A Conceptual Framework for Inclusive Circular Urban Waste Management Systems

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Abstract Rapid urbanization in combination with unsustainable production and consumption patterns leads to the generation of substantial amounts of urban waste. The circular economy promises to bring solutions both with top-down and with bottom-up activities. The former relate to the implementation of policies which are based on the waste hierarchy principles by local governments, whereas the latter are about the adoption of circular business models by urban stakeholders. However, a circular economy does not automatically endow cities with inclusion or resilience against shocks. Consequently, any decision which relates to such a transition is not trivial. This chapter presents an integrative framework to assist urban decision makers in considering inclusion and circularity simultaneously when developing urban waste management systems where urban regeneration has a central role. The framework places explicit attention on improving the accessibility of social groups to various forms of capital and stimulating the development of local economies through improved circulation of resources and information within the urban fabric.

Keywords Inclusion · Urban waste management system · Circularity

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M. de Jong et al. (eds.), *The Inclusive Circular Economy*, Urban Sustainability,
https://doi.org/10.1007/978-981-96-6867-0_4

1 Introduction

Realizing inclusive circular cities aims to eliminate linear waste flows in which the development and management of urban waste management systems (UWMS) as resource collection and distribution networks play an important role by involving various societal stakeholders, including vulnerable ones. Since the establishment of waste sorting facilities along with waste-to-energy plants represents a long-term investment and any transition to a different type of waste management system is hard and costly, potentially harmful lock-ins due to the construction of a suboptimal waste management infrastructure should be avoided. This is particularly important in countries where substantial power asymmetries between urban actors might exist, where the design process may get politicized, and where consultation with local stakeholders can be easily overlooked. Consequently, UWMSs need to be developed along *circularity principles* whereby all stakeholders act responsibly and adhere to *inclusion principles*, such that vulnerable but relevant groups can also do their say; that task is not easy to achieve.

This chapter aims to establish a framework to study the development of UWMSs in which both circularity and inclusion principles are respected. Section 2 introduces a design procedure, called the Double Diamond, and subsequently applies it to (a) discover the implications of the key circularity and inclusion principles in an urban context, (b) define the resulting design requirements, (c) develop a rationale for key input and output elements to assess the circularity and inclusion of UWMSs, and (d) deliver a final framework based on these suggestions. Finally, Sect. 4 discusses the implications of the framework and highlights that circularity and inclusion both provide important guidelines for the development of UWMSs which can boost the sustainability performance of cities. In Sect. 5, conclusions are drawn.

2 Applying the Double Diamond to Produce a Conceptual Framework

2.1 What is the Double Diamond Method?

The **Double Diamond (DD) method** is a design-based research method known for its diverging and converging phases in which a problem at hand is explored and a solution developed (British Design Council 2007). The consideration of diverging and converging features of the DD method fit well with the purposes of this chapter because the challenge which needs to be solved has three tiers. The first tier is making a conceptual linkage between circularity and inclusion across different levels (city, its UWMS, and actors and physical facilities). The second tier is the contextual embedding for a clear translation of the circularity and inclusion principles into integrated UWMSs. The third tier is the tailoring nature of the chosen design approach: it needs to be applicable to different urban contexts and adaptable to various requirements.

These three tiers benefit from an open consultation step followed by strict evaluation steps.

The research design based on the DD method follows four consecutive phases. The **discover phase** is a first diverging step where the dimensions of an existing problem are investigated. In the **define phase** the emerging opportunities to deal with the problem are analyzed and synthesized into a development plan. This plan is then used as input for the **develop phase** to initiate, elaborate and evaluate the ideas for their usefulness. Finally, the **deliver phase** guides the implementation of the ideas by iteratively building and testing the chosen design. The next section explains how these research steps evolve.

2.2 DD as a Research Process in Four Phases

To facilitate going through the empirical steps, this study was conducted in three workshops with researchers of the Inclusive Wise Waste Cities (IWWC) project by following the research setup shown in Fig. 1. Each phase in this research setup included methodological choices which require justification. Below, the main points are described and tagged with brackets […] corresponding with the numbers of Fig. 1.

Discover phase: Here, an actual problem analysis was set prior to the design-objective (DO) and guided by a combination of secondary and primary research. It was important to set aside any prior assumptions about the problem so that the relevant circularity and inclusion requirements for an UWMS could be identified (e.g., via second-hand data derived from other studies). General insights regarding circularity and inclusion were identified from literature study and presented above in Chapters 2 and 3. Thereafter, specific characteristics of UWMSs were identified during a brainstorming workshop among six IWWC researchers.

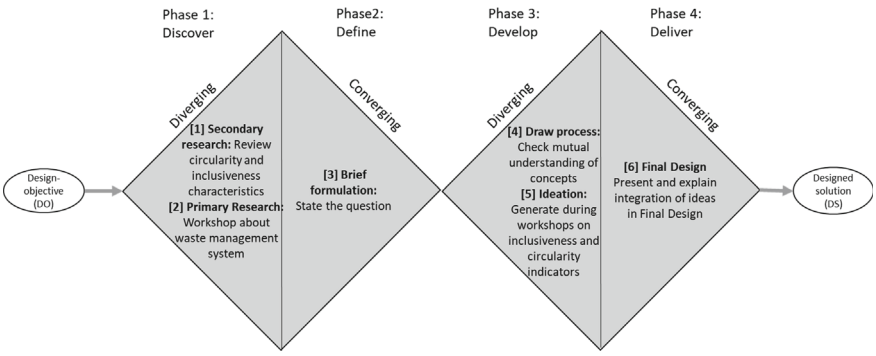

Fig. 1 Setup following the double diamond design-based research method

Define phase: During this phase the output of the discovery phase was analyzed and synthesized in pursuance of providing a clear brief. Moreover, expectations and conditions were formulated as part of the design brief.

Develop phase: This phase generated tangible ideas to lay the foundation for a design with input from the preceding phase. It required a clear target for further elaborating the ideas. We focused on the ways in which circularity and inclusion can be measured and evaluated in the ways UWMSs are operated. A fallback was organized by means of two additional workshops with members of the development team to create a common understanding around circularity and inclusion. Ideas were then generated covering the input from the define phase to the best possible degree and to assure meaningful incorporation of both circularity and inclusion related requirements in a preliminary framework.

Deliver phase: At this phase no designed elements were permanently established. Rather, topics remained subject to possible changes which allowed for further refinement before a final conceptual framework could be produced. This step helped to secure the appropriate and coherent positioning of various elements and relations within that final framework.

3 Towards a Conceptual Framework for Inclusive Circular UWMSs

In this section, we apply the four phases of the DD method to deliver a framework for inclusive circular Urban Waste Management Systems.

3.1 Discover

A broad search in the academic literature highlighted several challenges associated with the development of inclusive and circular UWMSs. More specifically, a city needs:

- *to adopt strategies tailored for circularity both from a top-down and bottom-up perspective.* The former is about implementing circular policies and directives at the local and regional levels to create an enabling environment for networked ecosystems to emerge, whereas the latter refers to the adoption of circular and regenerative business models [31] by a variety of urban actors to facilitate the effective cross-circulation of different types of resources such as materials, energy, money, and information [e.g., narrowing, slowing, intensifying, and dematerializing resources [5, 7, 24]].
- *to be able to bring on-board a plurality of actors both from the public and the private sectors* including stakeholders who are not normally considered as part of the industrial cohort (e.g., NGOs, banks, and citizens amongst others) to jointly

identify relevant opportunities and challenges in the local context. Here, transition brokers can play an instrumental role for the practical implementation of CE initiatives because they can facilitate the alignment of interests between regime and niche actors, and bolster their collaborative efforts [15].

- *to be able to measure and track circularity and foster inclusion across geographical scales*. Circularity indicators are often rather technical in orientation to address different issues at the micro-, meso-, and macro-levels. Multiple tools and frameworks are constantly being developed to meet these needs. For example, [20] proposed a systematic framework to help decision makers in selecting appropriate methods for assessing the implementation of CE strategies [4] listed thirty-five waste-related indicators and twenty-four circular economy indicators. Ten out of those indicators were categorized by the authors as dashboard indicators since they are meant to provide a summarized perspective on the performance of an UWMS within a given area.
- *to ensure that marginalized groups are not excluded or left behind*. A city can considerably improve the efficiency of its UWMS by empowering informal recyclers who with their tacit knowledge contribute substantially to the collection and recycling activities for various types of solid waste streams. In this way, they create value for their cities as key economic and environmental actors [17], they help in building resilience, and they can even help in tackling several of the UN Sustainable Development Goals [27]. Their contribution varies considerably across many low- and middle-income countries but it is difficult to quantify and generalize waste collection and recycling rates due to their invisibility in the formal economy and their stigmatization, discrimination, and otherwise, exclusion from the society at large [17, 28, 37, 56, 60]. Therefore, the inclusion of informal recyclers is crucial for the transition towards a CE but only when issues which typically include (but are not limited to) the recognition of their professions and enterprises, the legalization of opportunities, and their integration in reliable, fair, and participatory positions in discussions [46], are structurally addressed.
- *to deploy infrastructure which informal recyclers can access easily* to participate actively, and where their contribution can be sustained as a regenerative capability [33]. In this way, they can offer their selective waste collection and resource recovery services to the city while at the same time improving social cohesion [28]. Secondary markets can dictate the emergence or decline of the informal sector in a city, which are of importance as they can be more effective than the formal ways of handling waste [3]. However, the inclusion of informal recyclers in UWMSs should not merely serve the expansion of the capabilities of recycling facilities but also actively support sustainable community initiatives [54]. To offer better and decent jobs related to resource management, local authorities will need to work together with social organizations [26]. It makes sense that the design process for UWMSs only takes place before the implementation of any CE policies to facilitate the identification of potential impact and shape effective cooperation while avoiding any risks of worsening livelihoods [47].

With these key insights from the academic literature in mind, a team of six researchers held a workshop with the aim to answer three questions, emphasizing on the rationale of the framework and focusing on potentially missing elements. Those questions concerned the necessity of the framework, the required know-how, and its future application. The main points highlighted during the workshop were that such a framework should:

1. *clearly demarcate the boundaries of the UWMS*. A metaphor was made to specify what was meant by boundaries: these were likened to the human body where the skin serves as its physical boundary and its organs and bones form the infrastructure of the larger system. Here, it is important to identify which stakeholders and physical elements are part of the UWMS [e.g., by following the economy-as-an-organism analogy propositions of [36]], and to clarify which system elements are to be analyzed and which not.
2. *enable the examination of possibilities to optimize effectiveness and handling emerging trade-offs within the system boundaries of the UWMS*. Following the analogy of the human body, one would expect the framework to target the optimization of the function of certain organs which might come at the cost of sub-optimizing other parts elsewhere in the organism. In this way, additional knowledge could be generated about the systemic limits in terms of circular performance, inclusive benefits, and emerging contradictions in the function of supporting infrastructure.
3. *allow for the consideration of a plethora of metrics and indicators to capture both dimensions of inclusiveness and circularity* to the best possible degree.
4. *allow for the identification of all relevant stakeholders in the UWMS along with all relevant stocks and flows*. With this knowledge the basic architecture of data requirements can be set up. To this end, methods from socio-metabolic research (e.g., [29, 49]) such as material and energy flow analyses are invaluable.
5. *allow for the examination of the regenerative potential of the UWMS by capturing relevant network properties such as its resilience, robustness, and circulation of resources*. Such an approach has been demonstrated in the assessment of the regenerative potential of the socio-economic metabolism of a small island [65].

3.2 Define

The design brief is formulated in the form of a "how might we…?" (HMW) question, addressing the expectations and expertise needed to answer that type of question:

1. *How might we establish a framework which, if used, can make the UWMS of a city capable of fulfilling the needs to:/*
    1. bring multiple actors on board when designing an inclusive and circular UWMS;
    2. ensure that all stakeholders are empowered to contribute to urban circularity to maximize the benefits from both established and more vulnerable groups;

3. measure circularity across scales;
4. establish supporting infrastructure to realize the points made above.

2. *In order to fulfil the following tasks:*

1. define system boundaries;
2. examine how goal achievement can be optimized and trade-offs made in well-considered ways;
3. identify relevant metrics & indicators;
4. identify relevant stocks, flows & actors; and
5. evaluate the regenerative potential of the UWMS.

3. *What are the expectations and expertise needed for an answer?*

The framework should:

1. invite research based on a mixed methods approach whereby both quantitative (e.g. surveys) and qualitative methodologies (semi-structured interviews; and participatory methods) can be used to capture relevant indicators and aspects of the system which otherwise is not quantifiable (e.g., behaviors, norms, and values).
2. allow for the development of tailor-made indicators to capture particular lifecycle stages of urban projects or plans relevant to the development of the UWMS.
3. account for exclusion aspects as negative side-effects. This can be important knowledge for setting system boundaries. For example, if a certain stakeholder is not supported in participating within an UWMS, its modelled interactions in relevant stocks and flows also ceases to exist. Choices as to how to deal with the removed stakeholder or with what remains of the system after its removal should be made consciously.
4. function as a canvas to facilitate consensus on its main purpose and target audience. It could be evaluative (i.e., judging an existing UWMS with certain criteria), comparative (i.e., comparing various cases to learn from differences and similarities between different UWMSs), or design-based (i.e., a framework which helps to develop an UWMS).
5. allow for a plurality of theories and concepts to fit in (e.g., on topics around the circular society, inclusive circular economy, inclusive capitalism, de-growth, post-growth, sustainable circular economy, strong or weak sustainability, and regenerative economics amongst others).

3.3 Develop

In this section, the design brief is taken as the starting point because it combines the identified challenges at the city level with the functions that the designed framework must meet (see Table 1). First, the input from stakeholders serves as a scoping exercise to identify the system boundaries of the UWMS. Second, the goals for the UWMS in terms of circularity and inclusion are identified. This way, the potential pitfalls which

might arise from the designed UWMS can be conceptualized. Third, the relevant indicators for circularity and inclusion representative of the goals can be listed. Fourth, the desired optimization targets for the UWMS and any potentially emerging trade-offs are clearly stated. Fifth, the identified indicators will determine the data requirements and the data collection plan. This involves the collection of raw data as sources or evidence for circularity (e.g., material stocks and flows) and of inclusion or exclusion of relevant actors [e.g. social, political, environmental, economic, spatial, and cultural inclusion as identified in Chapter 3; [1]]. Finally, this process will allow for the first steps towards evaluating the regenerative potential of the UWMS, to be made.

Table 1 can be conceptualized as a network (Fig. 2), which is helpful to understand the subsequent actions below. For example, *"A: Gathering and aligning views of multiple stakeholders"* can be interpreted as a first step whereas *"6: evaluation"* is the final step. In between, there are other operationalization steps which involve the identification of stocks and flows, the identification of metrics and indicators, the testing of possibilities of a solution space for the framework, and the examination of the optimization potential and trade-offs.

Table 1 can then be conceptualized as a sequence of steps (Fig. 3) to cover clear themes. The first step is the engagement of multiple key stakeholders and align their views on common goals. Thereafter, the design of the UWMS can be planned by specifying the scope in terms of its system boundaries and the quantitative model requirements in terms of indicators and data. These steps serve as a preparation for designing and measuring the performance of an UWMS.

Once a preliminary version of the UWMS design is proposed, in the next steps its performance relative to the desired optimization goal and the potential emergence of trade-offs can be assessed. Both the model examination and the real-world engagements are also conceptualized to allow for the evaluation of the regenerative aspects of the UWMS. The evaluation (step 6) is useful for an assessment of the overall performance of the system and can serve as a feedback loop should a need to *"recalibrate"* it arise (steps 7a and 7b). This overall process takes the form of a Plan-Do-Check-Act cycle.

During this cycle, it is important to first identify the *"hardware"* and *"software"* elements constituting the UWMS. The former consists of waste handling and treatment facilities including waste collection, upcycling sites (green points), recycling and reprocessing factories, waste-to-energy plants, and landfills. The latter refers to intangible aspects which guide the process of waste management, such as waste management policies, standards on soil protection, secondary materials, and air quality, promotion activities for desired citizen behavior (e.g., dry separation at the source), the use of relevant software, and extended producer responsibility schemes. Software elements are important as they can largely influence participation rates in the UWMS.

Table 1 Challenges and required functions for developing the framework

No	Necessity for framework Description of challenges (summary of table 2)	Define system boundaries	Examine optimization options	Examine potential trade-offs	Identify relevant metrics & indicators	Identify relevant stocks, flows & actors	Evaluate regenerative potential
1	gathering and aligning the views of multiple stakeholders	X					
2	achieving circularity and enjoying inclusiveness benefits for all stakeholders			X			
3	measuring and quantifying circularity across scales		X		X	X	
4	empowering and facilitating the participation of marginalized groups		X		X	X	
5	establishing supporting infrastructure to prove and improve the capability of marginalized groups		X	X		X	X

3.3.1 Exploring Indicators for Circularity

Indicators for circularity at four different levels

During the workshop, it was acknowledged that circularity can be quantified at various levels, i.e. at the *nano level* (referring to products), *micro level* (company or local level), *meso level* (business ecosystems or regions) and *macro level* (referring to the system-of-systems, or national or international level) [20].

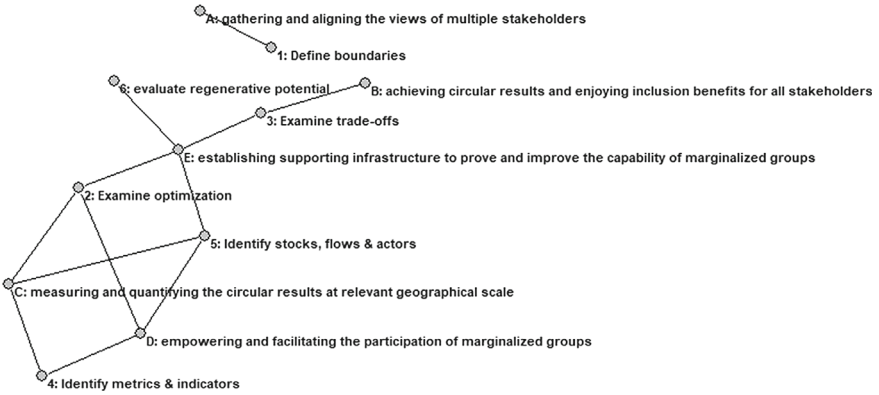

Fig. 2 Connections between description of challenges and necessity for framework

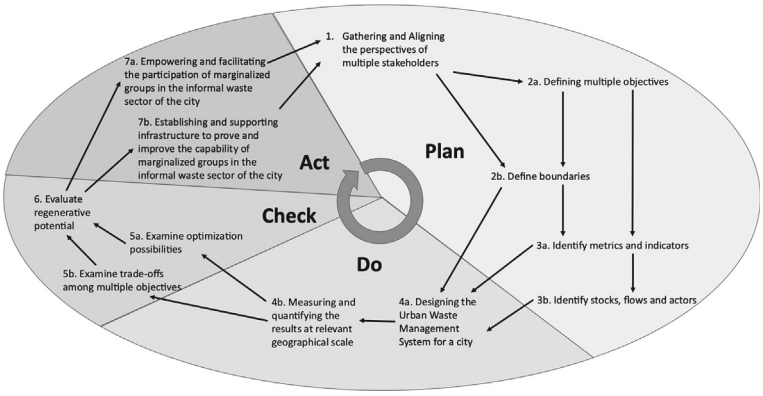

Fig. 3 Methodology for developing inclusive and circular UWMSs

The nano level aims to address the circularity of products: measurements should capture the implementation of closing, slowing, narrowing, and dematerializing loops, all efforts can help track possible reductions in material use.

At the micro level, Life Cycle Assessment (LCA) can be useful for quantifying the social, environmental, and economic impact of various products (e.g., raw material extraction, production, usage of product, and end-of-life management). Moreover, the level of 'demountability' of assets, products, or resources that a company or a local actor works with could be used as a proxy of the agency of an actor to quickly divest certain activities.

At the meso level, material flow analysis can be used to estimate the quantities of materials flowing from one destination to the next, thereby separating their quality in terms of sustainable or circular origin (e.g., with recycled input, or as output planned for reuse). Through industrial symbiosis, eco-innovations can improve mutually beneficial transactions between stakeholders [34]. For individual actors

in the emerging ecosystem, two types of responsibility were identified: corporate social responsibility refers to the stakeholder-oriented behavior of corporations to be socially responsible and improve stakeholders' welfare (Liang and Renneboog 2017). Useful indicators for this concept include the provision of employee benefits or environmentally friendly investments. Extended producer responsibility schemes make producers accountable for the environmental impacts throughout the life cycle of products (Gupt and Sahay 2015). There, a potential indicator could be the number of actors in an ecosystem vowing for such responsibility, and the number of visible activities that can be witnessed to curb expired products from becoming waste.

Finally, at the macro level, indicators such as the circular material rate (CMR) of the European Union [22] tend to be used to monitor progress in the transition to a circular economy.

Capturing the circularity for UWMS

Circularity indicators can be categorized in terms of context and content.

Context indicators describe the system from afar, at various scales. At the largest scale, this involves the LCA of the entire resource flow from cradle to cradle/grave, irrespective of system boundaries. Content indicators target the flows up close, both outside and inside the UWMS.

A few indicators address actors in UWMSs. The number of corporate declarations in annual reports is an example of an indicator for capturing aspects of corporate social responsibility. The extent of the materials life cycle that producers haul back beyond the sales (e.g., amount of material that actors have returned into their possession after previously sold products are discarded by their customers) is an example of an indicator which can capture aspects of extended producer responsibility schemes.

3.3.2 Exploring Indicators for Inclusion

The discussion on what inclusion really is gave rise to two different points of view. On the one hand, it was thought to refer mainly to 'everyone benefiting equally of something' and to 'treating people equally without exception'. On the other hand, inclusion was described in terms of participation. This distinction helped to organize the answers to the second question.

The Gini-coefficient is a statistical measure that expresses the inequality between values (like income, wealth or consumption) along a frequency distribution for countries or certain social groups [61]. The Palma ratio expresses the ratio of the share of all income that is received by the 10% richest people divided by the share of income received by the 40% poorest people [39]. The Theil index is used to measure economic inequality and has its origin as an entropy-based metric [13]. The Inclusive Wealth Index differs from other metrics in that it does not focus on Gross Domestic Product but expresses values which measure whether a country develops in a way which allows future generations to meet their own needs with the accumulated wealth (UNEP 2018). This indicator comes close to how the original sustainability definition by Brandt (1988) was intended as passing on the earth to future generations. The Human Development Index (HDI) was developed by the UNDP to emphasize

that people and their capabilities should be the ultimate criteria for assessing the development of a country (UNDP 2023). It combines all kinds of social aspects of a country's people in a composite index, like life expectancy, education, and per capita income. This metric has been updated and adjusted various times. The latest time was in 2010, when it was introduced as the inequality-adjusted HDI, or IHDI. This new version corrected for differences in inequalities in a country meant to reflect the actual level of human development, whereas the older version was only focusing on the potential that a country could develop if there were no inequality (UNDP 2023). The Multidimensional Inclusiveness Index (MDI) was introduced by Dorffel and Schuhmann [18]; it is composed of two sub-indices, one on development equity and development achievements. These contain an aggregation of 14 variables in these subindices, which better reflect trends that result from major political events and distinguish regional development patterns.

Alternative ways to measure inclusion were mentioned when adopting the participation-oriented point of view. In S-LCA, one can find other indicators such as Access to material resources, Access to immaterial resources and Community engagement. Affordability of goods and services to all people in the population was mentioned as a generic measure. This requires knowledge of the relative relation between what should be affordable and to what extent this needs financial sacrifice in the wallet of the individual. The Big Mac Index (as a specific affordability measure) was first quantified in 1987 by the Economist as the price difference of a burger from McDonalds in different countries to measure the purchasing power parity between countries' currencies [19]. Accessibility to resources was described as a means to measure the access to information, knowledge, and social groups among others. The participation rate describes the relative proportion of people engaged in an activity. Employment rate was mentioned and describes the extent that available labor resources are actually used (OECD 2023). The consideration rate was also mentioned and explained as a certain effectiveness of a policy to include stakeholders in its intended effects. In absence of a clear definition by an established institution, it was exemplified through criteria that assured the weight of certain stakes in the decision-making process. In the workshop, also the presence of formal recognition was mentioned. This had no established statistic but was meant to capture the degree to which certain activities or initiatives in a city are officially recognized. The level of institutionalization captures the extent of a formal status of an activity or initiative. The veil of ignorance is related to the ability of an individual to imagine the position of another [44]. The level of sharing was discussed as a means to consider how much of the time a product is shared and used [63].

Capturing inclusion with regard to UWMSs

Here too, indicators are categorized in terms of context and content.

Context indicators are meant to describe the socio-economic context of a city. Examples include the Inclusive Wealth Index and the Theil index. These indicators capture either a narrow economic scope (e.g., Palma ratio and Gini coefficient) or a broader societal scope (IHDI and MDI).

Content indicators describe measurements which can be influenced by local waste management policies. This category covers participatory aspects, for example,

the presence of formal recognition of an organization or the consideration rate of marginalized groups during decision making. In this regard, inclusion indicators could be recognized for their differences in more active municipal influence (e.g. participation rate and level of sharing) or passive municipal influence (e.g. level of institutionalization and veil of ignorance).

Figure 4 shows the system boundaries, actors, resource flows, and indicators useful for the development of inclusive and circular UWMS. It shows the actors in the center as part of the formal waste sector with input and output flows (which can be described by the circular symbiosis indicators and circular actor indicators). The municipality is the dark grey layer that includes the formal sector. The municipality decides how it wishes to manage the formal sector by its inclusion-related policy indicators. The informal sector may be scoped outside of the municipalities control or consideration. Therefore, the informal sector is highlighted in light grey. The municipality manages the consideration of the informal sector by the inclusion-related context indicators. In essence, the circularity can be measured for this entire configuration of this UWMS system, through the proposed circularity context indicators, start and end of loop indicators.

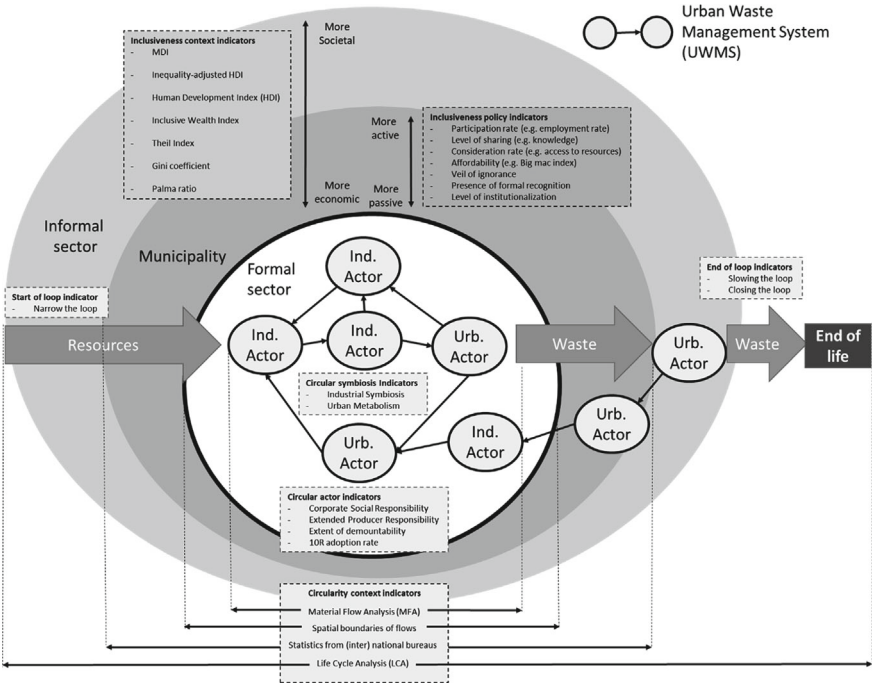

Fig. 4 System boundaries, actors, resource flows, and indicators useful for the development of inclusive and circular UWMSs

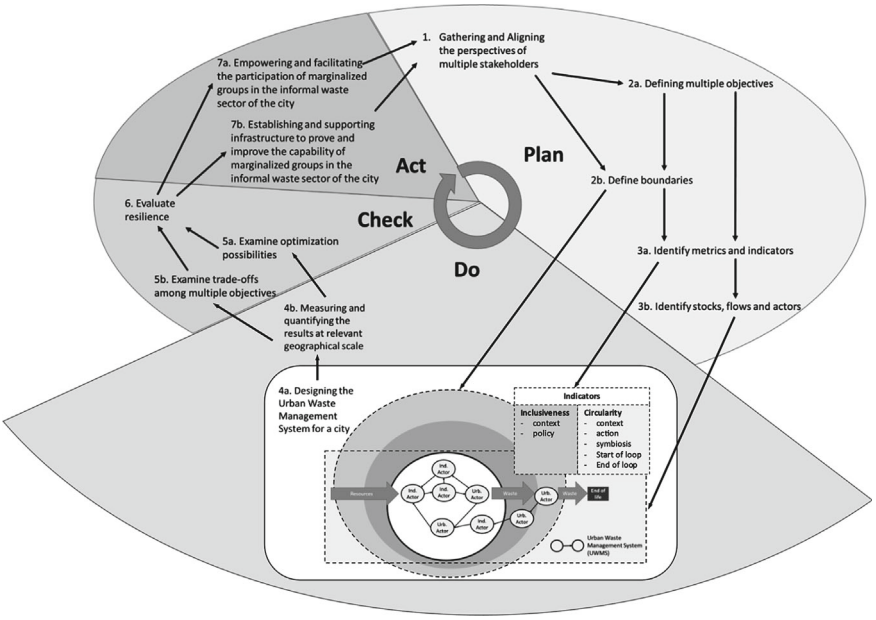

Fig. 5 Final design

3.4 Deliver

Here, we synthesize the previous insights from the workshops into a holistic framework schematically representing the various elements and indicators that could be used for developing an inclusive and circular UWMS. Figure 5 shows the framework integrating the process of the development and the design steps.

Synthesis is relevant for steps 2b, 3a, 3b, 4a and 4b. First, inputs for the UWMS need to be defined. Step 2b describes the system boundaries of the UWMS system. This is relevant to understand the jurisdiction for the municipality to manage its UWMS and to define the extent to which the municipality could integrate the informal waste sector. Step 3a identifies the relevant metrics and indicators based on the identified objectives (step 2a). Step 3b describes the specific flows, stocks, and actors that are part of the UWMS.

Step 4a allows the simultaneous consideration of the current actors, stocks, and flows, and how these make up the current UWMS system. Step 4b describes the relevant data to be collected and the relevant indicators to be measured and quantified. These results can then be fed into the check stage for optimization and trade-offs, and consequently for the evaluation of the regenerative potential of the UWMS.

4 Concluding Remarks

Both circularity and inclusion are important for characterizing any Urban Waste Management System (UWMS). Circularity indicators emphasize the monitoring of resources and waste flows running through a city and its UWMS. Inclusion may not only improve its circular capability, but it also boosts the social cohesion and regenerative potential of a city. Regeneration here is understood both in terms of increased availability of raw materials and in terms of agency provision to a plurality of stakeholders for collaborative learning and capacity building. The framework developed above offers a basis for improving UWMS with more complimentary solutions for circularity and inclusion allowing for further consideration of additional concepts that emerge in the literature such as that of the circular society [9, 10, 16].

The framework, however, has strong references to the Dutch waste management context which the authors of this chapter know best. Therefore, one critical limitation concerns the fact that different countries reveal different societal contexts, and these should be accounted for, *mutatis mutandis,* when applying it there. For example, the urbanization rate, the state of waste disposal, and type of environmental hazards can vary enormously across countries. Nonetheless the Double Diamond (DD) approach with its four sequential steps is, to our knowledge, largely universal in its applicability and many of the theoretical insights and indicator suggestions may need to be reconsidered, validated and calibrated in new institutional contexts and contents but will preserve their general applicability. The framework that emerges for this DD approach captures various aspects of circularity and inclusion in a city, yet it is agnostic towards the type of waste addressed. At the same time, it acknowledges that both dimensions have local as well as global consequences where the implications for different types of waste can be very different as they might be having their own sub-system configurations within an UWMS.

Appendix 1 Definitions of inclusiveness

Definition quotes	Authors	Year	Outlet
Inclusiveness is a **multi-dimensional concept** that needs to be unbundled before its connection with creativity is firmly established. Various tensions can arise when cities decide to adopt both creative city and inclusive city branding and urban policy initiatives	Alsayel, de Jong, Fransen	2022	Cities

(continued)

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Definition quotes	Authors	Year	Outlet
Principle of inclusiveness is the **idea** that healthcare staff and service users hold unique and valuable knowledge that can inform learning, as well as the notion that learning is a social process that involves people actively reflecting on shared knowledge. Despite initiatives to facilitate inclusiveness, research shows that embracing and learning from diverse perspectives is difficult	Kok, J., de Kam, D., Leistikow, I., Grit, K., Bal, R	2022	Health Care Analysis
Inclusiveness is multidimensional and comprised of spatial, social, environmental, economic, and political dimensions in which the characteristics of participation, equity, accessibility and sustainability are sometimes interwoven	Liang, D., De Jong, M., Schraven, D., Wang, L	2022	International Journal of Sustainable Development and World Ecology
The **principle** of inclusiveness in urban design which bears the meaning of "space for all" ensures the fulfillment of this aspect. Inclusiveness is one of the indicators of the Sustainable Development Goals (SDGs), and the same principles applies to Indonesia through the Decree of the Minister of Public Works number 5 year 2008, which includes the provision of green open spaces in order to launch Indonesian citizens' livelihood towards an ideal quality	Hariyani, D.S., Pratama, A.R	2021	IOP Conference Series: Earth and Environmental Science
Inclusiveness is a **key factor** for both job satisfaction and willingness to recommend, whilst innovation prone organizations appear to be the most attractive for nurses. The levers mix is slightly different among the age classes	Vainieri, M., Seghieri, C., Barchielli, C	2021	Health Services Management Research
Designing for inclusiveness is a complex and challenging activity that requires the adoption of a specific inclusive design process to create human-centred solutions based on user desire and needs	Canina, M.R., Parise, C., Bruno, C	2021	Lecture Notes in Networks and Systems

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Definition quotes	Authors	Year	Outlet
Inclusiveness is largely shaped by domestic politics, pre-existing institutions and power relations, as well as the resources, capacities and prior experiences of civil society and subnational governments. In practice, the SDGs' emphasis on inclusiveness does not necessarily mean that a wider range of perspectives are taken into account in domestic contexts	Siegel, K.M., Bastos Lima, M.G	2020	World Development
Inclusiveness is a **key theme** in scholarship on Responsible Innovation (RI) and Responsible Research and Innovation (RRI). RI/RRI researchers make a strong case for involving stakeholders into science and innovation processes	Koch, S	2020	Journal of Responsible Innovation
Inclusiveness is conducive to expanding the connotation of urbanization quality, which could provide guidance for improving the quality of urbanization	Yu, W., Zhao, L	2018	Chinese Journal of Applied Ecology
Inclusiveness is essential to deliberative democracy, but factors influencing citizens' willingness to participate in deliberation need to be better understood	Jennstål, J	2018	European Political Science Review
Inclusiveness is the **process** of valuing, respecting and supporting members of an entity. Resilience in permanent organizations can be defined as the capability to respond to and prepare for disruption and thus, promote business continuity	Blay, K	2018	Construction Research Congress
The **notion** of dynamic inclusiveness is framed in terms of imagined normative allocations of the inter-temporal product of growth, as dictated by notions of equity of varying orders of demandingness	Jayaraj, D., Subramanian, S	2012	Economic and Political Weekly
Inclusiveness is the **growth mantra** for policymakers today - not just in India, but the world over	Das, K	2010	Journal of Rural Development
Inclusiveness is a **way** to increase efficiency in city management and service delivery across urban and peri-urban areas. New norms of practice and reform of institutional procedures in cities is dependent upon strengthening modes of inclusive urban governance	McCarney, P	2010	Peri-urban Water and Sanitation Services: Policy, Planning and Method

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Definition quotes	Authors	Year	Outlet
Inclusiveness is an important **principle** of a country's democracy and can encourage citizens to participate in politics	Kittilson, M.C., Schwindt-Bayer, L	2010	Journal of Politics
By inclusiveness is meant the **existence of mechanisms**, formal or informal, to extend terms and conditions negotiated by workers with strong bargaining power to workers with less bargaining power	Salverda, W., Mayhew, K	2009	Oxford Review of Economic Policy
Inclusiveness is a matter of definition and **process** that has been encountered in other foresight style activities where the opinions of the polity need to be taken into account	Loveridge, D., Street, P	2005	Foresight
Based on a historical review of successive conceptualizations of development, his case for "inclusiveness" is a **plea** for correcting this asymmetrical process striking a better balance between economic efficiency, decent work and environmental protection	Sachs, I.2004	2004	International Labour Review
At the heart of optimal distinctiveness theory is the idea that a group's level of inclusiveness is a **significant determinant** of how well that group can meet members' needs for assimilation and differentiation	Pickett, C.L., Silver, M.D., Brewer, M.B	2002	Personality and Social Psychology Bulletin
Using SASA as the basis for our discussion, we argue that inclusiveness is inextricably tied to discourses about democracy, which privilege the notion of participation, through which it is assumed inclusiveness will be achieved in ways that are considered to be appropriate. We demonstrate that rather than actually realizing the full extent of inclusiveness made possible by the new Constitution, SASA circumscribes such inclusiveness in ways that may potentially marginalize the historically marginalized in South Africa (inter alia, black, working-class and rural people), and rather than redressing past inequities, may perpetuate and further exacerbate them	Sayed, Y., Carrim, N.1998	1998	International Journal of Inclusive Education

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Definition quotes	Authors	Year	Outlet
Inclusiveness is increased when teachers expose students to: (a) historical theories that demonstrate early respect for diversity and the role of sociocultural events in personality formation, (b) recent reformulations of traditional theory, (c) feminist approaches that focus on the relational elements of development, and (d) cognitive developmental perspectives that value desires for related-ness and strivings for independence	Enns, C.Z	1989	Teaching of Psychology

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