Best Practice Municipal Waste Management: Information pool on approaches towards a sustainable design of municipal waste management and supporting technologies and equipment. Texte 40/2018, 310 pp. Accessed 30 August 2018.

BMUB, 2016. Modern waste - Goals and Paths: Germany's expertise for an advanced circular economy, 28 pp. https://www.giz.de/de/downloads/giz2016-en-vdma_Modern_Waste_Management.pdf. Accessed 11 January 2022.

Campitelli, A., Aryoug, O., Ouazzani, N., Bockreis, A., Schebek, L., 2022a. Assessing the Performance of a Waste Management System towards a Circular Economy in the Global South: The Case of Marrakech. submitted. Waste Manage.

Campitelli, A., Kannengießer, J., Schebek, L., 2022b. Approach to Assess the Performance of Waste Management Systems towards a Circular Economy: Waste Management System Development Stage Concept (WMS-DSC). MethodsX (9), 101634.

Campitelli, A., Schebek, L., 2020. How is the performance of waste management systems assessed globally? A systematic review. J. Cleaner Prod. 272.

Castellani, V., Benini, L., Sala, S., Pant, R., 2016. A distance-to-target weighting method for Europe 2020. Int J Life Cycle Assess 21 (8), 1159–1169.

Climate Chance, 2020. DÉCHETS La société marocaine en ordre dispersé contre la prolifération des déchets: CAS D'ÉTUDE MAROC 2020, 23 pp. Accessed 30 August 2021.

Cristóbal, J., Sierra, L., Margallo, M., Kannengießer, J., Aldaco, R., Schebek, L., Irabien, Á., 2021. Techno-economic and environmental assessment of methane oxidation layer measures through small-scale clean development mechanism - The case of the Seychelles. Waste management (New York, N.Y.) 124, 244–253.

Daddi, T., Frey, M., Iraldo, F., Nabil, B., 2011. The implementation of an Environmental Management System in a North-African local public administration: the case of the City Council of Marrakech (Morocco). Journal of Environmental Planning and Management 54 (6), 813–832.

Dados, N., Connell, R., 2012. The Global South. Contexts 11 (1), 12–13.

Dangi, M.B., Schoenberger, E., Boland, J.J., 2017. Assessment of environmental policy implementation in solid waste management in Kathmandu, Nepal. Waste Management & Research 35 (6), 618–626.

Diaco, M., Alami Merrouni, M., Bougarrani, S., Koehler, J., Hemkhaus, M., Ahlers, J., Desmond, P., Van Hummelen, S. & McGovern, M., 2020. Circular Economy in Africa-EU Cooperation: Country Report Morocco. Trinomics B.V. ACEN, adelphi Consult GmbH and Cambridge Econometrics Ltd, 118 pp. Accessed 15 July 2021.

Douglas, M., 1966. Purity and Danger: An analysis of the concepts of pollution and taboo, Auflage von 2001 ed. Taylor & Francis e-Library, 203 pp.

EcoActu, 2019. De la gestion des déchets vers un modèle marocain d'économie circulaire. https://www.ecoactu.ma/de-la-gestion-des-dechets-vers-un-modele-marocain-deconomie-circulaire/. Accessed 13 January 2022.

EPA, 2021. National Recycling Strategy: Part One of a Series on Building a Circular Economy for All, 68 pp. Accessed 7 March 2022.

European Commission, 2011. Toolkit for capacity development 2010. Tools and methods series Reference document, Luxembourg, 69 pp. Accessed 20 May 2020.

European Commission, 2019. The European Green Deal. COM(2019) 640 final, Brussels, 24 pp. Accessed 28 December 2021.

European Commission, 2020. A new Circular Economy Action Plan: For a cleaner and more competitive Europe. COM(2020) 98 final, Brussels.

Fatimah, Y.A., Govindan, K., Murniningsih, R., Setiawan, A., 2020. Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia. J. Cleaner Prod. 269, 122263.

Filho, W.L., Brandli, L., Moora, H., Kruopiene, J., Stenmarck, A., 2016. Benchmarking approaches and methods in the field of urban waste management. J. Cleaner Prod. 112, 4377–4386.

Finnveden, G., Bjoerklund, A., Moberg, A., Ekvall, T., 2007. Environmental and economic assessment methods for waste management decision-support: possibilities and limitations. Waste Management & Research 25 (3), 263–269.

Fuldauer, L.I., Ives, M.C., Adshead, D., Thacker, S., Hall, J.W., 2019. Participatory planning of the future of waste management in small island developing states to deliver on the Sustainable Development Goals. J. Clean Prod. 223, 147–162.

Ghariani, F., 2020. Programme National de Valorisation des Déchets (PNVD), 16 pp. Accessed 16 July 2021.

Giusti, L., 2009. A review of waste management practices and their impact on human health. Waste Manage. 29 (8), 2227–2239.

GIZ, 2019. Stratégie Nationale de Réduction et de Valorisation des Déchets (SNRVD), 250 pp. https://siredd.environnement.gov.ma/BeniMellal-Khenifra/Content/images/documents/Liens/ETUDE%20SNRVD%20-%2016-04-2019%20VF.pdf. Accessed 12 April 2021.

GreenDot, w.y. Product Specifications, 28 pp. https://www.gruener-punkt.de/fileadmin/Dateien/Downloads/PDFs/spezifikationen/englisch/Product_Specification.pdf. Accessed 7 October 2021.

Grießhammer, R., Brohmann, B., 2015. Wie Transformationen und gesellschaftliche Innovationen gelingen können. Nomos, 52 pp.

Hafidi, M., 2015. L'Impact et la gestion des déchets solides. Konrad-Adenauer-Stiftung, 104 pp. https://www.kas.de/documents/252038/253252/7_dokument_dok_pdf_43542_3.pdf/ec58b765-b3a1-3309-662b-55b8a44ab451?version=1.0&t=1539651527141. Accessed 8 October 2018.

Halkos, G., Petrou, K.N., 2019. Assessing 28 EU member states' environmental efficiency in national waste generation with DEA. Journal of Cleaner Production 208, 509–521.

HCP, 2014. Morocco Population Census - Marrakesh.

IMANOR, 2022. Certifications SM Accueil » Certifications SM. https://www.imanor.gov.ma/certifications-sm/. Accessed 28 January 2022.

Islam, M.S., Moniruzzaman, S.M., 2019. Simulation of sustainable solid waste management system in Khulna city. Sustain. Environ. Res. 29.

ISO, 2021. The ISO Survey of Management System Standard Certifications 2020. https://www.iso.org/the-iso-survey.html. Accessed 12 December 2021.

Kannengießer, J., 2017. Feasibility Study on Waste Management Concepts for Mahé Island, Seychelles, 84 pp. Accessed 19 June 2017.

Kapepula, K.-M., Colson, G., Sabri, K., Thonart, P., 2007. A multiple criteria analysis for household solid waste management in the urban community of Dakar. Waste Manage. 27 (11), 1690–1705.

Karmperis, A.C., Aravossis, K., Tatsiopoulos, I.P., Sotirchos, A., 2013. Decision support models for solid waste management: Review and game-theoretic approaches. Waste Manage. 33 (5), 1290–1301.

Kassahun, T., Birara, E., 2018. Assessment of Solid Waste Management Practices in Bahir Dar City, Ethiopia. Pollution 4 (2), 251–261.

Kaufman, S.M., Krishnan, N., Themelis, N.J., 2010. A screening life cycle metric to benchmark the environmental sustainability of waste management systems. Environmental science & technology 44 (15), 5949–5955.

Kaza, S., Yao, L., Bhada-Tata, P., van Woerden, F., 2018. What a waste 2.0: A Global Snapshot of Solid Waste Management to 2050, 296 pp. Accessed 21 September 2018.

Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. Resour. Conserv. Recycl. 127, 221–232.

Korhonen, J., Nuur, C., Feldmann, A., Birkie, S.E., 2018. Circular economy as an essentially contested concept. J. Cleaner Prod. 175, 544–552.

Lalitha, S., Fernando, R., 2019. Solid waste management of local governments in the Western Province of Sri Lanka: An implementation analysis. Waste Management 84, 194–203.

Lerpiniere, D., Wilson, D.C., Velis, C., Evans, B., Voss, H., Moodley, K., 2014. A Review of International Development Co-operation in Solid Waste Management: A report from the ISWA Task Force on Globalisation and Waste Management, Vienna, 48 pp. Accessed 9 May 2019.

Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gøtzsche, P.C., Ioannidis, J.P.A., Clarke, M., Devereaux, P.J., Kleijnen, J., Moher, D., 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ (Clinical research ed.) 339, b2700.

Lopez, A.J., 2007. Introduction: The (Post) Global South. The Global South 1 (1), 1–11.

Majeed, A., Batool, S.A., Chaudhry, M.N., 2018. Environmental Quantification of the Existing Waste Management System in a Developing World Municipality Using EaseTech: The Case of Bahawalpur, Pakistan. Sustainability 10 (7).

Makarichi, L., Techato, K., Jutidamrongphan, W., 2018. Material flow analysis as a support tool for multi-criteria analysis in solid waste management decision-making. Resources Conservation and Recycling 139, 351–365.

mapecology, 2020. Marrakech: La gestion des déchets confiée à l'Etablissement « Grand Marrakech » [Marrakech: Waste management entrusted to the Establishment "Grand Marrakech"]. http://mapecology.ma/slider/marrakech-gestion-dechets-confiee-a-letablissement-grand-marrakech/. Accessed 24 January 2022.

Markard, J., 2011. Transformation of Infrastructures: Sector Characteristics and Implications for Fundamental Change. J. Infrastruct. Syst. 17 (3), 107–117.

Marshall, R.E., Farahbakhsh, K., 2013. Systems approaches to integrated solid waste management in developing countries. Waste Manage. 33 (4), 988–1003.

Mbaye, K., 2020. Ban on plastic bags: new turn of screw of the guardianship. [Interdiction des sacs plastique : nouveau tour de vis de la tutelle.]. LesEco.ma, October 1.

MEF, 2020. La Loi n°46-18 relative aux contrats de Partenariat Public-Privé adoptée par la Chambre des Représentants: 14/01/2020. hhttps://www.finances.gov.ma/fr/Pages/detail-actualite.aspx?fiche=4689. Accessed 1 February 2022.

Menikpura, S.N.M., Gheewala, S.H., Bonnet, S., 2012. Sustainability assessment of municipal solid waste management in Sri Lanka: problems and prospects. Journal of Material Cycles and Waste Management 14 (3), 181–192.

METI, 2020. Circular Economy Vision 2020, 33 pp. Accessed 7 March 2022.

MMEME, 2019. Inauguration officielle du Centre d'Enfouissement et de Valorisation des déchets de Marrakech. http://environnement.gov.ma/fr/133-a-la-une/2193-lancement-officiel-de-l-activite-du-centre-d-enfouissement-et-de-valorisation-cev-de-marrakech-4-janvier-2018s. Accessed 7 October 2021.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L.A., Prisma-P Group, 2015. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews 4 (1), 1–9.

Monnerjahn, M., 2019. There is much to do in Morocco's waste management sector [In Marokkos Abfallwirtschaft gibt es viel zu tun]. sector report. https://www.gtai.de/de/trade/marokko/branchen/in-marokkos-abfallwirtschaft-gibt-es-viel-zu-tun-204428. Accessed 22 March 2022.

Morocco-export.com, 2019. Waste: new conditions for import and export. Morocco-export.com, September 10.

MTEDD, 2022. Les missions [our missions]. https://www.environnement.gov.ma/fr/departement-de-l-environnement/2015-03-05-11-53-51/missions. Accessed 24 January 2022.

Nguyen Phuc Thanh, Matsui, Y., 2013. Assessment of potential impacts of municipal solid waste treatment alternatives by using life cycle approach: a case study in Vietnam. Environ. Monit. Assess. 185 (10), 7993–8004.

Ogundipe, F.O., Jimoh, O.D., 2015. Life Cycle Assessment of Municipal Solid Waste Management in Minna, Niger State, Nigeria. International Journal of Environmental Research 9 (4), 1305–1314.

Okato, 2021. 1er site d'annonces de pièces détachées d'occasion au Maroc. https://okato.ma/pourquoi-choisir-la-piece-auto-doccasion-au-maroc/. Accessed 13 January 2022.

Ouchagour, L., 2021. Marrakech will soon have a new Ecocenter.[Marrakech se dotera bientôt d'un nouvel Ecocentre]. https://aujourdhui.ma/economie/marrakech-se-dotera-bientot-dun-nouvel-ecocentre?unapproved=49212&moderation-hash=048260d2ac062e27a7733e964b5be205#comment-49212. Accessed 19 July 2021.

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.

Oyoo, R., Leemans, R., Mol, A.P., 2014. Comparison of environmental performance for different waste management scenarios in East Africa: The case of Kampala City, Uganda. Habitat International 44, 349–357.

Pfaff-Simoneit, W., 2012. Development of a sectoral approach for the establishment of sustainable waste management systems in developing countries in the context of climate change and resource scarcity: [Entwicklung eines sektoralen Ansatzes zum Aufbau von nachhaltigen Abfallwirtschaftssystemen in Entwicklungsländern vor dem Hintergrund von Klimawandel und Ressourcenverknappung]. [Dissertation], Rostock, 249 pp.

Pires, A., Martinho, G., Chang, N.-B., 2011. Solid waste management in European countries: a review of systems analysis techniques. Journal of environmental management 92 (4), 1033–1050.

Rademaekers, K., Smit, T., Artola, I., Koehler, J., Hemkhaus, M., Ahlers, J., van Hummelen, S., Chewpreecha, U., Smith, A. & McGovern, M., 2020. Circular economy in Africa-EU cooperation: Continental report. Trinomics B.V., Tomorrow Matters Now Ltd., adelphi Consult GmbH and Cambridge Econometrics Ltd., Luxembourg, 1147 pp. Accessed 14 October 2021.

Rana, R., Ganguly, R., Gupta, A.K., 2019. Life-cycle assessment of municipal solid-waste management strategies in Tricity region of India. J. Mater. Cycles Waste Manag. 21 (3), 606–623.

Rand, T., Haukohl, J., Marxen, U., 2000. Municipal Solid Waste Incineration: A Decision Maker's Guide, Washington, D.C., 18 pp. Accessed 9 May 2019.

Rifki, R., 2021. Interview regarding the valorisation plant and landfill CEV in Marrakech, online.

Rodić, L., Wilson, D., 2017. Resolving Governance Issues to Achieve Priority Sustainable Development Goals Related to Solid Waste Management in Developing Countries. Sustainability 9 (3), 404.

Rodríguez-Antón, J.M., Rubio-Andrada, L., Celemín-Pedroche, M.S., Ruíz-Peñalver, S.M., 2021. From the circular economy to the sustainable development goals in the European Union: an empirical comparison. International environmental agreements : politics, law and economics, 1–29.

Royame du Maroc, 2017. Stratégie nationale de développement durable (SNDD) 2030: Résumé Exécutif, Rabat. http://faolex.fao.org/docs/pdf/Mor185348.pdf. Accessed 8 October 2021.

Saadoun, L., Campitelli, A., Kannengiesser, J., Stanojkovski, D., El Alaoui El Fels, Abdelhafid, Mandi, L., Ouazzani, N., 2021. Potential of medium chain fatty acids production from municipal solid waste leachate: Effect of age and external electron donors. Waste management (New York, N.Y.) 120, 503–512.

Salamy Bebila, L., 2020. Mouvement transfrontière des déchets: Importation et réutilisation des déchets au Maroc. Mediaterre.org, August 18.

Schneider, N., 2017. Between Promise and Skepticism: The Global South and Our Role as Engaged Intellectuals. The Global South 11 (2), 18.

seariousbusiness.com, 2021. Morocco - MOSSUP. https://www.seariousbusiness.com/morocco. Accessed 1 February 2022.

Sharma, B.K., Chandel, M.K., 2017. Life cycle assessment of potential municipal solid waste management strategies for Mumbai, India. Waste Management & Research 35 (1), 79–91.

Singh, A., Basak, P., 2018. Economic and environmental evaluation of municipal solid waste management system using industrial ecology approach: Evidence from India. Journal of Cleaner Production 195, 10–20.

SIREDD, 2022a. Accueil / Indicateurs - Environnement Socio Human - Dechet. https://siredd.environnement.gov.ma/Marrakech-Safi/indicateur#. Accessed 26 January 2022.

SIREDD, 2022b. Direction régionale de l'environnement. https://siredd.environnement.gov.ma/Marrakech-Safi/Home/observatoire. Accessed 24 January 2022.

Sparke, M., 2007. Everywhere but Always Somewhere: Critical Geographies of the Global South. The Global South 1 (1), 117–126.

Striegel, K.-H., 2015. Stage concept for sustainable circular economy: Contribution of the waste management sector to resource and climate protection within international cooperation. [Stufenkonzept zur nachhaltigen Kreislaufwirtschaft. Beitrag der Abfallwirtschaft zum Ressourcen- und Klimaschutz in der internationalen Zusammenarbeit.]. 14. Meeting of the ANS/DWA technical committee AK-5 „International waste management“, 28 October 2015, Frankfurt am Main.

Syeda, A.B., Jadoon, A., Chaudhry, M.N., 2017. Life Cycle Assessment Modelling of Greenhouse Gas Emissions from Existing and Proposed Municipal Solid Waste Management System of Lahore, Pakistan. Sustainability 9 (12).

UN, 2018. Annual Population of Urban Agglomerations with 300,000 or more in 2018 (thousands): World Urbanization Prospects 2018. Data Query.

UNEP, 2015. Global Waste Management Outlook, 346 pp.

UN-Habitat, 2021. Waste Wise Cities Tool: Step by Step Guide to Assess a City's Municipal Solid Waste Management Performance through SDG indicator 11.6.1 Monitoring, 84 pp. Accessed 15 December 2021.

Wang, J., Maier, S.D., Horn, R., Hollaender, R., Aschemann, R., 2018. Development of an Ex-Ante Sustainability Assessment Methodology for Municipal Solid Waste Management Innovations. Sustainability 10 (9).

Whiteman, A., Webster, M., Wilson, D.C., 2021. The nine development bands: A conceptual framework and global theory for waste and development. Waste Manage. Res., 734242X211035926.

Wilson, D.C., 2007. Development drivers for waste management. Waste Manage. Res. 25 (3), 198–207.

Wilson, D.C., Rodic, L., Scheinberg, A., Velis, C.A., Alabaster, G., 2012. Comparative analysis of solid waste management in 20 cities. Waste Manage. Res. 30 (3), 237–254.

Wit de, M., Hoogzaad, J., Daniels von, C., 2020. The Circularity Gap Report: When circularity goes from bad to worse: The power of countries to change the game, 69 pp. Accessed 5 February 2021.

World Bank, 2020a. Data for Morocco and Cote d'Ivoire. https://data.worldbank.org/?locations=MA-CI.

World Bank, 2020b. Projects: Search criteria: Waste management. https://projects.worldbank.org/en/projects-operations/projects-list?lang=en&searchTerm=solid%20waste%20management. Accessed 25 May 2020.

WWF, 2019. Stop the flood of plastic.: A guide for policy-makers in Morocco. https://wwfeu.awsassets.panda.org/downloads/05062019_wwf_marocco_guidebook.pdf. Accessed 1 February 2022.

Yadav, P., Samadder, S.R., 2018a. Assessment of applicability index for better management of municipal solid waste: a case study of Dhanbad, India. Environmental Technology 39 (12), 1481–1496.

Yadav, P., Samadder, S.R., 2018b. Environmental impact assessment of municipal solid waste management options using life cycle assessment: a case study. Environmental Science and Pollution Research 25 (1), 838–854.

Yahya, A., 2021. Marrakech adopte un système de gestion intégrée du service de propreté [Marrakech adopts an integrated management system of the cleaning service. https://www.mapnews.ma/fr/actualites/r%C3%A9gional/marrakech-adopte-un-syst%C3%A8me-de-gestion-int%C3%A9gr%C3%A9e-du-service-de-propret%C3%A9.

Yang, Q., Fu, L., Liu, X., Cheng, M., 2018. Evaluating the Efficiency of Municipal Solid Waste Management in China. International journal of environmental research and public health 15 (11).

Zaman, A.U., 2014. Measuring waste management performance using the 'Zero Waste Index': the case of Adelaide, Australia. J. Cleaner Prod. 66, 407–419.

Zaman, A.U., Lehmann, S., 2013. The zero waste index: a performance measurement tool for waste management systems in a ‘zero waste city’. J. Cleaner Prod. 50, 123–132.

Zaman, A.U., Swapan, M.S.H., 2016. Performance evaluation and benchmarking of global waste management systems. Resour. Conserv. Recycl. 114, 32–41.

Zurbrügg, C., Caniato, M., Vaccari, M., 2014. How Assessment Methods Can Support Solid Waste Management in Developing Countries-A Critical Review. Sustainability 6 (2), 545–570.

5. List of publications

Peer-review articles (sorted by publication year):

Campitelli, A.; Kannengießer, J.; Schebek, L. (2022): Approach to Assess the Performance of Waste Management Systems towards a Circular Economy: Waste Management System Development Stage Concept (WMS-DSC). MethodsX, 9, 101634, doi:10.1016/j.mex.2022.101634.

Saadoun, L.; **Campitelli, A.**; Kannengiesser, J.; Stanojkovski, D.; El Alaoui El Fels, Abdelhafid; Mandi, L.; Ouazzani, N. (2022): Acidogenic digestion of organic municipal solid waste in a pilot scale reactor: Effect of waste ratio and leachate recirculation and dilution on hydrolysis and medium chain fatty acid production. Bioresource Technology Reports, 17, 100872, doi:10.1016/j.biteb.2021.100872.

Saadoun, L.; **Campitelli, A.**; Kannengiesser, J.; Stanojkovski, D.; El Alaoui El Fels, Abdelhafid; Mandi, L.; Ouazzani, N. (2021): Potential of medium chain fatty acids production from municipal solid waste leachate: Effect of age and external electron donors. Waste Manag., 120, 503–512, doi:10.1016/j.wasman.2020.10.013.

Yebouet, O.F.; **Campitelli, A.**; Amoikon, S.L.T.; Kannengiesser, J.; Stanojkovski, D.; Mrukwia, T.; Dje Koffi, M.; Djeni, T.N. (2021): Assessment of the diversity and abundance of bacterial population and its correlation with medium chain fatty acids production from fermentation of two leachate qualities. Bioresource Technology Reports, 16, 100840, doi:10.1016/j.biteb.2021.100840.

Dierks, C.; Hagedorn, T.; **Campitelli, A.**; Bulach, W.; Zeller, V. (2021): Are LCA Studies on Bulk Mineral Waste Management Suitable for Decision Support? A Critical Review. Sustainability, 13, 4686, doi.org/10.3390/su13094686.

Campitelli, A.; Schebek, L. (2020): How is the performance of waste management systems assessed globally? A systematic review. J. Cleaner Prod., 272, doi:10.1016/j.jclepro.2020.122986.

Campitelli, A.; Cristóbal, J.; Fischer, J.; Becker, B.; Schebek, L. (2019): Resource efficiency analysis of lubricating strategies for machining processes using life cycle assessment methodology. J. Cleaner Prod., 222, 464–475, doi:10.1016/j.jclepro.2019.03.073.

Haag, S.; Bauerdick, C.; **Campitelli, A.**; Anderl, R.; Abele, E.; Schebek, L. (2018): A Framework for Self-Evaluation and Increase of Resource-Efficient Production through Digitalization, Procedia CIRP, Volume 72, 2018, Pages 850-855, ISSN 2212-8271, https://doi.org/10.1016/j.procir.2018.03.304.

Conference proceedings (sorted by publication year):

Saadoun, L.; **Campitelli, A.**; Kannengießer, J.; Stanojkovski, D.; Mandi, L.; Ouazzani, N. (2021). Medium chain fatty acids production from organic municipal solid waste in pilot scale reactor: effect of leachate recirculation and dilution. Conference Proceedings, SDEWES 16th Conference on sustainable development of energy, water and environmental systems, 10.-15.10.2021, Dubrovnik, Croatia.

Campitelli, A.; Saadoun, L.; Kannengießer, J.; Stanojkovski, D.; Mandi, L.; Ouazzani, N.; Schebek, L. (2021). Implementation of a medium chain fatty acid extraction biotechnology in the Global South: A case study of Morocco. Conference Proceedings, 8th International Conference on Sustainable Solid Waste Management, 23.-25.06.2021, Thessaloniki, Greece.

Campitelli, A.; Kannengiesser, J.; Schebek, L. (2020): Assessment of Waste Management Systems, Worldwide: A Systematic Literature Research. Proceedings SUM 2020, 5th Symposium on Urban Mining and Circular Economy, 18.-20.11.2020, Venice, Italy.

Saadoun, L.; **Campitelli, A.**; Kannengießer, J.; Stanojkovski, D.; Mandi, L.; Ouazzani, N. (2020): Comparative study of medium chain fatty acids potential production of different age of leachate samples through chain elongation process with different external electron donors. Conference Proceedings, SDEWES 15th Conference on sustainable development of energy, water and environmental systems, 10.-15.10.2021, Cologne, Germany.

Campitelli, A.; Kuhn, C.; Kannengiesser, J.; Schebek, L. (2018): Implementation of an Innovative Biotechnology to Produce Biobased Products out of Bio-waste: Case Study Morocco and Côte d'Ivoire. Proceedings VENICE 2018, 7th International Symposium on Energy from Biomass and Waste, 15.-18.10.2018, Venice, Italy.

Schebek, L.; **Campitelli, A.**; Becker, B. (2016): Assessing resource efficiency of production processes in a Life Cycle approach: the case of metal working processes. Conference Proceeding. In: SETAC Europe 26th Annual Meeting, 22.-26.05.2016, Nantes, France.

Campitelli, A.; Becker, B.; Schebek, L. (2016): Steigerung der Ressourceneffizienz in der metallbearbeitenden Industrie: das Pilotprojekt „LernRess“. Conference Proceeding. In: 6. Wissenschaftskongress Deutsche Gesellschaft für Abfallwirtschaft e.V., 10.-11.03.2016, Berlin, Germany. ISBN 978-3-00-052365-6.

Schebek, L.; Becker, B.; **Campitelli, A.** (2015): Ressourceneffizienz in der Produktion am Beispiel der spanenden Metallbearbeitung. Conference Proceeding. In: 5. Wissenschaftskongress Deutsche Gesellschaft für Abfallwirtschaft e.V., 19.-20.03.2015, Innsbruck, Austria. ISBN 978-3-902936-66-0.

6. Appendices

Appendix I: Detailed WMS-DSC matrix description

Appendix II: Case study analysis results (Marrakech, Morocco)

Appendix III: Recommendations for action to promote a CE in Marrakech (Morocco)

Appendix I: Detailed WMS-DSC matrix description

Approach to Assess the Performance of Waste Management Systems towards a Circular Economy: Waste Management System Development Stage Concept (WMS-DSC)

Abbreviations:

C&D	Construction and demolition
CE	Circular economy
CMUR	Circular material use rate
Comp.	Company level
DR	Diversion rate
EOL	end-of-life
EPR	Extended producer responsibility
FE	ferrous materials
FGC	Flue gas cleaning
GDP	Gross Domestic Product
GHG	Greenhouse gas
GPS	Global Positioning System
MIS	Management information systems
Mun.	Municipal level
Nat.	National level
NF	non-ferrous materials
NGO	Non-Governmental Organization
OHSM	Occupational health and safety measures
PPP	Public-Private-Partnership
Reg.	Regional level
R&D	Research and development
RDFs	Refuse-derived fuels
SDG	Sustainable development goal
WM	Waste management
ZWI	Zero-waste index

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Driver(s)	**Removal of waste**	**Protection of human health**	**Environmental and climate protection**	**Resource value of waste**	**Conserve natural resources**
Target(s)	**Collection and removal of waste from housing areas**	**Stop of uncontrolled dumping and open burning**	**Reduction of landfill volume and its emissions**	**Increased use of waste as a resource**	**Avoid waste and increase resource efficiency**
Governance – Legislation and other policies I (G.1 – G.3)					
G.1 Duties and targets *(nat.)*	G.1.1.1 National waste management (WM) targets are missing. G.1.1.2 A defined waste hierarchy is missing.	G.1.2.1 Preliminary **WM targets** are defined in legislation. G.1.2.2 **Waste disposal is a state responsibility.**	G.1.3.1 Environmental and climate protection aspects are included in targets formulation. G.1.3.2 Time dependent targets to develop sustainable WM systems exist at all political levels[1] [1]. G.1.3.3 WM targets are reviewed regularly [1] and their (non-)achievement is communicated openly. G.1.3.4 A **5-stage waste hierarchy** has been introduced: 1. prevention - 2. preparation for reuse - 3. material recovery - 4. energy recovery - 5. disposal.	G.1.4.1 WM targets are formulated based on Sustainable Development Goals (SDGs). G.1.4.2 Formulation of targets for CE and Zero-Waste targets [2]. G.1.4.3 The wording changes from WM to circular economy (CE); Wastes = Resources [3].	G.1.5.1 Achievement of ambitious targets regarding CE and waste avoidance.
G.2 Laws, Regulations and Agreements *(nat.)* *Impact on SDG 12.1, 12.4, 12.7 SDG 12.c.*	G.2.1.1 A national law on waste disposal is missing or in preparation [4].	G.2.2.1 Preliminary waste law[2] regulating waste disposal at national level is in force [4,5]. ☐ Formulation of definitions for "wastes" and respective types of waste. ☐ Responsibility and role of different stakeholders in WM are identified [1]. ☐ Sanctions for non-compliance with legal regulations are anchored in waste laws. G.2.2.2 Clear guidelines for local authorities specify how waste laws and policies shall be implemented [11].	G.2.3.1 The **regulatory framework for WM** consists of comprehensive waste laws[3] and associated directives (regarding waste streams[4] and treatment plants[5]) [2]. ☐ Mandatory recyclables collection from households. ☐ Substance or product bans. ☐ Ban of combined disposal of hazardous and non-hazardous waste [1]. G.2.3.2 Technical instructions and implementation regulations are legally binding [4]. G.2.3.3 Media related laws or ordinances (e.g., soil, water protection, air pollution control) enter into force. G.2.3.4 All WM related international agreements[10] are ratified. G.2.3.5 **Extended producer responsibility (EPR)** is introduced [11].	G.2.4.1 Laws and directives are constantly developed and tightened (max. every 5 years) to promote CE[6], remove barriers [8] and respond to (inter-)national challenges [1]. ☐ Mandatory recyclables collection from businesses. ☐ Financial incentives and eco-labelling to promote sustainable products and processes [9]. ☐ Minimum use rates for recyclates in product manufacturing [10]. ☐ Right to repair[7] and further incentives[8] are defined to promote CE. G.2.4.2 Legal areas[9] are more closely interlinked to counteract illegal export or import of wastes [4]. G.2.4.3 Duties from ratified international conventions are fulfilled. G.2.4.4 In public procurement, at least 50 % are ecologically efficient and environmentally friendly products [12,13]. G.2.4.5 Through stewardship obligations and EPR, environmental policy transfers more responsibility[11] (financial or organizational) to manufacturers [7]. G.2.4.6 An ecological evaluation of license fees in the context of EPR (e.g., for packaging) is implemented [14]. G.2.4.7 EPR is extended beyond national borders along global supply chains for all life cycle phases (cradle to grave) [7].	G.2.5.1 CE is promoted more by market drivers than by legal regulations. G.2.5.2 In public procurement, at least 80 % are ecologically efficient and environmentally friendly products. G.2.5.3 Cross-border EPR enables promising, fair and enforceable distribution of responsibility along global supply chains [7].
G.3 Nomenclature *(nat.)*	G.3.1.1 Lack of a legally established and standardized nomenclature for waste.	G.3.2.1 An initial simple nomenclature for certain types of wastes (organics, residual waste, plastics, metals, glass) is regulated by law [4].	G.3.3.1 A detailed **nomenclature[12] for waste types** is regulated by law with the differentiation between non-hazardous and hazardous waste [4].	G.3.4.1 The nomenclature is updated regularly in order to directly take into account new types of waste as well as new state of the art industrial processes and technologies[7].	G.3.5.1 (Supra-)National collection of waste data enables a more targeted implementation of measures.

[1] All political levels means on national, regional (subnational) and municipal level.
[2] Waste law describes at minimum: scope, WM tasks, relevant WM stakeholders, and actions for achieving the defined targets.
[3] European Waste Framework Directive (https://eur-lex.europa.eu/eli/dir/2008/98) and its updates (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705&qid=1642604892683) as orientation. When implementing laws based on EU standards (https://ec.europa.eu/environment/topics/waste-and-recycling/waste-law_en), it is important to adapt the laws to local conditions.
[4] European directives with a focus on waste streams (e.g., biowaste, waste electronics, packaging, batteries, sewage sludge, vehicles, hazardous substances, commercial waste) as orientation: https://ec.europa.eu/environment/waste/legislation/c.htm.
[5] European directives related to WM facilities (e.g., landfills, waste incineration plants) as orientation: https://ec.europa.eu/environment/waste/legislation/b.htm.
[6] Laws promoting material recycling, eco-design, and the reparability and longevity of products [6]. Guiding legal regulations (e.g., to adjust the economic framework conditions or target quotas) are implemented if other drivers in the market are lacking or are insufficient [7].
[7] This right obliges manufacturers to make their products repairable and to provide spare parts, software updates and repair manuals, volunteer repair initiatives and consumers for at least a specified period of time [10],[6].
[8] E.g., tax relief, increase of statutory warranty depending on product, repair index (see also https://www.ecologie.gouv.fr/indice-reparabilite).
[9] E.g., commercial, transport, regulatory, customs and environmental law.
[10] These include global agreements such as: Basel Convention (1989), London Convention (1972), Joint Convention (Vienna, 1997), Hong Kong International Convention (2009), Kyoto Protocol incl. amendments (1997) or Paris Agreement (2016), Espoo Convention (1997), Aarhus Convention (1998), Nairobi (2007) and agreements for specific associations of states, such as Bamako (1991; for African states), Waigani (1995, South Pacific states), Decision of the Council on the Control of Transboundary Movements of Wastes Destined for Recovery Operations (2001, for OECD states).
[11] Manufacturers must carry out cleaning measures themselves or bear the costs in the event of improper behavior by users.
[12] European Waste Catalogue [15] for orientation.

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Governance – Legislation and other policies II (G.3 – G.6)					
G.4 National level WM *(nat.)*	G.4.1.1 A central body responsible for the development and implementation of WM strategies/policies is missing.	G.4.2.1 Existence of a **central body** (e.g. ministry of environment) responsible for the development and implementation of WM strategies/policies [1,11]. G.4.2.2 **National regulatory authority** exists.			
	G.4.1.2 A national WM program that specifies the development of the waste sector by means of specific measures is lacking.	G.4.2.3 A **national WM program** exists.	G.4.3.1 **National waste prevention programs** (incl. targets and measures) are published.	G.4.4.1 WM programs, strategies and concepts are revised and specified regularly (max. 5 years) focusing more on climate and resource protection aspects [4].	
		G.4.2.4 A **national WM plan** exists [5,11].			
		G.4.2.5 Concepts for safe disposal of hospital waste exist.	G.4.3.2 Concepts for proper disposal or recycling of mining, construction, forestry, agricultural and hazardous waste (industrial sludge, chemical waste, etc.) exist [4].		
				G.4.4.2 Government is increasingly involved in attempts to realize globally led collective actions for sustainable resource management [9].	G.4.5.1 The involvement of the government contributes to ensure the proper disposal of waste nationally and combat global environmental problems to a great extent.
				G.4.4.3 Government implements measures to combat global problems that are related to improper disposal (e.g., marine and space debris, microplastics).	
	G.4.1.3 Lack or fragile funding [4] for WM activities [16]. G.4.1.4 Lack of national funding to improve WM systems on regional or municipal level [17,18].	G.4.2.6 A WM budget is set in the federal budget, but it is not guaranteed [16]. G.4.2.7 National government grants financial aid to regions or municipalities [19].	**G.4.3.3 A guaranteed WM budget is set in the federal budget [16], which is sufficient to promote WM activities at all political levels.**		
G.5* Regional level WM[13] *(reg.)* **(if applicable)* *Impact on SDG 11.b*	G.5.1.1 WM functions are dispersed across the regional administration [17]; responsibilities are unclear.	G.5.2.1 A **central body** (e.g., a ministry of environment) developing and implementing WM strategies or policies and coordinating waste disposal and recovery activities exists [1,5,11].	G.5.3.1 Regional responsibilities regarding waste disposal and recycling are clear and transparent. G.5.3.2 **Interdisciplinary cooperation** with other authorities (e.g., spatial planning) exist [4]. G.5.3.3 Effective mechanisms for siting landfills and other waste treatment facilities are in place [11].		G.5.5.1 Regional efforts regarding CE lead to the rise of several circular cities.
	G.5.1.2 A regional WM law and plan is missing or in preparation.	G.5.2.2 A **regional waste law** is in force. G.5.2.3 A simplified **regional WM plan** is published.	G.5.3.4 Regional waste laws are adapted to revised national waste laws (G.2.3.1) G.5.3.5 A detailed regional WM plan is in place. G.5.3.6 **Regional waste prevention programs** are published.	G.5.4.1 Regional WM laws, plans, strategies and concepts are revised and concretized regularly (max. 5 years) focusing more on climate and resource protection aspects [4].	
		G.5.2.4 Regional concepts for the proper disposal of hospital wastes are published. (G.4.2.5)	G.5.3.7 Regional concepts for mining, construction, forestry, agricultural and hazardous waste exist [4].	G.5.4.2 Regional plans exist ensuring sound waste disposal in catastrophic events (natural disasters, pandemics, crashes, attacks, war, etc.) [20].	
	G.5.1.3 Due to the lack of or fragile funding basis [4], WM activities are reduced to a minimum.	G.5.2.5 A more **stable regional funding base** [4] for cost recovery of WM activities is established[14] [17].	G.5.3.8 Budget for WM is sufficient to further optimize it at regional and municipal level.	G.5.4.3 Supra-regional activities promoting CE are implemented.	
G.6 Municipal level WM *(mun.)* *Impact on SDG 11.b*	G.6.1.1 Lack of jurisdiction and authority competences of the municipality to plan, finance and operate WM system or to outsource tasks to e.g. private firms [16]. G.6.1.2 WM functions are spread across different municipal institutions [16–18]; responsibilities are unclear.	G.6.2.1 **Municipality has the jurisdiction and authority** to plan, finance and operate its WM system or to outsource tasks [5,16]. G.6.2.2 An **independent WM authority** is established to ensure municipal WM [1]; some functions are still spread across other municipal institutions [18]. G.6.2.3 Emerging of inter-municipal cooperation's to carry out WM tasks more efficiently[15] [5,11,21]. G.6.2.4 Institutionalization of waste counseling for households commercial operators [4].	G.6.3.1 **Institutional coherence** [11] in WM is communicated clearly and transparently and publicly available. G.6.3.2 Cooperation between WM and other municipal service sectors (wastewater management, transport planning, etc.) exist in city management [5]. G.6.3.3 Public WM companies and authorities use complaints mechanisms [11,17].	G.6.4.1 Municipality strives to become a "Circular City"[22].	G.6.5.1 The preconditions for achieving the status of "Circular City" [20] are in place.
	G.6.1.3 A municipal waste bylaw and WM concept is missing or in preparation.	G.6.2.5 A **municipal waste bylaw** is in force. G.6.2.6 A **municipal WM concept** is publicly available.	G.6.3.4 Waste bylaws are adapted to revised national (G.2.3.1) and regional waste laws (G.5.3.4). G.6.3.5 **A municipal waste prevention program** (incl. targets and measures) is published.	G.6.4.2 Municipal WM bylaws and concepts are revised regularly (max. 5 years) focusing on climate and resource aspects [4]. G.6.4.3 Municipal plans exist ensuring sound waste disposal in catastrophic events (natural disasters, war, etc.) [20].	
	G.6.1.4 Due to lack or fragile funding base and high dependence on funds from higher levels (e.g. national government) [4,16–18,23], WM activities are reduced to a minimum. G.6.1.5 Uneconomic waste collection and disposal [5,18].	G.6.2.7 A **stable municipal funding base** [4] for WM activities exists[16] [17,18]. G.6.2.8 Budgeting and cost accounting methods are used to determine WM costs [18].	G.6.3.6 Municipal WM budget is sufficient.	G.6.4.4 Activities promoting CE in cooperation with foreign municipalities exist.	

[13] "Regional" means political structures and institutions that lie between the municipal level and the national level. These can vary from nation to nation. If no regional structures are existent, then the points mentioned here should exist either at national or municipal level.
[14] E.g., by a functioning fee collection system or by increased support for higher levels of administration.
[15] E.g., joint waste collection, realization and maintenance of WM facilities.
[16] E.g., through a functioning purpose-based socially responsible fee collection (e.g., consumption- or demand-based contributions) or increased promotion of higher administrative levels. Increase of willingness to pay, waste fees are linked to other taxes/charges (e.g. property, energy or water) [17],[18].

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Governance – Administration and monitoring (G.7 – G.11)					
G.7 Stakeholder cooperation *(nat., reg., mun.)*	G.7.1.1 Interaction opportunities between the public sector and other relevant WM stakeholders are missing [16].	G.7.2.1 First platforms, committees emerge to promote exchange between the public sector and other relevant WM stakeholders.	G.7.3.1 Several **stakeholder platforms and committees** exist and are essential for the exchange between the public sector and other relevant WM stakeholders.	G.7.4.1 Competency centers are established to improve the exchange between relevant WM stakeholders [14].	G.7.5.1 Innovative digital exchange formats improve the flow and exchange of information between WM stakeholders.
G.8 Control mechanisms *(nat., reg., mun.)* *Impact on SDG 10.5*	G.8.1.1 Lack of governmental bodies which monitor and control WM activities.	G.8.2.1 **National governmental control bodies** for monitoring of WM activities exist. G.8.2.2 **Regional councils** exist for the lawful enforcement of WM activities on a regional level.	G.8.3.1 **Certification and accreditation** bodies exist, which are responsible for conformity assessments of e.g., products, persons or bodies. G.8.3.2 Local authorities monitor activities of firms performing municipal WM functions [5].	G.8.4.1 Successful transfer of WM tasks to private and public-private-partnership (PPP) companies [18] due to skilled supervisory institutions.	G.8.5.1 Reduction of state regulation [4] due to functioning self-regulation and compliance with existing rules by business and society [24].
			G.8.3.3 Introduction of regulated and recognized **certification of specialized WM companies.**	G.8.4.2 Definition of nationally standardized requirements for expert qualification and for inspections performance [14]. G.8.4.3 Regular training of experts is established [14]	
		G.8.2.3 Monitoring of compliance with legal requirements occurs selectively.	G.8.3.4 **Stricter controls** are established[17] (G.2.3.1) [4]. G.8.3.5 State controls are carried out selectively to inspect labor and working conditions.	G.8.4.4 State controls increase to verify the compliance of labor and worker protection measures.	G.8.5.2 Control mechanisms work well to identify and sanction illegal behavior and activities in CE.
			G.8.3.6 Transport controls of imported and exported waste and recycled materials take place.	G.8.4.5 Regular transport inspections for waste and recycling materials increase detection of illegal disposal routes.	
		G.8.2.4 Monitoring of the construction, operation and aftercare of landfills is carried out selectively.	G.8.3.7 Monitoring of all landfills (construction, operation and aftercare) and waste treatment plants takes place.	G.8.4.6 Strict monitoring of all emissions from landfills and other treatment plants.	
		G.8.2.5 Despite possible sanctions (G.2.2.1), they are rarely imposed in case of legal violations in WM context.	G.8.3.8 Sanctioning in case of legal violations is increasing.	G.8.4.7 Sanctioning has effect and incorrect practices in CE decrease.	
		G.8.2.6 Control mechanisms to limit corruption and monopoles are introduced but barely applied.	G.8.3.9 Further development of anti-corruption mechanisms lead to an increased detection of corruption [25].	G.8.4.8 Monopolies in CE are regulated [23].	G.8.5.3 Corruption is almost contained due to functioning control mechanisms. G.8.5.4 Corporate monopolies in the WM sector are prevented [5].
G.9 Authorization and public participation *(nat., reg., mun.)*	G.9.1.1 There is a lack of regulated and systematic official authorization procedures. G.9.1.2 Public participation is missing in authorization procedures.	G.9.2.1 **Official authorization procedures** for WM disposal and recovery facilities are implemented. G.9.2.2 Public participation is included in authorization procedures.	G.9.3.1 Public participation is mandatory in authorization procedures for large-scale WM plants. G.9.3.2 Public participation in political WM decisions [24].	G.9.4.1 Recognized NGOs can participate in participation and hearing procedures [4]. G.9.4.2 Public participation in political decision-making processes regarding the CE is desired and made possible [26].	G.9.5.1 Full transparency of authorization procedures is guaranteed [4].
G.10 Quality standards and threshold values *(nat.)*	G.10.1.1 Quality standards and emission limits for waste and treatment disposal plants are lacking.	G.10.2.1 Quality standards and emission limits for waste disposal and treatment plants exist.	G.10.3.1 Permission requirements for disposal and treatment plants are tightened (G.2.3.1). G.10.3.2 **Emission limits[18] and quality standards are uniform and nationally coordinated**.	G.10.4.1 Emission limits and quality standards for disposal and treatment plants are updated and tightened regularly (max. every 5 years).	G.10.5.1 Emission limits and reference values for disposal facilities and secondary raw materials and fuels are tightened in an extent that environmental risks are reduced to a minimum.
	G.10.1.2 Quality standards (incl. pollutant limits) for secondary materials are lacking.	G.10.2.2 Quality standards and pollutant limits for certain secondary materials exist. G.10.2.3 Institutions / associations emerge, who promote unified standards for secondary materials and fuels.	G.10.3.3 **Introduction of standardized national quality standards for certain secondary materials** (e.g., plastics, glass, compost) and substitute fuels.	G.10.4.2 Expansion of and tighten quality standards increases the quality of secondary materials and refuse derived fuels (RDFs).	
G.11 Data collection, reporting and evaluation *(nat., reg., mun.)*	G.11.1.1 Data on waste collection and disposal (quantity, type, etc.) is missing [4].	G.11.2.1 Waste collection and disposal records are introduced.	G.11.3.1 Data for all disposed wastes are documented (G.3.3.1) and updated annually. G.11.3.2 Municipalities and regions are obliged to record waste data and forward it to superior authorities. G.11.3.3 **Waste data is documented centrally and uniformly.** G.11.3.4 Different registration and notification procedures (G.8.3.4) are established for various wastes [14] also for its export [4]	G.11.4.1 Registration and notification procedures for different types of waste are standardized [14].	G.11.5.1 WM data and other environmentally relevant data are available to the public at all political levels [4].
		G.11.2.2 Simple management information systems (MIS) [11] to identify, record and analyze waste relevant data e.g. in public administration, are introduced.	G.11.3.5 Increase use of MIS in public administration.	G.11.4.2 Innovative MIS (with data warehouses and big data applications) are used to analyze large data amounts user-friendly and more quickly.	G.11.5.2 A smart WM system is emerging in which waste data is integrated into large data centers and is available in real time [24].
	G.11.1.2 Representative waste statistics at national, regional or municipal level are lacking.	G.11.2.3 Municipal or regional waste statistics (collection and disposal) are created without being publicly available.	G.11.3.6 Waste statistics are publicly available. G.11.3.7 Waste balances and forecasts through improved data.	G.11.4.3 Data basis in the CE enables precise forecasts, meaningful reporting and is a basis for political decisions.	G.11.5.3 (Supra-)National standardized benchmark indicators to evaluate WM systems exist.
			G.11.3.8 **Indicators are used to evaluate WM systems.**	G.11.4.4 Use of different indicators for WM systems evaluation and monitoring on all political levels .[19]	
	G.11.1.3 Specific collection, disposal, recovery and recycling rates are lacking.	G.11.2.4 Collection, disposal, recovery and recycling rates are estimated on all political levels.	G.11.3.9 **Uniform collection, disposal and recycling rates** exist on all political levels.		

[17] E.g., inspections, reporting requirements, registration and notification requirements.
[18] See also European Union emission limit values for emissions from industry (incl. emissions from waste treatment plants) [27].
[19] Different indicators are used on the different levels, which makes a benchmark impossible [28].

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Governance – Education and research (G.12 – G.14)					
G.12 Education *(nat., reg., mun.)* *Impact on SDG 4.7 and SDG 12.8*	G.12.1.1 Lack of training opportunities to qualify personnel in WM.	G.12.2.1 **Education and training opportunities** are available to train personnel in the field of WM. G.12.2.2 Specific job profiles (skilled workers, technicians, engineers, etc.) emerge for urban cleaning, waste collection, sorting and disposal.	G.12.3.1 Emerging of job profiles for recycling or recovery. G.12.3.2 WM issues are addressed in professions for which the handling of waste is relevant [24].	G.12.4.1 Qualification offers for specialized personnel in the field of CE are expanded and adapted to current developments (Zero-Waste, waste prevention, climate protection, etc.).	G.12.5.1 CE is an integral part of educational courses either for academics, pupils and workers.
		G.12.2.3 Study programs without WM focus are available to train academic specialists (e.g., engineers), who can be employed in WM.	G.12.3.3 **Environmental science and WM study programs** to train academic staff exist.		
	G.12.1.2 Lack of educational programs for pupils in schools regarding WM.	G.12.2.4 WM relevant topics are voluntarily addressed in preliminary and secondary schools. G.12.2.5 Educational pilot projects are launched selectively, which are financed externally, e.g., by international active donors, NGOs or companies.	G.12.3.4 **In schools, environmental and waste topics are taught** increasingly on a voluntary basis [29].	G.12.4.2 In elementary and secondary schools, environmentally and CE relevant topics (e.g., recycling and waste prevention) are included in the curricula to raise awareness among children, adolescents and young adults [30].	
G.13 Research *(nat., reg.)* *Impact on SDG 9.5 and SDG 9.5.a*	G.13.1.1 Lack of faculties or institutes[20], studying WM issues on their own or in cooperation with other countries. G.13.1.2 WM issues are only investigated by foreign disciplines, research institutions or firms.	G.13.2.1 **Research and development (R&D) faculties** are established at national or regional level [1] to study WM issues. G.13.2.2 Cooperation's with foreign research institutions or firms and countries[21] [31] regarding research and education exist.	G.13.3.1 At national and regional level, the expansion of R&D facilities [1] is promoted intensively. G.13.3.2 Increasing number of faculties/institutes at national level studying WM issues or having cooperation's with other countries regarding research and education.	G.13.4.1 Interdisciplinary research centers are established to study relevant CE issues.	
	G.13.1.3 Research activities focus mainly on the setup of waste collection and disposal infrastructures.	G.13.2.3 Research activities focus mainly on the efficient collection, disposal and treatment of waste, and the minimization of social and economic risks.	G.13.3.3 Research activities are mainly focused on optimized and efficient waste recycling, risk minimization (social, economic and environmental) and resource efficiency. G.13.3.4 **WM issues are more likely studied interdisciplinary**.	G.13.4.2 Research activities focus mainly on the optimization of process flows in the CE (e.g., through digitalization or industrial symbiosis), bioeconomic approaches, waste avoidance and Water-Waste-Soil Nexus [32]. G.13.4.3 Increase studies exploring CE potentials in companies.	G.13.5.1 CE related research projects are usually interdisciplinary and holistic.
G.14 Awareness building *(nat., reg., mun.)* *Impact on SDG 12.8*	G.14.1.1 Lack of awareness campaigns regarding WM.	G.14.2.1 **WM awareness campaigns[22] [4] are carried out on some political levels.**	G.14.3.1 National and municipal initiatives/projects to raise WM awareness are implemented.	G.14.4.1 Awareness campaigns especially to promote waste prevention and closing loops are carried out on all political levels.	
	G.14.1.2 Population neglects the importance of WM and lives mainly according to the "not-in-my-backyard" principle [33].	G.14.2.2 Awareness regarding knowledge and concerns about WM is increasing in small parts of the population [33].	G.14.3.2 Society and individual companies gain experience and acquire a basic understanding of aspects of WM, including in the context of sustainability [33].	G.14.4.2 Survey results show positive changes in the attitude regarding waste and CE in large parts of the population and companies. G.14.4.3 Learned values, interests and the motivation of individuals are reflected in the growing public participation in political decision-making processes (G.9.3.2) regarding CE [33].	G.14.5.1 Behavior changing of population and companies enable a sustainable CE [24,33]. G.14.5.2 Increasing environmental awareness among the population enables the achievement of ambitious CE or zero-waste goals [34].
Governance – Occupational safety, health and environmental protection (G.15 – G.16)					
G.15 Occupational health and safety *(reg., mun., comp.)* *Impact on SDG 3.3, 3.8 and 8.8*	G.15.1.1 Occupational health and safety measures (OHSM)[23] in WM sector are fully neglected. G.15.1.2 (Fatal) accidents, illnesses, etc. of personnel [18] occur frequently.	G.15.2.1 **OHSM in WM [4,16,35,36] are increasingly** implemented in the formal sector and rarely in the informal sector. G.15.2.2 Decrease of work-related accidents, illnesses, etc. are registered firstly in the formal sector.	G.15.3.1 OHSM (e.g., increased automation) are implemented entirely in formal and increasingly in the informal sector. G.15.3.2 Decrease of work-related accidents, illnesses, etc. are registered in both sectors.	G.15.4.1 Due to existing control mechanisms (G.8.3.4 and SM.6.3.7), a high level of occupational health and safety exists.	G.15.5.1 The number of work-related accidents, illnesses, etc. is reduced to a minimum.
	G.15.1.3 Waste pickers work and live under poor conditions at waste dumps / landfills [18,21] G.15.1.4 Children work as waste pickers.	G.15.2.3 Only adults work at controlled landfills. G.15.2.4 Living in dumps or landfills and child labor is generally prohibited, but still exists.	G.15.3.3 The prohibition of living on landfills and child labor is fully realized.		
G.16 Environmental protection *(nat., reg., mun., comp.)*	G.16.1.1 Environmental and climate aspects are neglected in decision-making processes in politics, companies and society [21].	G.16.2.1 **Environmental and climate protection measures are integrated in WM.**	G.16.3.1 WM and pollution control are more significant in environmental politics.	G.16.4.1 WM issues (waste-to-energy, secondary raw materials), are increasingly integrated in resource and energy efficiency concepts [4].	G.16.5.1 CE makes a significant contribution to a resource-efficient and low-GHG economy.
		G.16.2.2 Emissions trading (G.2.3.4) is applied; but, GHG emissions from WM increase compared to 1990.	G.16.3.2 Initial emission savings in WM (WD.2.3.2); GHG emissions decrease by ≤ 10% compared to 1990.	G.16.4.2 GHG emissions related to CE are >10% to ≤ 50% lower compared to 1990.	G.16.5.2 GHG emissions from CE are > 50% lower compared to 1990.

[20] In the case of small regions (island states or small countries), there are may be no universities. If this is the case, it should be checked whether there are cooperation's with other countries that enable the training of qualified personnel and research in WM.
[21] Applies to small states or island states.
[22] E.g. campaigns on proper waste separation, recycling and prevention of wild dumping, increasing the acceptance of waste treatment facilities, and on environmental and climate protection (e.g., clean-up campaigns).
[23] Among these measures are: uniforms, gloves, low loading heights, risk allowances, medical insurance, health care, etc. [16].

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Sector and Market (SM.1 – SM.5)					
SM.1 Sector development *(nat., reg., mun., comp.)*	SM.1.1.1 The existing WM sector is unstructured.	SM.1.2.1 **Institutional structuring of WM** (G.4.2.1, G.5.2.1, G.5.3.1, G.6.2.2 and G.7.2.1) enables creation of a WM sector [18].	SM.1.3.1 WM is evolving into a relevant economic sector (classification E according to ISIC), so that it is now part of the industrial policy [21].	SM.1.4.1 The WM sector is growing, especially in the area of recycling and resource recovery [37].	SM.1.5.1 Due to close cooperation with other sectors, a functioning CE is implemented that is improving constantly.
	SM.1.1.2 Interests of companies or persons from the WM sector are neglected at the political level due to the lack of a lobby.	SM.1.2.2 Formation of associations and interests groups representing interests of the WM sector.	SM.1.3.2 **Integrative approaches to address WM challenges are developed through increased dialogue among various stakeholders.**	SM.1.4.2 Initial efforts to collaborate with other sectors to address the challenges of the CE are evolving.	
SM.2 Jobs *(nat., reg., mun., comp.)*	SM.2.1.1 Jobs in the formal sector are available without requiring qualifications for the work performed. SM.2.1.2 Lack of qualified staff and expertise in institutions dealing with WM issues [19,24]	SM.2.2.1 Certain jobs in WM require appropriate qualification, but there is still a lack of qualified personnel [24]. SM.2.2.2 Waste collection and sorting hold great employment potential [21].	SM.2.3.1 Many jobs are created in WM (especially in the recycling sector) [21]. SM.2.3.2 Great demand of qualified personnel, especially for the construction and operation of plants.	SM.2.4.1 Additional jobs are created as the recycling industry expands. SM.2.4.2 Increasing recruitment of personnel for in-house waste disposal and recycling in companies.	SM.2.5.1 Qualified specialized personnel for the development, planning, construction and operation of advanced high-tech facilities are increasingly in demand.
SM.3 Informal sector *(nat., reg., mun.)* *Impact on SDG 8.3*	SM.3.1.1 The informal sector is unstructured and informal workers are self-reliant.	SM.3.2.1 Some informal workers form small communities.	SM.3.3.1 Reorganization of the sector through responsible cooperatives or umbrella organizations [4,18].	SM.3.4.1 Complete formalization of the informal sector by their integration into formal municipal, private sector enterprises or cooperatives is achieved [23,38].	
	SM.3.1.2 Their role and contribution to WM is neglected by policy makers and public authorities [18]. SM.3.1.3 The distrust of informal workers towards the public sector is high. SM.3.1.4 The informal sector is disadvantaged compared to the formal sector[24].	SM.3.2.2 Their role and WM contribution are perceived by policy makers and public authorities. SM.3.2.3 **Start of institutional attempts[25] to integrate informal workers [17].** SM.3.2.4 They get support from development banks and NGO's to improve their rights and working conditions [40].	SM.3.3.2 Profession "waste picker" is recognized by policy makers and public authorities [39]. SM.3.3.3 Emerging initiatives to integrate them into the formal sector (e.g. waste collection and recycling) [38,40]. SM.3.3.4 Experiences of waste pickers are actively used to optimize WM activities [41].		
	SM.3.1.5 Informal sector is accepted by a minority of the society [40].		SM.3.3.5 Informal sector is accepted by a majority of the society.		
	SM.3.1.6 Share of informal workers compared to the total number of employees in WM ≥ 35%.	SM.3.2.5 Share of informal workers compared to the total number of employees in WM < 35% and > 10% [42].	SM.3.3.6 Share of informal workers compared to the total number of WM employees ≤ 10% [42].		
SM.4 WM system structure and organization *(nat., reg., mun., comp.)*	SM.4.1.1 Waste disposal is carried out uncoordinated and inefficient by public or private companies and waste pickers.	SM.4.2.1 WM coordination between various actors is improving, but economic, personnel, technical and organizational inefficiencies remain [24].	SM.4.3.1 PPP-projects are emerging in the waste sector [4,43]. SM.4.3.2 Companies specialized in waste recycling/disposal need a specific certification (G.8.3.3) to work in WM. SM.4.3.3 Strict controls (G.8.3.4) increase the bureaucratic burden on WM companies [44].	SM.4.4.1 Dynamic interplay between small innovative companies and internationally operating large companies in the WM industry exist.	
			SM.4.3.4 **A dual WMS (G.2.3.5) or other systems exist** that fulfill disposal and recycling obligations of manufacturers, retailers and distributors of products (e.g., packaging).	SM.4.4.2 Dual WMS or other systems are a reliable and efficient waste disposal systems with a large number of service providers.	SM.4.5.1 Dual WMS or other systems ensure that recycling and return rates, reach high levels in order to close the cycles in the best possible way.
SM.5 Financial funding *(nat., reg., mun.)*	SM.5.1.1 WM projects are mostly financed externally (e.g., by internationally operating governmental organizations, development banks, NGO's).	SM.5.2.1 **Higher financial support of national funders for WM development** [28]. SM.5.2.2 Financially weak municipalities receive loans from banks through state guarantees [18].	SM.5.3.1 Financial support from (inter-)national donors to develop a sustainable WM and CE (incl. energy and resource efficiency) is increasing [45]. SM.5.3.2 Financial supporting of companies to implement clean production measures[26] [9,28] is available.	SM.5.4.1 Financial support from (inter-)national donors to promote CE is increasing, with greater consideration of digitization, bioeconomy and waste prevention. SM.5.4.2 Funding for industrial [28] and urban [46] symbiosis and cooperation between companies and municipalities [28].	SM.5.5.1 Financial support of R&D projects helps to achieve ambitious CE targets (G.1.5.1).
	SM.5.1.2 Approved funding is inefficiently used or misused, so that many projects fail. SM.5.1.3 Failing subsidies, misfunding and double funding (e.g., due to poor arrangements within public institutions) happen often.	SM.5.2.3 Investments by municipalities are controlled and managed by the state [18]. SM.5.2.4 Conditions for obtaining subsidies are becoming stricter; nevertheless, misuse and inefficient use of approved grants are still prevalent.	SM.5.3.3 **Control mechanisms reduce misuse and inefficient use of funds.** SM.5.3.4 Double funding, failing subsidies, and misfunding are identified[27] and countered.		SM.5.5.2 Receiving of (non-)governmental financial support is generally linked to compliance with sustainability criteria.

[24] E.g., by impairing access to wastes [39].
[25] Possible measures to integrate the informal sector into the formal sector, see the catalog of measures in [39].
[26] E.g., measures to increase energy and resource efficiency as well as measures for low-waste, low-emission or low-pollution production and the recycling of waste from production.
[27] E.g., through better coordination between different public institutions and stricter monitoring of the allocation of funding.

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Sector and Market II (SM.6 – SM.7)					
SM.6 Enterprises *(comp.)* *Impact on SDG 9.4 and 12.6*	SM.6.1.1 Companies (manufacturers, distributors, or retailers) neglect WM issues.		SM.6.3.1 Manufacturers, distributors, or retailers of certain products[28] must participate financially or organizationally in WM (**G.2.3.5**) [11]. SM.6.3.2 Companies purchase insurance against environmental damages caused and the insurance industry enforces solutions for potential risks from such damages.	SM.6.4.1 Zero-Waste targets are defined at company level [2].	SM.6.5.1 Company responsibility and transparency are generally high.
			SM.6.3.3 Companies are starting to design their supply chains in a circular supply chain manner [12].	SM.6.4.2 Companies use innovative MIS[29] and blockchain to get rapid and user-friendly analysis of large data amounts to improve their processes sustainably [12].	
			SM.6.3.4 First company cooperation's form symbioses regarding their material flows [12].	SM.6.4.3 Large-scale projects on industrial or urban symbiosis (G.13.4.2 and SM.5.4.2) are implemented (e.g., eco-industrial parks) .	
	SM.6.1.2 The provision of product information for customers is lacking.		SM.6.3.5 Initially, manufacturers are required to **provide product information** to their customers regarding its composition (e.g. hazardous ingredients) and handling during the use and disposal phases.	SM.6.4.4 Companies are increasingly recording data on material and waste flows, including the disposition or losses to the environment, and provide this information to consumers and WM companies [6,7].	SM.6.5.2 Products generally contain environmentally relevant information (e.g. Carbon or water footprints, material usage).
	SM.6.1.3 Business reports, containing WM data and measures to improve WM are missing.		SM.6.3.6 First **environmental business reports** are published, containing WM data and measures to improve WM. SM.6.3.7 Audits[30] (G.8.3.1) are carried out in companies [28]. SM.6.3.8 Few companies use eco labels and environmental certificates to promote their products.	SM.6.4.5 Environmental or sustainability reports (with inclusion of SDGs) are increasingly published by companies. SM.6.4.6 Eco-Labels are used in mostly all products to inform the consumers regarding environmental impact, use of biobased materials, recycled materials, etc.	SM.6.5.3 Environmental and sustainability reports are published by domestic and foreign companies with which trade is conducted [9].
SM.7 Recycling market *(nat., reg., mun.)*	SM.7.1.1 Markets for waste and recyclables are small, mostly informal and unregulated; trade structures are non-transparent.	SM.7.2.1 Recycling markets are expanding and are starting to self-regulate, but trading structures remain non-transparent.	SM.7.3.1 **Trading structures for waste and recyclables**[31] are regulated and transparent [4,21]. SM.7.3.2 Price fluctuations of certain secondary materials and fuels are regulated by governmental measures. SM.7.3.3 Exchange platforms for secondary products and wastes emerge.	SM.7.4.1 Strengthening of the secondary resource market through government incentives (G.2.4.1) [6,21]. SM.7.4.2 Strong connection of companies regarding exchange and trade of secondary materials, by-products or other materials for reuse [21,47]. SM.7.4.3 New actors (e.g. volunteers) participate in collection of recyclables; revenues are invested in social or environmental projects.	SM.7.5.1 Automated logistics and market platforms allow simplified searching and purchasing of waste or secondary materials [37].
			SM.7.3.4 Secondary materials provide a small portion of industrial demand and generate revenues [21].	SM.7.4.4 Secondary materials cover a large part of the industrial demand for raw materials [21]	SM.7.5.2 Supply risks are reduced through a systematic CE.
			SM.7.3.5 It is difficult for high-quality recyclates to enter the market or its use is inadequate (firing instead of recycling) [37]. SM.7.3.6 Secondary resources are perceived to be of low value due to missing quality information [37].	SM.7.4.5 Pure plastic recyclates volumes increase (G.1.4.2, G.2.4.1, CT.4.3.1 and WR.4.4.2), while the volume of mixed plastics recovered decreases. SM.7.4.6 Improved information on secondary materials quality reduces biases.	SM.7.5.3 Strict limits (G.10.4.2) enable high quality recyclates.
	SM.7.1.2 Import and export of waste (including electronic waste, shipwreck, etc.) and recyclables, is unregulated and occurs without compliance with any requirements.	SM.7.2.2 Trading of wastes and recyclables occurs predominantly in the country. SM.7.2.3 Restrictions may be imposed for import and export of wastes and recyclables (G.10.2.2), but controls occur selectively.	SM.7.3.7 International trade with other countries regarding waste and recyclables is increasing. SM.7.3.8 Initial import/export bans on hazardous wastes exist (G.2.3.4), but insufficient control encourages illegal transport.	SM.7.4.7 **Introduction of stricter import and export criteria** for (non-)hazardous, hardly recyclable wastes and used goods[32] [6].	SM.7.5.4 Smart WM system enables real-time networking [24], so that secondary resources[33] can automatically be traded globally [37].

[28] E.g., packaging, electronic equipment, batteries, end-of-life vehicles.
[29] Also, in combination with data warehouses and big data applications.
[30] E.g., audits to improve quality management (ISO 9001) and environmental management (ISO 14001), to increase occupational health and safety (according to ISO 45001) and energy efficiency (ISO 5001).
[31] E.g., compost, waste paper, waste glass, metal, RDFs.
[32] E.g., used cars, cell phones, notebooks, TV's.
[33] Through e.g. the Internet of Things, recyclable products can market themselves on platforms by publishing relevant product information, such as composition and possible applications [37].

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Collection and transport (CT1. – CT.8)					
CT.1 Waste collection *(mun.)*	CT.1.1.1 Lack of regulated and systematic collection [4], collection is limited to important areas[34]. CT.1.1.2 Uniform waste bins for collection are missing.	CT.1.2.1 A systematic, reliable and regulated collection [4,21] is ensured, but carried out in an inefficient manner (economically, organizationally) [18]. CT.1.2.2 Uniform and compatible aboveground systems are primarily used in waste collection. CT.1.2.3 Collection points are within 200m distance [48].	CT.1.3.1 Measures (e.g. waste locks, QR-tracking), concepts to optimize waste collection (collection intervals[35]) and route planning make waste collection more efficient. CT.1.3.2 New waste bin systems, such as waste locks, are used often in densely populated areas. CT.1.3.3 Available service for cleaning up bins from households.	CT.1.4.1 Underground systems[36] are installed in public spaces. CT.1.4.2 Waste bins with fill level sensors are used [24,49]. CT.1.4.3 More digitalization[37] measures are introduced to increase collection efficiency.	CT.1.5.1 Waste bins without negative effect on the urban landscape are in public spaces. CT.1.5.2 Avoidance of overfilling by using smart waste bins. CT.1.5.3 Smart waste bins recognize types of waste and separate them automatically [24].
	CT.1.1.3 Basic principles of urban hygiene are neglected [4,21], major littering exists [48].	CT.1.2.4 Principles of urban hygiene are partially met [4] by regular urban cleaning and emptying public bins, but littering in public spaces is still a problem [48].			CT.1.5.4 Principles of urban hygiene are fully maintained [4] and littering in public spaces is not a problem anymore [48].
CT.2 Service provider *(mun.)*	CT.2.1.1 Waste collection is carried out partially or predominantly by waste pickers [4].	CT.2.2.1 Waste collection is mainly done by the formal sector; existing collection gaps are filled by waste pickers.	CT.2.3.1 Waste collection is carried out exclusively by the formal sector or by an organized informal sector (SM.3.3.1).		CT.2.5.1 Waste collection is carried out exclusively by the formal sector (SM.3.4.1).
CT.3 Collection rates *(mun.)* *Impact on SDG 11.6*	CT.3.1.1 Collection rate: ☐ urban: ≤ 50% OR no data ☐ rural: ≤ 30% OR no data	CT.3.2.1 Collection rate: ☐ urban: > 50% and ≤ 70% ☐ rural: > 30% and ≤ 50%	CT.3.3.1 Collection rate: ☐ urban: > 70% and ≤ 80% ☐ rural: > 50% and ≤ 80%	CT.3.4.1 Collection rate: ☐ urban: > 80% and ≤ 95% ☐ rural: > 80% and ≤ 95%	CT.3.5.1 **Collection rate:** ☐ **urban: > 95% and ≤ 100%** ☐ **rural: > 95% and ≤ 100%**
CT.4 Separate collection *(mun.)*	CT.4.1.1 Residual waste from households and (small) businesses is collected collectively. CT.4.1.2 Solely informal workers collect profitable recyclables directly from households or landfills [21].	CT.4.2.1 First forms **of separation at source collection** (e.g. metals, organics, glass or paper, wet/dry, etc.) emerge (e.g. separation in 2 fractions) [48]. CT.4.2.2 Recyclables are collected also by the formal sector.	CT.4.3.1 **Separation at source collection for households and businesses is mandatory**, with few exceptions (G.2.3.1). Separation in 3 or more fractions is implemented [48]. CT.4.3.2 Recycling centers are set up for the collection of various types of waste (incl. hazardous waste).	CT.4.4.1 Measures are introduced to reduce the illegal collection of e.g. used electronics [51].	CT.4.5.1 All recyclables are collected separately (G.2.4.1).
			CT.4.3.3 Separate collection leads to a better recovery of recyclables, but the rate of incorrect sorting is > 30%.	CT.4.4.2 Rate of incorrect sorting of recyclables is between > 10% and ≤ 30%[38].	CT.4.5.2 Rate of incorrect sorting of recyclables is ≤ 10%.
		CT.4.2.3 Start of separate collection of hospital waste in healthcare facilities (G.5.2.4).	CT.4.3.4 Official separate collection of electrical, construction and demolition, agricultural and forestry waste (G.5.3.7).		
CT.5 Collection of recyclables *(mun.)*	CT.5.1.1 Recyclables collection rates are missing, only estimations are available or data is not publicly available.	CT.5.2.1 Recyclables[39] collection rate (G.11.3.3): ☐ Metals: ≤ 50% ☐ Paper: ≤ 30% ☐ Glass: ≤ 30% ☐ Organics: ≤ 30% ☐ Plastics: ≤ 10% ☐ Textiles: ≤ 10%	CT.5.3.1 Recyclables[39] collection rate: ☐ Metals: > 50 and ≤ 70% ☐ Paper: > 30 and ≤ 70% ☐ Glass: > 30 and ≤ 70% ☐ Organics: > 30 and ≤ 70% ☐ Plastics: > 10 and ≤ 50% ☐ Textiles: > 10 and ≤ 50%	CT.5.4.1 Recyclables[39] collection rate: ☐ Metals: > 70 and ≤ 90% ☐ Paper: > 70 and ≤ 90% ☐ Glass: > 70 and ≤ 90% ☐ Organics: > 70 and ≤ 90% ☐ Plastics: > 50 and ≤ 90% ☐ Textiles: > 50 and ≤ 90%	CT.5.5.1 Recyclables[39] collection rate: ☐ Metals: > 90% ☐ Paper: > 90% ☐ Glass: > 90% ☐ Organics: > 90% ☐ Plastics: >90% ☐ Textiles: >90%
CT.6 Waste transport *(mun.)*	CT.6.1.1 Formal sector: Use of simple small vehicles (e.g., small trucks, pick-ups).	CT.6.2.1 Formal sector: Mostly large vehicle fleet and more automation available for waste collection; use of large waste collection vehicles.	CT.6.3.1 Formal sector: Waste logistics companies improve vehicle fleets [4]. Waste collection vehicles with compactors and lifters take over waste collection [21].	CT.6.4.1 Use of different collection vehicles depending on waste[40].	CT.6.5.1 Highly engineered and fully automated collection vehicles facilitate collection through integrated false waste detection, quantity calculation and automatic data collection and transfer.
	CT.6.1.2 Informal sector: Only use of pack animals or simple handcart, wheelbarrows or bicycles.	CT.6.2.2 Informal sector: Mostly use of modified wheelbarrows, motorcycles, small vehicles.	CT.6.3.2 Informal sector: Mostly use of modernized small trucks.	See SM.3.4.1.	
CT.7 Transfer stations *(mun.)*	CT.7.1.1 Waste is transported directly to landfills or dumps by waste collectors. CT.7.1.2 Road sections are used as transfer areas.	CT.7.2.1 **Decentralized transfer stations** at favorable traffic nodes are introduced [21]. CT.7.2.2 Transfer stations are simple and unrestricted accessible for public.	CT.7.3.1 Transfer stations increase collection efficiency. CT.7.3.2 Transfer stations are advanced (use of differentiated collection, handling and storage techniques [4]) and with restricted access for public.		CT.7.5.1 All existing decentralized transfer stations correspond to the current state of the art.
CT.8 Collection of hazardous wastes *(mun.)* *Impact on SDG 6.3 and 12.4*	CT.8.1.1 Hazardous waste from households and (small) businesses are collected together with other waste fractions [4].	CT.8.2.1 Small quantities of hazardous waste from households are collected separately through designated public waste containers.	CT.8.3.1 Small quantities [4] can be disposed free of charge.	CT.8.4.1 All hazardous waste flows are collected separately (G.2.4.1).	CT.8.5.1 Hazardous waste quantities from households and industry are reduced to a minimum (PR.4.4.2 and PR.4.5.2).
	CT.8.1.2 Lack of separate collection of hazardous waste from industry.		CT.8.3.2 **Hazardous waste from industry is collected almost completely separated** [4].		

[34] E.g., places of interest, with high visibility, culturally or politically important areas as well as wealthy areas and for companies who are willing to pay.
[35] Depending on the waste material, climate conditions, container type or region, this can vary from daily to monthly.
[36] Underground systems reduce emissions (noise, pollution) and contribute to a more attractive cityscape than aboveground systems.
[37] Possible measures e.g., data collection during waste collection (through e.g. QR coding), sensor-based waste containers [50], GPS for more efficient route planning [49].
[38] Reasons for this are: systematic waste separation, manual misthrow control by collection service providers and a growing separation awareness among the population.
[39] Metals include ferrous and non-ferrous metals; paper includes cardboard; plastics includes composites.
[40] For example, for the collection of organic waste, vehicles with rotary drum can be used to homogenize the waste.

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Waste disposal (WD.1 – WD.5)					
WD.1 Waste disposal *(nat., reg., mun.)* *Impact on SDG 6.3, 11.6, 11.b*	WD.1.1.1 Lack of targeted and centralized waste disposal [4]. WD.1.1.2 Wastes (incl. hazardous wastes) are mainly disposed in open dumps, uncontrolled landfills, roads, open areas and in water (river, sea) [19]. WD.1.1.3 Waste is openly burned for better recovery of metals or used as fuel in households for heating and cooking [21].	WD.1.2.1 Targeted and centralized waste disposal in minimum controlled landfills [4,21] is regulated by law (G.2.2.1). WD.1.2.2 Open burning and waste dumping are illegal, but still practiced due to lack of controls (G.8.2.3), collection gaps or other inefficiencies.	WD.1.3.1 Landfill classes[41] with differentiated disposal requirements for various wastes are introduced [4]. WD.1.3.2 **Hazardous and non-hazardous waste are no longer disposed mixed on landfills**. WD.1.3.3 Liquid waste are no longer be disposed in landfills. WD.1.3.4 (In)active landfill forms with low standards are converted to sanitary landfills [1].	WD.1.4.1 Predominantly mineral waste is landfilled [4]. WD.1.4.2 Recyclables are rarely landfilled [45,53]. WD.1.4.3 The after-use of former landfill sites after their closure is becoming more relevant. WD.1.4.4 Waste is disposed exclusively on sanitary landfills. WD.1.4.5 Approved sites allow the municipality to quickly and safely dispose excessive waste in disaster [20].	WD.1.5.1 Waste landfilling is becoming less important. WD.1.5.2 Very small waste quantities are landfilled [4]. WD.1.5.3 Closed landfill areas are usually reused for other purposes, so that they are available safely. WD.1.5.4 The rehabilitation of old landfills with potential recycling options is gaining in importance [4]. WD.1.5.5 Illegal dumping is fully avoided.
	WD.1.1.4 This landfill status predominates: open dump or controlled dump	WD.1.2.3 This landfill status of active landfills predominates: controlled landfill or engineered landfill		WD.1.4.6 This landfill status of active landfills predominates: **sanitary landfill**.	WD.1.5.6 All existing (in)active landfills have been almost converted to sanitary landfills.
WD.2 Operational measures *(reg., mun.)*	WD.2.1.1 Lack of disposal controls such as waste registration (type, quantity or origin). WD.2.1.2 Waste is burned on dumping sites [48]. WD.2.1.3 Landfill access controls are lacking or inadequate [48]. WD.2.1.4 Dumping sites are not staffed or only in short times for site checking [48].	WD.2.2.1 Registration of waste type, quantity and origin and weighing of waste before disposal. WD.2.2.2 Waste burning on landfill sites is missing [48]. WD.2.2.3 Placement and compaction of waste with daily use of cover material is mainly implemented [48,54]. WD.2.2.4 Site drawing showing landfill boundary and filling area in place [48]. WD.2.2.5 Site is staffed during operational hours [48].	WD.2.3.1 Registration and compaction of waste are the norm. WD.2.3.2 **A systematic pre-treatment of waste is mandatory (G.2.3.1) [4].** WD.2.3.3 A systematic landfill management is carried out for the placement of the landfilled waste. WD.2.3.4 Measures for final covering, closure and post-closure management are realized [54].		WD.2.5.1 All existing and new landfills comply with the current state of the art, so that they pose little to no risk to human health or the environment.
WD.3 Leachate water management *(reg., mun.)* *Impact on SDG 6.3*	WD.3.1.1 Leachate infiltrates the soil or evaporates. WD.3.1.2 Surface and groundwater monitoring is lacking [54].	WD.3.2.1 Leachate collection systems are available [54]. WD.3.2.2 Recirculation of leachate to the landfill body is often implemented as treatment option. WD.3.2.3 Surface and groundwater monitoring is implemented [54].	WD.3.3.1 Leachate collection, treatment and monitoring is established and carried out in all active landfills.	WD.3.4.1 Strict limits (G.10.3.2) are fulfilled for surface and groundwater monitoring [54].	WD.3.5.1 Appropriate measures lead to a high decrease of leachate and a reduction in its toxicity, so that it no longer poses any health or environmental risks.
WD.4 Landfill gas management *(reg., mun.)*	WD.4.1.1 Landfill gas is released into the atmosphere [54].	WD.4.2.1 Passive gas collection or flaring of landfill gas is implemented as a measure.	WD.4.3.1 Active landfill gas collection for further energy recovery and gas monitoring takes place [54].	WD.4.4.1 Strict limits (G.10.3.2) are fulfilled for landfill gas monitoring.	WD.4.5.1 Controlled flaring of landfill gas is done only in case of emergency ("emergency flaring") and when it is unprofitable (e.g., at small gas quantities).
WD.5 Other means of disposal *(nat., reg., mun.)*	WD.5.1.1 Waste burning or dumping in high seas and in coastal waters takes place.		WD.5.3.1 By joining international agreements (London, Bamako) (G.2.3.4) waste burning or dumping in high seas and in coastal waters is prohibited. But, they still take place due to lack of controls.		WD.5.5.1 Strict and regular controls (G.8.4.4) and greater environmental awareness (G.14.4.2) lead to the avoidance of waste burning or dumping in high seas and in coastal waters.

[41] Landfill classes: landfill for hazardous waste, landfill for non-hazardous waste and landfill for inert waste [52].

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Energy recovery (ER.1 – ER.3)*					
ER.1 Thermal disposal and energy recovery *(reg., mun.)*	ER.1.1.1 A controlled energy recovery or thermal disposal of waste is missing.	*Pre-check before implementing an incineration plant**:* *To successfully implement waste incineration plants, these organizational criteria [55–57] must be respected:* ☐ *Waste is disposed in controlled landfills (WD.1.2.3).* ☐ *Qualified staff is available (G.12.2.1 and G.12.2.3).* ☐ *Collection is systematic and organized (CT.1.2.1).* ☐ *Sorting at source is implemented to control waste, which is not suitable for incineration (CT.4.2.1).* ☐ *Basic laws and rules on WM have been developed (G.2.2.1 and G.2.3.1).* ☐ *Incineration plants are positioned in upper level plans (master plans, national strategies, etc.) (G.4.2.4 and G.5.2.3).* ☐ *Political and social will for the installation is given.* ☐ *Total costs for the plant are secured.* ☐ *Public or private actors shall be experienced in managing incineration plants efficiently.* ☐ *Most spare parts for maintenance can be purchased locally. Sales offices for spare parts to be imported are locally available.* *These technical criteria [55–57] are essential:* ☐ *Supply of combustible waste must be stable over the year and at least 50,000 Mg/year.* ☐ *Lower heating value must be at least 7 MJ/kg on average and must always be above 6 MJ/kg in any season.* ☐ *Bottom ash and fly ash can be treated safely.*	ER.1.3.1 Energy recovery or thermal disposal is increasingly used to treat large quantities of the cities' waste (e.g., residual, bulky, forestry, hazardous and industrial waste) inside or outside the country. ER.1.3.2 Depending on the organizational affiliation of the installation, irrevocable agreements are in place that regulate waste delivery, energy sales, and pricing [55]. ER.1.3.3 At least 150.000 tons per year of suitable waste fractions are available for incineration [57].	ER.1.4.1 Although material recycling increase, energy recovery continues to be an essential treatment alternative. ER.1.4.2 The lower heating value is at least 11 MJ/kg on average.	ER.1.5.1 The amount of waste for energy recovery tends to decrease as waste is recycled more (WR.7.5.1).
	ER.1.1.2 Co-incineration of waste is missing.	ER.1.2.1 Specific wastes or RDFs are co-incinerated in industrial firing plants (e.g., cement plants) in compliance with specific quality standards (G.10.2.2).	ER.1.3.4 Energy recovery establishes as an alternative to landfilling; energy-intensive industries (blast furnaces, cement and power plants) often make use of it [4].		
ER.2 Incineration plants *(reg., mun.)*	ER.2.1.1 Waste incinerators are neither in operation nor planned in the country.	*ER.2.2.1* Incineration plants[42] (incl. flue gas cleaning - FGC) for controlled energy recovery or thermal disposal can be in planning or construction stage in the country or simple operating incineration plants, which are engineered with process controls, but without an FGC can be assigned to this stage. At least operating parameters (temperature, smoke etc.) shall continuously be monitored and recorded [48].	ER.2.3.1 Only waste incinerators with FGC are in use[43], which meet this requirements [48]: ☐ Continuous monitoring of operating parameters and emissions. ☐ Monitoring systems are routinely calibrated. ☐ Maintenance plans or schedules are in place. ☐ Evidence that equipment is well maintained. ☐ Fire extinguishers available on site.	ER.2.4.1 High-tech and state of the art processes and equipment are used to ensure high operational reliability and safe destruction of organic pollutants and a safe removal of heavy metals and other compounds [7]. ER.2.4.2 Flue gas controls compliant with applicable environmental standards (G.10.4.1) [48].	ER.2.5.1 Existing data concerning composition and quality of the incinerated waste in combination with the integration of digital measures ensures an automatic and homogeneous waste input.
ER.3 Energy and raw material recovery *(reg., mun.)* *Impact on SDG 7.1 and 7.2*	ER.3.1.1 Raw material production and energy recovery through controlled waste incineration is missing.		ER.3.3.1 Recovered energy from incineration is sold as electrical or thermal energy (e.g. district heating or steam for industrial purposes) or as a combination of both. [48,55] ER.3.3.2 Incineration or RDF plants are located in an area with moderate heat demand. Good transport and energy infrastructure exists [57].		ER.3.5.1 Incinerators and other thermal recycling facilities are increasingly replacing primary energy sources [21].
			ER.3.3.3 Recovered metals from the incineration process are sold; other by-products (gypsum, salts, slags, bottom and fly ash etc.) are treated safely, but recycled rarely.	ER.3.4.1 Slags are increasingly recycled and reused for example in road construction in compliance with limit values (G.10.4.2).	ER.3.5.2 All by-products from waste incineration are almost completely reintroduced into the economic cycle due to high quality standards (G.10.5.1) and established policy incentives (G.2.4.1).

***Note: Incineration plants are a possible, but not a mandatory treatment option. In case incineration plants are planned or in operation, the component energy recovery should be considered in the assessment.**

****Note: This section is exceptionally structured differently. Here, the preconditions for the construction of a waste incineration plant are presented. These criteria are only to be considered if there is no incineration plant in the case study, yet. If one plant exists, then this section can be neglected.**

[42] Depending on the type of waste, the following incineration technologies are used: Residual waste: grate firing; sewage sludge: fluidized bed firing; hazardous waste: rotary kiln. Further thermal utilization technologies are pyrolysis and gasification.

[43] Incineration plants do not necessarily have to be physically present in the investigated city. In the case of very small municipalities, regions, countries or island states, they may well be located in a neighbouring country and be jointly used by the city under investigation or the waste may be recycled there.

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Waste recycling (WR.1 – WR.8)					
WR.1 Waste recycling *(reg., mun.)*	WR.1.1.1 Material recycling is rarely done, but open-loop recycling and downcycling predominate [58].		**WR.1.3.1 Waste treatment is extended by including mechanical, biological, and chemical-physical treatment components [4].**	WR.1.4.1 (Semi-)closed-loop recycling and upcycling increase [58]. WR.1.4.2 Dialogues between manufactures and recyclers and other relevant stakeholders take place to identify and solve recycling problems jointly [6].	WR.1.5.1 (Semi-) closed-loop recycling dominates [7]. WR.1.5.2 A circular bioeconomy is implemented where technically possible [6].
	WR.1.1.2 Ensured input for recycling plants is lacking.		WR.1.3.2 Input for recycling plants is partly ensured.	WR.1.4.3 Input for recycling plants is fully ensured (G.2.4.1).	
WR.2 Composting *(reg., mun.)*	WR.2.1.1 Organic waste is landfilled or recycled through home composting or used to feed animals.	WR.2.2.1 The majority of organic waste from households, businesses, from parks and markets are recycled in simple open or covered composting facilities or with the help of mobile aggregates [21].	WR.2.3.1 Introduction of static, closed composting in tunnels and containers including sorting technologies to reduce interfering materials in compost (G.10.3.3).	WR.2.4.1 Dynamic or quasi-dynamic processes are integrated in existing composting plants.	WR.2.5.1 Microplastics can be removed from compost to a very large extent [6].
		WR.2.2.2 Low compost quality and small use in agriculture.	WR.2.3.2 The use of compost in agriculture and landscape management is increasing due to better qualities.	WR.2.4.2 Compost is of very high quality (G.10.4.2), but still contains pollutants such as microplastics. WR.2.4.3 Use of compost in the private sector is increasing.	WR.2.5.2 Compost has a very high quality and purity level.
WR.3 Fermentation *(reg., mun.)*	WR.3.1.1 Fermentation plants are neither in operation nor planned.	WR.3.2.1 Fermentation plants may be in the planning stage or under construction.	WR.3.3.1 Fermentation plants are in operation to recycle organics from households, agriculture and forestry.		WR.3.5.1 Biogas plants as biorefineries are an essential component for CE, bioeconomy and energy supply.
			WR.3.3.2 Separation of impurities, such as water and H2S, in order to utilize biogas mixtures energetically (e.g. in combined heat and power plants).	WR.3.4.1 Introduction of a CO_2 separation stage at plants with a min. capacity of 30,000 Mg/a to get natural gas quality. WR.3.4.2 Biomethane is fed into the natural gas grid or used as fuel in combustion engines.	
			WR.3.3.3 Nutrient-rich fermentation residues are used as fertilizers in agriculture (G.10.3.3).	WR.3.4.3 Digestates are of very high quality (G.10.4.2), but still contain pollutants such as microplastics.	WR.3.5.2 Mostly full removal of microplastics from digestates by new treatment techniques.
WR.4 Sorting and recycling plants *(reg., mun.)* *Impact on SDG 12.4*	WR.4.1.1 Sorting of recyclables (e.g. metals, plastics, paper, glass, textiles) is done manually. WR.4.1.2 Electrical and electronic waste is rarely or very inefficiently dismantled and without any protective measures. Only valuable materials (metals, etc.) are recovered.	WR.4.2.1 Partially automated operating sorting plants with simple shredding and separation units (e.g., air classifier, magnetic separator) are used for better recycling. WR.4.2.2 Use of mechanical-biological plants for residual waste pre-treatment to recover metals and high-calorific fractions (RDFs).	WR.4.3.1 Operative sorting plants include mechanical separation stages, screening and visual aggregates to increase the efficiency of hand sorting [21]. WR.4.3.2 Optical separation aggregates allow the production of high quality mono-fractions [21]. WR.4.3.3 Stabilate processes are used for pre-treatment of residual waste to separate metals and RDFs.	WR.4.4.1 Increased use of separation processes for plastics and color sorting (e.g., spectral, X-ray, LIBS) [21,59]. WR.4.4.2 Modern sorting facilities produce high quality individual fractions from separately collected waste [21]. WR.4.4.3 Raw material recycling (e.g., solvolysis, pyrolysis, gasification) of plastic waste is performed to produce e.g., synthesis gases, methanol [60].	WR.4.5.1 Recycling technologies are increasingly digitalized [24]. WR.4.5.2 Increasing implementation of digitalization measures[44] to rise the recyclability of products. WR.4.5.3 Ensure safe recycling of waste containing harmful substances through improved technical processes for the removal of pollutants [7].
WR.5 Refuse derived fuel (RDFs) *(reg., mun.)*	WR.5.1.1 Lack of RDFs recovery from waste.	WR.5.2.1 Start of recovery of RDFs (high-calorific fractions for energy recovery) from waste treatment plants.	WR.5.3.1 Increased recovery of RDFs from waste [4,21].		WR.5.5.1 Amount of RDFs is decreasing due to higher closed loop recycling.
WR.6 Recycling of construction and demolition waste (C&D) *(reg., mun.)*	WR.6.1.1 Only conventional demolition of (non-)residential buildings occurs.	WR.6.2.1 Mostly a conventional demolition of (non-)residential buildings occurs, but semi-selective deconstruction increases.	WD.6.3.1 Semi-selective demolition occurs predominantly, but selective demolition increases.	WR.6.4.1 Selective demolition predominates.	WR.6.5.1 Only selective demolition occurs.
	WR.6.1.2 Depollution is carried out rarely.	WR.6.2.2 Depollution is carried out more frequently.		WR.6.4.2 Depollution is usual practice in demolition.	
	WR.6.1.3 C&D waste disposal on landfills or dumps predominates.	WR.6.2.3 Under certain conditions [61], C&D material is used as filler for surface excavations or landfill construction.	WD.6.3.2 Quantity of C&D materials as filler for surface excavations and for landfill construction increases. WD.6.3.3 New recycling routes as using C&D material in e.g., road construction, are emerging in compliance with strict limits.	WR.6.4.3 Increase in high quality recycled construction materials (e.g., substitutes for building and road construction) [6]. WR.6.4.4 Heavy or non-recyclable construction materials are treated thermally or landfilled. WR.6.4.5 Robotics are used for efficient sorting of C&D waste [62].	WR.6.5.2 Heavy or non-recyclable construction materials are no longer allowed for building or road construction. WR.6.5.3 C&D waste is almost exclusively recycled, a marginal quantity is landfilled.
WR.7 Recycling rates *(nat., reg., mun.)*	WR.7.1.1 Recycling rates can be high for certain recyclables (e.g., metals), but due to a lack of data, precise numbers are missing.	WR.7.2.1 Recycling rates[39] of household waste: ☐ Metals: ≤ 40 % ☐ Paper: ≤ 40 % ☐ Glass: ≤ 40 % ☐ Composites: ≤ 20 % ☐ Plastics: ≤ 20 % WR.7.2.2 Recycling rates for E-Waste and C&D waste: ☐ E-Waste: > 10 and ≤ 40 % ☐ C&D waste: > 10 and ≤ 40 %	WR.7.3.1 Recycling rates[39] of household waste: ☐ Metals: > 40 and ≤ 70 % ☐ Paper: > 40 and ≤ 70 % ☐ Glass: > 40 and ≤ 70 % ☐ Composites: > 20 and ≤ 60 % ☐ Plastics: > 20 and ≤ 60 % WR.7.3.2 Recycling rates for E-Waste and C&D waste: ☐ E-Waste: > 40 and ≤ 70 % ☐ C&D waste: > 40 and ≤ 70 %	WR.7.4.1 Recycling rates[39] of household waste: ☐ Metals: > 70 and ≤ 90 % ☐ Paper: > 70 and ≤ 90 % ☐ Glass: > 70 and ≤ 90 % ☐ Composites: > 60 and ≤ 90 % ☐ Plastics: > 60 and ≤ 90 % WR.7.4.2 Recycling rates for E-Waste and C&D waste: ☐ E-Waste: > 70 and ≤ 90 % ☐ C&D waste: > 70 and ≤ 90 %	WR.7.5.1 Recycling rates[39] of household waste: ☐ Metals: > 90 % ☐ Paper: > 90 % ☐ Glass: > 90 % ☐ Composites: > 90 % ☐ Plastics: > 90 % WR.7.5.2 Recycling rates for E-Waste and C&D waste: ☐ E-Waste: > 90 % ☐ C&D waste:> 90 %
WR.8 Diversion rate (DR) and Circular material use rate (CMUR) *(nat.)* *Impact on SDG 8.4, 12.2 and 12.5*	WR.8.1.1 DR: ≤ 0,10 DR or no data WR.8.1.2 CMUR: ≤ 1 % CMUR OR no data	WR.8.2.1 DR: > 0,10 and ≤ 0,20 DR WR.8.2.2 CMUR: > 1 % and ≤ 10 % CMUR	WR.8.3.1 DR: > 0,20 and ≤ 0,40 DR WR.8.3.2 CMUR: > 10 % and ≤ 30 % CMUR	WR.8.4.1 DR: > 0,40 and ≤ 0,70 DR WR.8.4.2 CMUR: > 30 % and ≤ 70 % CMUR	WR.8.5.1 DR: > 0,70 and ≤ 1,00 DR WR.8.5.2 CMUR: > 70 % CMUR

[44] Measures as cyber-physical systems, block chain applications, digital passports.

	Stage 1 Absence or lack of essential elements of WM	Stage 2 Reliable collection and improved landfill sites	Stage 3 Separate collection and sorting	Stage 4 Expansion of the recycling industry	Stage 5 Circular economy - waste as a resource
Prevention and reuse (PR.1 – PR.6)					
PR.1 Prevention *(nat., reg., mun.)* *Impact on SDG 8.4, 12.2 and 12.4*	PR.1.1.1 Waste prevention is motivated by poverty.	PR.1.2.1 Waste prevention is predominantly motivated by lack of resources (e.g. materials, metals).			PR.1.5.1 Decoupling of GDP and waste generation has been achieved through a functioning CE [4].
			PR.1.3.1 Food waste is given a higher political priority.	PR.1.4.1 Initial targets to avoid of food waste are formulated and measures[45] implemented [6].	PR.1.5.2 Amount of food waste is reduced to a minimum by successful implementation of measures.
			PR.1.3.2 Few disposables (e.g. plastic bags) is banned or only permitted exceptionally.	PR.1.4.2 All disposables are banned or permitted exceptionally. PR.1.4.3 Prohibited destruction of unsold durable goods (e.g., returns from online sale) [6].	PR.1.5.3 Increase of substance/product bans[46] (G.2.3.1). PR.1.5.4 CE reduces negative impacts of materials and products by avoiding resources or waste [7].
			PR.1.3.3 Initiatives (e.g., 3R) are emerging which, in addition to closing loops, also aim to educate the population.		PR.1.5.5 CE provides a long use of raw materials (incl. products, buildings, etc.) in the cycle [7].
				PR.1.4.4 Lifetime-extension of buildings is ensured before construction phase [6,7].	PR.1.5.6 The full deconstruction of buildings after use, is ensured, before their realization.
					PR.1.5.7 Waste prevention and life cycle considerations are the basis of consumption decisions [4,21].
PR.2 Circular business and usage models *(comp.)*	PR.2.1.1 Circular business and usage models are lacking.	PR.2.2.1 Spare parts of end-of-life (EoL) products are used to repair electronic devices or vehicles.	PR.2.3.1 Increase use of spare parts of EoL products to repair electronic devices or vehicles. PR.2.3.2 Repair of products (e.g., electronics, textiles, furniture) is used by a small part of the population.	PR.2.4.1 Repair of products is used by a large part of the population.	PR.2.5.1 Permanent provision of spare parts through increased digitalization of process and production chains (e.g., with 3D printing) [64].
			PR.2.3.3 Minimum online market for spare parts exists.	PR.2.4.2 Various online spare part markets exist.	PR.2.5.2 Spare part markets are integral part of CE [37].
			PR.2.3.4 Product service systems, such as sharing and leasing business models, are offered.		PR.2.5.3 Sharing and leasing models are an integrative part of CE [37].
		PR.2.2.2 Voluntary take-back systems are in place for certain wastes (e.g., pharmaceuticals, batteries).	PR.2.3.5 Introduction of mandatory take-back or deposit-refund systems for waste (e.g. beverage packaging) [4,29].	PR.2.4.3 Deposit obligation is extended to all single-use beverage packaging and deposit contribution is higher compared to reusable packaging [6]. PR.2.4.4 Introduction of deposits on other material-relevant products (e.g., smartphones, tablets) or other financial incentives for returning products [51].	PR.2.5.4 Innovative take-back and collection systems enable reuse and high-quality recycling [7].
PR.3 Product design *(comp.)*	PR.3.1.1 Companies neglect end-of-life (EoL) issues of their products. PR.3.1.2 Innovative composite materials are causing disposal problems due to the negligence of EoL in the product design phase. PR.3.1.3 Companies neglect issues such as recyclability, material savings or substitution of hazardous substances in product design phase.	PR.3.2.1 Some companies (pioneers) are considering EoL issues of their products. PR.3.2.2 Some companies consider issues such as recyclability, material savings or substitution of hazardous substances in product design phase.	PR.3.3.1 Through eco-design, several manufacturers are beginning to design their products in a more environmentally friendly way (e.g. increase recyclability, material savings and substitution of harmful substances) [4,9].	PR.3.4.1 Increased use of homogenous easy separable, harmless and secondary materials; less use of disruptive substances (= decrease of composites). PR.3.4.2 Recyclability, upgradability and durability is generally considered in product design phase [6].	PR.3.5.1 High use of secondary, recyclable or biobased materials for product manufacturing [12]. PR.3.5.2 EoL concepts for innovative products prior to market introduction are elaborated to minimize problems at the EoL phase [12,15]. PR.3.5.3 High product recyclability is one basic condition for products entering the market.
				PR.3.4.3 Increased assessment of environmental impacts and resource consumptions of products during their entire life cycle (cradle-to-grave).	PR.3.5.4 Almost all companies consider all life cycle phases during the product design phase.
			PR.3.3.2 Voluntarily companies are setting minimum use rates for secondary resources in their product manufacturing.	PR.3.4.4 Legal minimum use rates for recyclates are between ≥30 % and <60 % to produce plastic packaging and other products [10].	PR.3.5.5 Legal minimum use rates for recyclates are at least 60 % to produce plastic packaging or other products.
PR.4 Process optimization and operational disposal strategies *(comp.)*	PR.4.1.1 Companies neglect issues regarding the proper disposal of their waste and waste avoidance.	PR.4.2.1 Some companies (pioneers) from manufacturing, trade and service sectors are considering how to improve waste disposal and prevent waste.	PR.4.3.1 Evaluation of production processes to minimize waste and identify recycling potentials [47].	PR.4.4.1 Increasing investigation of resource efficiency potentials of production processes (life-cycle perspective) and implementation of measures[47].	PR.4.5.1 Waste avoidance and closing of loops are common practice in medium-sized and large companies.
			PR.4.3.2 Joining international agreements (G.2.3.4) lead to the substitution of some hazardous materials in manufacturing with less hazardous materials.	PR.4.4.2 Several companies are substituting hazardous substances with non-hazardous substances [47].	PR.4.5.2 Use of pollutants in CE is possible, if a controlled circulation is ensured in safe, application-based cycles with tolerance thresholds [6,7].
PR.5 Waste generation[48] *(nat., reg., mun.)* *Impact on SDG 12.5*	PR.5.1.1 Waste generation per capita and day: ☐ ≥ 2,0 kg	PR.5.2.1 Waste generation per capita and day: ☐ ≥ 1,5 and < 2,0 kg	PR.5.3.1 Waste generation per capita and day: ☐ ≥ 1,0 and < 1,5 kg	PR.5.4.1 Waste generation per capita and day: ☐ ≥ 0,5 and < 1,0 kg	PR.5.5.1 Waste generation per capita and day: ☐ < 0,5 kg
PR.6 Zero-waste index *(nat., reg., mun.)*	PR.6.1.1 Zero-waste index (ZWI): ☐ ≤ 0,05 ZWI	PR.6.2.1 Zero-waste index (ZWI): ☐ > 0,05 and ≤ 0,15 ZWI	PR.6.3.1 Zero-waste index (ZWI): ☐ > 0,15 and ≤ 0,40 ZWI	PR.6.4.1 Zero-waste index (ZWI): ☐ > 0,40 and ≤ 0,90 ZWI	PR.6.5.1 Zero-waste index (ZWI): ☐ > 0,90 ZWI

[45] Possible measures to avoid food waste see [63].
[46] The use of disposables is banned or only permitted in certain exceptions.E.g., the use of disposables to ensure sterility of products or in cases where the majority of the disposable product is made of recyclates or biobased materials.
[47] E.g., identify potentials of waste avoidance, recycling of materials and increase of product output and e.g. ensure that recycled materials/wastes are returned in the process or sold to other costumers.
[48] Orientation towards waste generation index [65].

Glossary

Term	Definition
Bioeconomy	„The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources, i.e. agriculture, forestry, fisheries and aquaculture; and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. It cuts across these sectors and systems, interlinking them and creating synergies. While biotechnology is at the heart of bio-based processes, health biotechnology and biological medicines are not included in the bioeconomy definition." [66]
Circular city	"A circular city is a city that practices Circular Economy principles to close resource loops, in partnership with the city's stakeholders (citizens, community, business and knowledge stakeholders), to realize its vision of a future-proof city." [22]
Circular economy	A CE is "[...] an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations." [67] The idea of CE is to reduce waste to a minimum and keep materials and products as long as possible in the economic cycle [68].
Circular material use rate (CMUR)	This "[...] indicator measures the share of material recovered and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. The circular material use (CMU) rate is defined as the ratio of the circular use of materials to the overall material use. The overall material use is measured by summing up the aggregate domestic material consumption (DMC) and the circular use of materials. DMC is defined in economy-wide material flow accounts. The circular use of materials is approximated by the amount of waste recycled in domestic recovery plants minus imported waste destined for recovery plus exported waste destined for recovery abroad. Waste recycled in domestic recovery plants comprises the recovery operations R2 to R11 - as defined in the Waste Framework Directive 75/442/EEC. The imports and exports of waste destined for recycling - i.e. the amount of imported and exported waste bound for recovery – are approximated from the European statistics on international trade in goods. A higher CMU rate value means that more secondary materials substitute for primary raw materials thus reducing the environmental impacts of extracting primary material." [69]
Circular supply chain	Circular supply Chain is defined as "the integration of circular thinking into the management of the supply chains and its surrounding industrial and natural ecosystems. It systematically restores materials toward a zero-waste vision through innovation from product/service design to end-of-life and waste management, involving all stakeholders" [12].
Closed-loop recycling	"According to ISO 14044 a loop is closed when "material from a product system is recycled in the same product system. [...] In closed loops, material is recycled without [...] changes." [70]
Collection rate	"This indicator takes into account all different MSW streams collected separately by all the different collection systems available in the territory considered (e.g. door-to-door, civic amenity sites, street containers). In areas where there is no detailed waste monitoring or where a part of the waste generated is not collected by the formal municipal waste collection system, figures on MSW generation could underestimate the real situation." [71]
Composting	"The controlled biological decomposition of organic material in the presence of air to form a humus-like material. Controlled methods of composting include mechanical mixing and aerating, ventilating the materials by dropping them through a vertical series of aerated chambers, or placing the compost in piles out in the open air and mixing it or turning it periodically. [72]
Construction and demolition waste	"Construction and demolition waste - Rubble and other waste material arising from the construction, demolition, renovation or reconstruction of buildings or parts thereof, whether on the surface or underground. Consists mainly of building material and soil, including excavated soil. Includes waste from all origins and from all economic activity sectors." [72]
Controlled dump	"A controlled dump is a non-engineered disposal site where improvement is implemented on the operational and management aspects rather than on facility or structural requirements, which would otherwise require substantial investment. Controlled dumps evolved due to the need to close open dumpsites and replace them with improved disposal facilities, and in consideration of the financial constraints of LGU's [local government units]. Controlled disposal of wastes may be implemented over existing wastes (from previous open dumping operations) or on new sites." [73] According to [54] a controlled dump has the following characteristic: • *Operation and Engineering Measures:* Registration and placement/compaction of waste; surface water monitoring; no engineering measures • *Leachate Management:* Unrestricted contaminant release • *Landfill Gas Management:* None
Controlled landfill	"Controlled landfill is a landfill whose operation is subject to a permit system and to technical control procedures in compliance with the national legislation in force. Includes specially engineered landfill." [72] According to [54] a controlled landfill/engineered landfill has the following characteristics: • *Operation and Engineering Measures:* Registration and placement/compaction of waste; uses daily cover material; surface and ground water monitoring; infrastructure and liner in place • *Leachate Management:* Containment and some level of leachate treatment; reduced leachate volume through waste cover • *Landfill Gas Management:* Passive ventilation or flaring
Deposit-refund system	"Surcharge on the price of potentially polluting products. When pollution is avoided by returning the products or their residuals, a refund of the surcharge is granted." [72]
Diversion rate	"Defined as the percentage of total waste that is diverted from disposal at permitted landfills and transformation facilities such as incineration, and instead is directed to reduction, reuse, recycling and composting programs. $Diversion\ rate = \frac{Weight\ of\ recyclables}{Weight\ of\ garbage + Weight\ of\ recyclables} * 100\ \%$ " [74] A diversion rate of 0,70 means that 70% of the municipal waste collected is recycled. If technically and economically feasible, the diversion rate can increase to 100%. The remaining quantities of collected municipal waste are either landfilled or treated thermally or energetically (≤ 30%).
Downcycling	"Downcycling refers to a recycling process. In contrast to upcycling, downcycling involves a decline in the value of a recyclate, as the quality deteriorates during a progressive number of recycling cycles or more primary raw materials have to be added. Downcycling is particularly important for plastics recycling; it ensures that raw materials continue to be used despite a loss of quality." [75]
Dual WM	"To reduce the quantity of packaging waste, and thereby of overall MSW, Germany introduced a far-reaching legislation to reduce waste, based on the producer's responsibility principle. Industry was given the option to set up a third party organization which would carry out the collection and sorting of sales packaging for care of manufacturers and retailers. Thus, some 600 companies created "Duales System Deutschland" in 1990 ("Dual" because it meant creating a second collection system in parallel to the existing waste collection system of the local authorities). Duales System Deutschland (DSD), now has overall responsibility for the separate collection and recycling of packaging. At present, the Dual System is the only nationwide system for the collection and sorting of sales packaging. Packaging participating in this collection system is marked with the Green Dot." [76]
Eco-design	"The integration of environmental aspects into the product development process, by balancing ecological and economic requirements. Eco-design considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the product life cycle." [72]
Energy recovery	"A form of resource recovery in which the organic fraction of waste is converted to some form of usable energy. Recovery may be achieved through the combustion of processed or raw refuse to produce steam through the pyrolysis of refuse to produce oil or gas; and through the anaerobic digestion of organic wastes to produce methane gas." [72]
Engineered landfill	See controlled landfill.
Extended producer responsibility (EPR)	"Extended Producer Responsibility (EPR) is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility could in principle provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals." [77]
Hazardous waste	"The term "hazardous waste" refers to various types of waste with defined hazardous properties that are harmful for the environment and/or human health. Hazardous waste must be handled using special techniques and processes that ensure safe and environmentally sound disposal by elimination of the hazardous substances contained in the waste." [78]
Household waste	"Solid waste composed of garbage and rubbish, which normally originates from houses." [72]
Incineration	"Controlled process by which solid, liquid, or gaseous combustible wastes are burned and changed into gases; residue produced contains little or no combustible material. The aims of the process of burning solid waste under controlled conditions are to reduce its weight and volume, and often to produce energy." [72]
Informal sector	"Informal sector waste workers are self-employed and are not officially registered for tax purposes. They do not receive a salary from any organization but derive their income from selling what they pick from the waste or from informal payments from individual households." [79]
Landfill	"A waste disposal site for the deposit of the waste onto or into land (i.e. underground)." [72]
Landfill gas	"Landfill gas means all the gases generated from the landfilled waste." [72]
Landfill leachate	"Liquid that has seeped through solid waste in a landfill and has extracted soluble dissolved or suspended materials in the process." [72]
Life cycle assessment (LCA)	"Life-cycle assessment (LCA) is a process of evaluating the effects that a product has on the environment over the entire period of its life thereby increasing resource-use efficiency and decreasing liabilities. It can be used to study the environmental impact of either a product or the function the product is designed to perform. LCA is commonly referred to as a "cradle-to-grave" analysis. LCA's key elements are: (1) identify and quantify the environmental loads involved; e.g. the energy and raw materials consumed, the emissions and wastes generated; (2) evaluate the potential environmental impacts of these loads; and (3) assess the options available for reducing these environmental impacts." [72]
Municipal waste	"Waste from households, as well as other waste which, because of its nature or composition, is similar to waste from household." [72]
Open burning	""Open burning" is the burning of unwanted materials such as paper, trees, brush, leaves, grass, and other debris where smoke and other emissions are released directly into the air. During open burning, air pollutants do not pass through a chimney or stack." [80]
Open dump	"Open dumpsites entail the least development and operational cost requirement [...] of land disposal, and thus, are the most prevalent type of disposal facilities in most developing countries. [...] they also pose the greatest threat to public health and the environment. [...] Open dumpsites are usually located in areas not feasible for such facilities because of the absence of proper siting considerations or criteria. They are usually located in any available vacant area, and are usually within a government-owned property. [...] There are no general

	operational guidelines governing proper operation of the facility and many operators of these dumpsites lack equipment as well as the necessary expertise. Often, burning of waste is done to reduce the volume of waste and preserve disposal space at the site. [...] Often, there is no control over the amount and/or type of waste that is disposed of in the site. If wastes other than municipal solid wastes, such as medical and toxic and hazardous wastes, are permitted for disposal in the site, the risks to public health and the environment become more significant. [...] Open dumpsites do not have the necessary facilities and measures to control and safely manage liquid and gaseous by-products of waste decomposition." [73]
Open-loop recycling	According to ISO 14044 "open loop recycling may, but does not have to, change the inherent properties of the recycled material." [70]
Organic waste	"Waste containing carbon compounds." [72]
Packaging	"Packaging shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. Non-returnable items used for the same purposes shall also be considered to constitute packaging. Packaging consists only of:(a) sales packaging or primary packaging, i.e. packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase; (b) grouped packaging or secondary packaging, i.e. packaging conceived so as to constitute at the point of purchase a grouping of a certain number of sales units whether the latter is sold as such to the final user or consumer or whether it serves only as a means to replenish the shelves at the point of sale; it can be removed from the product without affecting its characteristics; (c) transport packaging or tertiary packaging, i.e. packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packaging in order to prevent physical handling and transport damage. Transport packaging does not include road, rail, ship and air containers." [72]
Product-service-systems	Product service systems that focus on the rental of products and thus provide incentives for low-maintenance, high-quality products with high utility value. This also includes the offer to combine particularly durable products with services for maintenance, repair or upgrades. [7]
Public-private-partnership (PPP)	"Public-private partnership (PPP) focuses on the privatization of MSW service from the public sector to the private sector. The definition of PPP is "the transfer and control of a good or a service currently provided by the public sector, either in whole or in part, to the private sector. It involves a wide range of private sector participation in public services and serves as a potential strategic management tool." [44]. [43] and [81] extended the definition of PPP to include formal sectors, informal sectors, private waste contractors, and comparatively formal entities like CBOs (community based organizations) and NGOs (non-governmental organizations)."[82]
Recyclable collection rate (or capture rate)	"This indicator measures the share of the estimated generation of a specific waste fraction that is collected separately (e.g. plastic, metal, paper and cardboard, glass and co-mingled packaging). This indicator is useful to monitor how efficient is a separate waste collection system in intercepting the recyclable fractions." [71]
Recycling	"(1) A resource recovery method involving the collection and treatment of a waste product for use as raw material in the manufacture of the same or a similar product. (2) the EU waste strategy distinguishes between: reuse meant as a material reuse without any structural changes in materials; recycling meant as a material recycling, only, and with a reference to structural changes in products; and recovery meant as an energy recovery only." [72]
Recycling rates	"% of waste that is actually recycled or sent for recycling out of the total waste covered by the EPR scheme." [71] <u>"Recycling rate for E-waste (in %):</u> The indicator is calculated by multiplying the 'collection rate' as set out in the WEEE Directive with the 'reuse and recycling rate' set out in the WEEE Directive; where: • The 'collection rate' equals the volumes collected of WEEE in the reference year divided by the average quantity of electrical and electronic equipment (EEE) put on the market in the previous three years (both expressed in mass unit). • The 'reuse and recycling rate' is calculated by dividing the weight of WEEE that enters the recycling/preparing for reuse facility by the weight of all separately collected WEEE (both in mass unit) in accordance with Article 11(2) of the WEEE Directive 2012/19/EU, considering that the total amount of collected WEEE is sent to treatment/recycling facilities." [69] <u>"Recycling rate for construction and demolition waste (in %):</u> The indicator is the ratio of C&D waste which is prepared for reuse, recycled or subject to material recovery, including through backfilling operations, divided by the C&D waste treated as defined in Regulation (EC) No 2150/2002 on waste statistics. The indicator covers the waste category 'Mineral waste from construction and demolition' (EWC-Stat 12.1). Only non-hazardous waste is taken into account." [69]
Refuse-derived fuels (RDFs)	"Refuse derived fuel (RDF) is produced from domestic and business waste, which includes biodegradable material as well as plastics. Non-combustible materials such as glass and metals are removed, and the residual material is then shredded. Refuse derived fuel is used to generate energy at recovery facilities, many of them in Europe where they produce electricity and hot water for communal heating systems." [83]
Reuse	"'Reuse' means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived." [84]
Sanitary landfill	"A sanitary landfill is an engineered disposal facility designed, constructed, and operated in a manner that minimizes impacts to public health and the environment. In contrast to open dumpsites and controlled dumps, sanitary landfills undergo thorough planning right from the selection of the site up to post-closure management. According to [54] a sanitary landfill has the following characteristic: • *Operation and Engineering Measures:* Registration and placement/compaction of waste; uses daily cover; measures for final top cover and closure; proper siting, infrastructure; liner and leachate treatment in place and post-closure plan • *Leachate Management:* Containment and leachate treatment (often biological and physico-chemical treatment) • *Landfill Gas Management:* Flaring with or without energy recovery
Separate collection	"The collection of individual components of solid waste from any source, usually separated into different collection containers, in order to recover, reuse or recycle the material or to facilitate its collection and disposal." [72]
Stakeholder	"An institution, organization, or group that has some interest in a particular sector or system." [72]
Stakeholders in WM	Stakeholders in WM are: Law and regulation bodies, research and educational institutions, media, WM companies, industry and commerce, service industries, members of the informal sector, planners and consultants in the public and the private sector, non-governmental organizations (NGOs) as well as political parties, associations, societies, trade unions, etc. [29]
Transfer stations	"Transfer stations play an important role in the overall waste management infrastructure network by providing means of consolidating and managing recyclables and waste. This is particularly important in rural and regional areas where efficient transport logistics determine the overall feasibility of providing waste and recovery services. In its simplest form, a transfer station is a facility with a designated receiving area where waste collection vehicles and/or small self-haul customers discharge their waste. The waste is then loaded into larger vehicles (e.g.: transfer trailers) for longhaul transport to a final disposal site (typically a landfill, treatment facility, materials recovery facility (MRF), or reprocessing plant). Ideally, there is no long-term storage of materials at a transfer station. Waste and recyclables are consolidated and loaded into larger vehicles for movement off site." [85]
Upcycling	"Upcycling is a form of reuse of materials (recycling). Seemingly useless waste products are transformed into new materials with the help of upcycling. Unlike recycling or downcycling, upcycling results in material upgrading. The process of reusing existing materials reduces the need for newly produced raw materials and thus conserves resources." [86]
Waste	"Materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded." [72]
Waste bylaw	A waste bylaw is a municipal ordinance regarding the collection and recovery of household waste at the municipal level concerning matters such as usage and integration into the public system, as well as municipal garbage collection charges. Adapted from [87]
Waste collection	Periodic or on-demand removal of solid waste from the point of generation, such as specific addresses or designated collection points, to facilities where the waste is recovered or disposed, regardless of collection modality (e.g., by municipal governments, non-state actors or informal sector). (adapted from [72] and [48]).
Waste disposal	"Disposal means any of the applicable operations provided for in Annex IIA to Directive 91/156/EEC:D1 Tipping above or underground (e.g. landfill, etc.), D2 Land treatment (e.g. biodegradation of liquid or sludge discards in soils, etc.), D3 Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.), D4 Surface impoundment (e.g. placement of liquid or sludge discards into pits, ponds or lagoons, etc.), D5 Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.), D6 Release of solid waste into a water body except seas/oceans, D7 Release into seas/oceans including seabed insertion, D8 Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are disposed of by means of any of the operations in this Annex, D9 Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are disposed of by means of any of the operations in this Annex (e.g. evaporation, drying, calcination, etc.), D10 Incineration on land, D11 Incineration at sea, D12 Permanent storage (e.g. emplacement of containers in a mine, etc.), D13 Blending or mixture prior to submission to any of the operations in this Annex, D14 Repackaging prior to submission to any of the operations in this Annex, D15 Storage pending any of the operations in this Annex, excluding temporary storage, pending collection, on the site where it is produced." [72]
Waste dumping	"The disposal of solid wastes without environmental controls." [72]
Waste export	"Transporting unwanted materials, including those leftover from a manufacturing processes, refuse, or trash to other countries or areas for the conduct of foreign trade." [72]
Waste generation	"The weight or volume of materials and products that enter the waste stream before recycling, composting, landfilling or combustion takes place. Also can represent the amount of waste generated by a given source or category of sources." [72]
Waste generation (indicator)	"The indicator measures the waste collected by or on behalf of municipal authorities and disposed of through the waste management system. It consists to a large extent of waste generated by households, though similar wastes from sources such as commerce, offices and public institutions may be included." [69]
Waste management (WM)	"'Waste management' means the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker;" [84]
Waste management system	A waste management system (WMS) is a system-relevant infrastructure system, which has the function of collecting, treating (incl. sorting) and disposing all types of generated waste. Activities that promote the waste prevention and reuse or concern trading and broking of waste or secondary raw materials are also part of the system as well as components regarding all governance (e.g. public authorities, laws, regulations), technical (e.g. treatment technologies), organizational (e.g. infrastructure, collecting services), aspects and other resources (e.g. qualified labour, financial resources, natural resources) required for this function.
Waste picker	"Waste pickers collect household or commercial/industrial waste. They may collect from private waste bins or dumpsters, along streets and waterways or on dumps and landfills. Some rummage in search of necessities; others collect and sell recyclables to middlemen or businesses. Some work in recycling warehouses or recycling plants owned by their cooperatives or associations. The term "waste picker" was adopted at the First World Conference of Waste Pickers in Bogota, Colombia in 2008 to facilitate global networking--and to supplant

	derogatory terms like "scavenger". Preferred terms vary, however, by place. For example, in South Africa "reclaimers" and "bagerezi" are used. In the United States, "canners" is often used. Other languages have their own preferred terms: catadores in Portuguese, recicladores in Spanish. What waste pickers have in common is that this work is their livelihood and often helps support their families." [88]
Waste prevention	"Prevention' means measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the reuse of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products" [84]
Waste prevention programs	"[Waste prevention programmes] shall be integrated either into the waste management plans provided for in [2008/98/EC Directive,] Article 28 or into other environmental policy programmes [...] or shall function as separate programmes. If [a] programme is integrated into the waste management plan or into other programmes, the waste prevention measures shall be clearly identified. The programmes [...] shall set out the waste prevention objectives [and] describe the existing prevention measures and indicate the usefulness of the examples of measures indicated [...] Appropriate qualitative or quantitative benchmarks for waste prevention measures shall be determined in order to monitor and assess the progress of the measures. Specific qualitative and quantitative targets and indicators for waste prevention measures shall be adopted in accordance with the regulatory procedure." [84]
Waste recycling	"'Recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations" [84]
Waste treatment	"The physical, thermal, chemical or biological processes, which change the characteristics of the waste in order to reduce its volume or hazardous nature, to facilitate its handling or to enhance recovery." [72]
WM concept	See also WM plan.
WM plan	"[A] waste management plan shall set out an analysis of the currents waste management situation in the geographical entity concerned. [It also includes] the measures, that are to be taken to improve environmentally sound preparing for reuse, recycling, recovery and disposal of waste as well as an evaluation of how the plan will support the implementation of the objectives and provisions of [Directive 2008/98/EC]. [A] waste management plan shall contain [...]: • type, quantity and source of waste generated within the territory, the waste likely to be shipped from or to the [...] territory, and an evaluation of the development of waste streams in the future; • existing waste collection schemes and major disposal and recovery installations, including [...] special arrangements for waste oils, hazardous waste or waste streams addressed by specific legislation; • an assessment of the need for new collection schemes, the closure of existing waste installations, additional waste installation infrastructure [...] and the [needed] investments; • sufficient information on the location criteria for site identification and on the capacity of future disposal or major recovery installations, [...] • general waste management policies, including planned waste management technologies and methods, or policies for waste posing specific management problems. [A] waste management plan may contain [...]: • organizational aspects related to waste management including a description of the allocation of responsibilities between public and private actors carrying out the waste management; • an evaluation of the usefulness and suitability of the use of economic and other instruments in tackling various waste problems, taking into account the need to maintain the smooth functioning of the internal market; • the use of awareness campaigns and information provision directed at the general public or at a specific set of consumers; • historical contaminated waste disposal sites and measures for their rehabilitation. A waste management plan also shall consider the geographical level and coverage of the planning area." [84] Waste Management plans, programs or concepts are often used in a same or similar context or even synonymously.
WM program	See also WM plan.
Zero-waste	"Zero Waste: The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health." [89]
Zero-waste-index	"The zero waste index is a tool to measure the potentiality of virgin materials to be offset by zero waste management systems. One of the important goals of the zero waste concept is zero depletion of natural resources. Therefore, measuring the performance of the zerowaste city would eventually measure the resources that are extracted, consumed, wasted, recycled, recovered and finally substituted for virgin materials and offset resource extraction by the waste management systems. The ZWI formula is as follows: $$ZWI = \frac{\sum potential\ amount\ of\ waste\ management\ by\ the\ city * substitution\ for\ the\ systems}{total\ amount\ of\ waste\ generated\ in\ the\ city}$$ The [ZWI] is based on the value of material that can potentially replace the virgin material inputs. The substitution of energy, water and greenhouse gas emissions is also considered with the material substitutions." [74]

Useful guidelines regarding:

Waste management (WM) in general: [47,90,91]

Implementation of WM facilities: [92,93]

Implementation of landfills: [73,94,95]

Implementation of incineration plants: [55–57]

Measures for new treatment facilities (Emissions in air, soil and water, occupational and community health and safety): [96]

References

1. Shekdar, A.V. Sustainable solid waste management: An integrated approach for Asian countries. Waste Manage. 2009, 29, 1438–1448, doi:10.1016/j.wasman.2008.08.025.
2. Zaman, A.U. A comprehensive review of the development of zero waste management: lessons learned and guidelines. J. Cleaner Prod. 2015, 91, 12–25, doi:10.1016/j.jclepro.2014.12.013.
3. Silva, A.; Stocker, L.; Mercieca, P.; Rosano, M. The role of policy labels, keywords and framing in transitioning waste policy. J. Cleaner Prod. 2016, 115, 224–237, doi:10.1016/j.jclepro.2015.12.069.
4. Striegel, K.-H. Stage concept for sustainable circular economy: Contribution of the waste management sector to resource and climate protection within international cooperation. [Stufenkonzept zur nachhaltigen Kreislaufwirtschaft. Beitrag der Abfallwirtschaft zum Ressourcen- und Klimaschutz in der internationalen Zusammenarbeit.], Frankfurt am Main, October 28, 2015.
5. Schuebeler, P.; Wehrle, K.; Christen, Jürg, SKAT. Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries: Working Paper No. 9, St. Gallen, 1996 (accessed on 20 March 2018).
6. EC. A new Circular Economy Action Plan: For a cleaner and more competitive Europe. COM(2020) 98 final, Brussels, 2020.
7. Müller, F.; Kohlmeyer, R.; Krüger, F.; Kosmol, J.; Krause, Susann, Dorer, Conrad; Röhreich, M. Guiding principles of a circular economy [Leitsätze einer Kreislaufwirtschaft], Dessau-Roßlau, 2020 (accessed on 26 November 2020).
8. Pajunen, N.; Watkins, G.; Husgafvel, R.; Heiskanen, K.; Dahl, O. The challenge to overcome institutional barriers in the development of industrial residue based novel symbiosis products – Experiences from Finnish process industry. Miner. Eng. 2013, 46-47, 144–156, doi:10.1016/j.mineng.2013.03.008.
9. Schanes, K.; Jäger, J.; Drummond, P. Three Scenario Narratives for a Resource-Efficient and Low-Carbon Europe in 2050. Ecol. Econ. 2019, 155, 70–79, doi:10.1016/j.ecolecon.2018.02.009.
10. Buschmann, R.; Meyer, K.; Scheider, H.; Heinz, R.; Jedelhauser, M.; Tauer, R. Making the EU fit for Future: What the German environmental associations want from the European Green Deal, 2020 (accessed on 5 February 2021).
11. Wilson, D.C.; Rodic, L.; Cowing, M.J.; Velis, C.A.; Whiteman, A.D.; Scheinberg, A.; Vilches, R.; Masterson, D.; Stretz, J.; Oelz, B. 'Wasteaware' benchmark indicators for integrated sustainable waste management in cities. Waste Manage. 2015, 35, 329–342, doi:10.1016/j.wasman.2014.10.006.
12. Maranesi, C.; Giovanni, P. de. Modern Circular Economy: Corporate Strategy, Supply Chain, and Industrial Symbiosis. Sustainability 2020, 12, 9383, doi:10.3390/su12229383.
13. Friant, M.C.; Vermeulen, W.J.; Salomone, R. Analysing European Union circular economy policies: words versus actions. Sustain. Prod. Consum. 2021, Volume 27, p. 337–353. doi:10.1016/j.spc.2020.11.001.
14. Recycling Magazin. Enforcement and further development of product responsibility [Vollzug und Weiterentwicklung der Produktverantwortung]. Available online: https://www.recyclingmagazin.de/2017/01/23/vollzug-und-weiterentwicklung-der-produktverantwortung/ (accessed on 7 January 2021).
15. European Union. Commission Decision of 18th December 2014 - amending Decision 2000/ 532/ EC on the list of waste pursuant to Directive 2008/ 98/ EC of the European Parliament and of the Council - (2014/ 955/ EU): 2014/955/EU. Official Journal of the European Union 2014.
16. van de Klundert, A.; Anschütz, J. Integrated Sustainable Waste Management - the Concept.: Tools for Decision-makers. Experiences from the Urban Waste Expertise Programme, Gouda, Niederlande, 2001 (accessed on 20 March 2018).
17. Filho, W.L.; Brandli, L.; Moora, H.; Kruopiene, J.; Stenmarck, A. Benchmarking approaches and methods in the field of urban waste management. J. Cleaner Prod. 2016, 112, 4377–4386, doi:10.1016/j.jclepro.2015.09.065.
18. Pfaff-Simoneit, W. Development of a sectoral approach for the establishment of sustainable waste management systems in developing countries in the context of climate change and resource scarcity: [Entwicklung eines sektoralen Ansatzes zum Aufbau von nachhaltigen Abfallwirtschaftssystemen in Entwicklungsländern vor dem Hintergrund von Klimawandel und Ressourcenverknappung]. [Dissertation]; Rostock, 2012.
19. Guerrero, L.A.; Maas, G.; Hogland, W. Solid waste management challenges for cities in developing countries. Waste Manage. 2013, 33, 220–232, doi:10.1016/j.wasman.2012.09.008.
20. World Bank Group. Solid waste management: optional sectoral module (English)., Washington, D.C., 2018. Available online: http://documents.worldbank.org/curated/en/733491525783750293/Solid-waste-management-optional-sectoral-module (accessed on 22 December 2020).
21. BMUB. Modern waste - Goals and Paths: Germany's expertise for an advanced circular economy, 2016. Available online: https://www.giz.de/de/downloads/giz2016-en-vdma_Modern_Waste_Management.pdf (accessed on 11 January 2022).
22. Prendeville, S.; Cherim, E.; Bocken, N. Circular Cities: Mapping Six Cities in Transition. Environ. Innov. Soc. Transit. 2018, 26, 171–194, doi:10.1016/j.eist.2017.03.002.
23. Caniato, M. Assessment and Design of Local Regulation in Solid Waste Management in Low- and Middle-Income Countries. In The Political Economy of Local Regulation: Theoretical Frameworks and International Case Studies; Asquer, A., Becchis, F., Russolillo, D., Eds.; Palgrave Macmillan UK: London, 2017; pp 277–286, ISBN 978-1-137-58828-9.
24. Fatimah, Y.A.; Govindan, K.; Murniningsih, R.; Setiawan, A. Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia. J. Cleaner Prod. 2020, 269, 122263, doi:10.1016/j.jclepro.2020.122263.
25. Romano, G.; Masserini, L.; Lombardi, G.V. Environmental performance of waste management: Impacts of corruption and public maladministration in Italy. J. Cleaner Prod. 2021, 288, 125521, doi:10.1016/j.jclepro.2020.125521.
26. Fuss, M.; Vasconcelos Barros, R.T.; Poganietz, W.-R. Designing a framework for municipal solid waste management towards sustainability in emerging economy countries - An application to a case study in Belo Horizonte (Brazil). J. Cleaner Prod. 2018, 178, 655–664, doi:10.1016/j.jclepro.2018.01.051.
27. European Union. Directive 2010/75/EU of the European Parliament and of the Council of the 24. November 2010 on industrial emissions (integrated pollution prevention and control): 2010/75/EU. (Recast). Official Journal of the European Union 2010.
28. Geng, Y.; Fu, J.; Sarkis, J.; Xue, B. Towards a national circular economy indicator system in China: an evaluation and critical analysis. J. Cleaner Prod. 2012, 23, 216–224, doi:10.1016/j.jclepro.2011.07.005.
29. Kranert, M. Introduction to the circular economy [Einführung in die Kreislaufwirtschaft]; Springer Fachmedien Wiesbaden: Wiesbaden, 2017.
30. Jesus, A. de; Mendonça, S. Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. Ecol. Econ. 2018, 145, 75–89, doi:10.1016/j.ecolecon.2017.08.001.
31. Campitelli, A.; Schebek, L. How is the performance of waste management systems assessed globally? A systematic review. J. Cleaner Prod. 2020, 272, doi:10.1016/j.jclepro.2020.122986.
32. Roidt, M.; Avellán, T. Learning from integrated management approaches to implement the Nexus. J. Environ. Manage. 2019, 237, 609–616, doi:10.1016/j.jenvman.2019.02.106.
33. ElSaid, S.; Aghezzaf, E.-H. A progress indicator-based assessment guide for integrated municipal solid-waste management systems. J Mater Cycles Waste Manag 2018, 20, 850–863, doi:10.1007/s10163-017-0647-8.
34. Song, Q.; Li, J.; Zeng, X. Minimizing the increasing solid waste through zero waste strategy. J. Cleaner Prod. 2015, 104, 199–210, doi:10.1016/j.jclepro.2014.08.027.
35. Bleck, D.; Wettberg, W. Waste collection in developing countries – Tackling occupational safety and health hazards at their source. Waste Manage. 2012, 32, 2009–2017, doi:10.1016/j.wasman.2012.03.025.
36. Ferronato, N.; Rada, E.C.; Gorritty Portillo, M.A.; Cioca, L.I.; Ragazzi, M.; Torretta, V. Introduction of the circular economy within developing regions: A comparative analysis of advantages and opportunities for waste valorization. J. Environ. Manage. 2019, 230, 366–378, doi:10.1016/j.jenvman.2018.09.095.
37. Wilts, H.; Berg, H. Digital Circular Economy: The Digital Transformation as a Pioneer of Resource-Saving Material Cycles [Digitale Kreislaufwirtschaft Die Digitale Transformation als Wegbereiter ressourcenschonender Stoffkreisläufe], in: inbrief, Wuppertal Insitute, 2017, 04.
38. Aleluia, J.; Ferrão, P. Characterization of urban waste management practices in developing Asian countries: A new analytical framework based on waste characteristics and urban dimension. Waste Manage. 2016, 58, 415–429, doi:10.1016/j.wasman.2016.05.008.
39. Velis, C.A.; Wilson, D.C.; Rocca, O.; Smith, S.R.; Mavropoulos, A.; Cheeseman, C.R. An analytical framework and tool ('InteRa') for integrating the informal recycling sector in waste and resource management systems in developing countries. Waste Manage. Res. 2012, 30, 43–66, doi:10.1177/0734242X12454934.
40. Medina, M. Waste Picker Cooperatives in Developing Countries 2005, doi:10.4324/9780203934074.pt4.
41. Ezeah, C.; Fazakerley, J.A.; Roberts, C.L. Emerging trends in informal sector recycling in developing and transition countries. Waste Manag. 2013, 33, 2509–2519, doi:10.1016/j.wasman.2013.06.020.
42. Turcott Cervantes, D.E.; Romero, E.O.; Del Consuelo Hernández Berriel, M.; Martínez, A.L.; Del Consuelo Mañón Salas, M.; Lobo, A. Assessment of some governance aspects in waste management systems: A case study in Mexican municipalities. J. Cleaner Prod. 2021, 278, 123320, doi:10.1016/j.jclepro.2020.123320.
43. Ahmed, S.A.; Ali, M. Partnerships for solid waste management in developing countries: linking theories to realities. Habitat Int. 2004, 28, 467–479, doi:10.1016/S0197-3975(03)00044-4.
44. Massoud, M.; El-Fadel, M. Public-private partnerships for solid waste management services. Environ. Manage. 2002, 30, 621–630, doi:10.1007/s00267-002-2715-6.
45. Hogg, D.; Ballinger, A. The Potential Contribution of Waste Management to a Low Carbon Economy: Main Report, 2015 (accessed on 6 July 2017).
46. Geng, Y.; Tsuyoshi, F.; Chen, X. Evaluation of innovative municipal solid waste management through urban symbiosis: a case study of Kawasaki. J. Cleaner Prod. 2010, 18, 993–1000, doi:10.1016/j.jclepro.2010.03.003.
47. World Bank Group. Environmental, Health, and Safety (EHS) Guidelines: General EHS Guidelines: Environmental - Waste Management, 2007 (accessed on 24 November 2020).
48. UN-Habitat. Waste Wise Cities Tool, 2021 (accessed on 15 December 2021).
49. Hannan, M.A.; Hossain Lipu, M.S.; Akhtar, M.; Begum, R.A.; Al Mamun, M.A.; Hussain, A.; Mia, M.S.; Basri, H. Solid waste collection optimization objectives, constraints, modeling approaches, and their challenges toward achieving sustainable development goals. J. Cleaner Prod. 2020, 277, 123557, doi:10.1016/j.jclepro.2020.123557.
50. Ramson, S.R.J.; Moni, D.J.; Vishnu, S.; Anagnostopoulos, T.; Kirubaraj, A.A.; Fan, X. An IoT-based bin level monitoring system for solid waste management. J Mater Cycles Waste Manag 2020, doi:10.1007/s10163-020-01137-9.
51. Sander, K.; Marscheider-Weidemann, F.; Wilts, H.; Hobohm, J.; Hartfeil, T.; Schöps, D.; Heymann, R. Waste management product responsibility under resource protection aspects (RePro): final report. [Abfallwirtschaftliche Produktverantwortung unter Ressourcenschutzaspekten (RePro)], Texte 52/2019, Dessau-Roßlau, 2019 (accessed on 6 January 2021).
52. Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste: 1999/31/EC, 1999.
53. Schodrowski, B. EU Parliament adopts resolution on "New Action Plan for the Circular Economy [EU-Parlament nimmt Entschließung zum „Neuen Aktionsplan für die Kreislaufwirtschaft" (nCEAP) an]. Press statement, 2021.
54. World Bank. What a Waste: A Global Review of Solid Waste Management, 2012 (accessed on 14 November 2016).
55. Rand, T.; Haukohl; J.; Marxen, U. Municipal Solid Waste Incineration: A Decision Maker's Guide, Washington, D.C., 2000 (accessed on 9 May 2019).

56. Liu, C.; Nishiyama Toru; Kawamoto, K.; Sasaki, S. Waste-to-Energy Incineration: CCET guideline series on intermediate municipal solid waste treatment technologies Waste-to-Energy Incineration, 2020 (accessed on 16 December 2021).
57. Mutz, D.; Hengevoss, D.; Hugi, C.; Gross, T. Waste-to-Energy Options in -Municipal Solid Waste Management: A Guide for Decision Makers in Developing - and Emerging Countries, 2017 (accessed on 16 December 2021).
58. Huysman, S.; Schaepmeester, J. de; Ragaert, K.; Dewulf, J.; Meester, S. de. Performance indicators for a circular economy: A case study on post-industrial plastic waste. Resour. Conserv. Recycl. 2017, 120, 46–54, doi:10.1016/j.resconrec.2017.01.013.
59. Gundupalli, S.P.; Hait, S.; Thakur, A. A review on automated sorting of source-separated municipal solid waste for recycling. Waste Manag. 2017, 60, 56–74, doi:10.1016/j.wasman.2016.09.015.
60. Meyer, B.; Lee, R.P. Synthesis gas from waste that is difficult to recycle [Synthesegas aus schwer verwertbaren Abfällen]. UmweltMagazin 2019, 49, 36–39, doi:10.37544/0173-363X-2019-09-36.
61. 20. requirements for recycling of mineral wastes -technical rules - General part. [20. Anforderungen an die stoffliche Verwertung von mineralischen Abfällen -Technische Regeln - Allgemeiner Teil]: Zuordnungswerte LAGA [Assignment values LAGA], 2003.
62. Wang, Z.; Li, H.; Yang, X. Vision-based robotic system for on-site construction and demolition waste sorting and recycling. J. Build. Eng. 2020, 32, 101769, doi:10.1016/j.jobe.2020.101769.
63. Schanes, K.; Dobernig, K.; Gözet, B. Food waste matters - A systematic review of household food waste practices and their policy implications. J. Cleaner Prod. 2018, 182, 978–991, doi:10.1016/j.jclepro.2018.02.030.
64. Schebek, L.; Kannengießer, J.; Campitelli, A.; Fischer, J.; Abele, E.; Bauerdick, C.; Anderl, R.; Haag, S.; Sauer, A.; Mandel, J.; et al. Resource Efficiency through Industry 4.0 - Potentials for Manufacturing SMEs [Ressourceneffizienz durch Industrie 4.0 - Potenziale für KMU des verarbeitenden Gewerbes], 2017 (accessed on 26 November 2020).
65. Kaza, S.; Yao, L.; Bhada-Tata, P.; van Woerden, F. What a waste 2.0: A Global Snapshot of Solid Waste Management to 2050, 2018 (accessed on 21 September 2018).
66. European Commission. A sustainable bioeconomy for Europe: Strengthening the connection between economy, society and the environment: updated bioeconomy strategy, Brüssel, 2018. Available online: https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/ (accessed on 17 August 2021).
67. Kirchherr, J.; Reike, D.; Hekkert, M. Conceptualizing the circular economy: An analysis of 114 definitions. Resour. Conserv. Recycl. 2017, 127, 221–232, doi:10.1016/j.resconrec.2017.09.005.
68. Korhonen, J.; Nuur, C.; Feldmann, A.; Birkie, S.E. Circular economy as an essentially contested concept. J. Cleaner Prod. 2018, 175, 544–552, doi:10.1016/j.jclepro.2017.12.111.
69. eurostat. CIRCULAR ECONOMY INDICATORS. Available online: https://ec.europa.eu/eurostat/web/circular-economy/indicators/monitoring-framework (accessed on 16 August 2021).
70. Geyer, R.; Kuczenski, B.; Zink, T.; Henderson, A. Common Misconceptions about Recycling. Journal of Industrial Ecology 2016, 20, 1010–1017, doi:10.1111/jiec.12355.
71. European Commission. Commission Decision of 3 April 2020 on the sectoral reference document on best environmental management practices, sector environmental performance indicators and benchmarks of excellence for the waste management sector under Regulation (EC) No 1221/2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS): 2020/519. Decisions. Official Journal of the European Union 2020.
72. European Environment Agency. EEA Glossary. Available online: https://www.eea.europa.eu/help/glossary/eea-glossary (accessed on 16 August 2021).
73. UNEP. Training Module: Closing an Open Dumpsite and Shifting from Open Dumping to Controlled Dumping and to Sanitary Land Filling, 2005. Available online: http://wedocs.unep.org/bitstream/handle/20.500.11822/8444/SPC_Training_Module_1.pdf?sequence=3&isAllowed=y (accessed on 27 June 2017).
74. Zaman, A.U.; Lehmann, S. The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city'. J. Cleaner Prod. 2013, 50, 123–132, doi:10.1016/j.jclepro.2012.11.041.
75. Günther, E. Downcycling: Gabler Wirtschaftslexikon. Available online: https://wirtschaftslexikon.gabler.de/definition/downcycling-33970 (accessed on 16 August 2021).
76. GEMET General Multilingual Environmental Thesaurus. Dual waste management. Available online: https://www.eionet.europa.eu/gemet/en/concept/2365 (accessed on 16 August 2021).
77. OECD. Extended producer responsibility. Available online: https://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm (accessed on 16 August 2021).
78. Umweltbundesamt. Hazardous Waste. Available online: https://www.umweltbundesamt.de/en/topics/waste-resources/waste-management/waste-types/hazardous-waste (accessed on 16 August 2021).
79. Coad, A. Collection of Municipal Solid Waste: Key issues for Decision-makers in Developing Countries, 2011 (accessed on 14 August 2018).
80. EGLE Michigan Department of Environment, Great Lakes, and Energy. open burning. Available online: https://www.michigan.gov/egle/0,9429,7-135-3310_4106_70665_70668---,00.html (accessed on 16 August 2021).
81. Oteng-Ababio, M.; Melara Arguello, J.E.; Gabbay, O. Solid waste management in African cities: Sorting the facts from the fads in Accra, Ghana. Habitat Int. 2013, 39, 96–104, doi:10.1016/j.habitatint.2012.10.010.
82. Ma, J.; Hipel, K.W. Exploring social dimensions of municipal solid waste management around the globe - A systematic literature review. Waste Manage. 2016, 56, 3–12, doi:10.1016/j.wasman.2016.06.041.
83. Clarity Environmental Limited. what is rdf & srf?: WASTE TO FUEL. Available online: https://www.clarity.eu.com/waste-to-fuel/what-is-rdf-srf/ (accessed on 16 August 2021).
84. European Union. Directive 2008/98/EC of the European Parliament and of the Council of 19. November 2008 on waste and repealing certain Directives, 2008.
85. Department of environment and conservation NSW. Handbook and design of rural and regional transfer stations, Sydney, 2006. Available online: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/warrlocal/060362-transferstation1.pdf?la=en&hash=FA2C668130BFBA811BFFB532031349EFC4585A47 (accessed on 16 August 2021).
86. PIUS Info-Portal. Upcycling: Glossar. Available online: https://www.pius-info.de/service/glossar/upcycling/ (accessed on 16 August 2021).
87. Umweltbundesamt. Waste regulations: Legal framework. Available online: https://www.umweltbundesamt.de/en/topics/waste-resources/waste-management/waste-regulations (accessed on 16 August 2021).
88. WIEGO. Waste Pickers. Available online: https://www.wiego.org/informal-economy/occupational-groups/waste-pickers.
89. ZWIA. ZW Definition. Available online: http://zwia.org/standards/zw-definition/ (accessed on 7 September 2018).
90. Bilitewski, B.; Wagner, J.; Reichenbach, J. Best Practice Municipal Waste Management: Information pool on approaches towards a sustainable design of municipal waste management and supporting technologies and equipment. Texte 40/2018, 2018 (accessed on 30 August 2018).
91. Kobus, D. Practical Guidebook on Strategic Planning in Municipal Waste Management: A Knowledge Product of the Cities of Change, Gütersloh, Washington, D.C., 2003.
92. World Bank Group. Environmental, Health, and Safety Guidelines for Waste Management Facilities, 2007 (accessed on 24 November 2020).
93. Kawai, K.; Liu, C.; Premakumara, J.D.G. Composting: CCET guideline series on intermediate municipal solid waste treatment technologies, 2020 (accessed on 16 December 2021).
94. Rushbrook, P.; Pugh, M. Solid Waste Landfills in Middle- and Lower Income countries: A Technical Guide to Planning, Design and Operation, 1999 (accessed on 6 May 2021).
95. International Solid Waste Association. A Roadmap for closing Waste Dumpsites: The World's most Polluted Places.
96. World Bank Group. Environmental, Health, and Safety General Guidelines: General EHS Guidelines: Introduction, 2007 (accessed on 6 November 2020).

Appendix II: Case study analysis results (Marrakech, Morocco)

Appendix II-a: Case study analysis results for the component governance

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Rationale / Source
Governance - Legislation and other policy measures (G.1 - G.6)											
G.1	**G.1.1.1** National waste management (WM) targets are missing	**nm**	**G.1.2.1** Definition of preliminary WM targets in legislation	**m**	**G.1.3.1** Targets include climate and environmental aspects	**m**	**G.1.4.1** WM targets based on UN SDGs	**nm**	**G.1.5.1** Achievement of ambitious targets regarding CE and waste avoidance	**nm**	**G.1.2.1 --> m:** law 28-00 Art. 1 **G.1.3.1 + G.1.3.2 --> m:** Objectives of the National Household Waste Program (PNDM) includes environmental time dependent targets. **G.1.3.3 --> pm:** The (non-)/achievements are communicated openly but not regularly. Last announcement End of April 2013: https://pndm.environnement.gov.ma/indicateurs_suivi https://pndm.environnement.gov.ma/presentation (last accessed 08.10.2021) **G.1.2.2 + G.1.4.3 --> m + G.1.4.2 --> pm:** "Morocco has committed at the highest level in putting in place policies and taking regulatory measures in favor of the environment and to fight climate change, which also take into account principles of the circular economy. However, the circular economy in Morocco as a concept is fairly new. It is predominantly focusing on the economy of waste (waste management and recovery) in accordance with the waste hierarchy." (Diaco et al. 2020, p.v) --> still focus on waste management, rather than circular economy. WM and CE-related targets are formulated in the National Strategy for Sustainable Development 2030 SNDD (Royame du Maroc, 2017a): - 2: Include public institutions in the logic of waste management and recovery, water and energy saving. - 25: Include the agricultural sector in programs for the development of a CE - 65: Enable the PNDM to achieve the objectives set for collection and treatment of waste. - 66: To move from a traditional waste management approach to a CE logic.
					G.1.3.2 Time-dependent targets for sustainable WM systems exist	**m**	**G.1.4.2** Formulation of targets for CE and Zero-Waste targets	**pm**			
					G.1.3.3 Regular review of WM targets; (non-)achievement is communicated openly	**pm**	**G.1.4.3** Change in wording from WM to CE	**nm**			
			G.1.2.2 Waste disposal is state responsibility	**m**							**G.1.2.2 --> m:** The responsibility for waste management falls on local authorities (law 28-00 Art. 16)
	G.1.1.2 Missing of waste hierarchy	**nm**			**G.1.3.4 Introduction of a 5-stage waste hierarchy:** 1. prevention - 2. reuse - 3. recycling - 4. energy recovery - 5. disposal	**pm**					**G.1.3.4 --> pm:** A 5-stage waste hierarchy is not defined in the waste law 28-00, yet. Although prevention, reuse, recycling and environmentally sound disposal are set as goals, the prioritization of the various waste types is not defined, as it is the case for the 5-stage waste hierarchy. But the SNDD includes the goals of Morocco, which shall promote the recycling and the reduction of waste (Royame du Maroc, 2017a). The National Strategy for Waste Reduction and Recovery (SNRVD) is making progress in implementing the waste treatment hierarchy for a better transition to a circular economy. (GIZ, 2019)

G.2	**G.2.1.1** National waste disposal law is missing or in preparation	**nm**	**G.2.2.1** Preliminary waste disposal law is in force	**m**	**G.2.3.1 Regulatory framework for WM consists of comprehensive laws and associated directives**	**pm**	**G.2.4.1** Constant development of laws and directives (each 5 years) to promote CE and react to global challenges	**pm**	**G.2.5.1** CE is promoted more by market drivers than by legal regulations	**nm**	**G.2.2.1 --> m:** It is all covered in waste law 28.00; I) definitions in Art. 3, II) responsibilities in different Articles, III) Sanctions in Title VIII Chapter 2. **G.2.3.1 --> pm:** Multiple regulatory framework are in force, and are reviewed and modified over the years. Law 28.00 was published in 2006 and two Decrees (n°2-09-284 and n°2-09-285) were introduced as a modification to the law. Then in 2012 Law n° 23-12 promulgated by dahir n° 1-12-25 amending law n° 28-00 relating to WM and disposal. Also relevant is the framework law on the national environment and sustainable development charter. I) --> nm; II) --> m; ban of plastic bags see law 77-15 and law 99-12 III) --> m; through landfill classes see Decree 2-09-284 "Within the Framework Law No. 99-12 on the National Charter for the Environment and Sustainable Development, in particular Article 30, Morocco has introduced an ecological tax of 1% ad valorem on plastics and articles thereof (raw materials, semi-finished products, finished products and plastic waste). The objective of this law is to develop the recycling and recovery of plastic waste. Also, under the Foreign Trade Law and the Basel Convention, Morocco has established export licenses for wastepaper and cardboard as well as for waste PET bottles to ensure the continuous supply of the recycling and recovery waste into these waste industries." (Rademaekers et al., 2020, p. 15) <u>WM related decrees in Morocco:</u> 2-07-253 (2008) Classification of waste and the listing of hazardous waste 2-09-139 (2009) Management of medical and pharmaceutical waste 2-09-284 (2009) Administrative procedures and technical requirements for controlled landfills 2-09-285 (2010) Regulates process and responsibilities for the preparation and implementation of regional WM master plans at district level. 2-09-538 (2010) Establishing the modalities for the elaboration of the national master plan for hazardous WM 2-09-683 (2010) Regulates process and responsibilities for the preparation and implementation of WM master plans in the four topographic areas. 2-09-85 (2011) Regulates the collection, transport and treatment of oils and specifies the technical requirements for these operations. 2-12-172 (2012) Establishment of technical rules for the disposal and recovery of waste by incineration 1-09-273 (2015) Decree on the management of hazardous waste in the Official Bulletin 2-14-85 (2015) Management of hazardous waste 2-17-587 (2018) Determination of the conditions and modalities for the import, export and transit of waste "Besides products, policy developments that can be supportive of a circular
			I) Formulation of definitions by law for "waste" and various waste types	**m**	**I)** Mandatory recyclables collection from households	**nm**	**I)** Mandatory recyclables collection from businesses	**nm**			
			II) Responsibility and role of divers stakeholders in WM are identified	**m**	**II)** Substance or product bans	**m**	**II)** Financial incentives and eco-labels to promote sustainable products and processes	**pm**			
			III) Sanctions for non-compliances are anchored in waste laws	**m**	**III)** Ban of combined disposal of hazardous and non-hazardous waste	**m**	**III)** Minimum use rates for recyclates in product manufacturing	**nm**			
							IV) Regulation of "right to repair" and further incentives to promote CE	**nm**			

											economy in the construction sector are gradually emerging across various African countries. In Morocco for instance, two draft laws are being prepared: 1) a decree on the management of non-hazardous waste which will define the necessary requirements for all types of non-hazardous waste, including construction and demolition waste, addressing collection, selective sorting and ecological treatment; and which will also govern the terms and conditions for the authorization of facilities for waste recovery; and 2) a decree that will deal with the introduction of a minimum threshold for sorting in-situ. The first decree is in its final stage of validation; the second decree is under development." (Rademaekers et al., 2020, p. 31f.) **G.2.4.1 --> pm:** The laws are constantly developed. However, these juridical development are not a promotion to the CE so that part is not met completely. I) --> nm; II) --> pm: "Morocco has introduced an ecological tax of 1% ad valorem on plastics and articles thereof (raw materials, semi-finished products, finished products and plastic waste). The objective is to develop the recycling and recovery of plastic waste." (Diaco et al., 2020, p.19); "Morocco does not yet have a nationally-driven financial programme tailored to circular economy. However, the country does have various ones in areas related to the circular economy." (Diaco et al., 2020, p.19) III) --> nm; IV) --> nm

			G.2.2.2 Guidelines for local authorities specify how waste laws and policies shall be implemented	m	**G.2.3.2** Technical instructions and implementation regulations are legally binding	m	**G.2.4.2** Interlinking of legal areas to counteract illegal waste transports	nm			**G.2.3.3 --> pm:** "Thanks to a strong political will, several advances have been made on the regulatory level, which cover almost all aspects relating to environmental law. These are: Law No. 99-12 National Charter for the Environment and Sustainable Development; Law 36-15 relating to water; Law 12-03 on impact studies; Law 13-03 on combating air pollution; Décret n° 2-09-631 air pollution limits for specific industrial sectors. Law 28-00 on WM and disposal; Law n° 15-58 relating to renewable energies amending law 13-09." (Diaco et al., 2020, p. 18f.) There is no law regarding soil security soil. **G.2.2.2 --> m:** Law 28.00 is the major guideline for all local authorities specifying the application of WM regulations. Also the Orders (Arrète 2817-10 from 2010 and Arrète 3413-11 from 2012), which contain criteria and guidelines for the elaboration of master plans for the management of household and similar waste (municipal level) and regional master plans for the management of non-hazardous industrial, medical and pharmaceutical waste, final waste, agricultural and inert waste. In addition, there is law 12.03 on environmental impact studies on the environment which evaluate the influence of any type of project on the surrounding environment (e.g. soil, air, etc.). See also list of WM related decrees in Morocco above.
					G.2.3.3 Media related (e.g. soil, air) laws or ordinances come into force	pm					
					G.2.3.4 All international agreements related to WM are ratified	pm	**G.2.4.3** Fulfillment of duties from international conventions	pm			**G.2.3.4 + G.2.4.3 --> pm:** Ratified international agreements related to WM: Basler and Minamata Convention, Kyoto Protocol and Paris Agreement (UN 2021a), London and Nairobi Convention (IMO 2021), Joint Convention (UN, 1997). However, no data is available regarding the fulfillment of duties from the ratified agreements. The following are missing: Hong Kong International Convention (IMO 2021), Espoo Convention (UNECE, 2021), Aarhus (UN 2021b), Bamako (African Union, 2019). **G.2.4.4. --> nm:** There are no regulations regarding the public procurement of ecofriendly goods, but such measures are suggested by WWF for example to stimulate the market for secondary materials (WWF, 2019).
							G.2.4.4 At least 50% of public procurement are ecologically efficient or environ. friendly goods	na	**G.2.5.2** 80% of goods for public procurement are ecologically efficient or environmentally friendly	na	
					G.2.3.5 Introduction of extended producer responsibility (EPR)	nm	**G.2.4.5** EPR transfers more responsibility to manufacturers	nm	**G.2.5.3** Cross-border EPR enables distribution of responsibility along global supply chains	nm	**G.2.3.5 --> nm:** There are no national policies regarding EPR (Rademaekers et al., 2020). "Local authorities could reinforce the regulatory framework with regards to waste management by integrating Extended Producer Responsibility (EPR), which can be more efficient than the polluter pays principle that is currently in application." (Diaco et al. 2020) COVAD recommends to strengthen and consolidate the status of EPR. (COVAD, 2020, p.8)
							G.2.4.6 Implementation of ecological evaluation of license fees regarding EPR	nm			
							G.2.4.7 Extension of EPR beyond national borders along supply chains	nm			

G.3	**G.3.1.1** Lack of standardized nomenclature for waste	**nm**	**G.3.2.1** Introduction of simple nomenclature for certain types of wastes (organics, residuals, plastics, metals, glass)	**nm**	**G.3.3.1 Detailed nomenclature for waste types** with differentiation between non-hazardous and hazardous waste exist	**m**	**G.3.4.1** Regluar update of waste nomenclature (incl. new waste and state of the art processes)	**nm**	**G.3.5.1** (Supra-)National collection of waste data enables targeted introduction of measures	**nm**	**G.3.3.1--> m:** The Decree n° 2-07-253 is concerning the classification of waste and fixing the list of dangerous waste. It gives a detailed nomenclature for waste types and indicating hazardous waste as DD (dechets dangereux).
G.4	**G.4.1.1** Central body responsible for WM strategies/policies is missing	**nm**	**G.4.2.1 Central body responsible for WM strategies/policies** exists	**m**							**G.4.2.1 + G.4.2.2 --> m:** Moroccan Ministry of Energy, Mines and Environment (MMEME): Based on Decree 2-14-758 (from 2014) MMEME has several missions, including for example of the elaboration of the national strategy of sustainable development and participation in the development, implementation, monitoring and evaluation of national environmental programs in collaboration with relevant departments. Related to waste these are namely e.g. PNVD (Ghariani, 2020), PNDM (Amounas, 2020) or SNRVD (GIZ et. al, 2019). They are also in charge of setting up necessary structures for the observation and monitoring of the state of the environment. (MMEME, 2015) The environmental control is a mission of the State in Morocco, and the environmental police (Decree 2-14-782 from 2015) is also part of these of controls where they check the levels of application of environmental laws.
			G.4.2.2 National environmental regulatory authority exists	**m**							
	G.4.1.2 National WM program specifying measures for waste sector development is lacking	**nm**	**G.4.2.3 National WM program** specifying measures for waste sector development exists	**m**	**G.4.3.1** National waste prevention programs are published	**nm**	**G.4.4.1** Regular revisions (max. 5 years) of WM programs, plans and concepts focusing on climate and resource aspects	**nm**			**G.4.2.3 --> m**: In Morocco the PNDM (National Program of Household and similar waste) exists since 2008 and it incorporates measures and time dependent targets to achieve for the waste sector. The program aims to reduce waste, recover (recycling, composting and energy production) 20% of waste in 2020 (against 10% in 2013) and rehabilitate or close all existing dumps (100%) by 2022. For the waste sector, the most important initiative is the National Program for the Recovery of Waste (PNVD), launched in 2008. The strategy defines the objectives and strategic axes for the reduction and recovery of waste, including measures to reach national waste management targets such as a 100% collection rate by 2030 or a 20% recycling rate by 2020. In addition to the PNDM, Morocco launched the national strategy in the field of waste reduction and recovery (SNRVD). The strategy defines the objectives and strategic axes for the reduction and recovery of waste. It constitutes a national reference and a decision-making tool for sustainable waste management and the promotion of the circular economy at territorial level. (Diaco et al., 2020, p. 14f.) In Morocco, the Ministry (MICEVN) is currently working on a roadmap for CE in the framework of a green economy plan. Moreover, it has CE-related policies (Rademaekers et al., 2020, p. 13)

			G.4.2.4 National WM plan exists	**m**							**G.4.2.4 --> m:** SNRVD includes the state of the waste management situation for 2015 for all Moroccan regions and measures to improve the WMS under analysis. (GIZ et. al, 2019) However, since waste management in Morocco is still in the development process, there is little reliable information available on the recycling situation and on waste prevention.
			G.4.2.5 Concepts for safe disposal of hospital waste exist	**pm**	**G.4.3.2** Existence of WM concepts for proper disposal or recycling of mining, construction, forestry, agricultural and hazardous waste	**nm**					**G.4.2.5 --> nm; G.4.3.2 --> nm:** The concepts for a safe disposal of hospital waste is existing in the general national Law 28.00 Title V; Concepts (regional master plans) for the management of non-hazardous industrial, medical and pharmaceutical wastes, ultimate, agricultural and inert wastes should be developed on regional level see Decree 2-09-683 and Arréte 3413-11. But on national level there is no website or any other platform, which contains all regional plans. In a report of Royaume Du Maroc (w.y.) Plans on national level regarding hazardous waste should exist according to Decree 2-09-538, but no national plan could be found online, that's why not met. Only two lists could be found: - List of Authorized Hazardous Waste Treatment Facility Companies - List of Authorized Companies for Collection and Transport of Hazardous Waste. (MMEME 2015b)
							G.4.4.2 Realization of globally led collective actions by government for sustainable resource management	**m**	**G.4.5.1** Measures ensure the proper disposal of waste nationally and combat global environmental problems to a great extent	**nm**	**G.4.4.2 --> m:** Marrakech organized a Global Submit in 2016 (COP 22). (Houzir, 2017)
							G.4.4.3 Implement measures to combat global problems related to improper disposal (marine and space debris, microplastics, etc.)	**nm**			
	G.4.1.3 Lack or fragile funding for WM activities	**nm**	**G.4.2.6** WM budget is set in the federal budget, but not guaranteed	**nm**	**G.4.3.3 Guaranteed and sufficient WM budget in the federal budget**	**m**					**G.4.2.7 + G.4.3.3 --> m:** Through different programs for example PNDM, grants were given to build up WMS (e.g. close uncontrolled dumps and build controlled landfills) for a specific duration. (Amounas, 2020) The Dutch development bank ("FMO") and the European Investment Bank ("EIB") have closed a facility for Banque Marocaine du Commerce Extérieur ("BMCE"), a universal bank in Morocco. The facility is dedicated to support BMCE's initiatives towards improvement of solid waste management practices and standards, one of the major environmental challenges in Morocco. The facility consists among others of a term loan facility of EUR 20 million to fund the pre-identified solid waste management projects. The loan facility is provided in partnership between FMO and EIB, with both institutions providing a EUR 10 million loan. (EIB, 2016)
	G.4.1.4 Lack of national funding to improve WM systems on regional or municipal level	**nm**	**G.4.2.7** Government grants financial aid to regions or municipalities	**m**							

G.5	**G.5.1.1** WM functions are dispersed across the regional administration; responsibilities are unclear	**nm**	**<u>G.5.2.1 Central body responsible for regional WM strategies or policies</u>** and coordinating waste disposal and recovery exists	**m**	**G.5.3.1** Regional responsibilities regarding waste disposal and recycling are clear and transparent	**nm**			**G.5.5.1** Regional efforts regarding CE lead to the rise of several circular cities	**nm**	**G.5.2.1 --> m:** The Regional Directorate of the Environment (DRE-MS) of the region Marrakech-Safi is one of the deconcentrated services of the Department of Environment, Ministry of Energy, Mines and Environment, created in the capital of the region Marrakech-Safi, by the Order No. 1362.16 of 27 Rejeb 1437 (May 5, 2016) fixing the powers and organization of the deconcentrated services of the Department of Environment, whereas waste management is one of their topics. The tasks of DRE are to: - operationalize the content of the national strategy of sustainable development at the regional level, in coordination with local actors and partners - monitor environmental indicators and produce reports on the state of the environment in the region - contribute to the elaboration and follow up the implementation of environmental upgrading programs and plans at regional and local levels - supervise the activities of local actors and partners and to strengthen their capacities for the integration of the environmental dimension in strategies, policies and projects at the local level - supervise, coordinate and evaluate regional environmental monitoring operations - sensitization, communication, training of regional actors in the field of environment and sustainable development at the regional level These tasks are taken over by the following entities: - Service de l'Observatoire Régionale de l'Environnement et de Développement Durable (SOREDD) - Service de la Gestion l'Environnementale (SGE) - Service du Contrôle et Etude d'Impact sur l'Environnement (SCEIE) (SIREDD, 2021)
					G.5.3.2 Interdisciplinary cooperation with other authorities exist	**m**					**G.5.3.2 --> m:** DRE-MS is a regional institution which coordinates the specific actors on regional and local level. The structure and tasks of DRE require interdisciplinary work with various other institutions (national, regional and local level). (SIREDD, 2021)
					G.5.3.3 Effective mechanisms for siting waste treatment plants exist	**nm**					

	G.5.1.2 A regional WM law and plan is missing or in preparation	m	**G.5.2.2** Regional waste law is in force	na	**G.5.3.4** Regional waste laws are adapted to revised national laws	nm	**G.5.4.1** Regional WM laws, plans, strategies and concepts are revised and concretized regularly (max. 5 years) focusing more on climate and resource protection aspects	nm			**G.5.1.2 --> m:** Regional adapted laws regarding WM do not exist.
			G.5.2.3 Simplified regional WM plan is published	nm	**G.5.3.5** Detailed WM plan is in place	nm					**G.5.2.3 --> nm:** By law (Dahir n° 1-06-153 Article 12) a provincial or prefectural master plan for WM should exist for the province Marrakech, but due to the fact that no information could be found online concerning this, we suppose it is not published.
					G.5.3.6 Regional waste prevention programs are published	nm					
			G.5.2.4 Concepts for proper disposal of hospital waste exist	na	**G.5.3.7** Regional concepts for mining, construction, agriculture, forestry and hazardous waste exist	pm	**G.5.4.2** Regional plans exist for sound waste disposal in catastrophic events (wars, pandemic, etc.)	nm			**G.5.2.4 --> m:** The concepts for a safe disposal of hospital waste is existing in the general national Law 28.00 Title V; Concepts (regional master plans) for the management of non-hazardous industrial, medical and pharmaceutical wastes, ultimate, agricultural and inert wastes should be developed on regional level see Decree 2-09-683 and Arréte 3413-11. Plans on national level regarding hazardous waste should exist according to Decree 2-09-538. But on regional level no master plans for Marrakech could be found.
	G.5.1.3 WM activities are reduced to a minimum due to lack of or fragile funding	nm	**G.5.2.5** More stable funding base for WM activities are available	m	**G.5.3.8** Sufficient WM budget available to optimize WM on regional and municipal level	nm	**G.5.4.3** Supra-regional activities promoting CE are implemented	nm			**G.5.2.5 --> m:** Through the PNDM and other programs, funds have gone into building up waste management in Marrakech (Amounas, 2020), for example for the construction of the El Mnabha controlled landfill and the CEV sorting plant. The municipality is also investing in improved waste collection (Yahya, 2021).
G.6	**G.6.1.1** Lack of jurisdiction and competences of municipality to plan, finance and operate WM system or to outsource tasks	nm	**G.6.2.1** **Municipality has jurisdiction and competences** to plan, finance and operate WM system and outsource tasks	m	**G.6.3.1** Institutional coherence in WM is transparent and publicly available	nm	**G.6.4.1** Municipality strives to become a "Circular City"	nm	**G.6.5.1** Preconditions for achieving status of "Circular City" are in place	nm	**G.6.2.1 --> m:** The prefectural or provincial master plan is drawn up on the initiative and under the responsibility of the governor of the prefecture or province in consultation with an advisory commission composed of representatives of the councils of the communes and their associations. Law 28-00 Art. 21 describes that the municipalities, their groupings or the operators must pay for the expenses related to the collection, transport, controlled landfilling, elimination, recovery of household and similar waste and, where applicable, sorting of such waste, as well as the costs of controlling the cleanliness of areas where this service is provided directly by the generators of this waste. The municipality can raise a collection fee, which are fixed by the town council, in accordance with the provisions of law n° 78-00 on the communal charter, in particular its article 69. (law 28-00 Art. 23)

	G.6.1.2 WM functions are spread across municipal institutions; responsibilities are unclear	**nm**	**G.6.2.2 Independent WM authority** ensures municipal WM; some functions are still spread across municipal institutions	**m**							**G.6.2.2. --> m:** The municipalities or their associated groups decide on the management methods of the public service for household and similar waste, by direct management, autonomous management concession or any other form of direct management or delegated management. (Loi 28-00 Art. 18) The municipality shall regulate the pre-collection and collection phases and shall decide for this purpose the modalities and conditions of collection and delivery of this waste according to their characteristics. It can in particular fix the modalities of selective collection and impose the separation of certain categories of waste. (Loi 28-00 Art. 19)
			G.6.2.3 Emerging of inter-municipal cooperation's to carry out WM tasks more efficiently	**m**	**G.6.3.2** Cooperation between WM and other municipal service sectors exist in city management	**na**					**G.6.2.3 --> m:** The Municipal Council of Marrakech has entrusted the mission of management, disposal and recovery of household waste and similar to the Establishment of Intercommunal Cooperation "Grand Marrakech". (mapecology, 2020) **G.6.3.2 --> na:** No information regarding cooperation between WM and other municipal service sectors could be found (that's why "na").
			G.6.2.4 Institutionalization of waste counseling for households commercial operators	**nm**	**G.6.3.3** Public WM companies and authorities use complaints mechanisms	**pm**					**G.6.3.3 --> pm:** It is planned to provide in Marrakech all people with a toll-free number and an electronic application for the receipt and processing of complaints and observations regarding the cleanliness of the city and the waste. (Yahya, 2021)
	G.6.1.3 Municipal waste bylaw and WM concept is missing or in preparation	**m**	**G.6.2.5 Municipal waste bylaw** is in force	**nm**	**G.6.3.4** Waste bylaws are adapted to revised national and regional waste laws	**na**	**G.6.4.2** Municipal WM bylaws and concepts are revised regularly (max. 5 years) focusing on climate and resource aspects	**nm**			**G.6.1.3 --> m:** According to Law 28-00 Art. 23 the town council can decide over collection fees. Where these fees are written down could not be found out. A waste bylaw or a WM concept for Marrakech could not be found on the website of the municipality.
			G.6.2.6 Municipal WM concept is publicly available	**nm**	**G.6.3.5** Municipal waste prevention program is published	**nm**	**G.6.4.3** Municipal plans exist ensuring sound waste disposal in catastrophic events	**nm**			
	G.6.1.4 Due to lack of funding and high dependency on funds from higher levels WM activities are reduced to a minimum	**nm**	**G.6.2.7** Stable funding base for WM activities exists	**m**	**G.6.3.6** Municipal WM budget is sufficient	**nm**	**G.6.4.4** Activities promoting CE in cooperation with foreign municipalities exist.	**nm**			**G.6.2.7 --> m:** "The municipality will double the value of the investment program of the two companies (more than 280 million DH), as well as the capacity of the dumpsters, and the replacement of those in plastic by others metallic or underground." (Yahya, A. 2021) Marrakech has a more stable funding base regarding the existing changes in WM. There are more investments to be done to improve the WMS, but if the budget is sufficient (G.6.3.6) could not be found out. The National Household Waste Program (PNDM) is a 40 billion dirham

	G.6.1.5 Uneconomic waste collection and disposal	**nm**	**G.6.2.8** Cost accounting / budgeting methods determine WM costs	**na**							(MAD) investment program launched in 2008 by the Ministry of the Interior, in collaboration with the Department of the Environment. The program runs from 2008 to 2023 with a system of funding and support programs. Local governments contribute 73% of the total cost of the PNDM, the State budget 9%, international cooperation 4%, waste fees and other taxes 12%, and the Clean Development Mechanism 3%." (Climate Chance, 2020)
Governance - Administration and monitoring (G.7 - G.11)											
G.7	**G.7.1.1** Missing interaction opportunities between public sector and relevant WM stakeholders	**n m**	**G.7.2.1** Platforms and committees emerge promoting exchange between public sector and other WM stakeholders	**m**	**G.7.3.1** Several platforms and committees exist and are essential for stakeholder exchange	**nm**	**G.7.4.1** Competency centers are established to improve the exchange between relevant WM stakeholders	**nm**	**G.7.5.1** Innovative digital exchange formats improve exchange of information between WM stakeholders	**nm**	**G.7.2.1 --> m:** "The Coalition for the Recovery of Waste (COVAD) was created in April 2016, bringing together actors from the private sector, civil society and government bodies. COVAD's mission is to contribute to the creation of a favorable environment, to the structuring of industries and to the promotion of the circular economy in waste management on a national and international scale." (Diaco et al. 2020, p. 27). COVAD did a webinar on 16.09.2020 with experts of WM to discuss the road of Morocco towards a circular economy regarding the valorization of waste (medias24, 2021b). Regarding circular economy Diaco et al. (2020, p. ix) recommended to "create a platform for international CE private actors to allow networking, training, scouting and capacity building that promote activities with more potential and benefits than only waste management, such as industrial symbiosis or eco-conception; well-established partners, like the Chamber of Commerce, could be involved."

G.8	**G.8.1.1** Lack of governmental bodies which monitor and control WM activities	**nm**	**G.8.2.1 Government control bodies to monitor WM activities exist**	**m**	**G.8.3.1 Certification and accreditation bodies exist**	**m**	**G.8.4.1** Successful transfer of WM tasks to private and PPP companies due to skilled supervisory institution.	**na**	**G.8.5.1** Reduction of state regulation due to functioning self-regulation and compliance with existing rules by business and society	**nm**	**G.8.2.1 --> m:** The environmental control is a mission of the State in Morocco, and the environmental police (law 99-12 Art. 35) is also part of these tasks of controls, where they check the levels of application of environmental laws. Environmental control is assigned to the Secretariat of State in charge of Sustainable Development by Decree 2-14-758 from 2014 on the organization and attributions of the Ministry in charge of the environment, particularly Art. 10 of the said decree, which stipulates that the Directorate of Control, Environmental Assessment and Legal Affairs (Direction de Contrôle, d'Evaluation Environnemental et des Affaires juridiques (DCEAJ)). DCEAJ has as its missions to ensure the application of the legislation and regulations in environmental matters by regularly carrying out controls and inspections in collaboration with the departments concerned. **G.8.3.1. + G.8.3.2 --> m:** IMANOR (Moroccan Institute of Standardization) certifies conformity to standards and normative reference systems in industries for instance (e.g. ISO 14001, ISO 9001, ISO 18001, ISO 50001). They are also member of the ISO group. (https://www.imanor.gov.ma/certifications-sm/)
			G.8.2.2 Regional councils exist for the lawful enforcement of WM	**m**	**G.8.3.2** Local authorities monitor activities of firms performing municipal WM functions	**na**					**G.8.2.2 --> m:** Direction régionale de l'environnement de la région Marrakech-Safi (SIREDD, 2021) **G.8.3.2 --> na:** If the transfer of the WM tasks are successfully transferred and how local authorities monitor the activities performing municipal WM functions cannot be assessed due to lack of information, that's why "na".
					G.8.3.3 Introduction of regulated and recognized certification of specialized WM companies	**nm**	**G.8.4.2** Standardized requirements for expert qualification and for inspection performance	**nm**			**G.8.3.3 --> nm:** There are no recognized certifications for companies, who are specialized in WM. (Ecomed, 2021)
							G.8.4.3 Introduction of regular training of experts	**nm**			
			G.8.2.3 Selective monitoring of compliance with legal requirements	**m**	**G.8.3.4** Introduction of stricter controls	**m**	**G.8.4.4** State controls increase to verify the compliance of labor and worker protection measures	**nm**	**G.8.5.2** Control mechanisms work well to identify and sanction illegal behavior and activities in CE	**nm**	**G.8.2.3 + G.8.3.4. --> m**: Law 99-12 Art. 35: "An environmental police force has been created with the mission of reinforcing the power of the administrations concerned in terms of prevention, control, inspection and administrative repression."

					G.8.3.5 State controls are carried out selectively to inspect labor and working conditions	**m**					**G.8.3.5 --> m:** The structure and organization of the labor inspection system on national and regional level in Morocco is explained in detail on the website of the ILO (2021). Moreover, by the end of 2021 the number of inspectors for the labor inspection will raise up to 100. (LesEcoMa, 2021) But the exact number of inspection controls in Marrakech are not available.
					G.8.3.6 Transport controls of imported / exported waste and recycled materials take place	**pm**	**G.8.4.5** Regular transport inspections increase detection of illegal disposal routes	**nm**			**G.8.3.6 --> pm:** Transboundary movements of wastes are governed at the international level by the Basel Convention, which was adopted on 22 March 1989 and entered into force on 5 May 1992. Morocco ratified this Convention in December 1995. Decree 2-17-587 (from 2018) contains the conditions and modalities for the import, export and transit of waste (hazardous and non-hazardous waste). But no regulations are existing regarding recycled materials. An information about the conduction of controls could not be found, that's why all in all partly met.
			G.8.2.4 Monitoring of construction, operation and aftercare of landfills is carried out selectively	**m**	**G.8.3.7** Monitoring of all landfills and waste treatment plants take place	**m**	**G.8.4.6** Strict monitoring of all emissions from landfills and other treatment plants	**nm**			**G.8.2.4 + G.8.3.7 --> m:** The law 28.00 title VIII Art. 63 states that the operators of controlled landfills and treatment, recovery, incineration, storage or disposal facilities as well as waste transporters are required to provide all waste and are obliged to provide all the necessary information to the persons in charge of the control. The CEV in Marrakech for example is monitored (Ecomed, 2021).
			G.8.2.5 Sanctions are imposed rarely in case of violations in WM	**pm**	**G.8.3.8** Sanctioning in case of legal violations is increasing	**na**	**G.8.4.7** Incorrect practices in CE decrease	**nm**			**G.8.2.5 --> pm + G.8.3.8 --> na:** Sanctioning takes place, but there is no information on how much sanctions are imposed regarding violations in WM in Marrakech. For example in Casablanca in 2020 the authorities in Casablanca decided to impose sanctions on the polluters (industries) (Afrik21, 2020).
			G.8.2.6 Introduction of control mechanisms to limit corruption and monopoles, but barely applied	**m**	**G.8.3.9** Development of anti-corruption mechanisms lead to an increased detection of corruption	**nm**			**G.8.5.3** Corruption is almost contained due to functioning control mechanisms	**nm**	**G.8.2.6. --> m:** Domestic bribery (private to public) is governed by Art. 248 to 256 of the Moroccan Criminal Code (the "Code"). There is no special regulatory body with authority to prosecute corruption. Corruption investigations and prosecutions are carried out by the public prosecutor and the criminal courts. (Globalcompliancenews, 2021). The regulation of monopoles was effective in the past for example for the telecommunications sector and in certain food sectors (tea, cereals market) (Eshmrah, 2021; Mawarid, w.y.). According to the corruption perceptions index (CPI) Morocco has a CPI of 40 in 2020 and is ranked 86/180. (https://www.transparency.org/en/cpi/2020/index/nzl)
							G.8.4.8 Monopolies in CE are regulated	**nm**	**G.8.5.4** Prevention of corporate monopolies in the WM sector	**nm**	

G.9	**G.9.1.1** Lack of regulated and systematic official authorization procedures and	**nm**	**G.9.2.1 Implementation of official authorization procedures** for WM plants	**m**	**G.9.3.1** Mandatory public participation for large-scale WM plants in authorization procedures	**m**	**G.9.4.1** Participation of recognized NGOs in hearing procedures	**nm**	**G.9.5.1** Full transparency of authorization procedures is guaranteed	**nm**	**G.9.2.1. + G.9.3.1 --> m:** Morocco calls, in chapter 4 of the Organic Law on Environmental Protection, Conservation and Management, for the need to subject projects to mandatory Environmental Impact Assessment. (Rademaekers et al., 2020, p. 15) Law 12-03 regulates the environmental impact studies for example for the construction of landfills as mentioned in Decree 2-09-284 Art. 3. The public participation for the environmental impact study is regulated in Decree 2-04-564.
	G.9.1.2 Public participation is missing in authorization procedures	**nm**	**G.9.2.2** Public participation is included in authorization procedures	**m**	**G.9.3.2** Public participation in political WM decisions	**m**	**G.9.4.2** Public participation in political decision-making processes regarding CE	**nm**			**G.9.3.2 --> m:** In 2010, a participatory workshop was held in Marrakech in which also waste management problems of different districts in Marrakech were discussed and their strengths and weaknesses were identified. (Ville Marrakech, 2016)
G.10	**G.10.1.1** Lack of quality standards and emission limits for waste disposal/treatment plants	**nm**	**G.10.2.1** Quality standards and emission limits for waste disposal and treatment plants exist	**pm**	**G.10.3.1** Permission requirements for disposal and treatment plants are tightened	**nm**	**G.10.4.1** Emission limits and quality standards for disposal and treatment plants are updated and tightened regularly (max. every 5 years)	**nm**	**G.10.5.1** Tightened emission limits and quality standards reduce environmental risks to a minimum	**nm**	**G.10.2.1 + G.10.3.2 --> pm:** There are currently no specific standards or regulations regarding leachate treatment objectives and the quality of the treated leachate discharge, however Morocco takes the French Decree of 31/12/2011 on the minimum criteria applicable to liquid effluent discharges as a current standard to follow. (Hafidi, 2015) Emission limits for landfills or other treatment plants are not regulated by a specific Decree (as for example the European Directive 2010/75/EC). Directive 2010/75/EC on industrial emissions is about minimizing pollution from various industrial sources (e.g. incinerations plants, landfills) throughout the European Union. An order exists (Arrète 1504-18 from 2018), which contains sectoral limit values for the release, emission or discharge of pollutants into the air by cement production facilities and cement production facilities using co-incineration of waste. Decree 2-12-172 (2012) contains technical rules for the disposal and recovery of waste by incineration. For emissions to water there are the following norms: Norms regarding water quality standards (including treated wastewater) for irrigation, general limit values for liquid discharges and specific limit values for sectors as ceramic, textile, paint and varnish, domestic waste, pulp and paper, cement and sugar industry and for discharges from the hot-dip galvanizing sector of the surface treatment activity (http://www.environnement.gov.ma/fr/lois-et-reglementations/normes) **G.10.1.2 --> m:** There are no quality standards or limits for secondary materials. If such standards exist, they are not centrally standardized and not publicly available. Diaco et al. are recommending for the recovery of products out of C&D waste: "Focus on amendment and levelling of legislation related to the management of C&D waste as well as the normalization aspect of the products resulting from their valuation." (Diaco et al., 2020, p. x) Moreover, the authors write: "At the legal level, two draft laws are being prepared. They are at two different levels of validation. [...] The second decree, which is under development, will deal with the introduction of a minimum threshold for sorting in-situ." (Diaco et al., 2020, p. 15) So, there are thresholds for products out of C&D waste planned in future.
					G.10.3.2 Emission limits and quality standards are uniform and nationally coordinated	**pm**					
	G.10.1.2 Lack of quality standards (e.g. pollutant limits) for secondary materials	**m**	**G.10.2.2** Quality standards and pollutant limits for certain secondary materials exist	**nm**	**G.10.3.3 Introduction of standardized national quality standards** for certain secondary materials (e.g., plastics, glass, compost) and substitute fuels	**nm**	**G.10.4.2** Expansion of and tighten quality standards increases the quality of secondary materials and refuse derived fuels (RDFs)	**nm**			
			G.10.2.3 Emerging institutions to promote standards for secondary materials and fuels	**nm**							

G.11	**G.11.1.1** Missing data on waste collection and disposal (quantity, type, etc.)	**nm**	**G.11.2.1** Introduction of waste collection and disposal records	**m**	**G.11.3.1** Data for all disposed wastes are documented and updated annually	**pm**	**G.11.4.1** Standardized registration and notification procedures for different wastes	**nm**	**G.11.5.1** Public availability of WM and other environmental data at all political levels	**nm**	**G.11.2.1 --> m + G.11.3.1. --> pm:** Waste collection and disposal records exists, but they are not published frequently and they are not up to date. At regional level SIREDD (https://siredd.environnement.gov.ma/Marrakech-Safi/indicateur#) has indicators for waste collection and waste generation, methane emissions from waste sector, but the last data is from 2017 (last accessed: 23.09.2021).
					G.11.3.2 Municipalities and regions are obliged to forward waste data to superior authorities	**m**					**G.11.3.2. --> m:** In law 28-00 and in Arrète 2817-10 (2010) and Arrète 3413-11 (2012) it is mentioned that the different master plans shall contain WM data (e.g. waste generation rates, collection rates) for 5 and 10 years. The plans has to be updated maximum every 10 years law 28-00 Art. 9, 11 and 13.
					<u>G.11.3.3 Waste data is documented centrally and uniformly</u>	**pm**					**G.11.3.3 --> pm:** The establishment of a Regional Information System on the Environment and Sustainable Development (SIREDD) for the Marrakech-Safi region aims to provide the Regional Observatory of the Environment and Sustainable Development (OREDD) and its partners with a viable source of information and an informational heritage to better guide decision making through the feeding of the system with data and the regular updating of a geographic database and the automatic generation of reports, dashboards, thematic maps, electronic cartographic atlases, etc. SIREDD of Marrakech-Safi thus presents a federating platform for the exchange and dissemination of information in the service of environmental protection and sustainable development in this region. (https://siredd.environnement.gov.ma/Marrakech-Safi/Home/Presentation_SIREDD) This regional information system exists for all Moroccan regions and is uniform. But it is not clear, how they use the data on the national level, that's why partly met. <u>indicators from SIREDD Marrakech-Safi</u> -Quantity of medical and pharmaceutical waste generated (data from 2007 – 2017 for Marrakech region) -Overall waste collection rate (data from 2007 – 2017 for Marrakech region) -Collection rate of household and similar waste (data from 2010 – 2016 with great gaps, data from 7 provinces only for one year) -Number of transfer centers planned (data from 2019 for 8 provinces) -Number of illegal dumps (data from 2020 for 7 provinces --> Marrakech 6 and the Region 40 illegal dumps in total) -Quantity of household waste generated (data from 2013 – 2017, with great gaps, data from 7 provinces only for one year) -Number of landfills rehabilitated (data from 2015 - 2019, with great gaps, data from 5 provinces only for one year) -Total volume of leachate stored (data from 2016, 2017 and 2020, with great gaps, data from 4 provinces only for one year) -Number of rehabilitated and closed landfills (data from 2020 for Marrakech and Safi) -Percentage of household and similar waste recovered (data for 2012

											(Rehamna) and 2020 (Marrakech)) -Percentage of household and similar waste recovered (no data) -Number of transfer centers built (no data) -Number of landfills and CEVs benefiting from incentives (no data) -Share of industrial waste treated (no data) -Share of medical and pharmaceutical waste treated as household waste (no data) -Share of non-hazardous medical and pharmaceutical waste (no data) -Amount of agricultural waste produced (no data) -Amount of industrial waste generated (no data) -Quantity of hazardous industrial waste (no data) -Collection rate of agricultural, industrial hazardous and medical and pharmaceutical waste (no data) -Rate of disposal of similar household waste in landfills (no data) -Industrial hazardous waste generation rate (no data) -Recycling rate of household and similar waste (no data) -Treatment rate of agricultural waste (no data) -Treatment rate of non-hazardous medical and pharmaceutical waste (no data) -Medical and pharmaceutical waste disposal rate (no data) -Total volume of leachate produced by controlled landfills (no data)
					G.11.3.4 Establishment of different registration / notification procedures for various wastes and for its exports	**m**					**G.11.3.4 --> m:** The notification procedures for wastes and export of wastes are different.
			G.11.2.2 Introduction of a simple management information system (MIS) in public administration	**m**	**G.11.3.5** Increase use of MIS in public administration	**pm**	**G.11.4.2** Use of innovative MIS to analyze large data amounts user-friendly and more quickly	**nm**	**G.11.5.2** Smart WM systems integrate large amounts of waste data in real time	**nm**	**G.11.2.2 --> m + G.11.3.5 --> pm:** It can be assumed that the administration uses MIS or similar software. The Moroccan government has created an e-government platform and has already drawn up plans in the early 2010s to promote digitization in Morocco. (http://www.egov.ma/en/operational-e-services) But what kind of MIS they are using is not known.
	G.11.1.2 Lack of representative waste statistics at all political levels	**nm**	**G.11.2.3** Municipal or regional waste statistics are created without being publicly available	**pm**	**G.11.3.6** Waste statistics are publicly available	**pm**	**G.11.4.3** Data basis enables precise forecasts, meaningful reporting and is a basis for political decisions	**nm**	**G.11.5.3** (Supra-)National standardized benchmark indicators to evaluate WM systems exist	**nm**	**G.11.2.3 --> m + G.11.3.6. --> pm:** Waste statistics exist on regional (see SIRED website) and presumably also on municipal level, because Ecomed forwards the collection and disposal rates for Marrakech to the municipality (Ecomed, 2021), but the published dates on SIREDD are not up to date and the municipality of Marrakech does not publish the data.

					G.11.3.7 Waste balances and forecasts through improved data	**nm**					
					G.11.3.8 Indicators are used to evaluate WM systems	**nm**	**G.11.4.4** Use of different indicators for WM systems monitoring	**nm**			**G.11.3.8. --> nm:** There are indicators related to WM as mentioned on SIREDD website, but if and how they are used for the evaluation of the WMS is not documented.
	G.11.1.3 Lack of specific collection, disposal, recovery and recycling rates	**nm**	**G.11.2.4** Collection, disposal, recovery and recycling rates are estimated on all political levels	**m**	**G.11.3.9 Uniform collection, disposal and recycling rates exist** on all political levels	**nm**					**G.11.2.4. --> m + G.11.3.9. --> nm:** Ecomed forwards the collection and disposal rates for Marrakech to the municipality (Ecomed, 2021). On regional level some waste rates (waste collection and generation) are published, but they are not up to date. On national level the report of GIZ et. al (2019) presents the amount of generated waste for different waste streams (residual, C&D, electronic and industrial waste, batteries, used oils, tires) in 2015 for Morocco and the different regions (p. 185), and their estimated recycling potentials and recycling rates also for the year 2015. But the numbers are not collected uniformly based on a national guideline.
Governance - Education and research (G.12 - G.14)											
G.12	**G.12.1.1** Lack of training opportunities to qualify personnel in WM	**nm**	**G.12.2.1 Availability of education and training opportunities** train personnel in the field of WM	**m**	**G.12.3.1** Emerging of job profiles for recycling or recovery	**nm**	**G.12.4.1** Expansion of qualification offers for specialized personnel in the field of CE (incl. also Zero-Waste, waste prevention, climate protection, etc.)	**nm**	**G.12.5.1** CE is an integral part of educational courses either for academics, pupils and workers.	**nm**	**G.12.2.1 + G.12.2.3 --> m:** In Marrakech master programs (Master IAMIGEL at the University Cady Ayyad) exist which are specialized in management of urban and industrial environment. There was also on national level an initiative that took place to reinforce capacities and training in educational system. **G.12.2.2 --> m:** Demands for WM specific job profiles (landfill management) could be found on indeed platform for Marrakech in July 2021. **G.12.3.2 --> m:** There are some courses regarding the Collection and Treatment of Industrial Waste and Hazardous Materials (Emploi.ma, 2021) as well as other ISO management courses (90001, 50001, etc.). **G.12.4.1 --> nm:** refers to national level --> "For education, curricula are still scarce with little meaning of CE in the majority of environmental education programmes. Overall, the Moroccan education system fails to sufficiently qualify graduates for a career in branches of the modern economy and green jobs, all of which offer a good opportunity to facilitate Morocco's transition towards a CE. The same applies to technical subjects, e.g. Vocational Education and Training programmes broadly do not yet have a CE or environmental focus. Notable efforts in this regard include activities under SwitchMed, aiming to facilitate a green entrepreneurship ecosystem in Morocco which can provide a basis for future development." (Diaco et al. 2020, p.vii)
			G.12.2.2 Emerging of specific job profiles for waste collection, sorting, disposal and recovery	**m**	**G.12.3.2** Addressing of WM issues in professions for which the handling of waste is relevant	**m**					
			G.12.2.3 Available study programs without WM focus train specialists, who can be employed in WM	**m**	**G.12.3.3 Existence of WM study programs or environmental science** to train academic staff	**m**					
	G.12.1.2 Lack of educational programs for pupils in schools regarding WM	**nm**	**G.12.2.4** WM relevant topics are voluntarily addressed in schools	**m**	**G.12.3.4** Increased teaching of WM topics in schools	**nm**	**G.12.4.2** Inclusion of CE and environmentally relevant topics in the curriculum of	**nm**			**G.12.2.4 --> m:** The Association of Teachers of Life and Earth Sciences of Morocco (AESVT Maroc) is a non-profit association, which launches educational projects to raise awareness for sustainable development (promote cleanliness of cities, marine debris, sorting at source, etc. (AESVT, 2021). COVAD recommends to include waste and environmental protection

					on a voluntary basis		elementary and secondary schools				in school and university curricula and create courses dedicated to the environment and waste management and recognize the Education / Communication component in any circular economy project and provide a dedicated budget as well as qualified and specialized human resources. (COVAD, 2020 p.8) (Diaco et al. 2020, p. 23f.)
			G.12.2.5 Selective launching of educational pilot projects, which are financed externally	**m**							**G.12.2.5 --> m:** There are existing educational and research projects e.g. with the University Cady Ayyad and the Technical university of Darmstadt (Trans4biotec and Biotec2Future):
G.13	**G.13.1.1** Lack of faculties which study WM issues alone or in cooperation with other countries	**nm**	**G.13.2.1 Establishing of research and development (R&D) faculties to study WM issues**	**m**	**G.13.3.1** Intensive promotion of R&D facilities on national/ regional level	**nm**	**G.13.4.1** Interdisciplinary research centers are established to study on relevant CE issues	**nm**			**G.13.2.1 --> m:** This exists and is possible at the University Cady Ayyad in Marrakech (Master IAMGEL). **G.13.2.2 --> m:** There is an existing partnership between the University of Marrakech and the Technical University of Darmstadt to finance phD students that are working on research projects (Trans4biotec and Biotec2Future) in the WM field. There is also an existing cooperation between Morocco and GIZ Germany to improve different sectors in Morocco (GIZ, 2020). **G.13.3.2. + G.13.3.4 --> na:** If there is an increasing number of national faculties cooperating with other countries regarding WM could not be found as well as if the research is mostly studied interdisciplinary. **G.13.3.3 --> nm:** refers to national level --> COVAD recommends to create or mandate an organization in charge of supporting the ecosystem of research and innovation in recycling and waste recovery. (COVAD, 2020, p.8)
	G.13.1.2 Investigation of WM issues only by foreign disciplines, research institutions or firms	**nm**	**G.13.2.2** Cooperation's with foreign research institutions or firms and country regarding research and education exist	**m**	**G.13.3.2** Increasing number of nat. faculties studying or cooperating with other countries regarding WM research and education	**na**					
	G.13.1.3 Research focus mainly on the setup of waste collection and disposal infrastructures	**nm**	**G.13.2.3** Research focus mainly on efficient collection, disposal and treatment of waste, and risk minimization (social and economic)	**m**	**G.13.3.3** Research focus mainly on optimized and efficient waste recycling, risk minimization (social, economic and environmental) and resource efficiency	**nm**	**G.13.4.2** Research focus mainly on optimization of flows in CE, industrial symbiosis, digitalization, bioeconomy, waste prevention and Water-Waste-Soil Nexus	**nm**	**G.13.5.1** CE research projects are usually interdisciplinary and holistic	**nm**	
					G.13.3.4 WM issues are more likely studied interdisciplinary	**na**	**G.13.4.3** Increase studies exploring CE potentials in companies	**nm**			

G.14	**G.14.1.1** Lack of awareness campaigns regarding WM	**nm**	**G.14.2.1 WM awareness campaigns are carried out** on some political levels	**m**	**G.14.3.1** Implementation of national or municipal initiatives/ projects to raise WM awareness	**m**	**G.14.4.1** Awareness campaigns especially to promote waste prevention and closing loops are carried out on all political levels	**nm**			**G.14.2.1 + G.14.3.1 --> m:** refers to national level --> "Over the recent years a number of awareness creation initiatives for CE related measures were launched in Morocco. In addition to state-organized donor- and state-funded initiatives, social entrepreneurs in Morocco are also increasingly involved in awareness-raising efforts for CE." (Diaco et al. 2020, p.23) As part of the support measures for the success of the PNDM, an awareness and communication project has been established. (Diaco et al. 2020, p.21) For Marrakech actions of awareness and sensitization of citizens are included in the contract of the new collection companies in charge with the waste collection. They should involve citizens in the process of strengthening and preservation of cleanliness and aesthetics of the city, providing them with a toll-free number and an electronic application for the receipt and processing of complaints and observations. (Yahya, A. 2021) As part of the annual awareness program, Mecomar Marrakech, in charge of the delegated management of the public service of household and similar waste, launches in coordination with the municipality of Marrakech, and under the supervision of the district of Menara, an awareness campaign under the theme "We take care of the service, and entrust you with the change of behavior" in April 2021 (Aujourd'hui, 2021).
	G.14.1.2 Population neglects importance of WM and lives according to the "not-in-my-backyard" principle	**nm**	**G.14.2.2** Increasing awareness regarding WM knowledge and concerns in small part of the population	**pm**	**G.14.3.2** Society and some companies gain experience and acquire basic understanding of WM in the context of sustainability	**pm**	**G.14.4.2** Positive changes in attitude regarding CE in large parts of the population and companies	**nm**	**G.14.5.1** Behaviour changing of population and companies enable a sustainable CE	**nm**	**G.14.2.2 + G.14.3.2 --> pm:** "Although still not the centre of interest, the national awareness for the circular economy concept is clearly on the rise in Morocco. Enterprises and industry initiatives are increasingly concerned with the economic potentials of new resource-saving and environmentally friendly business models. In the context of logistic companies Kammas (2016) concludes that companies are more aware in superficial optimization than sustainable development (Kammas, 2016). These efforts are now more frequently supported by national institutions. However, the financial success of large-scale CE business projects is often hampered by a lack of consumer awareness, which is usually linked to consumers' financial constraints." (Diaco et al., 2020, p. 69).
							G.14.4.3 Growing public participation in political decision-making processes regarding CE	**nm**	**G.14.5.2** Achieving of CE and zero-waste goals due increased awareness	**nm**	

Governance - Occupational safety, health and environmental protection (G.15 - G.16)											
G.15	**G.15.1.1** Neglecting occupational health and safety measures (OHSM) in WM sector	**nm**	**G.15.2.1 Increased implementation of OHSM in WM** in formal sector and rarely in informal sector	**m**	**G.15.3.1** OHSM are implemented entirely in formal sector and increasingly in informal sector	**nm**	**G.15.4.1** High level of occupational health and safety exists	**nm**	**G.15.5.1** Number of work-related accidents, illnesses, etc. is reduced to a minimum	**nm**	**G.15.2.1 --> m:** Article 30 of law 28.00 requires that preventive and sanitary measures have to be taken to ensure the safety of personnel. In Marrakech there are also companies that are certified ISO 9001, OHSAS 18001 and ISO 14001 like Pizzorno (Pizzorno, 2019). Implementation of OHSM measures for the informal sector could not be found, but the health risks for waste pickers and the bad working conditions could be found on the website bossons-fute (2014).
	G.15.1.2 Accidents, illnesses, etc. of personnel occur frequently	**m**	**G.15.2.2** First decrease of work-related accidents, illnesses, etc. are registered in formal sector	**na**	**G.15.3.2** Decrease of work-related accidents, illnesses, etc. are registered in both sectors	**na**					**G.15.1.2 --> m:** No data regarding the accidents and illnesses of personnel could be found openly. That's why, stage 1 was chosen.
	G.15.1.3 Waste pickers work and live under poor conditions at waste dumps/landfills	**nm**	**G.15.2.3** Only adults work at controlled landfills	**m**	**G.15.3.3** Prohibition of living on landfills and child labor is fully realized	**pm**					**G.15.1.4 --> pm:** Legally, the employment of children under the age of 15 is prohibited by Moroccan law, but also by ILO Convention 138 on the minimum age, adopted in 1973 and ratified by Morocco in 2000 (medias24, 2015). In Morocco, the phenomenon of child labor has declined by more than 26% in 2020. (medias24, 2021) Unfortunately, still some kids are working in the informal sector regarding WM. **G.15.2.3 + G.15.2.4 --> m:** However, only adults are employed in the controlled landfill in Marrakech (Ecomed, 2021).**G.15.3.3. --> pm:** 10% of waste pickers are children in Morocco (WWF, 2019), in Marrakech there are no waste pickers living on landfills, that is why all in all the criteria is partly met.
	G.15.1.4 Children work as waste pickers	**pm**	**G.15.2.4** Ban of living on landfills and child labor, but still exists	**m**							
G.16	**G.16.1.1** Neglecting climate and environmental aspects in decision-making processes (in politics, companies and society)	**nm**	**G.16.2.1 Integration of climate and environmental protection measures in WM**	**m**	**G.16.3.1** WM and pollution control are more significant in politics	**m**	**G.16.4.1** Increase integration of WM issues (waste-to-energy, secondary raw materials) in resource and energy efficiency concepts	**nm**	**G.16.5.1** CE makes a significant contribution to a resource-efficient and low-GHG economy	**nm**	**G.16.2.1 + G.16.3.1 --> m:** "Waste in Morocco, a major emission sector declared a "national priority"." (ClimateChance, 2021, p.3) (Royaume Du Maroc, w.y.) "A Low Carbon Development Strategy is being developed that will coordinate the mitigation objectives of all sectoral strategies and action plans, including energy, agriculture, transportation, water, waste, forestry, industry, housing and infrastructure. [...] During the COP21 and COP22, the Moroccan pavilion was a showcase of sectoral initiatives in integration of climate change into public policies." (Houzir, 2017) Loi 99-12 Art. 34: "A legal regime of environmental liability providing a high level of environmental protection is established. This system is accompanied by mechanisms for repairing damage, restoring and compensating for damage caused to the environment, to individuals and to property and, in particular, by a financial guarantee, if necessary."
			G.16.2.2 Emissions trading is applied; but GHG emissions from WM increase compared to 1990	**m**	**G.16.3.2** Initial emission savings in WM; GHG emissions decrease by ≤ 10% compared to 1990	**nm**	**G.16.4.2** GHG emissions related to CE are >10% to ≤ 50% lower compared to 1990	**nm**	**G.16.5.2** GHG emissions from CE are > 50% lower compared to 1990	**nm**	**G.16.2.2 --> m:** From 2010 to 2016 there has been a 3,4% increase in GHG emissions from the WM sector. 90% of the GHG emissions from the waste sector are Methane emissions, which derive from landfilling. (MMEME, 2019b) In 2017 Morocco aims to create, in the coming years, a carbon market in line with its economic situation and capable of generating carbon assets, allowing for involvement in the international greenhouse gas (GHG) emissions trading system (mapecology, 2017). Morocco was one of the first countries in Africa and the MENA region to engage in the Clean Development Mechanism (CDM). For the implementation of this mechanism, it established the Designated National Authority (DNA) in 2002, building the institutional grounds for the development and validation of CDM projects. In October 2013, there were 14 registered CDM projects, accounting for a total emissions reduction potential of 2.4 MtCO2eq/a. (Terrapon-Pfaff & Amroune, 2018).

Appendix II-b: Case study analysis results for the component sector and market

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Rationale / Source
Sector and market (SM.1 - SM.7)											
SM.1	**SM.1.1.1** Existing WM sector is unstructured	**nm**	**SM.1.2.1 Institutional structuring of WM enables creation of sector**	**m**	**SM.1.3.1** WM is a part of the industrial policy	**m**	**SM.1.4.1** Growing of WM sector especially in recycling and resource recovery	**nm**	**SM.1.5.1** Functioning CE due to close cooperation with other sectors	**nm**	**SM.1.2.1 --> m:** It is predicted that there is a big potential in Morocco in the recycling sector, but it is not exploited right now (Diaco et al. 2020, p.21). **SM.1.3.1 --> m:** WM is part of the industrial policy (Haut-commissariat au plan, 2012)
	SM.1.1.2 Neglection of interests of WM companies at political level due to missing lobby	**nm**	**SM.1.2.2** Formation of interests groups and associations, who represent interests of WM sector	**m**	**SM.1.3.2 Integrative approaches to address WM challenges are developed through increased stakeholder dialogue**	**m**	**SM.1.4.2** Growing collaboration with other sectors to address CE challenges	**nm**			**SM1.2.2 + SM1.3.2 --> m:** The Coalition for the Recovery of Waste (COVAD) was created in April 2016, bringing together actors from the private sector, civil society and government bodies. COVAD's mission is to contribute to the creation of a favorable environment, to the structuring of industries and to the promotion of the circular economy in waste management on a national and international scale. (Diaco et al., 2020, p. 27)
SM.2	**SM.2.1.1** Jobs in formal sector are available without requiring specific qualifications	**nm**	**SM.2.2.1** Certain jobs require appropriate qualification, but there is a lack of personnel	**m**	**SM.2.3.1** Creation of many jobs in the WM sector (recycling sector)	**nm**	**SM.2.4.1** Creation of additional jobs in the recycling industry	**nm**	**SM.2.5.1** Increased demand of qualified specialized personnel for advanced high-tech facilities.	**nm**	**SM.2.2.1 --> m:** In online job platforms there has been many offers with or without specifying the qualifications depending on the type of the post to be occupied (https://ma.indeed.com/Maroc-emplois-Gestion-Des-Dechets?vjk=5d96af478f86fffe; last accessed 01.08.2021) **SM.2.3.1 --> nm:** The construction of additional recycling facilities in Marrakech is expected to increase this occupational search, but it is not currently the case.
	SM.2.1.2 Lack of qualified staff and expertise in institutions dealing with WM issues	**m**	**SM.2.2.2** Great employment potential in collection and sorting	**m**	**SM.2.3.2** Great demand of qualified personnel for plant construction and operation	**nm**	**SM.2.4.2** Increasing recruitment of personnel for in-house waste disposal and recycling in companies.	**nm**			

SM.3	**SM.3.1.1** Unstructured informal sector and self-reliant informal workers	**nm**	**SM.3.2.1** Formation of small communities of informal workers	**m**	**SM.3.3.1** Reorganization of sector through cooperatives or umbrella organizations	**nm**	**SM.3.4.1** Complete formalization of the informal sector by integration into the formal sector	**nm**			**SM.3.2.1 --> m:** It is known in Marrakech that some informal workers are formed as small communities. **SM.3.2.2. + SM.3.2.3 + SM.3.3.3 --> m:** In Marrakech an ecocenter is planned, which besides to the recycling and recovery of waste, aims to ensure the legal recognition of the profession of waste collectors, polish its image and structure its work within a cooperative or delegated management of waste collection. It also aims to create jobs in the field of waste separation and recycling, but also to encourage the creation of micro-enterprises in the field of recycling activities. (Ouchagour, 2021 and Ismaili, 2021). **SM.3.3.1 --> nm:** Morocco (Marrakech) is not part of WIEGO, IDWF or the global alliance of waste pickers. Also no other associations regarding waste pickers could be found in Marrakech and in Morocco. (--> https://globalrec.org/where-are-we/ ; https://www.wiego.org/wiego-institutional-members; https://idwfed.org/en/affiliates/africa-1)
	SM.3.1.2 Neglecting informal sector's role by policy makers and public	**nm**	**SM.3.2.2** Role and contribution of informal sector is perceived by policy makers and public authorities	**m**	**SM.3.3.2** Profession "Waste Picker" is recognized by policy makers and public authorities	**na**					
	SM.3.1.3 High distrust of informal workers towards public sector	**m**	**SM.3.2.3 First institutional attempts to integrate informal workers**	**m**	**SM.3.3.3** Emerging programs to integrate the informal workers in the formal sector	**m**					
	SM.3.1.4 Informal sector is disadvantaged compared to formal sector	**m**	**SM.3.2.4** Support from NGOs and development banks to improve rights and working conditions	**m**	**SM.3.3.4** Optimization of WM activities through waste picker experiences	**m**					
	SM.3.1.5 Informal sector is accepted by a minority	**m**			**SM.3.3.5** Informal sector is accepted by a majority	**na**					
	SM.3.1.6 Share informal workers to total number of WM employees ≥ 35%	**na**	**SM.3.2.5** Share informal workers to total number of WM employees < 35% and > 10%	**na**	**SM.3.3.6** Share informal workers to total number of WM employees ≤ 10%	**na**					

SM.4	**SM.4.1.1** Waste disposal done by public or private companies and waste pickers is uncoordinated und inefficient	**nm**	**SM.4.2.1** Improving WM coordination between various actors, big inefficiencies remain	**m**	**SM.4.3.1** Emerging of WM PPP-projects	**m**	**SM.4.4.1** Interplay between small innovative and large companies in WM industry exists	**nm**			**SM.4.3.1 --> m**: As one example the new ecocentre built in Marrakech can be named (Ouchagour, 2021 and Ismaili, 2021). Law 86-12 (2015) regulates the PPP activities in Morocco. In 2020 a new law (46-18) was adopted, which amends and supplements law 86-12. A lot of changes had been done to improve and increase PPP in Morocco. (MEF, 2020) In an international conference of 2019 presented ideas for new model for the Moroccan circular economy. The current Moroccan WM is more a linear economy, which shall be changed in future through a paradigm change, to be more circular. For this a structural change is necessary (e.g. intermunicipal cooperations). Means divide the tasks (divide with private sector - PPP) with each other and in the same time to unify the competences to make the challenges financially viable. (EcoActu, 2019)
					SM.4.3.2 Companies specialized in waste recycling/disposal need a specific certification to work in WM	**nm**					**SM.4.3.2 --> nm:** For example Mecomar and Ecomed, who are responsible for waste collection and treatment do not have any certificates on their official websites: https://www.ecomed.ma/ http://mecomar.com/.
					SM.4.3.3 Increased bureaucratic burdens due to strict controls on WM companies	**nm**					**SM.4.3.3 --> nm:** Bureaucratic burdens can be high, but not necessarily due to strict controls.
					SM.4.3.4 Dual WM or other systems exist that fulfill disposal and recycling obligations of manufacturers, retailers and distributors	**nm**	**SM.4.4.2** Reliable and efficient dual WM or other systems with many service providers	**nm**	**SM.4.5.2** Ensuring high recycling and return rates due to dual WM or other system	**nm**	**SM.4.3.4 --> nm:** Does not exist in Morocco.

SM.5	**SM.5.1.1** WM projects are mostly financed externally (e.g. governmental organizations, development banks, NGO's)	**pm**	**SM.5.2.1 Higher financial support of national funders for WM development**	**m**	**SM.5.3.1** Increased (inter)national financial support for sustainable WM and CE	**m**	**SM.5.4.1** Increased (inter)national financial support to promote CE incl. digitization, bioeconomy and waste prevention	**nm**	**SM.5.5.1** Financial support of R&D support helps achieve CE targets	**nm**	**SM.5.2.1 + SM.5.3.1 + SM.5.3.2 --> m:** The German Development Bank (KfW) and the World Bank have provided assistance to Morocco in establishing a viable financing system to develop the PNDM. According to the World Bank website, an "effective results-oriented incentive mechanism allocating national financial resources to support municipalities" is the result of these efforts. More funding sources see Diaco et al. (2020, p. 20) and Royaume Du Maroc (2019). **SM5.2.2. --> na:** no data available.
			SM.5.2.2 Loans from banks for financially weak municipalities through state guarantees	**na**	**SM.5.3.2** Financial support to implement clean production measures	**m**	**SM.5.4.2** Increased funding for industrial/urban symbiosis and cooperation's between companies and municipalities	**nm**			
	SM.5.1.2 Inefficiently used or misused funding, so that many projects fail	**nm**	**SM.5.2.3** Investments by municipalities are controlled and managed by the state	**m**	**SM.5.3.3 Control mechanisms reduce misuse and inefficient use of funds**	**na**			**SM.5.5.2** Financial support is generally linked to compliance with sustainability criteria	**nm**	**SM5.2.3 --> m:** Public and national funds for municipal WM investments are managed by the state. How efficient the managing is, could not be found out.
	SM.5.1.3 Mis-subvention, mis-funding, double funding happen often	**nm**	**SM.5.2.4** Stricter conditions for subsidies; misuse and inefficient use of grants are still prevalent	**m**	**SM.5.3.4** Identification and countering of double funding, failing subsidies, and misfunding	**na**					**SM.5.2.4 --> m:** Conditions exist to prevent misuse, but how they are could not be found out.
SM.6	**SM.6.1.1** Neglection of WM issues by companies	**pm**			**SM.6.3.1** Mandatory participation (financially, organizational) of some companies (manufacturers, retailers, distributors) in WM	**nm**	**SM.6.4.1** Zero-Waste targets are defined at company level	**nm**	**SM.6.5.1** High company responsibility and transparency	**nm**	**SM.6.1.1 --> pm:** This cannot be generalized for all companies, but it can be said that the majority of WM issues are not in focus of companies.

					SM.6.3.2 Companies purchase insurances against caused environmental damages	**nm**					**SM.6.3.2 --> pm:** law 99-12 Art. 34 "A legal regime of environmental liability providing a high level of environmental protection is established. This system is accompanied by mechanisms for repairing damage, restoring and compensating for damage caused to the environment, to individuals and to property and, in particular, by a financial guarantee, if necessary." Law 99-12 describes that environmental protection and repair of environmental damages is a goal, but there is no information available regarding, if Moroccan or Marrakech companies purchase insurances against caused environmental damages. In a check of 2 big insurance companies, which are also active in Morocco (AXA and Allianz), it was found out that they have no offers for companies in Morocco, which enables companies to insure themselves against damages to foreign soils, environment and biodiversity. However, these two insurance companies do offer this in the European area, e.g. for France or Germany. 1- Allianz (https://www.allianz.ma/fr_MA/professionels/metiers-secteurs/entreprises/industrie.html) 2- AXA (https://entreprises.axa.ma/)
					SM.6.3.3 Companies start with circular supply chains	**nm**	**SM.6.4.2** Companies use innovative MIS and blockchain to improve their processes sustainably	**nm**			
					SM.6.3.4 First company cooperation's form industrial symbioses	**nm**	**SM.6.4.3** Implementation of large-scale projects on industrial or urban symbiosis	**nm**			**SM.6.3.4. --> nm:** Diaco et al. (2020) stated some recommendations to improve the CE activities in Morocco as "Create a platform for international CE private actors to allow networking, training, scouting and capacity building that promote activities with more potential and benefits than only WM, such as industrial symbiosis or eco-conception; well-established partners, like the Chamber of Commerce, could be involved;" (Diaco et al., 2020, p. ix). The OCP Group (Office Chérifien des Phosphates - big Moroccan phosphate producer) is developing an inclusive CE program with the ambition to recover the maximum value from the phosphate resource by valorizing co-products and to implement the best technologies to treat and recycle emissions and effluents. The program also aims industrial symbiosis. (FinancesNews 2019) No direct information was found regarding industrial symbiosis projects in Marrakech.

	SM.6.1.2 No product information for customers	**nm**			**SM.6.3.5 Manufacturers provide product information** (e.g. hazardous ingredients, handling during use and disposal phases)	**m**	**SM.6.4.4** Companies increasingly record material and waste flows and provide this to consumers and WM companies	**nm**	**SM.6.5.2** Products contain environmentally relevant information (e.g. footprints)	**nm**	**SM.6.3.5 --> m:** The Moroccan Standard NM 03.2.100 is based on the directive 67/548/EEC (Hazard labeling) and its adaptations. It presents the classification, packaging and labeling of hazardous products. Additionally, law 24.09 is related to the safety of products and services, which refers mostly to hazardous products also regarding the disposal handling (law 24.09. Art. 9). Decree n° 2-12-502 implements the law 24.09; Art. 1 defines the characteristics, which have to be available for products and product categories in terms of its safety (e.g., composition, conditions of production, assembly, reuse, recycling, distribution, storage and labeling) (Décret n° 2-12-502 du 2 rejeb 1434 (13. Mai 2013))
	SM.6.1.3 No business reports to improve WM	**pm**			**SM.6.3.6 First environmental business reports**	**m**	**SM.6.4.5** Environmental reports (with SDGs) are increasingly published by companies	**nm**	**SM.6.5.3** Environmental and sustainability reports are published by domestic and foreign importing companies.	**nm**	**SM.6.3.6 --> m:** Such reports are available for very large and internationally operating companies (e.g. Emirates airline, MarsaMaroc), but these reports are rather rare for companies that only operate locally. But these still meet the requirements to set it as "met". 1- Emirates: https://www.emirates.com/ma/french/about-us/our-planet/environmental-reports/ 2- MarsaMaroc: https://www.marsamaroc.co.ma/documents/10157/1589891/RAESG+2019VF.pdf 3 - Clubmed: http://sustainability.clubmed/corporate-social-responbility-reports/
					SM.6.3.7 Audits are carried out in companies	**m**					**SM.6.3.7 --> m:** In companies' environmental standard audits are carried out in order to have the final certificates (see G.8.3.1. + G.8.3.2). E.g. for Marrakech City Council of Marrakech (Daddi et al. 2011), Ménara Holding (Ménara, 2021), Pizzorno (Ouchen, 2018). For Morocco the ISO data of 2020 shows certificates numbers and sites (ISO, 2021): ISO 9001: 1099 (certificates) and 1583 (sites) ISO 45001: 142 (certificates) and 219 (sites) ISO 14001: 196 (certificates) and 282 (sites) ISO 50001: 2 (certificates) and 7 (sites)
					SM.6.3.8 Few companies use eco labels and environmental certificates to promote their products	**m**	**SM.6.4.6** Eco-Labels are used in mostly all products	**nm**			**SM.6.3.8 --> m:** Eco-labels are used in products and companies, but not mostly all products have eco-labels. 17 eco-labels exist in Morocco according to (https://www.ecolabelindex.com/ecolabels/?st=country,ma ; last access: 01.02.2022) La clef verte is a Moroccan eco-label for ecofriendly tourism for e.g. hotels, which increased through the years (Bouaouinate and Saloui 2016).

SM.7	**SM.7.1.1** Markets for waste and recyclables are small, mostly informal and unregulated; trade structures are non-transparent	**pm**	**SM.7.2.1** Recycling markets are expanding and self-regulated; trading structures remain non-transparent	**pm**	**SM.7.3.1 Trading structures for waste and recyclables are regulated and transparent**	**pm**	**SM.7.4.1** Government incentives strengthen secondary resource market	**nm**	**SM.7.5.1** Automated logistics and market platforms simplified searching and purchasing of waste/secondary materials	**nm**	**SM.7.1.1, SM.7.2.1 + SM.7.3.1 --> pm:** Currently, the plastics recycling sector in the informal sector is highly structured. Informal recyclers are now able to produce average quality raw materials that compete with formal players, especially for PE and PP. (GIZ, 2019) Incentives exists to strengthen the recycling market (e.g. ecotax for plastic bags or export licenses for plastic and paper), but it is not strengthen the recycling so much (Diaco et al, 2020) that is why **SM.7.4.1. --> nm.**
					SM.7.3.2 Governmental measures regulate price fluctuations of certain secondary materials/fuels	**nm**					
					SM.7.3.3 Emerging of exchange platforms for secondary products and wastes	**nm**	**SM.7.4.2** Strong connection of companies regarding exchange and trade of secondary materials	**nm**			**SM.7.3.3 --> nm:** Exchange platforms do not exist; that is why COVAD recommends to set up a "waste exchange" that would allow to organize the exchange of co-products, through a connection between industrialists and those who are looking for a secondary raw material for their processes. (COVAD, 2020, p. 8)
							SM.7.4.3 New actors participate in recyclables collection; revenues are invested in environmental and social projects	**nm**			
					SM.7.3.4 Secondary materials provide a small portion of industrial demand and generate revenues	**m**	**SM.7.4.4** Large industrial demand cover through secondary materials	**nm**	**SM.7.5.2** Supply risks are reduced by a systematic CE	**nm**	**SM.7.3.4. --> m**
					SM.7.3.5 Difficulties for high-quality recyclates to enter the market or its use is inadequate (firing instead of recycling)	**na**	**SM.7.4.5** Increased use of pure plastic recyclates, while use of mixed plastics decreases	**nm**	**SM.7.5.3** Strict limits enable high quality recyclates.	**nm**	

					SM.7.3.6 Secondary materials are perceived to be of low value due to missing quality information	**na**	**SM.7.4.6** Improved information on secondary materials quality reduces biases	**nm**			
	SM.7.1.2 Import and export of waste and recyclables, is unregulated and occurs without compliance with any requirements	**nm**	**SM.7.2.2** Trading of wastes and recyclables occurs predominantly in the country	**pm**	**SM.7.3.7** Increasing trading of waste and recyclables with foreign countries	**pm**	**SM.7.4.7 Introduction of stricter import/export criteria for (non-) hazardous, hardly recyclable wastes and used goods**	**pm**	**SM.7.5.4** Smart WM system enables real-time networking; secondary resources can automatically be traded globally	**nm**	**SM.7.2.2. + SM.7.3.8 + SM.7.4.7 --> pm:** Law 28-00 Art. 42 prohibits the import of hazardous waste. The said wastes can only transit through the national territory with the authorization of the administration. Decree 2-17-587 defines criteria and procedures for granting import and export authorizations for waste. "This decree pursuant to the provisions of articles 42, 43, 44 and 45 of Act No. 28-00 on "waste management and disposal", details the conditions and criteria for granting authorizations for the import, export and transit of hazardous and inert or non-hazardous waste. The granting of these authorizations must comply with the provisions of Articles 42, 43 and 44 of Law No 28-00, under the control of the authorities responsible for sustainable development, after verification of the nature of the waste, its destination and its final use." Morocco-export (2019) More details and regulations are stated in the Law 28.00 under Title VI. **SM.7.3.7 --> pm:** The Ministry of Energy, Mines and Environment announced on August 3, 2020, its decision to authorize the import of combustible waste signed on July 14. For the authorities, this waste from tires is a source of energy for industrial enterprises (factories) and promotes industrial recycling. (Salamy Bebila, 2020). "Also, under the Foreign Trade Law and the Basel Convention, Morocco has established export licenses for wastepaper and cardboard as well as waste PET bottles to ensure the continuous supply of the recycling and recovery waste into these waste industries." (Diaco et al. 2020, p.19) **SM.7.2.3 --> m and SM.7.3.8. --> pm:** Since illegal transport of waste cannot be completely avoided in Morocco partly met was selected for SM.7.3.8, which also implies missing regular controls SM.7.2.3.
			SM.7.2.3 Restrictions may be imposed for import and export of wastes and recyclables, but controls occur selectively	**m**	**SM.7.3.8** Insufficient controls on import/export bans of hazardous wastes encourages their illegal transport	**pm**					

Legend: m = fully met; pm = partially met; nm = not met; na = not available

Appendix II-c: Case study analysis results for the component collection and transport

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Rationale / Source
Collection and transport (CT.1 - CT.8)											
CT.1	**CT.1.1.1** Lack of systematic collection; limited collection	**nm**	**CT.1.2.1** Collection is systematic, but inefficient	**m**	**CT.1.3.1** Efficient collection through optimizing measures and concepts	**pm**	**CT.1.4.1** Underground systems in public spaces	**pm**	**CT.1.5.1** Waste bins have no negative effect on landscape	**nm**	**CT1.2.2 + CT.1.2.1 --> m, CT.1.3.1, CT.1.4.1 + CT.1.4.3 --> pm**, because only planned, yet, see text below: - adoption of digital and technological control (GPS system) for the collection and sorting of waste in different neighborhoods, various modes of collection (door-to-door, collection points, night collection), development of two centers dedicated to this operation and their submission to continuous monitoring - huge investment allocated to the acquisition of machinery and cleaning logistics (nearly 145 million DH) - establishment of underground dumpsters; waste collection at night - careful electronic monitoring of vehicle traffic and the situation of dumpsters through a communal platform (control of cleanliness and public lighting, connected to a microchip placed in the trucks and provided to workers) The municipality of Marrakech has commissioned 2 companies with the service of cleanliness for a period of 7 years, whose first tranche (districts of Guéliz, Medina, Sidi Youssef Ben Ali and the Palmeraie) was entrusted to "Arma", while the second concerning the district of Menara has been assigned to "Mecomar. (Yahya, 2021) - Arma, will mobilize 156 vehicles and machines for collection and cleaning, 95 trucks and motorcycles, 7,742 dumpsters and 3,000 garbage cans, and will proceed with the recruitment of 1,022 employees who will benefit from continuous training, while increasing the waste collected daily to 80 tons, in addition to the adoption of applications for the service quality evaluation and monitoring - use of new technologies that can contribute to the optimal management of the service of cleanliness in Marrakech (e.g., mobile plates for the transfer of waste and electric trucks) - Mecomar collects household waste and cleans the district of Menara, knowing that the annual volume of waste is estimated at about 158,775 tons. They will use environmentally friendly fleet and sophisticated equipment in the field of cleanliness, and proceed to strengthen the financial and human resources, especially during the summer season. They will double the capacity of dumpsters, the use of hydraulic platforms and underground dumpsters and strength human resources with 150 additional workers. (Yahya, 2021) **CT.1.3.3 --> m,** This service does exist. **CT.1.2.3 --> m**, in the city center the urban hygiene is good, but still problems exist regarding waste in the city (throwing away of waste on roadsides and in remote places). Measures are planned to raise the cleanliness in the city.
	CT.1.1.2 Lack of uniform collection bins	**nm**	**CT.1.2.2** Use of uniform aboveground systems	**m**	**CT.1.3.2** Use of new bin systems (e.g. waste locks)	**nm**	**CT.1.4.2** Waste bins with fill level sensors	**nm**	**CT.1.5.2** Avoid of container overfilling (smart bins)	**nm**	
			CT.1.2.3 Collection points are within 200m distance	**na**	**CT.1.3.3** Service provision of cleaning up bins	**m**	**CT.1.4.3** Introduction of digitalization measures	**pm**	**CT.1.5.3** Smart waste container separation	**nm**	
	CT.1.1.3 Missing of basic principles of urban hygiene, major littering exists	**nm**	**CT.1.2.4** Urban hygiene principles are partially met, but littering in public spaces remains a problem	**m**					**CT.1.5.4** Full maintenance of urban hygiene principles and no littering in public spaces	**nm**	

CT.2	**CT.2.1.1** Collection mostly by waste pickers	**nm**	**CT.2.2.1** Collection mostly by formal sector	**m**	**CT.2.3.1** Collection mostly by formal or organized informal sector	**nm**			**CT.2.5.1** Waste collection exclusively by formal sector	**nm**	**CT.2.2.1 --> m:** mostly formal collection (Arma, and Mecomar), but also collection from not organized informal sector.
CT.3	**CT.3.1.1** Collection rate (CR): urban ≤ 50% OR no data	**nm**	**CT.3.2.1** CR: urban > 50 and ≤ 70%	**na**	**CT.3.3.1** CR: urban > 70 and ≤ 80%	**nm**	**CT.3.4.1** CR: urban > 80 and ≤ 95%	**nm**	**CT.3.5.1 CR: urban > 95% and ≤ 100%**	**m**	**CT.3.4.1 - urban --> m and CT.3.1.1 - rural --> m, due to:** national average: urban CR 86% (national average); rural CR no data (World Bank, 2017; WWF, 2019); for Marrakech city: 100% CR (Ecomed, 2021). According to the official regional site SIREDD (2022) the following CR are published for MSW and for general waste: MSW CR (formula: (Tons collected*1000) / (Municipal population*Waste generation ratio)) for Marrakech: 100% (2010); Essaouira: 80% (2013); Chichaoua: 35% (2013); Al Haouz: 49% (2014); Rehamna: 70% (2012) El Kelâa des Sraghna: 83% (2015); Youssoufia: 54% (2016) Safi: no data; MSW CR for Marrakech-Safi: no data Overall waste CR (formula: not known) for 2017: Marrakech: 11,95%; Essaouira: 37%; Chichaoua: 82,03%; Al Haouz: 15%; Rehamna: 83%; El Kelâa des Sraghna: 80%; Youssoufia: 58,85%; Safi: 70,77%; MSW CR for Marrakech-Safi: 11,87%
	rural ≤ 30% OR no data	**m**	rural > 30 and ≤ 50%	**na**	rural > 50 and ≤ 80%	**na**	rural > 80 and ≤ 95%	**na**	**rural > 95% and ≤ 100%**	**na**	
CT.4	**CT.4.1.1** Collective collection of residual waste	**m**	**CT.4.2.1 First forms of separation at source collection (2 fractions)**	**pm**	**CT.4.3.1 Mandatory waste collection for households and businesses (>3 fractions)**	**nm**	**CT.4.4.1** Reduction of illegal collection (e.g. electronics)	**nm**	**CT.4.5.1** All recyclables are collected separately	**nm**	**CT.4.1.1 + CT.4.1.2 --> m:** Marrakech households have only one bin for waste collection; the informal sector is collecting recyclables. A CEV is available, but an official recycling center for the separate disposal of recyclables and other waste (hazardous) for the residents does not exist. **CT.4.2.1 + CT.4.2.2 --> pm:** Recyclables are collected often by informal sector. A pilot project will soon start in a district in Marrakech, where separate collection will be tried for the first time. **CT.4.3.1 --> nm:** It is not included in the law 28-00. **CT.4.3.4 --> nm:** "Rabat is the only municipality in the PNDM report that has established a separate construction, demolition and green waste contract with a waste management company, which delegates the collection and disposal of C&D waste, along with green waste." (Diaco et al., 2020, p. 15) **CT.4.2.3 --> m:** Hospital waste is collected separately, but sometimes hospital waste is found in the CEV plant. (Ecomed, 2021) It is also regulated in law 28.00 title 5 and mentioned in the Circulaire n° 230 DHSA 22 on cleanliness, hygiene of the premises, management and treatment.
	CT.4.1.2 Recyclables solely collected by waste pickers	**m**	**CT.4.2.2** Recyclables collected by (in)formal sector	**pm**	**CT.4.3.2** Set up of recycling centers	**nm**					
					CT.4.3.3 Rate of incorrect sorting > 30%	**na**	**CT.4.4.2** Rate of incorrect sorting > 10 to ≤ 30%	**na**	**CT.4.5.2** Rate of incorrect sorting ≤ 10%	**na**	
			CT.4.2.3 Separate collection of hospital waste	**m**	**CT.4.3.4** Separate collection of: electrical, construction, demolition, agricultural and forestry waste	**nm**					

CT.5	**CT.5.1.1** CR are missing, only estimations are available or data is not publicly available	m	**CT.5.2.1 Recyclables CR:**		**CT.5.3.1 Recyclables CR:**		**CT.5.4.1 Recyclables CR:**		**CT.5.5.1 Recyclables CR:**		**CT.5.1.1 -> nm:** no data available for Marrakech, because of lack of data (GIZ, 2019, p. 184). But recycling rates can be high due to informal sector, who is collecting recyclables in Marrakech. The amount of recyclables coming from the sorting plant is estimated low, due to picking of recyclables before waste trucks enters sorting plant, because due to open transfer station and informal sector collecting the recyclables. (Ecomed, 2021)
			Metals: ≤ 50%	na	Metals: > 50 and ≤ 70%	na	Metals: > 70 and ≤ 90%	na	Metals: > 90%	na	
			Paper: ≤ 30%	na	Paper: > 30 and ≤ 70%	na	Paper: > 70 and ≤ 90%	na	Paper: > 90%	na	
			Glass: ≤ 30%	na	Glass: > 30 and ≤ 70%	na	Glass: > 70 and ≤ 90%	na	Glass: > 90%	na	
			Organics: ≤ 30%	na	Organics: > 30 and ≤ 70%	na	Organics: > 70 and ≤ 90%	na	Organics: > 90%	na	
			Plastics : ≤ 10%	na	Plastics: > 10 and ≤ 50%	na	Plastics: > 50 and ≤ 90%	na	Plastics: >90%	na	
			Textiles: ≤ 10%	na	Textiles: > 10 and ≤ 50%	na	Textiles: > 50 and ≤ 90%	na	Textiles: >90%	na	
CT.6	**CT.6.1.1** Formal: Only use of simple vehicles	nm	**CT.6.2.1** Formal: Mostly use of large fleets and automation	m	**CT.6.3.1** Formal: Waste firms improve vehicle fleets (incl. compactors, lifters).	m	**CT.6.4.1** Use vehicles depending on waste type	nm	**CT.6.5.1** Higly engineered and fully automated vehicles	nm	**CT.6.2.1 + CT.6.3.1 --> m:** "This contract also provides for the adoption of digital and technological control (GPS system) for the collection and sorting of waste in the various districts, as well as various modes of collection (door-to-door, collection points, night collection), in addition to the development of two centers dedicated to this operation and their submission to continuous monitoring." (Yahya, A. 2021)
	CT.6.1.2 Informal: Only use of pack animals, handcarts, etc.	nm	**CT.6.2.2** Informal: Mostly use of small or modified vehicles	m	**CT.6.3.2** Informal: Mostly use of modernized small trucks	nm	**See WM 3.4.1**				
CT.7	**CT.7.1.1** Direct transport of waste to landfills or dumps	nm	**CT.7.2.1 Introduction of transfer stations (TS)**	m	**CT.7.3.1** TS increase collection efficiency	nm			**CT.7.5.1** All existing TS are state of the art	nm	**CT.7.2.1 + CT.7.2.2 --> m:** Two transfer stations exist in Marrakech. Up to now they are open to public. (Ecomed, 2021) **CT.7.3.1 + CT.7.3.2 --> nm:** It is planned to increase the equipment and restrict the access to public, that is why not met. (Ecomed, 2021)
	CT.7.1.2 Roads used as transfer areas for waste	nm	**CT.7.2.2** Simple TS are unrestricted accessible to public	m	**CT.7.3.2** Advanced TS with restricted access to public.	nm					
CT.8	**CT.8.1.1** Lack of separate collection of hazardous waste (HW) from households	m	**CT.8.2.1** Small HW quantities from households are collected separatly	nm	**CT.8.3.1** Disposal of small quantities of HW is free of charge	nm	**CT.8.4.1** Full collection of HW flows	nm	**CT.8.5.1** HW quantities are reduced to a minimum	nm	**CT.8.1.1 --> m:** There is no extra collection of HW from households. (Ecomed, 2021) **CT.8.3.2. --> m:** For industrial waste specific firms has to be commissioned, which can be also from other parts of Morocco. (Ecomed, 2021)
	CT.8.1.2 Lack of separate collection of industrial HW	nm	-	-	**CT.8.3.2 Industrial HW is collected almost separately**	m					

Legend: m = fully met; pm = partially met; nm = not met; na = not available

Appendix II-d: Case study analysis results for the component waste disposal

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Rationale / Source
Waste disposal (WD.1 - WD.5)											
WD.1	**WD.1.1.1** Lack of targeted and centralized waste disposal	**nm**	**WD.1.2.1** Targeted and centralized waste disposal in minimum controlled landfills	**m**	**WD.1.3.1** Introduction of landfill classes	**m**	**WD.1.4.1** Mineral waste is predominantly landfilled	**nm**	**WD.1.5.1** Waste landfilling gets less important	**nm**	Decree 2-09-284 sets the administrative procedures and technical requirements for controlled landfills. **WD.1.2.1 + WD.1.2.3 --> m:** Waste elimination and recycling Center in Marrakech CEV) is a controlled landfill and the only one in practice. **WD.1.2.2 --> pm:** open burning and open dumping more often in rural surroundings of Marrakech, because they are not covered by the waste collection system. C&D waste is also dumped openly. (Ecomed, 2021) Marrakech has 6 illegal dumps and the region Marrakech-Safi counts 40 illegal dumps in total (SIREDD, 2022) **WD.1.3.1 -> m:** Three waste classes are defined in law 28-00 Art. 48, which are Class 1 (landfills for household and similar waste), Class 2 (landfills for non-hazardous industrial, medical and pharmaceutical waste, agricultural waste, final and inert waste) and Class 3 (hazardous waste landfills). **WD.1.3.5 --> nm:** The rehabilitation of inactive dumping site is realized, but not in sanitary standard, that's why partly met. The rehabilitation of open dumps or uncontrolled landfills is promoted by the PNDM (Amounas, 2020). **WD.1.4.3 --> pm:** In Decree 2-09-284 the rehabilitation plan and the plan for after-use is mandatory to open a controlled landfill. But the after-use of the landfill is not so relevant right now.
	WD.1.1.2 Disposal in open dumps, uncontrolled landfills, roads etc.	**nm**	**WD.1.2.2** Open burning and dumping is illegal, but still practiced	**m**	**<u>WD.1.3.2 Non-hazardous and hazardous waste are no longer disposed together</u>**	**m**	**WD.1.4.2** Recyclables are rarely landfilled	**nm**	**WD.1.5.2** Small quantities of waste are landfilled	**nm**	
	WD.1.1.3 Open burning for elimination and energy recovery	**nm**			**WD.1.3.3** Liquid waste is no longer disposed in landfills	**m**	**WD.1.4.3** After-use of landfills gets more relevant	**nm**	**WD.1.5.3** Reuse of closed landfill areas for other purposes	**nm**	
					WD.1.3.4 Conversion of (in)active landfills to sanitary standard.	**pm**	**WD.1.4.4** Waste is disposed exclusively on sanitary landfills	**nm**	**WD.1.5.4** Importance of rehabilitation of old landfills	**nm**	
							WD.1.4.5 Safe disposal of disaster waste on approved sites	**na**	**WD.1.5.5** Full avoidance of illegal dumping	**nm**	
	WD.1.1.4 Open dump and controlled dump predominate	**nm**	**WD.1.2.3** Controlled or engineered landfill predominate	**m**			**WD.1.4.6** Sanitary landfill predominates	**nm**	**WD.1.5.6** All (in)active landfills have sanitary landfill standard	**nm**	

WD.2	**WD.2.1.1** Lack of disposal controls (waste registration)	**nm**	**WD.2.2.1** Registration of waste type, etc. before disposal	**m**	**WD.2.3.1** Registration and compaction of waste are the norm	**m**			**WD.2.5.1** All existing and new landfills comply with the current state of art	**nm**	**WD.2.2.1, WD.2.2.2, WD.2.3.1 + WD.2.3.3 --> m:** all the incoming waste is registered. The waste is classified into 4 types (green waste, animal waste, residuals from households and assimilated waste from commerce and industry). They are all non-hazardous.(Ecomed, 2021) **WD.2.3.2 --> nm:** Pretreatment of residual waste is not mandatory. The CEV plant has a sorting unit installed and the composting unit will be installed in future. (Ecomed, 2021)
	WD.2.1.2. Waste is burned on dumping sites	**nm**	**WD.2.2.2** Waste burning on landfill sites is missing	**m**	**<u>WD.2.3.2 Systematic pre-treatment of waste is mandatory</u>**	**nm**					
	WD.2.1.3 Landfill access controls are lacking or inadequate	**nm**	**WD.2.2.3** Compaction and daily cover of waste	**m**	**WD.2.3.3** Systematic landfill management is carried out	**m**					
			WD.2.2.4 Site drawing showing landfill boundary and filling area in place	**m**	**WD.2.3.3** Realization of measures for (post-) closure management	**m**					
	WD.2.1.4 Dumping sites are not staffed or only in short times for site checking	**nm**	**WD.2.2.5** Site is staffed during operational hours	**m**							
WD.3	**WD.3.1.1** Leachate infiltrates soil or evaporates	**m**	**WD.3.2.1** Available leachate collection	**m**	**WD.3.3.1** Leachate collection and treatment in all active landfills	**nm**	**WD.3.4.1** Compliance of strict limits at water monitoring	**nm**	**WD.3.5.1** Decrease of leachate and toxicity	**nm**	**WD.3.1.1 + WD.3.2.1 --> m:** Landfill (CEV) has basins for leachate, but no installed leachate treatment, yet. Currently, the leachate evaporates. The construction of leachate treatment units (physical-chemical and biological treatment and ultrafiltration) is planned for the next years. CEV will start probably in 2022 with the first leachate treatment unit. (Ecomed, 2021)
	WD.3.1.2 Lack of surface and groundwater monitoring	**nm**	**WD.3.2.2** Recirculation of leachate in the landfill body	**nm**							**WD.3.2.3. --> m:** Physico-chemical and bacteriological analyses of groundwater and surface water quality as well as air quality shall be done twice a year according to Decree 2-09-284 Art. 17a.
			WD.3.2.3 Surface and groundwater is monitored	**m**							**WD.3.4.1 --> nm:** Decree 2-09-284 Art. 11c: "In case of discharge of these leachate waters in the natural environment, they must respect the limit values of discharge envisaged by the decree n° 2-04-553 of 13 hija 1425 (January 4, 2005) relating to the discharges, flows, discharges, direct or indirect deposits in the surface or underground waters"

WD.4	**WD.4.1.1** Landfill gas is released into the atmosphere	**nm**	**WD.4.2.1** Implementation of passive collection or flaring of landfill gas	**m**	**WD.4.3.1** Landfill gas collection for energy recovery and gas monitoring	**nm**	**WD.4.4.1** Compliance of strict limits for gas monitoring	**nm**	**WD.4.5.1** Controlled flaring of landfill gas only in emergencies and when it is unprofitable (small gas quantities)	**nm**	**WD.4.2.1 --> m;** The inactive landfill has a gas collection system, and it is planned to produce energy out of the biogas in 2022. The active landfill is flaring the landfill gas. It is not used to produce energy, because the landfill was planned to dispose pretreated (mostly inert) waste, for which the organic fraction is sorted out and composted. (Ecomed, 2021)
WD.5	**WD.5.1.1** Waste burning or dumping on high seas and coastal waters	**nm**			**WD.5.3.1** Waste burning or dumping on high seas and coastal waters is prohibited, but still takes place	**m**			**WD.5.5.1** Avoidance of waste burning or dumping on high seas and coastal waters	**na**	**WD.5.3.1 --> m:** Morocco is a part of the London Convention. IMO_LCLP (2019)

Legend: m = fully met; pm = partially met; nm = not met; na = not available

Appendix II-e: Case study analysis results for the component energy recovery

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Rationale / Source
Energy Recovery (ER.1 - ER.3)											
ER.1	**ER.1.1.1** Controlled energy recovery or thermal disposal is missing	m	**Availability of organizational criteria:**		**ER.1.3.1** ER is used to treat large waste quantities of the city inside or outside the country	nm	**ER.1.4.1** ER is essential treatment alternative	nm	**ER.1.5.1** Incinerated waste amount decreases due to higher recycling rates	nm	**Organizational criteria --> pm:** Some preconditions for incineration plants are available, but more detailed waste analysis is needed. **I) --> m** = WD.1.2.3 --> m **II) --> pm** = CT.1.2.1 --> pm **III) --> pm,** either G.12.3.3 --> m, Waste Management is taught for example in the University Cadi Ayyad, but there is no focus on thermal treatment of waste (incineration). Maybe there are process engineers, who could operate such an incineration plant, but also other qualified technicians are needed, who are trained in this field, and they are missing. That's why only partly met. **V) --> pm:** G.2.2.1 --> m; G.2.3.1 --> pm **Technical criteria -> pm:** **I) --> na;** no data available **II) --> m**; low calorific value between 8,5 Mj/kg and 9,5 MJ/kg (Diaco et al., 2020, p. 13) -> refers to national scale (average) **ER.1.2.3 --> m:** Co-incineration of waste (waste tires or RDF) in cement plants exists.
			I) controlled landfills	m	**ER.1.3.2** Agreements regulate waste delivery, energy sales and pricing	nm					
			II) qualified staff	pm	**ER.1.3.3** At least 150.000 tons/y of suitable waste are available for incineration	nm	**ER.1.4.2** Lower heating value has to be at least 11 MJ/kg	nm			
			III) systematic collection	pm							
			IV) Sorting at source is implemented	nm							
			V) Basic WM laws and rules are developed	pm							
			VI) Incineration plants are positioned in political plans	nm							
			VII) Political and social will is given	na							
			VIII) Total costs for the plant are secured	na							
			IX) Public or private actors are experienced in managing incineration plants efficiently	nm							
			X) Spare parts can be purchased locally or imported	na							
			Availibility of technical criteria:								
			I) stable supply of combustible waste	na							
			II) lower heating value at least 7 MJ/kg	m							
			III) Bottom and fly ash can be treated safely	na							
	ER.1.1.2 Co-incineration of waste is missing	nm	**ER.1.2.3** Co-incineration of specific waste or RDFs in industrial firing plants	m	**ER.1.3.4** ER as alternative for landfilling; energy-intensive industries often make use of it	nm					

ER.2	**ER.2.1.1** Waste incinerators are neither operating or planned in the country	**m**	**ER.2.2.1** Incineration plants (incl. flue gas cleaning - FGC) are in planning or construction in the country or simple incineration plants without FGC are in operation with engineered process controls (incl. continuous monitoring and recording of operating parameters)	**na**	**ER.2.3.1** Operation of waste incinerators with FGC	**na**	**ER.2.4.1** High-tech and state of the art processes ensure reliability and safe emission elimination	**na**	**ER.2.5.1** Automatic and homogenous waste input	**na**	**ER.2.1.1 --> nm:** An incineration plant is currently neither operating nor planned.
					I) Continuous monitoring of operating parameters and emissions	**na**	ER.2.4.2 Flue gas controls compliant with applicable environmental standards	**na**			
					II) Monitoring systems are routinely calibrated	**na**					
					III) Maintenance plans or schedules are in place	**na**					
					IV) Evidence that equipment is well maintained	**na**					
					V) Fire extinguishers available on site	**na**					
ER.3	**ER.3.1.1** Raw material and ER through controlled waste incineration is missing	**m**	**ER.3.2.1** Possible recovery of energy through waste incineration	**na**	**ER.3.3.1** Selling of recovered energy (electrical, thermal, combination)	**na**			**ER.3.5.1** Increased replacing of primary energy resources	**na**	**ER.3.1.1 --> m:** due to the fact that ER.2.1.1 is met.
					ER.3.3.2 Incineration or RDF plants are located in areas with moderate heat demand and good transport and energy infrastructure exists	**na**					
			ER.3.2.2 Recycling of incineration residues is missing	**na**	**ER.3.3.3** Recovered metals from incineration process are sold; other by-products are treated safely, but recycled rarely	**na**	**ER.3.4.1** Increased recycling and reuse of slags	**na**	**ER.3.5.2** Almost complete reintroduction of by-products from incineration into the economic cycle	**na**	

Legend: m = fully met; pm = partially met; nm = not met; na = not available

Appendix II-f: Case study analysis results for the component waste recycling

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Rationale / Source
Waste recycling (WR.1 - WR.8)											
WR.1	**WR.1.1.1** Material recycling is rarely done, open-loop and downcycling predominate	m			**WR.1.3.1 Extension of waste treatment by mechanical, biological, etc. treatment options**	nm	**WR.1.4.1** (Semi-)closed-loop recycling and upcycling increase	nm	**WR.1.5.1** (Semi-) closed-loop recycling dominates	nm	**WR.1.1.1 + WR.1.1.2 --> m:** A waste elimination and recycling center (CEV) is available in Marrakech. It is a controlled landfill with an operating sorting plant for recyclables. It is planned to include a composting unit and to produce RDF, but it is not realized, yet (Ecomed, 2021). **WR.1.3.1 --> nm:** Because the biological treatment (composting unit) and the RDF unit are still missing in the CEV.
							WR.1.4.2 Dialogues between manufactures and recyclers take place to identify and solve recycling problems	nm	**WR.1.5.2** Implementation of circular bioeconomy	nm	
	WR.1.1.2 Ensured input for recycling plants is lacking	m			**WR.1.3.2** Input for recycling plants is partly ensured	nm	**WR.1.4.3** Input for recycling plants is fully ensured	nm			
WR.2	**WR.2.1.1** Organic waste is landfilled or is composted at home or used as animal food	m	**WR.2.2.1** Recycling of organics in simple or open composting plants or with mobile aggregates	nm	**WR.2.3.1** Introduction of static, closed composting in tunnels / containers with sorting technologies	nm	**WR.2.4.1** Integration of (quasi-) dynamic processes in existing plants	nm	**WR.2.5.1** Microplastics is removed from compost	nm	**WR.2.1.1 --> m + WR.2.2.1 --> pm:** A composting unit will be constructed in the CEV, but up to now it is landfilled without biological pretreatment.
			WR.2.2.2 Compost has low compost quality	nm	**WR.2.3.2** Increased use of compost in agriculture & landscape management	nm	**WR.2.4.2** High quality compost, which still contains microplastics	nm	**WR.2.5.2** Very high quality and purity level of compost	nm	
							WR.2.4.3 Increased use of compost in the private sector	nm			
WR.3	**WR.3.1.1** No planned or operation fermentation plants	m	**WR.3.2.1** Planning or construction of fermentation plants	nm	**WR.3.3.1** Fermentation plants recycle organics	nm			**WR.3.5.1** Biogas plants are an essential component of CE	nm	**WR.3.1.1 --> m:** There is no fermentation plant in Marrakech neither operating nor planned.
					WR.3.3.2 Separation of impurities for energetic use of biogas (e.g. in combined heat and power plants)	nm	**WR.3.4.1** Introduce CO2-separation stage at plants	nm			
							WR.3.4.2 Feeding of biomethane into the natural gas grid	nm			
					WR.3.3.3 Fermentation residues are used as fertilizers	nm	**WR.3.4.3** Very high quality of digestates	nm	**WR.3.5.2** Nearly full removal of microplastics from digestates	nm	

WR.4	**WR.4.1.1** Manual sorting of recyclables	**m**	**WR.4.2.1** Partially automated sorting of recyclables (incl. shredding and separation units)	**m**	**WR.4.3.1** Increase of sorting efficiencies through mechanical separation, screening aggregates	**nm**	**WR.4.4.1** Generation of high-quality fractions through modern sorting facilities	**nm**	**WR.4.5.1** Increasingly digitalized recycling technologies	**nm**	**WR.4.1.1 --> m:** sorting of recyclables is done manually by informal sector and by workers at the CEV in the sorting plant. **WR.4.1.2 --> m:** Electronic waste is disposed on the landfill or not recycled appropriately. Most of the electronic devices are repaired and reused. (Ecomed, 2021) **WR.4.2.1 --> m + WR.4.2.2 --> pm:** CEV has a sorting plant for recyclables with magnetic separators. Glass, aluminum, plastics and metals are sorted out in the CEV and brought then to Casablanca for further recycling (Ecomed, 2021).
	WR.4.1.2 Inefficient recovery of valuable materials from electronic waste	**m**	**WR.4.2.2** Recovery of metals and RDFs in mechanical-biological plants	**pm**	**WR.4.3.2** Generation of high quality mono-fractions	**nm**			**WR.4.5.2** Increasing use of digitalization measures to rise recyclability of products	**nm**	
					WR.4.3.3 Use of stabilate processes to separate metals and RDFs	**nm**	**WR.4.4.2** Production of methanol or synthesis gas from raw material plastic recycling	**nm**			
									WR.4.5.3 Safe recycling of waste containing harmful substances	**nm**	
WR.5	**WR.5.1.1** Lack of RDFs recovery from waste	**m**	**WR.5.2.1** Start of RDF recovery from waste treatment plants	**nm**	**WR.5.3.1** Increasing recovery of RDFs from waste	**nm**			**WR.5.5.1** RDF is decreasing due higher closed loop recycling	**nm**	**WR.5.1.1 --> m:** A RDF unit is planned to be installed in the CEV, but up to now it is not existing.

WR.6	**WR.6.1.1** Only conventional demolition of buildings	**m**	**WR.6.2.1** Mostly conventional demolition of buildings	**nm**	**WR.6.3.1** Semi-selective demolition occurs predominantly	**nm**	**WR.6.4.1** Predomination of selective demolition	**nm**	**WR.6.5.1** Only selective demolition occurs	**nm**	**WR.6.1.1 - WR.6.1.3 --> m:** "Most of the time, C&D waste ends up in landfills mixed with domestic waste or used to fill an old extraction field of natural aggregates." (Diaco et al., 2020, p. 14) "At present, in Morocco, sorting is rarely carried out on site either due to construction codes which do not allow the recovery (for traceability and safety issues) or the absence of a recovery process." (Diaco et al., 2020, p. 14) (Royaume Du Maroc, w.y.) **--> refers to national level; no specific data available for Marrakech** In Marrakech the C&D waste often is open dumped in the surroundings or also landfilled, but not recycled (Ecomed, 2021). IMANOR published a guide in 2020 concerning "Roles of standards for better assimilation of development principles and practices", in this guide all relevant norms are presented to get an overview over the existing norms according the sustainable construction. (IMANOR, 2020) **WR.6.2.3 --> pm:** refers to national level (Diaco et al., 2020, p. 14)
	WR.6.1.2 Depollution is done rarely	**m**	**WR.6.2.2** More frequent de-pollution	**nm**			**WR.6.4.2** Depollution is usual practice in demolition	**nm**			
	WR.6.1.3 C&D waste disposal on landfills/dumps predominates	**m**	**WR.6.2.3** Rare use of C&D material as filler for surface excavations or landfill construction	**pm**	**WR.6.3.2** Increased use of C&D materials as filler or for landfill construction	**nm**	**WR.6.4.3** Increased high quality recycled construction material	**nm**	**WR.6.5.2** Almost complete recycling of C&D waste, little is landfilled	**nm**	
					WR.6.3.3 Emerging of recycling routes for C&D materials (road construction)	**nm**	**WR.6.4.4** Thermal treatment or landfilling of non-recyclable construction materials	**nm**	**WR.6.5.3** Prohibition of non-recyclable materials for construction	**nm**	
							WR.6.4.5 Use of robotics for efficient sorting	**nm**			

WR.7	**WR.7.1.1** Precise recycling rate numbers are missing	**m**	**WR.7.2.1 Recycling rates:**		**WR.7.3.1 Recycling rates:**		**WR.7.4.1 Recycling rates:**		**WR.7.5.1 Recycling rates:**		**WR.7.1.1 --> m:** No precise data is available for Marrakech. Only estimated recycling rates for the region Marrakech-Safi (from 2015) exist: Most rates are in stage 2, plastics in 3 and metals in 4 (GIZ, 2019, p. 237): Metals: 62%, Paper: 22%, Glass: n.a., Composites: n.a., Plastics: 27%, E-Waste: 9%, C&D waste: 0% **Note: Data has to be evaluated critically, for this they were excluded from the evaluation.** Recycling rates for specific recyclables (plastics or metals) could be high due to informal sector collecting the waste, but no exact numbers exist.
			Metals: ≤ 40 %	**na**	Metals: > 40 and ≤ 70 %	**na**	Metals: > 70 and ≤ 90 %	**na**	Metals: > 90 %	**na**	
			Paper: ≤ 40 %	**na**	Paper: > 40 and ≤ 70 %	**na**	Paper: > 70 and ≤ 90 %	**na**	Paper: > 90 %	**na**	
			Glass: ≤ 40 %	**na**	Glass: > 40 and ≤ 70 %	**na**	Glass: > 70 and ≤ 90 %	**na**	Glass: > 90 %	**na**	
			Composites: ≤ 20 %	**na**	Composites: > 20 and ≤ 60 %	**na**	Composites: > 60 and ≤ 90 %	**na**	Composites: > 90 %	**na**	
			Plastics: ≤ 20 %	**na**	Plastics: > 20 and ≤ 60 %	**na**	Plastics: > 60 and ≤ 90 %	**na**	Plastics: > 90 %	**na**	
			WR.7.2.2 Recycling rates:		**WR.7.3.2 Recycling rates:**		**WR.7.4.2 Recycling rates:**		**WR.7.5.2 Recycling rates:**		
			E-Waste: > 10 and ≤ 40 %	**na**	E-Waste: > 40 and ≤ 70 %	**na**	E-Waste: > 70 and ≤ 90 %	**na**	E-Waste: > 90 %	**na**	
			C&D waste: > 10 and ≤ 40 %	**na**	C&D waste: > 40 and ≤ 70 %	**na**	C&D waste: > 70 and ≤ 90 %	**na**	C&D waste: > 90 %	**na**	
WR.8	**WR.8.1.1** DR: ≤ 0,1 OR no data	**m**	**WR.8.2.1** DR: > 0,1 ≤ 0,2	**na**	**WR.8.3.1** DR: > 0,2 ≤ 0,4	**na**	**WR.8.4.1** DR: > 0,4 ≤ 0,7	**na**	**WR.8.5.1** DR: > 0,7 ≤ 1,0	**na**	**WR.8.1.2 --> m**: no data available for Marrakech, but probably DR is also below 0,1 due to low expected recycling performance.
	WR.8.1.2 CMUR: ≤ 1 % OR no data	**m**	**WR.8.2.2** CMUR: > 1 % ≤ 10 %	**na**	**WR.8.3.2** CMUR: > 10 % ≤ 30 %	**na**	**WR.8.4.2** CMUR: > 30 % ≤ 70 %	**na**	**WR.8.5.2** CMUR: > 70 %	**na**	**WR.8.1.1 --> m:** no data available for Marrakech

Legend: m = fully met; pm = partially met; nm = not met; na = not available

Appendix II-g: Case study analysis results for the component prevention and reuse recycling

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Rationale / Source
Prevention and reuse (PR.1 - PR.6)											
PR.1	**PR.1.1.1** Prevention is motivated by poverty	m	**PR.1.2.1** Prevention is motivated by lack of resources	nm					**PR.1.5.1** Decoupling of GDP and waste generation	nm	**PR.1.1.1 --> m:** Due to lack of data, PR.1.1.1 has been set as "met".
					PR.1.3.1 Higher political priority for food waste issues	nm	**PR.1.4.1** Formulation of food waste avoidance targets and implementation of measures	nm	**PR.1.5.2** Food waste is reduced to a minimum	nm	**PR.1.3.1 --> nm:** No information regarding the political priority of food waste could be found for Morocco.
					PR.1.3.2 Few disposables are banned or permitted exceptionally	m	**PR.1.4.2** All disposables are banned or permitted exceptionally	nm	**PR.1.5.3** CE reduces negative impacts of materials and products by avoiding resources or waste	nm	**PR.1.3.2 --> m:** Following the law 77-15 and the decree n° 2-16-174 Morocco has banned the manufacturing, trade and sale of plastic bags. Regulations are being tightened to remove existing gray areas in the law to ban illegal selling and distribution of plastic bags altogether. (Mbaye, 2020)
							PR.1.4.3 Prohibited destruction of unsold durable goods	nm	**PR.1.5.4** Increase of bans for substances and products	nm	**PR.1.4.3 --> nm:** A prohibition for unsold durable goods does not exist, yet.
					PR.1.3.3 Emerging initiatives to educate the population regarding closing-loops	pm			**PR.1.5.5** CE provides long use of raw materials in the cycle	nm	**PR.1.3.3 --> m:** Raising awareness on circular economy is prominent, for instance many actions has been taken like creation of the Association des Enseignants des Sciences de la Vie et de la Terre du Maroc (AESVT Maroc) which is a non-profit association, that launches educational projects to spread the word about sustainable development (by promote cleanliness of cities, marine debris, sorting at source, etc.) (AESVT Maroc, 2021), this association is operating also in Marrakech city, Morocco. They have an own department called AESVT section Marrakech (mapecology, 2020a).
							PR.1.4.4 Ensured lifetime-extension of buildings before construction	nm	**PR.1.5.6** Full deconstruction of buildings is ensured before their realization	nm	**PR.1.4.4 --> nm:** No information regarding this issue could be found.
									PR.1.5.7 Consumption decisions based on waste prevention	nm	**PR.1.5.7 --> nm:** No information regarding this issue could be found.

PR.2	**PR.2.1.1** Lack of circular business and usage models	**nm**	**PR.2.2.1** Spare parts of End-of-life (EoL) products are used for repair	**m**	**PR.2.3.1** Increased use of EoL spare parts	**m**			**PR.2.5.1** Permanent provision of spare parts through digitalization	**nm**	**PR.2.1.1 --> m:** The current Moroccan WM is more a linear economy, which shall be changed in future through a paradigm change, to be more circular. (EcoActu, 2019) **PR.2.2.1 --> m:** Using spare parts of EoL is not mandatory in Morocco, however professionals should inform of the origins of the parts, and be used if they are functional and present any kind of risk to the environment. But spare parts are used for repairing. **PR.2.3.1 --> m:** The use of EoL spare parts is not only active in the automotive sector but also in the construction sector. (Diaco et al., 2020)
					PR.2.3.2 Small use of professional repair by small part of the population	**nm**	**PR.2.4.1** High use of professional repair by big part of the population	**pm**			**PR.2.4.1 --> pm:** Repair is especially in African countries a very widespread practice (Rademaekers et al. 2020). Based on experience big part of the Marrakech population uses repair services instead of rebuying (depending on the products), especially for electronic products, furniture and textiles, but no data to prove this has been found, that is why partly met.
					PR.2.3.3 Minimum one online spare market exists	**m**	**PR.2.4.2** Various online spare markets exist	**m**	**PR.2.5.2** Spare part markets are an integral part of CE	**nm**	**PR.2.3.3 --> m**: In Morocco there are several spare parts online markets (moulpieces.ma, monauto.ma, mister-auto.ma, etc.) for the sale of automotive spare parts (Mounadi, 2015). On 15.01.2022 a new website of advertisements of general second-hand spare parts for Morocco has been launched. (Okato, 2022)
					PR.2.3.4 Product service systems (sharing and leasing) are offered	**m**			**PR.2.5.3** Sharing and leasing are an integral part of CE	**nm**	**PR.2.3.4 --> m:** Example for carpool service (but not product-service system) in Morocco is "Pip Pip Yalah" (https://pippipyalah.com/#telecharger_app).
			PR.2.2.2 Voluntary take-back systems for certain wastes (e.g. pharmaceuticals, batteries) exist	**m**	**PR.2.3.5** Introduction of take-back or deposit systems for certain wastes (e.g. beverage packaging)	**pm**	**PR.2.4.3** Deposit obligation to all single-use beverage packaging and change of deposit contribution	**nm**	**PR.2.5.4** Innovative take-back and collection systems enable reuse and high-quality recycling	**nm**	**PR.2.2.2 --> m:** There are several companies that collect specific types of waste like "Kilimanjaro" that collectes waste cooking oil from restaurants in Marrakech. (El Affas, 2015) **PR.2.3.6 --> pm:** In Morocco there are no mandatory deposit systems for products. Voluntary deposit system for PET bottles exists for Marjan and Carrefour, which are supermarket chains. Marjan introduced it in different supermarkets in 2021 and plans to expand it in future due to good customer feedback. (seariousbusiness.com, 2021 and Schleicher, 2021) That is why, partly met.
							PR.2.4.4 Introduction of deposits on material relevant products (e.g. tablets, smartphones)	**nm**			

PR.3	**PR.3.1.1** Companies neglect EoL issues of their products	**nm**	**PR.3.2.1** Pioneer companies are considering EoL issues of their products	**m**	**PR.3.3.1** Through Eco-design several manufacturers are producing in a more environmental friendly way	**pm**	**PR.3.4.1** Increased use of homogenous easy separable, harmfree and secondary materials; less use of disruptive substances	**nm**	**PR.3.5.1** High use of secondary, recyclable or biobased materials for product manufacture	**nm**	**PR.3.2.1 --> m:** Green logistics is a concept that some Moroccan companies are adopting by being in compliance with the international environmental standard like ISO 14001. (Kammas, 2016) Some examples for companies in Marrakech, which consider EoL issues in their processes is e.g. UCC Paul Lagache (http://uccpaullagache.com/) or siti tea (https://siti-tea.com/). **PR.3.3.1 --> pm:** Groupe SEB has signed an agreement with a Moroccan company, this group has created its own ECOdesign label that has been certified ISO14020 and ISO 14021, this shows the willingness of the Moroccan market to have an environmental friendly production of goods. (Groupe SEB, 2021)
	PR.3.1.2 Innovative composite materials are causing disposal problems due to the negligence of EoL in the product design phase	**m**					**PR.3.4.2** Recyclability, durability and upgradability is generally considered in product design phase	**nm**	**PR.3.5.2** EoL concepts for innovative products prior to market introduction are elaborated to minimize problems at EoL phase	**nm**	**PR.3.1.2 --> m:** Regarding plastic according to the WWF report of 2019, Morocco produces large quantities of plastic, and is facing some challenges when it comes to waste management. Out of 0.55 MT/year of plastic waste is generated, only 0.04 kT of plastic was recycled in 2016 and reintegrated in the production lines as a secondary material. This shows that the EoL management is not prominent, yet. (WWF, 2019) This includes innovative composite materials as well.
	PR.3.1.3 Companies neglect recyclability, material saving and substitution of hazardous substances during product design phase	**nm**	**PR.3.2.2** Some companies consider recyclability, material savings and substitution of hazardous substances in product design phase	**m**					**PR.3.5.3** Product recyclability is one basic condition for product marketing	**nm**	**PR.3.2.2 --> m:** With the law 22-16 (from 16 July 2010) that prohibits the manufacturing and marketing of non-degradable bags and the application of the Eco-Tax some companies in Morocco are developing design requirements taking in consideration the recyclability of the products. (WWF, 2019; GIZ et al., 2019) Some examples for companies with a environmental and social committment in Marrakech are Siti tea (https://siti-tea.com/) or UCC Paul Lagache (http://uccpaullagache.com/).
							PR.3.4.3 Increasing life cycle assessment of products	**nm**	**PR.3.5.4** Almost all companies consider all life cycle phases	**nm**	
					PR.3.3.2 Pioneer companies set voluntarly a minimum use rates for secondary resources in their products	**nm**	**PR.3.4.4** Legal minimum use rates for recyclates in plastic products: between ≥ 30 % and < 60 %	**nm**	**PR.3.5.5** Legal minimum use rates or recyclates in plastic products: ≥ 60 %	**nm**	

PR.4	**PR.4.1.1** Neglection of issues for proper waste disposal and waste avoidance in companies	**nm**	**PR.4.2.1** Pioneer companies consider issues as improving their waste disposal and prevent waste	**m**	**PR.4.3.1** Evaluation of production processes	**nm**	**PR.4.4.1** Inreased investigation of resource efficiency potentials	**nm**	**PR.4.5.1** Waste avoidance and closing loops practice in companies	**nm**	**PR.4.2.1 --> m:** On a national level, the Extended Enterprise Resource Planning demands businesses to show that a minimum of 50% of the produced plastic is safely disposed of. Another example is, in the surrounding villages of Marrakech, the remaining bread is used as animal feed, as for the meat/fish processing remaining's, they are used to make soups. This shows that these industries are being aware and taking the necessary actions for waste prevention. Clubmed (hotels are also in Marrakech) did a study regarding food waste generation in their hotels and in this study they name measures to take into consideration to reduce the generated food waste in the hotels (Clubmed, 2015).
					PR.4.3.2 Substitution of some hazardous materials with non or less hazardous materials	**pm**	**PR.4.4.2** Several companies are substituting hazardous with non-hazardous substances	**nm**	**PR.4.5.2** Use of pollutants in CE, if controlled circulation considering thresholds is ensured	**nm**	**PR.4.3.2 --> pm:** According to the Decree n° 2-98-975 of 28 chaoual 1421 (23 January 2001) relating to the protection of workers exposed to asbestos dust, Morocco prohibits the use of amphiboles and products containing them in the construction field, but nothing has been mentioned about the substitution of this substance.
PR.5	**PR.5.1.1** WG: ≥ 2 kg/cap + d	**nm**	**PR.5.2.1** WG: ≥ 1,5 < 2 kg/cap + d	**nm**	**PR.5.3.1** WG: ≥ 1 < 1,5 kg/cap + d	**nm**	**PR.5.4.1** WG: ≥ 0,5 < 1 kg/cap + d	**m**	**PR.5.5.1** WG: < 0,5 kg/cap + d	**nm**	**PR.5.4.1 --> m:** According to Diaco et al. (2020; p.13) the urban population generates around 0,76 kg per capita per day of waste, as for the rural population 0,30 kg per capita per day is produced. --> refers to national scale (average).
PR.6	**PR.6.1.1** ZWI: ≤ 0,05	**m**	**PR.6.2.1** ZWI: > 0,05 ≤ 0,15	**nm**	**PR.6.3.1** ZWI: > 0,15 ≤ 0,4	**nm**	**PR.6.4.1** ZWI: > 0,4 ≤ 0,9	**nm**	**PR.6.5.1** ZWI: ≥ 0,9	**nm**	**PR.6.1.1 --> m:** According to Zaman & Swapan (2016), the Zero Waste Index for most African countries is very low and is estimated to be less than 0,05.

Legend: m = fully met; pm = partially met; nm = not met; na = not available

References

AESVT (2021): Association des Enseignants des Sciences de la Vie et de la Terre du Maroc (AESVT Maroc). Available online: https://www.aesvtmaroc.org/notre-association-aesvt/ (last accessed: 14.10.2021).

AESVT Maroc (2021): L'AESVT Maroc. Available online: https://www.aesvtmaroc.org/projets-nationaux-aesvt/ (last accessed 16.07.2021)

African Union (2019). Bamako Convention on the ban of the import into Africa and the control of transboundary movement and management of hazardous wastes within Africa, 14.01.2019.

Afrik21 (2020): MAROC: les autorités décident de sanctionner les pollueurs publics de Casablanca. Par Luchelle Feukeng 27.01.2020. Available online: https://www.afrik21.africa/maroc-les-autorites-decident-de-sanctionner-les-pollueurs-publics-de-casablanca/ (last accessed: 15.10.2021).

Amounas, M. (2020): Programme National des Déchets Ménagers (PNDM), Moroccan Ministry of Energy, Mines and Environment.

Aujourd'hui (2021): Gestion des déchets ménagers et assimilés: Mecomar lance une campagne de sensibilisation à Marrakech. Aujourd'hui, 08.04.2021. Available online: https://aujourdhui.ma/societe/gestion-des-dechets-menagers-et-assimiles-mecomar-lance-une-campagne-de-sensibilisation-a-marrakech (last accessed: 14.10.2021)

bossons-fute (2014): Chiffonnier des décharges publiques (Maroc). bossons-fute. Available online: http://www.bossons-fute.fr/index.php?option=com_content&view=article&id=1242:chiffonnier&catid=2&Itemid=3 (last accessed 14.10.2021).

Bouaouinate, A. and Saloui, A. (2016): « L'évolution du label touristique « La Clef Verte » au Maroc », Téoros [En ligne], 35, 1 | 2016, mis en ligne le 05 septembre 2016, consulté le 01 février 2022. URL: http://journals.openedition.org/teoros/2872

Bouvet (2015): Etude gaspillage alimentaire au club med, 2015. Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiozvuKuufxAhWVhv0HHeZSB-YQFnoECCUQAA&url=http%3A%2F%2Fdeveloppementdurable.clubmed%2Fwp-content%2Fuploads%2F2015%2F12%2FFR-Etude-gaspillage-alimentaire.pdf&usg=AOvVaw2R2Fg3zZZFeEHdJt3W6qvE (last accessed: 16.07.2021).

ClimateChance (2021): DÉCHETS La société marocaine en ordre dispersé contre la prolifération des déchets: CAS D'ÉTUDE MAROC 2020, 2020 (last accessed: 30.08.2021).

Clubmed (2015): Etude gaspillage alimentaire au club med. Clubmed. Online: http://developpementdurable.clubmed/wp-content/uploads/2015/12/FR-Etude-gaspillage-alimentaire.pdf (last accessed: 01.02.2022).

COVAD (2020). Plaidoyer pour un modèle d'économie circulaire performant et efficient. Policy Paper, 2020 (last accessed: 03.09.2021).

Daddi, T.; Frey, M.; Iraldo, F.; Nabil, B. (2011): The implementation of an Environmental Management System in a North-African local public administration: the case of the City Council of Marrakech (Morocco). Journal of Environmental Planning and Management 2011, 54, 813–832, doi:10.1080/09640568.2010.537543.

Diaco, M.; Alami Merrouni, M.; Bougarrani, S.; Koehler, J.; Hemkhaus, M.; Ahlers, J.; Desmond, P.; Van Hummelen, S. & McGovern, M. (2020): Circular Economy in Africa-EU Cooperation: Country Report Morocco, 2020 (last accessed: 15.07.2021).

EcoActu (2019): De la gestion des déchets vers un modèle marocain d'économie circularie. EcoActu. Available online: https://www.ecoactu.ma/de-la-gestion-des-dechets-vers-un-modele-marocain-deconomie-circulaire/ (last accessed: 13.01.2022)

Ecomed (2021): Online-Interview with Redouane Rifki on 01.10.2021. Plant manager of the valorisation plant and landfill CEV in Marrakech.

EIB (2016): A Boost for Climate Action: FMO and EIB support solid waste management in Morocco. European Investment Bank (EIB). Online: hhttps://www.eib.org/en/press/all/2016-286-a-boost-for-climate-action-fmo-and-eib-support-solid-waste-management-in-morocco (last accessed: 19.10.2021).

El Affas, Aziza (2015): Kilimanjaro Environnement: De l'huile alimentaire dans les moteurs. Les affaires, 18.11.2015. Online: https://www.lesaffaires.com/dossier/changements-climatiques-40-solutions-business/kilimanjaro-environnement--de-lhuile-alimentaire-dans-les-moteurs/583405 (last accessed: 13.01.2022)

Emploi.ma (2021): Nos formations Qualité & Sécurité & Environnement. Emploi.ma. Online: https://www.emploi.ma/training/quality_security (last accessed: 18.10.2021).

Eshmrah, Y. (2021): Les télécommunications au Maroc: du monopole à la libéralisation. Journal of Human Resources Development for Studies and Research: Atheist ten Issue – January 2021. Democratic Arab Center. Available online: https://democraticac.de/?p=72245 (last accessed: 15.10.2021).

FinancesNews (2019): L'OCP développe un programme d'économie circulaire à portée sociale. FinancesNews. Online: https://fnh.ma/article/developpement-durable/l-ocp-developpe-un-programme-d-economie-circulaire-a-portee-sociale (last accessed: 23.09.2021)

Ghariani, F. (2020): Programme National de Valorisation des Déchets (PNVD), Moroccan Ministry of Energy, Mines and Environment.

GIZ (2020): Morocco. Deutsche Gesellschaft für Zusammenarbeit (GIZ), 31.12.2020. Available online: https://www.giz.de/en/worldwide/340.html (last accessed: 14.10.2021).

GIZ et. al (2019): Stratégie Nationale de Réduction et de Valorisation des Déchets (SNVRD), GIZ, Moroccan Ministry of Energy, Mines and Environment, ECJ and MEVAC.

Globalcompliancenews (2021): Anti-Corruption in Morocco. Blog by BakerMcKenzie. Available online: https://www.globalcompliancenews.com/anti-corruption/anti-corruption-in-morocco/ (last accessed: 15.10.2021).

Groupe SEB (2021): Groupe SEB creates its ECOdesign label and launches in Europe a range of eco-designed products. Groupe SEB, 05.10.2021 Available online: https://www.groupeseb.com/en/news/groupe-seb-creates-its-ecodesign-label-and-launches-europe-range-eco-designed-products (last accessed: 13.01.2022)

Hafidi, M. (2015): L'Impact et la gestion des déchets solides. Ed. Konrad-Adenauer-Stiftung. 2015. Online: https://www.kas.de/documents/252038/253252/7_dokument_dok_pdf_43542_3.pdf/ec58b765-b3a1-3309-662b-55b8a44ab451?version=1.0&t=1539651527141 (last accessed: 8.10.2018).

Haut-Commissariat au plan (2012). Nomenclature Marocaine d'activites: NMA 2010, 2012 (last accessed: 03.09.2021).

Houzir, Meriem (2017): De la COP21 a la COP22 Bilan et perspectives pour le Maroc. Ed. Foundation Heinrich Böll, Afrique du Nord - Rabat, Rischewski Dorothea, 2017.

ILO (2021): Morocco - Structure et organisation du système d'inspection du travail. International Labour Organization (ILO). Online: https://www.ilo.org/labadmin/info/WCMS_159111/lang--en/index.htm (last accessed: 23.09.2021)

IMANOR (2020): Guide - Développement Durable dans la Construction [Sustainable Development in Construction]: Rôles des normes pour une meilleure assimilation des principes et pratiques de développement durable dans la construction [Roles of standards for better assimilation of development principles and practices], 2020 (accessed on 28 January 2022).

IMO (2021): Status of Conventions "Ratifications by State" (Excel file), 14.07.2021. International Maritime Organization (IMO). Online: https://wwwcdn.imo.org/localresources/en/About/Conventions/StatusOfConventions/x-Status.xlsx (last accessed: 19.07.2021)

IMO_LCLP (2019) Map of Parties to the London Convention/Protocol (LCLP), International Maritime Organization (IMO). Online: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Parties%20to%20the%20LCLP%20February%202019.pdf (last accessed: 16.07.2021)

Ismaili, Fayçal (2021): Recyclage: un nouvel Ecocentre bientôt construit à Marrakech. Le360; 12/05/2021. Online: https://fr.le360.ma/economie/recyclage-un-nouvel-ecocentre-bientot-construit-a-marrakech-238464 (last accessed: 19.07.2021)

ISO (2021): The ISO Survey of Management System Standard Certifications 2020. International Organization for Standardization (ISO). Excel-Table. Online: https://www.iso.org/the-iso-survey.html (last accessed: 12.12.2021)

Kammas, S. (2016): LA LOGISTIQUE VERTE: Concepts, Etat des lieux au Maroc et proposition d"une démarche de mise en place chez les industriels et les prestataires logistiques Marocains. Revue des Etudes et Recherches en Logistique et Développement (RERLED). Edition 2016 – Vol 1, N° 2. ISSN 2458-5890.

LesEcoMa (2021): Inspection du travail: le corps se renforce. LesEcoMa, 11.08.2021. Online: https://leseco.ma/maroc/inspection-du-travail-le-corps-se-renforce.html (last accessed: 23.09.2021)

mapecology (2017): "Le Maroc veut créer un marché carbone conforme à sa conjoncture économique", mapecology, 07/07/2017. Available online: http://mapecology.ma/actualites/maroc-veut-creer-marche-carbone-conforme-a-conjoncture-economique/ (last accessed 14.10.2021)

mapecology (2020): "Marrakech: La gestion des déchets confiée à l'Etablissement « Grand Marrakech »", mapecology, 03/01/2020. Online: http://mapecology.ma/slider/marrakech-gestion-dechets-confiee-a-letablissement-grand-marrakech/ (last accessed 16.07.2021)

mapecology (2020a): "L'AESVT- section Marrakech renouvelle son bureau dirigeant", mapecology, 13/01/2020 Available online: https://mapecology.ma/institutions/aesvt/ (last accessed 13.02.2022)

Mawarid (w.y.): Stratégie de libéralisation et de démonopolisation au Maroc: Construction Juridique et Fiscale. Available online: https://www.mawarid.ma/document-2596.html (last accessed: 15.10.2021).

Mbaye, Khadim (2020): Interdiction des sacs plastique: nouveau tour de vis de la tutelle. LesEco.ma, 01.10.2020. Online: https://leseco.ma/maroc/interdiction-des-sacs-plastique-nouveau-tour-de-vis-de-la-tutelle.html (last accessed: 03.09.2021)

medias24 (2015): 69.000 enfants de 7 à 15 ans travaillent au Maroc, malgré l'interdiction légale. Medias24, 18.06.2015. Available online: https://www.medias24.com/2015/06/18/69-000-enfants-de-7-a-15-ans-travaillent-au-maroc-malgre-linterdiction-legale/#:~:text=Sur%20le%20plan%20l%C3%A9gislatif%2C%20le,par%20le%20Maroc%20en%202000. (last accessed: 14.10.2021).

medias24 (2021): Au Maroc, le phénomène du travail des enfants en baisse de plus de 26% en 2020 (HCP). Medias24, 14.06.2021. Available online: https://www.medias24.com/2021/06/14/au-maroc-le-phenomene-du-travail-des-enfants-en-baisse-de-plus-de-26-en-2020-hcp/#:~:text=En%202020%2C%20le%20ph%C3%A9nom%C3%A8ne%20du,l'ensemble%20des%20m%C3%A9nages%20marocains. (last accessed: 14.10.2021).

medias24 (2021b): Economie circulaire: le rôle des PPP dans la valorisation des déchets (experts). Medias24, modified 11.04.2021. Available online: https://www.medias24.com/2020/09/21/economie-circulaire-le-role-des-ppp-dans-la-valorisation-des-dechets-experts/ (last accessed: 15.10.2021).

MEF (2020): La Loi n°46-18 relative aux contrats de Partenariat Public-Privé adoptée par la Chambre des Représentants: 14/01/2020. Moroccan Ministry of Economy and Finances (MEF). Online: hhttps://www.finances.gov.ma/fr/Pages/detail-actualite.aspx?fiche=4689 (last accessed: 01.02.2022)

Ménara (2021): Ménara Préfa, une démarche qui a été couronnée de succès à travers l'obtention de la certification ISO 14001 version 2015. 05/04/2021 updated 25/05/2021. Menara holding. Online: https://menara-holding.ma/fr-fr/les-actualites/filiales/menara-prefa-une-demarche-qui-a-ete-couronnee-de-succes/ (last accessed: 01.02.2022)

MMEME (2015): Les missions. Moroccan Ministry of Energy, Mines and Environment (MMEME). Online: https://www.environnement.gov.ma/fr/departement-de-l-environnement/2015-03-05-11-53-51/missions (last accessed: 18.10.2021).

MMEME (2015b): Les déchets Moroccan Ministry of Energy, Mines and Environment (MMEME). Online: http://environnement.gov.ma/fr/dechets/117-theme/dechets (last accessed: 18.10.2021).

MMEME (2019): Inauguration officielle du Centre d'Enfouissement et de Valorisation des déchets de Marrakech. Moroccan Ministry of Energy, Mines and Environment (MMEME). Online: http://environnement.gov.ma/fr/133-a-la-une/2193-lancement-officiel-de-l-activite-du-centre-d-enfouissement-et-de-valorisation-cev-de-marrakech-4-janvier-2018s (last accessed: 07.10.2021)

MMEME (2019b): 2eme Rapport Biennal Actualisé. Dans le cadre de la convention cadre des Nations Unies sur les changements climatiques. Moroccan Ministry of Energy, Mines and Environment (MMEME). Décembre 2019.

MMEME (2021): Mouvements transfrontaliers des déchets et des produits chimiques. Moroccan Ministry of Energy, Mines and Environment (MMEME). Online: https://www.environnement.gov.ma/fr/service/mouvements-transfrontaliers-des-dechets-et-des-produits-chimiques (last accessed: 23.09.2021)

Morocco-export (2019): Waste: new conditions for import and export. Morocco-export.com, 10.09.2019. Online: https://morocco-export.com/waste-new-conditions-for-import-and-export/ (last accessed: 09.09.2021)

Mounadi, Mohamed (2015): Monauto.ma: Le 1er site internet de vente de pièces détachées. Aujourd'hui le Maroc, 24.03.2015. Online: https://aujourdhui.ma/automobile/monauto-ma-le-1er-site-internet-de-vente-de-pieces-detachees-118537 (last accessed: 13.01.2022)

Okato (2022): 1er site d'annonces de pièces détachées d'occasion au Maroc. Okato. Available online: https://okato.ma/pourquoi-choisir-la-piece-auto-doccasion-au-maroc/ (last accessed: 13.01.2022)

Ouchagour, Leila (2021): Marrakech se dotera bientôt d'un nouvel Ecocentre. Aujourd'hui le Maroc, 13.05.2021. Online: https://aujourdhui.ma/economie/marrakech-se-dotera-bientot-dun-nouvel-ecocentre?unapproved=49212&moderation-hash=048260d2ac062e27a7733e964b5be205#comment-49212 (last accessed: 19.07.2021)

Ouchen (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.

Pizzorno (2019): Déclaration de performance extra-financière. Pizzorno Environment. Available online: http://www.pizzorno.com/fileadmin/documents/publications/2019/DPEF_2018.pdf (last accessed: 14.10.2021)

Rademaekers, K.; Smit, T.A.B; Artola, I.; Koehler, J.; Hemkhaus, M.; Ahlers, J.; Van Hummelen, S.; Chewpreecha, U.; Smith, A. & McGovern, M. (2020) Circular economy in the Africa-EU cooperation – Continental report. Continental report under EC Contract ENV.F.2./ETU/2018/004 Project: "Circular Economy in Africa-Eu cooperation", Trinomics B.V., Tomorrow Matters Now Ltd., adelphi Consult GmbH and Cambridge Econometrics Ltd.

Royame du Maroc (2017a): Stratégie nationale de développement durable (SNDD) 2030: Résumé Exécutif, Rabat, 2017. Available online: http://faolex.fao.org/docs/pdf/Mor185348.pdf (last accessed: 8.10.2021).

Royame du Maroc (2017b): La Loi 24.09 relative a la sécurité des produits et des services. Direction de la Protection du Consommateur, de la Surveillance du Marché et de la Qualité. 12.12.2017. Available online: http://www.imanor.gov.ma/wp-content/uploads/2016/05/Loi-24-09_FNC2017.pdf (last accessed: 18.01.2022).

Royaume du Maroc (2018): Cadre de Gestion Environnementale et Sociale (CGES) relatif au Projet d'Entretien Communautaire des Routes Rurales (ECRR).

Royaume du Maroc (2019): Guide d'Accès à la Finance Climat: Destiné aux acteurs territoriaux 2019.

Royaume du Maroc (w.y.). Valorisation et gestion durable des déchets au Maroc: Développement des Filières, w.y. (accessed on 19 October 2021).

Salamy Bebila, Lelis (2020): Mouvement transfrontière des déchets: Importation et réutilisation des déchets au Maroc. Mediaterre.org, 18.08.2020. Online: https://www.mediaterre.org/actu,20200818132713,11.html (last accessed: 09.09.2021)

Schleicher, Anni (2021): Marjane expands DRS and reusable container program after "incredibly positive" consumer feedback. Packaging insights, 10.06.2021. Online:

https://www.packaginginsights.com/news/marjane-expands-drs-and-reusable-container-program-after-incredibly-positive-consumer-feedback.html (last accessed: 13.01.2022)

seariousbusiness.com (2021): Morocco - MOSSUP. Available online: https://www.seariousbusiness.com/morocco (accessed on 1 February 2022).

SIREDD (2021): Direction Régionale de l'Environnement. Système d'Information Régional de l'Environnement et de Développement Durable (SIREDD). Online: https://siredd.environnement.gov.ma/Marrakech-Safi/Home/observatoire (last accessed: 03.09.2021)

SIREDD (2022): Accueil / Indicateurs - Environnement Socio Human - Dechet. Système d'Information Régional de l'Environnement et de Développement Durable (SIREDD). Online: https://siredd.environnement.gov.ma/Marrakech-Safi/indicateur# (last accessed: 25.01.2022)

Terrapon-Pfaff, J.; Amroune, S. (2018): Implementation of Nationally Determined Contributions: Morocco Country Report. 30/2018, 2018.

Toufik, Hajar (2020): "Vidéo. Collecte des déchets de Marrakech: ce qui va changer", le360, 31/12/2020, https://fr.le360.ma/societe/video-collecte-des-dechets-de-marrakech-ce-qui-va-changer-230455 (last accessed 16.07.2021)

UN (1997): Joint Convention on safety of spent fuel, radioactive waste management opens for signature in Vienna. United Nations (UN), Press Release IAEA/1318, 10 October 1997. Online: https://www.un.org/press/en/1997/19971010.IAEA1318.html (last accessed 19.07.2021)

UN (2021a): Multilateral Treaties Deposited with the Secretary-General, Participan Search: Morocco [Excel file]. United Nations (UN). https://treaties.un.org/pages/TreatyParticipantSearch.aspx?clang=_en (last accessed: 19.07.2021)

UN (2021b): 13. Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters. United Nations (UN). 19.07.2021. Online: https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-13&chapter=27&clang=_en (last accessed: 19.07.2021)

UNECE (2021): Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991) - the 'Espoo (EIA) Convention'. United Nations Economic Commission for Europe (UNECE). Online: https://unece.org/fileadmin/DAM//env/eia/ratification.htm (last accessed: 19.07.2021)

United Nations. Examen des performances environnementales: Maroc Synopsis, 2014 (last accessed: 23.09.2021).

Ville Marrakech (2016): Les Ateliers Participatifs. Available online: https://www.ville-marrakech.ma/les-ateliers-participatifs/37/ (last accessed: 15.10.2021).

World Bank (2017): Le Coût de la Dégradation de l'Environnement au Maroc. Environment and Natural Resources Global Practice Discussion Paper #5, Washington, D.C., 2017 (last accessed: 30.08.2021).

WWF (2019): Stop the flood of plastic. A guide for policy-makers in Morocco. World Wide Fund for Nature - WWF. Available online: https://wwfeu.awsassets.panda.org/downloads/05062019_wwf_marocco_guidebook.pdf (last accessed: 13.01.2022).

Yahya, A. (2021): Marrakech adopte un système de gestion intégrée du service de propreté [Marrakech adopts an integrated management system of the cleaning service. Agence Marocaine de presse (MAP). 04.01.2021 [Online]. Available online: http://mapecology.ma/actualites/marrakech-adopte-systeme-de-gestion-integree-service-de-proprete/ (last accessed: 09.09.2021).

Zaman, A.U.; Swapan, M.S.H. (2016): Performance evaluation and benchmarking of global waste management systems. Resour. Conserv. Recycl. 2016, 114, 32–41, doi:10.1016/j.resconrec.2016.06.020.

Appendix III: Recommendations for action to promote a CE in Marrakech (Morocco)

Measure	Related components	Recommendations for action	Level of application	State of priority
Cluster A: Increase collection rate and separate collection of waste				
M1	G.2, CT.4	A mandatory separate collection for wastes from households and businesses (CT.4.3.1) should be prescribed by law (G.2.3.1).	National	Essential (I)
M2	CT.4	Introduce a separate collection of different waste types (e.g. organics, plastics/paper, residuals) at source (CT.4.2.1). It could be started with 2 or 3 sources: wet waste (e.g. residuals, organics) and dry waste (e.g. plastics/paper) or residuals, organics and plastics/paper. Due to the fact that the waste elimination and recycling center (CEV) in Marrakech will have a composting unit, the introduction of wet/dry collection could be anticipated. The separate collection of organics could be done subsequently, after ensuring that the population has accepted this new segregation concept; stand-alone composting or even fermentation plants are planned.	Municipal	Essential (I) **Precondition M1**
M3	CT.4, CT.8	Introduce decentralized drop-off bins for other types of residual wastes, such as batteries, textiles, glass, and small electrical waste, or set up recycling centers to dispose big electrical, construction and demolition (C&D) and hazardous waste (cleaners, lubricants, paints, varnishes, solvents, etc.) from households as well as companies (CT.4.3.4 and CT.8.2.1). In the best case, the disposal for households should be free of charge (CT.8.3.1) to raise the motivation for proper disposal.	Municipal	Relevant (II)
M4	G.6, G.11, CT.1, CT.3	The collection rate (CR) in urban areas seems to be already in stage 5 (CT.3.5.1), but in rural areas, the actual state is not clear, due to lack of data. The collection rate should be raised to at least 80% in rural areas (CT.3.4.1) with the goal to reach stage 5 (>95%) within the next 5 years (CT.3.5.1). In this context, the informal sector should be integrated in order to obtain higher CR of wastes, especially in rural areas. Moreover, the CR must be recorded (G.11.2.1), published annually (G.11.3.1) and publicly available (G.11.3.6) (e.g. in a municipal WM concept G.6.2.6) to ensure a better understanding and to monitor the collection state (G.11.4.3 and G.11.4.4). Higher CR can contribute to meeting the principles of urban hygiene (CT.1.5.4).	Municipal	CR rural area + WM concept: Essential (I) CR documentation: Relevant (II) **Dependency to M20**
M5	CT.7	By increasing the number of collected waste types, the importance of transfer stations, which are necessary to transfer the various wastes into larger trucks, grows; this should be considered in further waste management (WM) planning as an important building block for improving collection and transport efficiency (CT.7.3.1). Actually, two transfer stations exist, which are open to the public. There are plans to restrict the open accessibility to the public (CT.7.3.2) and provide better equipment. Moreover, their efficiency can be raised by considering specific aspects (check Bilitewski et al., 2018, p. 119). These conditions should be compared with the planned optimization measures.	Municipal and/or regional	Relevant (II)

Measure	Related components	Recommendations for action	Level of application	State of priority
M6	G.11, CT.5	By implementing different forms of separation at source (door-to-door or drop-off stations), the CR of recyclables and other wastes can be recorded for the first time (CT.5). In this context, it is recommended that data collection procedures should be prescribed at the national level (G.11.3.3) to ensure uniform data collection, thus providing a good picture of the actual situation. The Regional Information System SIREDD for the region of Marrakech-Safi is already publishing waste related data. Unfortunately, the data is not up-to-date. It is recommended that the data should be published annually (G.11.3.1) for all provinces and the prefecture of Marrakech (G.11.3.9). The CR of recyclables should be increased. Due to missing data, the first goal would be to reach stage 2 (CT.5.2.1). Therefore, the informal sector should also be included in order to obtain higher CR for recyclables.	National, regional and municipal	Uniformity: Essential (I) CR recording: Relevant (II)
Cluster B: Control, Regulation, Monitoring and Assessment				
M7.1	G.2, PR.1, PR.3	The regulatory WM framework (G.2.3.1) can be enhanced by including regulations regarding soil protection, extended producer responsibility (EPR) (see M7.3) as well as CE promoting measures (G.2.4.1), such as minimum use rates in products (PR.3.4.4), the right to repair, increase in the rate of eco-friendly products (e.g. sustainable products, biobased products, etc.) in official procurement, and product bans, when recycling is not an option (concerning recyclability or other technical or economic aspects) or to reduce waste amounts (PR.1.4.2). WM programs contain time-dependent goals and improvement measures for the future, but what is missing is the review of these goals. National WM programs and strategies have to be updated at least every 2 to 5 years to foster CE development. Moreover, targets regarding food waste avoidance should be defined at the national level, and measures should be implemented to achieve food waste reduction (PR.1.4.1).	National	WM framework: Essential (I) PR measures: Relevant (II) **Dependency to M7.3**
M7.2	G.1	It is highly recommended that the 5-stage waste hierarchy should be fixed in the Waste Law 28-00 (G.1.3.4). The legal prioritization of waste treatment options is one factor that promotes waste recycling and the move towards a CE.	National	Essential (I)
M7.3	G.2, SM.4, SM.6	Firstly, introduce EPR legally by including it in the Waste Law 28.00 (G.2.3.5); secondly, create structures (e.g. associations like the Green Dot in Germany) that are in charge of EPR execution and ensure the fulfilment of disposal and recycling obligations of manufacturers, retailers and distributors (SM.4.3.4). Furthermore, this enables a mandatory participation (financially and organizational) of manufacturers, retailers, and distributors in WM (SM.6.3.1).	National	Essential (I)
M8	G.2, WD.2, WR.1, WR.4	A systematic pretreatment of waste (WD.2.3.2, WR.1.3.1, and WR.4.2.1) should be mandatory to guarantee less methane emissions through anaerobic reactions. With this measure, the activity of the waste is reduced (Bilitewski et al., 2018). The obligation of systematic pretreatment before waste disposal for MSW should be included in the Waste Law 28-00 (G.2.3.1).	National	Essential (I)

Measure	Related components	Recommendations for action	Level of application	State of priority
M9	G.5., G.6, CT.4, CT.8, PR.1	WM laws at the regional (G.5.2.2) and municipal level (G.6.2.5) can be an essential component to adapt or extend the legal framework to the regions and to legally define the municipal WM conditions (e.g. obligations and rights of citizens and waste service providers, fees, etc.). Make WM plans or concepts at the regional (G.5.2.3) and/or municipal level (G.6.2.6) including: i) WM as well as CE targets also including food avoidance (PR.1.4.1); ii) the actual state and strategy for the collection, treatment and disposal of different kind of wastes (from households and specific sectors, such as industry, forestry, agriculture, C&D, hospitals, etc.) (CT.4.2.1, CT.4.2.3 and CT.4.3.4), especially hazardous wastes (CT.8.2.1 and CT.8.3.2); iii) prevention measures. Regional and/or municipal programs should also be developed to show prevention potentials (G.5.3.6 and G.6.3.5). These laws, plans and concepts should be publicly accessible (G.5.2.3 and G.6.2.6). Plans and concepts should be updated at least every 2 to 5 years to have a good picture of the actual state and future trends as well as to better control or promote possible developments (e.g. CE).	Municipal and/or regional	Essential (I)
M10	G.1, G.4, G.5, G.6	The regular review of targets and open communication of their achievements and failures (G.1.3.3) independent of the political level is necessary to reflect and analyze the development efforts and, in case of failures, formulate new measures to achieve the targets and increase transparency. This is also relevant in the context of WM plans, programs and concepts (G.4.2.3, G.4.3.1, G.5.3.5, G.5.3.6, G.6.2.6 and G.6.3.5). Moreover, the linking of WM targets to the SDGs (G.1.4.1) is getting more important on the global scale and should be considered.	National, regional and municipal	Relevant (II)
M11	G.2	The following international agreements related to WM should be ratified: Hong Kong International Convention, Espoo Convention, Aarhus and Bamako (G.2.3.4).	National	Relevant (II)
M12	G.3	Regular update of the waste nomenclature (incl. new waste types and state of the art processes) has to be done to capture new types of waste and technologies at an early stage (G.3.4.1).	National	Relevant (II)
M13	G.8, SM.4	Companies that work in the field of WM (recycling, disposal and collection) should meet certain requirements that allow them to work in this field. Such requirements should be defined first and then be linked with an official state-approved certification (G.8.3.3), which periodically has to be revalidated by an authorized body to avoid irregular working practices (SM.4.3.2). It was not possible to find out whether and how monitoring of private WM companies that perform municipal tasks (e.g. waste collection) exists. If such monitoring is lacking, it should be implemented in order to detect possible errors at an early stage.	National	Relevant (II)

Measure	Related components	Recommendations for action	Level of application	State of priority
M14	G.10	Emission limits (G.10.3.2) for landfills (e.g. leachate and hazardous or climate-relevant substances) and other treatment plants should be defined by laws or directives, to minimize the risks to health and environment, and should be updated regularly (max. every 5 years) (G.10.4.1). The same applies to quality standards (G.10.3.3) for secondary raw materials (e.g. glass, compost, plastics, secondary building materials, etc.) and refuse derived fuels (RDF) (G.10.4.2) to ensure high quality recycling. The definition of standards and limits for recyclables (plastics, aluminum, metals and paper) after the sorting phase (e.g. product specifications from the Green Dot (GreenDot, w.y.) and for recycled plastics (as the quality assurance system for recycling plastics RAL-GZ 720) are necessary to obtain a suitable quality and to avoid high impurities and harmful contaminants, which in turn can disrupt the recycling process.	National	Essential (I)
M15	G.11	Clear and uniform collection, disposal and recycling rates shall be implemented at all political levels and documented centrally (G.11.3.1, G.11.3.3 and G.11.3.9). These rates are good indicators to monitor the actual WM state (G.11.3.8). Updates have to be done regularly, at least once a year (G.11.3.1). This is linked to M6.	National, regional and municipal	Essential (I) **Dependency to M6**
M16	G.15, SM.3	The informal sector should organize itself so that they can work more efficiently and can become established as relevant stakeholder. They could organize themselves into an umbrella organization (SM.3.3.1) to improve working conditions (e.g. occupational safety and health) (G.15.3.1), reduce risks for individual waste pickers (G.15.3.2) and raise their acceptance in the population (SM.3.3.5).	Regional and municipal	Relevant (II)
M17	SM.7	The trading structures for waste and recyclables are not openly traceable (SM.7.3.1). To change this, regulations and a data base to record the quantities received or sold as well as controls are necessary. If required, stricter import/export criteria for (non-)hazardous, hardly recyclable wastes and used goods (SM.7.4.7) as well as more controls (SM.7.3.8) have to be introduced to avoid illegal imports/exports.	National	Relevant (II)
M18	SM.6	Insurance companies should offer insurance services for companies to protect them against caused environmental damages (SM.6.3.2).	Company	Optional (III)
M19	WD.1	Approved sites that allow the municipality to quickly and safely dispose excessive waste in times of disasters (floods, storms, crashes, explosions and other forms of accidents) should be determined at least at regional level (WD.1.4.5) to support city resilience.	Regional or municipal	Optional (III)

Measure	Related components	Recommendations for action	Level of application	State of priority
Cluster C: Promote closing the loop in Marrakech				
M20	WD.2, WD.4, WR.1, WR.4	The sorting unit is already in operation in the CEV (WD.2.3.2, WR.1.3.1, WR.4.2.1 and WR.4.2.2), but the composting unit, which ensures a reduction of the methane emissions, is still missing (WD.2.3.2 and WR.1.3.1). This unit is planned and will be constructed in future. Once the composting unit is in operation, landfill gas volumes will decrease significantly (WD.4.4.1). In the future, the capacities of the sorting plant and composting unit should be expanded after reviewing the demand to ensure disposal security, especially if an increase in CR is desired in rural areas (M4).	Regional and/or municipal	Essential (I) **Dependency to M4**
M21	WD.3	The generated leachate from the active landfill should be treated (e.g. physical-chemical treatment, biological treatment, ultrafiltration, and reverse osmosis) to reduce the harm of the leachate to the environment and health (WD.3.3.1).	Regional and/or municipal	Relevant (II)
M22	G.10, G.16, WR.2, PR.1	If a separation at source for organic waste is implemented (M2) and the composting unit is fully in operation (M20), it is thinkable to sell the generated compost for agriculture (WR.2.3.2). In this context, a high quality has to be ensured (low impurities). Standards for compost (G.10.2.2) should be implemented (such as the quality assurance system for compost RAL- GZ 251 for Germany (Bilitewski et al., 2018)) and the awareness of farmers should be increased so that the product (compost) becomes more attractive. Financial incentives (e.g. free compost or at low cost) and awareness campaigns (G.16.4.1 and PR.1.3.3) are necessary.	National and municipal	Relevant (II) **Preconditions:** **M2 and M20**
M23	ER.1, WR.4, PR.2, PR.3	The implementation of M2 and M5 can increase the amount of recyclables for further material recycling (higher quality recyclables; WR.4.3.2 and M14) or for co-incineration (lower quality recyclables with high heating value, e.g. plastics; ER.1.2.3). The production of lower-quality RDFs for energy recovery should, therefore, not be the main objective but should rather be a small part in a CE. For example, near infrared sensors should be integrated in the CEV sorting plant (WR.4.3.1). This measure is directly connected with M24. Raising the sorting of high-grade mono-fractions such as PET, PP, HDPE, etc. (WR.4.3.2), which in turn can be recycled, is recommended. This can be achieved by introducing take-back or deposit systems for certain products/wastes (e.g. beverage packaging) (PR.2.3.5) as well as by designing products that are homogenous, easily separable, harm free and consist of secondary materials (incl. biodegradable material), with less disruptive substances (less composites) (PR.3.4.1 and PR.3.5.1). Meanwhile, recyclability, durability and upgradability should be considered more in the product design phase to facilitate recycling and reuse (PR.3.4.2).	Municipal and company	Relevant (II) **Preconditions:** **M2, M5 and M14** **Dependency to M24**

Measure	Related components	Recommendations for action	Level of application	State of priority
M24	G.2, SM.7	Once M14 and M23 are achieved, the secondary resource market has to be ready to use the existing potential of high-quality recyclates to enter the market (SM.7.3.5 and SM.7.4.5). Therefore, efforts have to be made beforehand to promote the use of secondary resources by law (G.2.4.1; see also M7.1), increase the secondary resource demand of industries (SM.7.4.4), introduce specific regulations enabling the trade of secondary resources with foreign countries (SM.7.5.4) and — if necessary — launch other government incentives to strengthen the secondary resource market (SM.7.4.1). The implementation of exchange platforms for secondary products and wastes for industries (SM.7.3.3) inside and outside of the country (SM.7.3.7) could also benefit the secondary resource market. Since these developments are still in their infancy in Marrakech and Morocco, the digitization of this system in a smart way is worth considering (e.g. real-time networking) (SM.7.5.4).	National, regional and company	Relevant (II) **Dependency to M7.1, M14, M23**
M25	G.4, G.5, G.6, SM.5, SM.6	A budget to promote WM activities (e.g. sanitary landfills and measures to reduce WM emissions) (G.4.3.3, G.5.3.8, G.5.4.3 and G.6.3.6) as well as CE activities (SM.5.4.1) is needed at all political levels (national, regional and municipal) in future to enable the financing of recycling plants, investment in companies and industrial symbiosis (SM.5.4.2 and SM.6.3.4) and social activities, which contribute to closing the loop.	National, regional and/or municipal	Essential (I)
M26	SM.6, PR.4	Most companies do not have the topic of WM and closing the loop in their focus yet (SM.6.1.1). Companies should, where possible, consider WM and CE topics (e.g. secondary resources in production, safe disposal of waste, reduction of hazardous substances (PR.4.4.2) and definition of targets (SM.6.4.1). The aspect of including more secondary resources in the production depends strongly on the secondary resource market. Hence, the successful implementation of these measures are strongly linked to the performance of M24. Moreover, the publishing of product information (e.g. hazardous ingredients and handling of product during use and after use (disposal)) (SM.6.3.5) is becoming more and more important in the long term, also in relation to exports to EU countries that demand certain information. Another relevant aspect is the evaluation of company performances regarding CE and environmental impacts (PR.4.3.1). For this purpose, the recording of material and waste flows is needed (SM.6.4.4); such recording is also needed in the context of waste and recyclables exchange platforms (see M24) as well as to inform customers. In this context, digitization measures can help to connect different needs (e.g. company performance evaluation and trade of waste and recyclables). This waste related data can be used for environmental reports (SM.6.4.5) or to receive specific eco-labels (SM.6.4.6).	Company	Relevant (II) **Dependency to M24**

Measure	Related components	Recommendations for action	Level of application	State of priority
M27	WR.6, WR.7, PR.1	C&D waste, which is very important in terms of mass and volume, should be more in the focus. In addition to contracts with companies responsible for collection and environmentally sound disposal, sorting and recycling facilities for C&D waste must also be established to bring the resources back into the cycle, starting with the use of C&D waste as filler or for street construction (WR.6.3.2). Furthermore, the selective demolition of buildings (WR.6.3.1) must be promoted in order to keep the materials longer in the economic cycle and to raise the recycling rates (WR.7.2.2). The recycling of C&D waste to generate secondary building materials should be promoted also by defining quality standards (M14). At the same time, lifetime-extension of buildings before construction should be ensured (PR.1.4.4).	National, municipal and company	**Relevant (II)** **Dependency to M14**
M28	WR.7, PR.2	In Marrakech, an increased reuse rate for electronic items can be assumed. However, it is not clear how the data really looks like. A recycling center for e-waste (from small devices, such as smartphones, and bigger ones, such as refrigerators) should be integrated into the WMS to increase the recycling rate (WR.7.2.2), recover critical and other materials and, consequently, prevent valuable and critical materials from ending up in landfills. The repair of these products could also be linked with it (PR.2.4.1).	Regional and/or municipal	Relevant (II)
Cluster D: Encourage cooperation between research, companies and society				
M29	G.7	Stakeholder platforms for CE have to be implemented to discuss and promote CE in Morocco (G.7.3.1). Competency centers can be established to improve the exchange between WM and CE stakeholders (G.7.4.1).	All levels	Relevant (II)
M30	G.12, G.14	WM and CE issues should be included in educational programs at elementary and secondary schools to raise awareness (e.g. sorting at source, dumping and open burning, closing loops, and prevention) (G.12.3.4 and G.12.4.2). Moreover, different awareness programs for adults and companies should be initiated to acquire a basic understanding of WM in the context of sustainability and CE (G.14.3.2 and G.14.4.1).	Regional and municipal	Relevant (II)
M31	G.13	Interdisciplinary research in the context of WM and CE activities (G.13.3.4) should be taken into consideration to include different perspectives on research topics (e.g. recycling and prevention measures, industrial symbiosis and digitalization in CE) (G.13.4.2).	National and/or regional	Relevant (II)
M32	SM.4	Increase the cooperation between universities, WM and recycling companies to intensify the exchange and networking between science and practice, as well as the recruitment of skilled personnel. Moreover, increase the interplay between small innovative and large companies in the WM industry by creating exchange platforms and fostering cooperation possibilities through project funding (SM.4.4.1).	All levels	Relevant (II)
M33	SM.1, SM.2, G.12	The partially existing and planned recycling facilities (CEV and Ecocenter) lead to an increase in the personnel requirements for waste recyclers (SM.2.3.1, G.12.3.1). Further investments in waste sorting and recycling plants (composting plants, anaerobic digestion plants, etc.) as well as recycling industries could further increase the need for skilled workers (SM.1.4.1, SM.2.4.1 and SM.2.4.2). For this purpose, training opportunities at universities and technical schools should also be offered at an early stage to cover the personnel requirements in the context of CE (incl. waste prevention and reuse) (G.12.4.1).	Regional and/or municipal	Relevant (II)