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A Collaborative Approach for Triggering Environmental Awareness: The 3Rs for Sustainable Use of Natural Resources in Ulaanbaatar (3R4UB)

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Abstract: Current environmental challenges invite us to deeply revise policies, governance models, and resource management toolkits towards a circular approach, in order to meet Sustainable Development Goals (SDGs) requirements. In this framework, circular waste management is one of the pillars of responsible and foresighted planning for territorial sustainability. The "3Rs for a sustainable use of natural resources in Ulaanbaatar" (3R4UB) project aims at transferring a sustainable approach to urban solid waste management, especially focusing on providing effective opportunities for developing circular supply chains locally. In this framework, an integrated approach has been developed in order to adapt the communication/exploitation plan of sustainable waste management within a SWITCH-Asia Country (EU Program) by combining engagement tools and participatory processes for the collaborative design of a waste management masterplan. This paper explores the spatialization of resources/waste flows in the formal and informal settlements, while also considering cultural traditions, social structures, and community habits, in terms of a purposely designed combination of spatial planning, governance modeling, and capacity building activities. Starting from a preliminary communication plan, this paper sets the frame for discussing the role of community engagement tools and protocols in producing an effective and generalizable collaborative waste management masterplan.

Keywords: waste management; civic engagement; collaborative governance; sustainability; EU SWITCH-Asia; Mongolia; Ulaanbaatar; 3Rs

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1. Introduction

This paper presents the ongoing results of one of the pillars of the "3Rs for a sustainable use of natural resources in Ulaanbaatar (Mongolia)" (3R4UB) project, led by the Institute for Research on Innovation and Services for Development (IRISS) of the National Research Council of Italy (CNR). This project—funded within the EU SWITCH-Asia program—aims at developing and transferring a site-specific sustainable approach to urban solid waste management, especially focusing on providing effective opportunities for developing circular supply chains in the target area of the Mongolian capital city Ulaanbaatar. The target of 3R4UB is to provide Ulaanbaatar with a co-designed masterplan for waste management and to enhance environmental awareness by adapting collaborative tools for civic engagement and capacity building.

According to the aims of the EU SWITCH-Asia funding program, a combined action of research, knowledge transfer, training, and civic engagement has been developed and delivered in order to contribute to capacity building and local empowerment towards sustainable development goals. In this framework, the research focuses on the spatialization

of resources/waste flows in the formal and informal settlements, while also considering cultural traditions, social structures, and community habits, in terms of a purposely designed combination of spatial planning, governance modeling, and capacity building activities. Enhancing technical knowledge, integrating the multilayer structure of the waste management technical organization within the urban master-planning, and supporting the development of a collaborative approach in rising and spreading environmental awareness are the main tasks the research group planned with the local institutional partners.

In so doing, an integrated approach has been developed in order to adapt the communication/exploitation plan of sustainable waste management within the SWITCH-Asia Country by combining engagement tools and participatory processes for collaborative design of the waste management masterplan. Environmental issues have been addressed from a stakeholder networking perspective by developing a multilayer circular adaptive civic engagement model, aimed at raising awareness and enhancing the efficiency and effectiveness of local policies within a waste management process project.

The background of the tailored model which the 3R4UB project is developing refers to the scientific debate regarding environmental crises and related societal challenges, starting from the comprehensive framework of the Sustainable Development Goals (SDGs) (https://sdgs.un.org/goals accessed on 6 August 2023). The well-known UN SDGs initiatives are the words of reference for encouraging the implementation of sustainable policies, strategies, programs, and projects by combining global awareness and local actions. The 17 Goals—including 169 Targets, 3806 Events, 1344 Publications, and 7440 Actions that are currently in progress (https://sdgs.un.org/2030agenda accessed on 6 August 2023)—have been deeply studied in their overlapping and cross-sector implications [1]. Within the 2030 Agenda for Sustainable Development implementation process, the SDGs are integrated and indivisible, according to the economic, social, and environmental dimensions of sustainable development. The integrated and intertwined nature of the SDGs needs to be mirrored by national development plans or sustainable development strategies. Under the umbrella of each sustainable development goal, scholars highlighted the need for a systemic perspective to reverse a command-and-control approach to environmental protection into a proactive and collaborative planning of resources in terms of ecosystem services and environmentally aware lifestyles [2]. A systematic literature review focusing on economic impacts and engagement opportunities provides evidence of a generalized interest in research theme clusters related to technological innovation, firms making contributions in developing countries, non-financial reporting, and education for SDGs [3]. "Among the domains that must be worked on to reach the SDGs, waste management in the present day Built Environment (BE) is a domain that has been found to be significantly involved in achieving the SDGs and ensuring a sustainable future" [4]. This relationship with the SDGs in general and, more specifically, the analogy of the guiding principles of UN-SDGs with that of circular economy (CE) solid waste management, refers to public health (SDG 3), environmental issues (SDGs 6 and 13), resource value (SDG 11), and climate change (SDG 13) [5,6]. Actions related to SDG 14 (marine issues related to the indiscriminate use and disposal of plastic waste) need to deal with waste management and its environmental and economic costs. Waste management can be considered as the main utility system in urban infrastructures that traces the divide between developed and developing countries, affecting more than two billion people [7]. According to Rodic and Wilson, the main challenges in addressing the sustainable development goals are to be dealt with in less developed contexts [7]. In developing countries with a fragile ecological environment, such as Mongolia, existing studies are highlighting the urgency to better understand the relationship between the ecological/environmental impacts of economic development in order to protect the socio-ecological system and the local communities at risk because they are dependent on it [3]. In fact, Mongolia is a country where tensions between economic development and environmental conservation are evident [8].

According to the geopolitical perspective outlined by the philosopher Bruno Latour (2017), "terrestrial" is the horizon of a revised way for (inter)acting with the Earth that

rebels [9]. Observing the relationships among climate change issues and environmental challenges, a fresh perspective on the "contract" with the Earth as a third actor in the ecological and territorial transition is needed. "Landing" on the territory to meet new requirements for a land use and consumption model in order to promote regenerative processes creates demands for us to enhance public awareness regarding natural resources management as a whole [10]. This perspective no longer embraces the concept of the Earth as a background for human activities and as a surface for human settlements, but rather "the earth takes part in this scenario of human action as an agent/actor of a new political interplay between the geosphere, sociosphere, and biosphere" [11]. As outlined by Swyngedouw (1996), at the biosphere level a metabolic process of commodity consumption and circulation is the common ground for everyday life activities and (natural, cultural, and social) capital accumulation [12]. Towards urban sustainability, a reconciliation of divergent positions is needed to overcome the conflict between a vision of the city as a driving force behind the environmental crisis and at the same time as a "socio-technical system capable of elaborating innovative responses to such crisis" [11].

Recently, the circular economy conceptualization adapted at urban scale has been considered as a way to manage this twofold nature of the city. At urban scale, this approach aims to increase the efficiency of resource use by promoting the adoption of closing-the-loop production patterns. Circularity thus by focusing on urban and industrial waste implies a balance between sustainable production patterns, consumer responsibility and awareness, renewable resources and technological innovation, and long-term policies and funding tools. "The lesson learned from successful experiences is that the transition towards Circular Economy (CE) comes from the involvement of all actors of the society and their capacity to link and create suitable collaboration and exchange patterns. Success stories also point out the need for an economic return on investment, in order to provide suitable motivation to companies and investors" [13]. From the environmental and urban planning perspective, the need for applying a CE approach to urban metabolism life cycles encourages us to revisit approaches and tools for waste management in terms of civic infrastructures [14,15]. In this framework, circular waste management is one of the pillars of a responsible and foresighted planning for territorial sustainability [16]. The way waste management is integrated within collaborative planning processes influences the environmental management and the free-riding extractions within the common pools of natural resources, such as interpreted by Elinor Ostrom in discussing Hardin's theory [17,18]. The environmental impacts of pursuing personal interests versus common interests is a widely explored topic and is relevant for reflecting on the collaborative profiles and entanglements among communities as background for providing informed and informing environmental planning processes [19,20].

Moreover, the stakeholders' role in promoting responsible behaviors, from both producer and consumer perspectives, is coupled with longsighted, collaborative, and stable decision-making processes. The latter is a major challenge in developing countries that are lacking in structural waste management protocols as well as in public awareness regarding the 3Rs approaches: reduce, reuse, recycle [15,21–23].

The 3R4UB research and cooperation process offers the opportunity to explore integrations among the waste management planning, the civic engagement process, the stakeholder listening campaign, and the green funding modeling. Public awareness campaigns are typically based on the promotion of scientific information and existing solutions, while communication is focused on changing peoples' behavior. The international research group aims to explore a new approach in which communication and science are used as tools to foster cooperation between citizens and government agencies. The goal of this approach is not only to encourage people to adopt a new behavior—waste recycling, for example—but rather, encourage people to cooperate with one another and other stakeholders (collective action) to reinforce the "community" for building social resilience. Starting from a preliminary communication plan, this paper sets the frame for discussing the role of

community engagement tools and protocols in producing an effective and generalizable collaborative waste management masterplan.

This paper is structured as follows: after setting the context by introducing the project aims as a whole, the communication/participation plot, and the study area (Section 2), it presents the results (Section 3), and discusses them (Section 4) in terms of civic engagement, participatory process, and capacity building. Conclusions and recommendations include steps towards a tailored policy design to be shared with Asian Countries included in the European Union Program SWITCH-Asia.

2. Materials and Methods

2.1. The 3R4UB Communication Aims and Approaches at a Glance

The 3R4UB project has been funded under the umbrella of the European Union Program SWITCH-Asia whose mission is to support the transition of Asian Countries to a low-carbon, resource efficient, and circular economy while promoting sustainable production and consumption patterns. Since its establishment in 2007, the program invested nearly EUR 300,000,000 towards promoting sustainable consumption and production (SCP) in Asia and Central Asia by funding 143 projects over a period of 15 years. These projects have been developed by over 500 Asian and European non-for-profit partners, about 100 private sector associates, and 80,000 Asian micro, small, and medium-sized enterprises (MSMEs) (www.switch-asia.eu accessed on 6 August 2023).

According to the EU Directive 2008/98/EC (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098 accessed on 6 August 2023), the 3R4UB project aims at providing a robust circular model for waste management and an innovative civic engagement process. By cooperating with the City of Ulaanbaatar (UB) and local MSMEs, the model will be validated through a Pilot Demonstration. In terms of capacity building, by working alongside the Mongolian Government Agency Fresh Water Resources and Nature Conservation Centre (FWRNCC), the research group opened a dialogue with local stakeholders and communities (Figure 1).

Figure 1. Integrated partnership of the project. Applicant and coordinator CNR IRISS—National Research Council of Italy, Institute of Research on Innovation and Services for Development (Italy); Partners Metellia Servizi (Italy); Municipality of Ulaanbaatar (Mongolia); FWRNCC—Mongolian Government Agency Fresh Water Resources and Nature Conservation Centre (Mongolia).

Within the framework of the cooperation program, the Italian interdisciplinary public research body CNR IRISS carried out a multi-level activity with its European and Asian partners. The peculiarity of the funding program requires an approach that integrates research with knowledge transfer, capacity building, and policy design activities. Cooperation has been interpreted by the Italian research group as an opportunity for mutual learning, for cultural exchange, and for capacity building through knowledge transfer, instead of technology transfer and services provider.

The pillars of the research are governance, capacity building, and collaborative planning for an innovative Smarter Consumption Plan through knowledge-sharing and co-design approaches, involving a wide range of stakeholders and the wider community towards innovative and competitive solutions for UB's societal and environmental problems.

The project activities synthesized in Figure 2 include (1) a waste management masterplan under the 3Rs (reduce, reuse, recycle) motto, to be tested through a (2) pilot project (waste sorting plant and collection of sorted waste in 15 schools of UB), as well as a (3) training program to reinforce technical competences and skills among MSMEs and Local Administrations about circular waste management. A (4) "green" financial toolkit will be developed in cooperation with economic players in order to support long-term initiatives for the implementation of the masterplan. This financial support action includes a feasibility study to promote public-private partnerships to support green-fund investments. The (5) communication-participation plan is a transversal activity, intertwined with each step of the project, targeting the following players and beneficiaries: 25,000 students and their families involved in the pilot initiative, 150,000 inhabitants of Ulaanbaatar, NGOs active in the area, technical stakeholders such as waste management public officers, scholars and professionals in the field, and MSMEs in the waste sector and financial and industrial investors.

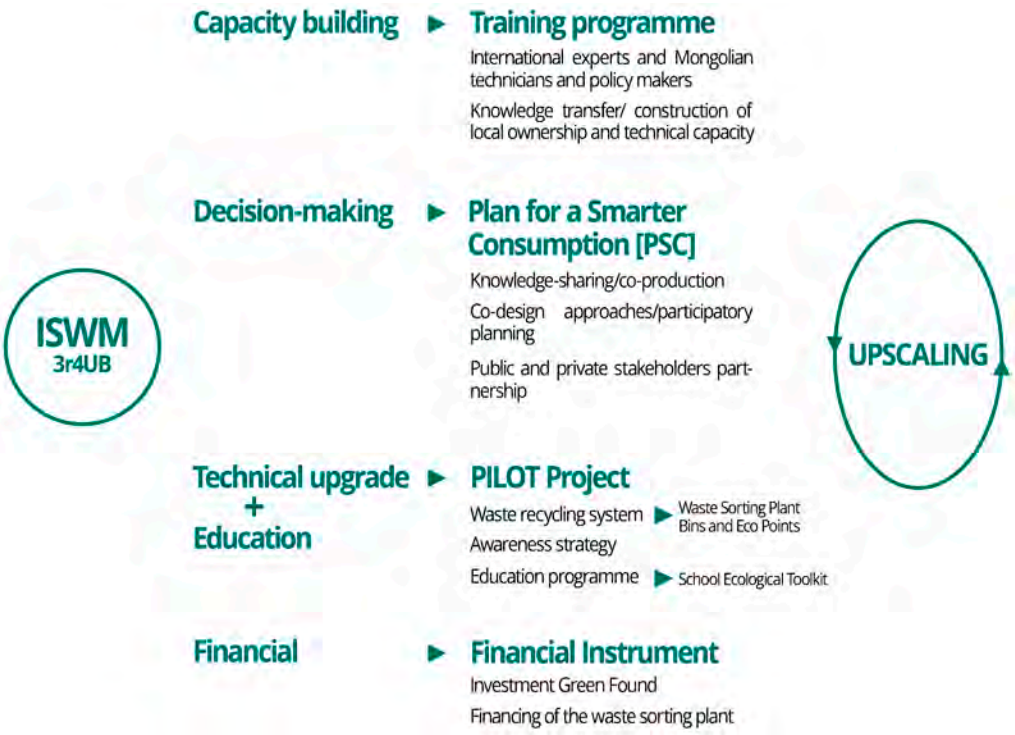

Figure 2. Synthetic scheme of project activities.

The expected results of the project can be summarized as follows:

- Improving the technical, financial, and administrative capacities of the Ulaanbaatar Waste Management Department to develop and implement a Plan for Smarter Consumption in Ulaanbaatar.

- Strengthening dialogue among stakeholders in the decision-making process on sustainable consumption policies through consultation, coordination, and cooperation.
- Improving the quality, delivery, and efficiency of waste management services developed by local MSMEs.
- Enhancing the capacities of Local Administrations in managing urban waste and air pollution by purposely designed training activities.
- Improving the circular economy driven by green, low carbon, and climate resilient development.
- Improving local public-private partnerships and funding opportunities in the field.
- Strengthening general awareness about waste prevention, reuse, and recycling.
- Due to the COVID-19 pandemic and the containment policies worldwide, the project had to deal with several issues and to adapt the timetable to a working-from-afar condition. Just as in the majority of field work activities, the engagement initiatives started by the Italian research group with the local partners have suffered setbacks during the different stages of lockdown policies in both European and Asian Countries. The four-year timespan (2020–2024) of the project and the fieldwork activities have been adapted to the unpredictable changing conditions (Figure 3).

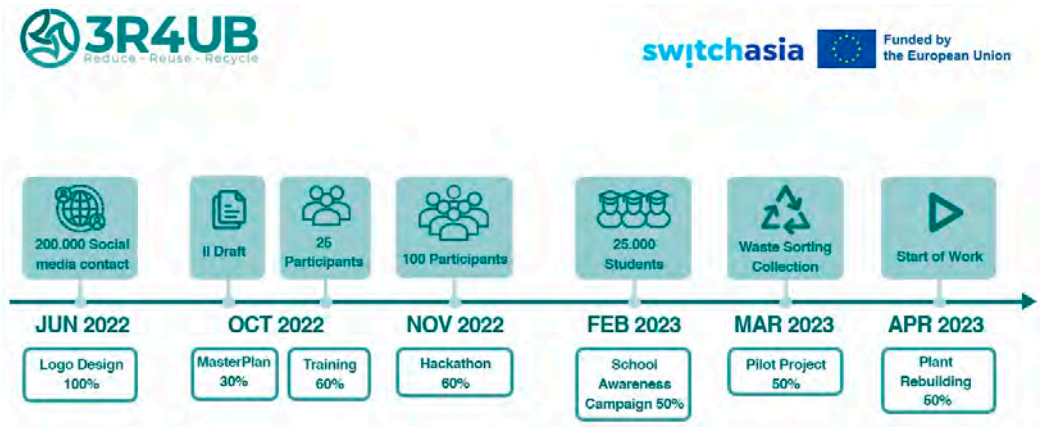

Figure 3. Project timeline. Where we are and where we want to achieve current activities.

According to an Integrated Sustainable Waste Management Model (ISWM), three dimensions can be recognized in analyzing, implementing, or changing a waste management system in developing countries [24]. The mentioned dimensions are the stakeholders interested in waste management, the different stages of materials flow from waste generation to treatment, and the perspectives through which the system is analyzed [25].

Several authors highlight that in addition to the above-mentioned dimensions, the engagement of communities and individuals as waste generators should be considered as a priority to allow larger behavioral shifting in waste production and recycling [7,26–32], considering also that household waste represents a large part of municipal waste composition in developing countries [33,34].

Therefore, the effective engagement of public and private stakeholders and individuals as waste generators is a priority to achieve improvements in the technical, environmental, financial, legal, and social aspects related to waste management [28,35]. The stakeholder's category selection is relevant to better address a topic in which perceptions, lifestyles, and trends supports overcoming the obstacles and everyday efforts needed to achieve adequate results in implementing the circular 3Rs approach [36]. It is also relevant for addressing a smooth and efficient chain of responsibility by engaging key stakeholders for developing a critical mass in a participatory process while avoiding the risk of tokenism [37]. The evolution of Arnstein's ladder of participation towards models of co-production and inclusive planning highlights the need to address the political and economic power inequalities that shape local decision-making. It is crucial for an effective participation to ensure processes that are capable for establishing more equitable partnerships between

multiple stakeholders and communities, thus overcoming the political and economic power differences between stakeholders that limit community influence over local decision-making and outcomes [38].

Stakeholders are defined as individuals, groups, or organizations that are interested and can have action or are impacted by a certain activity, project, or initiative [39,40]. Therefore, stakeholder engagement can be understood as a way to co-create knowledge aimed at influencing changes at different levels depending on the specific role or interest played by the actors engaged related to the waste sector (e.g., decision-making, technical management, industrial chain) [41].

Community engagement refers to the process of actively collaborating and working together with groups of individuals who share a common geographic location, specific interests, or similar circumstances [42]. The purpose is to collectively address and tackle issues that have an impact on the overall welfare and well-being of those individuals. This collaborative approach recognizes the importance of engaging and involving people who are directly affected by the issues at hand in order to find effective solutions and promote their overall well-being [43].

In order to ensure long-lasting positive effects, both stakeholder and community engagement implies a strong collaborative approach to involve the main players of the waste sector to shift the traditional system of management and to engage communities in a behavioral change that implies a shift of conventional mindsets [28].

In fact, it is key to involve individuals in more responsible behavior, environmental education on sustainability, and ways to sort waste in order to trigger community commitment to participate in attaining the policy's target and improve the willingness to adopt sustainable behaviors such as waste-sorting.

Pillars for both stakeholder and community engagement for an integrated sustainable waste management are considered including capacity building, awareness, and education. These aspects can be developed through a combination of approaches, including community participation, public-private partnerships, knowledge transfer and collective learning, incentives, and international cooperation [44–47].

The following paragraph introduces the study area of Ulaanbaatar, selected according to the requirements of the funding scheme of the project.

2.2. The Study Area: Ulaanbaatar Metabolism

Cities function like an organism that consists of an input of energy and resources and an output of waste to maintain its vital functions. As a result of metabolic processes, the outputs of the system originate environmental pollution. Considering that waste management can be considered one of the main topics to be addressed in order to study urban metabolism, the spatialization of the production-consumption-waste cycle needs to be studied with a system approach. This complex approach is paramount in dealing with the complexity of issues, resources, and trends affecting the capital city of Mongolia. Ulaanbaatar is the only metropolitan city in Mongolia having a population of 1,639,172 inhabitants constituting 49.7% of the Mongolian population as of 2021 [48], whereas around one million Mongolians continue to reside in the vast steppes of the country, leading a nomadic or semi-nomadic lifestyle.

The territorial dynamics of the rapid process of urbanization that emerged in Mongolia in the last 30 years are characterized by a strong tension between urban and semi-nomadic lifestyles, reflected in urban development patterns.

The population of Ulaanbaatar is continuously increasing due to migration from rural areas and a high birth rate. Natural disasters such as "dzud" (harsh climatic conditions for herders that provokes the death of a large number of livestock) and drought lead to migration from rural areas to Ulaanbaatar, representing the promise of more working opportunities. The process of the rural-to-urban migration of nomadic families from rural provinces to the capital lead to the growth of the peripheral Ulaanbaatar area, creating a unique urban pattern. In this spatial organization, the "gers"—traditional Mongolian

portable dwellings used by the nomadic population—generate informal and semi-formal settlements that are progressively turning into permanent residential structures, despite the lack of basic infrastructural services [49]. Despite how the economic growth of Ulaanbaatar that started in the 1990s brought the city to be the largest economy in Mongolia and to play a major role in the country's development, it did not arrest the increasing numbers of ger settlements. The city has a leading role in the gross domestic product having 64.6% of the country's GDP [38], and the increasing rate is faster than the other region (Figure 4), attracting people with new job opportunities and with new residential blocks promising an easier lifestyle than the nomadic one [49]. The demographic pressure coupled with a slow improvement of infrastructural upgrade determines several issues in terms of natural resources management, impacting the city metabolism.

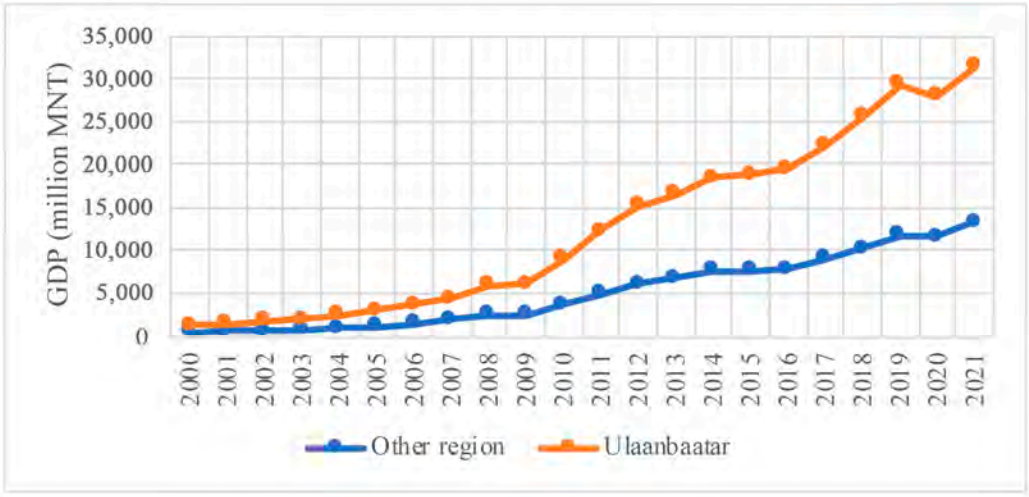

Figure 4. Time series plot of GDP in Ulaanbaatar and other regions of Mongolia.

The combination of swift urbanization and enhanced living conditions leads to an annual generation of over 3.4 million tons of waste, marking a fourfold increase compared to ten years ago. Approximately 92% of this waste originates from municipal solid waste sources [50].

The capital city consists of nine districts: Bagakhangai, Baganuur, Bayangol, Bayanzurkh, Chingeltei, Khan-Uul, Nalaikh, Songinokhairkhan, and Sukhbaatar. Six central districts (Bayangol, Bayanzurkh, Chingeltei, Khan-Uul, Songinokhairkhan, and Sukhbaatar) belong to Ulaanbaatar city, while three remote districts (Bagakhangai, Baganuur, and Nalaikh) constitute the capital city (Figure 5). More than half of Ulaanbaatar's population lives in ger areas [51] in which traditional mobile dwellings serve as the central structures within semi-formal compounds, representing a continuous attempt to combine a new urban lifestyle with a nomadic identity [49]. Ger settlements lack essential urban infrastructures like sanitation, adequate water supply, paved roads, proper waste management, etc., as well as public services and spaces [49,52]. The lack of a centralized heating system contributes to the use of stoves for cooking and heating that are fueled by the burning of coal, wood, and other combustible materials and waste with the result of high levels of air pollution in winter and the production of ashes [53] that also represent a particularly high rate in household waste composition [50].

Continuous urban growth adds to demand for urban services including water supply, energy, and heating. Water also shows an unsustainable level of use. Continuous population growth and heating demands in cold winters contribute to the worsening of air pollution. The concentrations of particulate air pollutants in Ulaanbaatar increased over the past decade, exceeding several times the national standard levels [54]. Energy consumption in Ulaanbaatar has risen by 225% from 2012 to 2022, experiencing a 6% growth rate per year. Over 80% of this energy is produced by coal-fired power plants.

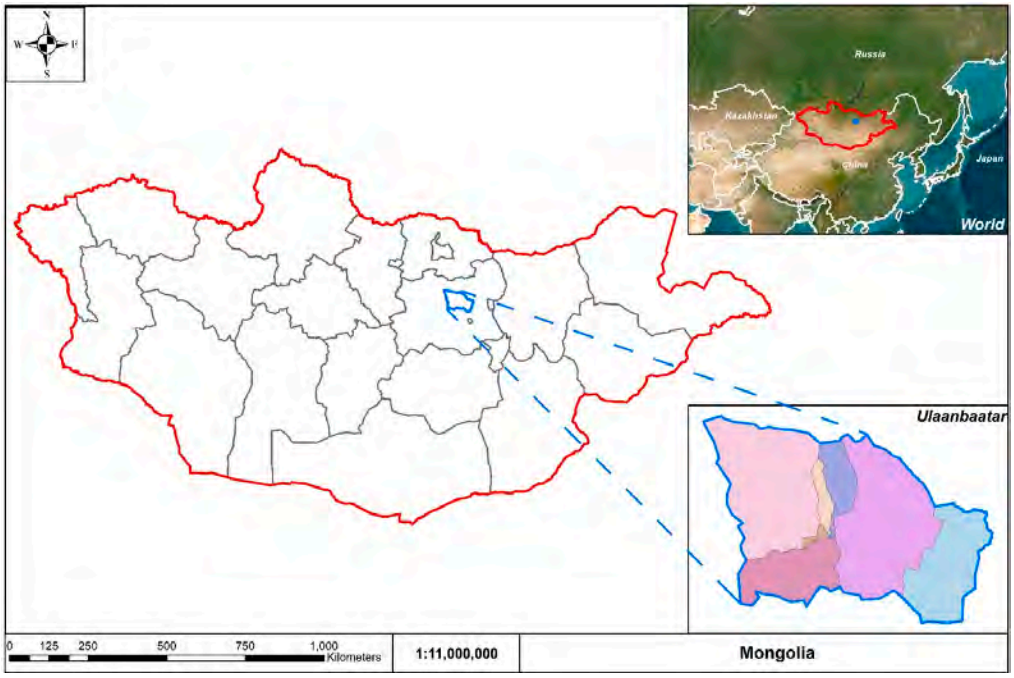

Figure 5. Map of Ulaanbaatar and its districts.

The urban metabolism of Ulaanbaatar's waste represents inefficient, unsustainable flow, i.e., mostly linear configuration (Table 1). It shows highly inefficient levels of consumption of raw materials producing nearly 1.4 million tons of waste annually in Ulaanbaatar and less than 10% of them get recycled [55]. The amount of waste increased four times during a decade from 2008 to 2018. The contribution of the waste sector to global greenhouse gas emissions is 5%, while in Mongolia the waste sector constitutes 0.46% of the greenhouse gas emissions of the country [55]. Greenhouse gas emissions from the waste sector in Mongolia tripled from 1990 to 2014 [17]. The majority of waste in Ulaanbaatar is disposed at three major (Narangiin enger, Tsagaan davaa, Moringiin davaa) and several minor disposal sites in the outskirts of the city.

Table 1. Metabolic profile of Ulaanbaatar city.

Population	Water Consumption	Food (kCal per Capita/Daily)	Waste (Grams per Capita/Daily)		Wastewater
			Summer	Winter	
1,639,172	112 L per capita/daily for apartments. Total consumption 78,107 million m^3	2682	377 for apartments, 466 g for gers	372 g for apartments 1006 g for gers	66 million m^3/yearly

Managing waste in Ulaanbaatar faces several problems at different levels:

- At macro-level: Lack of a legal environment, weak enforcement, and an incentive system whereby improvement in particular legislation is still needed. For example, the Li-ion batteries of hybrid cars have not yet been included in legal documents, the issues of disposal, collection, and treatment have not been legally resolved, and no proper actions in short- and mid-term periods have been planned. However, there are several policy documents such as "Mongolia's Sustainable Development Agenda-2030" and "Green Development Policy" that mention increasing recycled waste to 20% and reducing the waste volume to be landfilled by 20% by 2020 but barriers at the macro-level made it impossible. The barriers are the lack of industrial plants, lack of private sector regulations, and lack of financial sources.

- At meso-level: Lack of human and financial resources whereby monitoring and controlling service are still very weak. There is still no accurate data, for example, the amount of recycled waste shows different numbers depending on reporters and is still not finalized.
- Lack of sorting and collection system and transportation: Sorting and collection of recyclable waste are undertaken by the private sector. Since there is no formal sorting and collection system and large-scale waste processing facility, recycling is not widely established and recyclable products go to recycling plants or are exported to China. In the disposal sites, waste pickers, who are typically socially and economically excluded, collect recyclable waste.
- Lack of proper disposal areas/technologies: Limited availability of technological resources. Landfill sites are highly polluted. Soil quality is degraded by waste leachate which threatens underground water quality.
- Lack of public waste management programs, stakeholders, and community engagement: Apart from appropriate legislation, technical, personnel, and funding availability, public awareness and attitude result in successful sustainable waste management.
- Moving from a traditional, linear to an efficient, circular flow requires a new approach to triggering environmental awareness. It is well known that conscious action and personal behavioral change have potential to reduce carbon footprints [56], new behaviors of consumers to reduce, reuse, and recycle (3R), and new solutions to process and turn waste into resources and energy are entirely encouraged in Ulaanbaatar.

Demand, problems, and challenges are present in Ulaanbaatar. Growing population, consumption patterns, social development, and current levels of the economy increase the amount of waste and lead to difficulties in achieving environmental targets [57]. Consumption is directly linked to high environmental risks—climate change through greenhouse gas emission, soil, water, and air pollution, and reduction in biological diversity. The concept of urban metabolism can help in supporting Integrated Sustainable Waste Management in Ulaanbaatar, applying a circular model at urban scale promoting sustainability in the pattern of production, consumption, and natural resources management.

2.3. Capacity Building Process

Waste management in Mongolia remains a significant challenge, requiring increased investment in infrastructure, public education and awareness, and better regulation and enforcement of waste management policies.

These challenges are related to the urban complexities that the country is facing and in particular the Metropolitan area of Ulaanbaatar and that are common to other developing countries. Common trends that are influencing the interaction between urban pattern and waste management are population and economic growth, social, spatial, and economic inequality, expansion of informal settlements, vulnerability in governance and technical capacity of local governments, and limited financial and regulatory instruments [53,58,59]. In particular, local services for waste management in developing countries have often remained inefficient and outdated due to costs, shortage of funds, institutional deficiencies, untrained and inefficient personnel, and political pressure [35].

Marshall et al. (2013) defined a framework for operating an Integrated Sustainable Waste Management approach in developing countries considering the following factors: 1. social, cultural, environmental, institutional, political, technical, economical context; 2. specific stakeholder goals; 3. external expertise; 4. source of waste; 5. waste materials [59]. Strategically those components influence and determine the action of the decision arena that should be driven by environmental effectiveness, social acceptability, and economic affordability towards the implementation of prevention, reduction, recovery, and disposal methods.

Considering such complexity, the establishment of a pattern towards sustainable waste management in Mongolia requires the effective engagement of different players in the waste sector in terms of public and private actors as well as the cooperation of multiple

stakeholders and citizens to reduce, reuse, and recycle according to specific contextual characteristics and values [28].

A central part of 3R4UB is a collaborative approach in defining a comprehensive strategy for the development of a waste management masterplan, intended as a strategic roadmap in which spatial planning information are coupled to governance assets and technical improvements that need to be implemented within the UB waste management system.

The above-mentioned collaborative approach can be intended as a set of actions aimed to generate direct impacts on the stakeholder's ecosystem engaged in the project and to reach a large target audience. This set of actions oriented to knowledge transfer and to create engagement is articulated in awareness raising activities, capacity building, educational activities, and technical support, and these actions are later discussed in the section of this paper dedicated to the results.

The two pillars of the actions for the engagement strategy are the involvement of technical and public stakeholders interested in waste management and the involvement of young generations and education professionals. This has been translated in a multilevel approach of engagement that aims to reach decision-making and education domains through piloting activities to test and upscale a model for sustainable waste management tailored on the Mongolian cultural and technical context.

It emerges from a literature review that the importance of stakeholder engagement has been extensively proven by research in several fields such as value creation, planning and decision-making, innovation, learning and knowledge creation, accounting, and reporting, as well as corporate social responsibility and sustainability [60].

In the field of sustainable waste management, existing research addressing stakeholder engagement is still limited and the interaction between stakeholders is underexplored [47]. According to Wang et al. (2022), the barriers for the effective implementation of stakeholder and community engagement in the waste sector can be overcome by promoting communication and integration between different stakeholders and by providing innovative structures for decision-making [47]. These actions have the potential to improve stakeholder coordination by avoiding silos and by allowing a wide participation of citizens who have the right to play an active role in environmental protection. Additional effort from a governance perspective in the engagement of stakeholders is required to obtain all management information needed for reconsidering the multifaceted interaction due to the high diversity of actors involved that have differential roles and responsibilities [60–62].

Stakeholders usually included in waste management include national, state, and local governments, research institutions and universities, NGOs, the private sector, funding agencies, and end-users. These stakeholders are considered to have a role to play to support priority actions, informal collectors and recyclers, waste generators, waste collectors, recycling companies, government agencies, NGOs, and the general public [24,35,63].

Indeed, raising awareness regarding the societal challenges embedded in the circular waste management process includes identifying stakeholders' categories, defining engagement strategies, building consistent datasets, and designing tailored toolkits for participation, as well as interpreting facts and perceptions. The explored literature about the perception/awareness of CE in the transition process highlights the need to carefully select the player categories and to purposely design the engagement tools to shape the reduction, repair, reuse, recover, remanufacturing, and recycling practices [36]. The project reflects this recommendation by designing tools for priority engagement actions that are tailored to local cultural, social, and environmental values and are context-based in particular for the involvement of young generations and awareness raising.

3. Results

In this section, the results of this study have been articulated in two main sub-sections regarding the engagement strategies developed by the 3R4UB project (Section 3.1) and the analysis of the actors, actions, and activities (Section 3.2).

3.1. Engagement Strategy

Engaging stakeholders in sustainable waste management in Ulaanbaatar has been critical for building support and promoting behavioral change according to the peculiarity of cultural, technical, and urban development patterns. Stakeholder engagement has been developed though five key objectives in order to achieve results in terms of knowledge transfer, technical capacity, environmental awareness, behavioral change, and social learning. The strands of the engagement strategy have been developed with the aim of building on the wide variety of information and knowledge held by the diversity of stakeholders, integrating local knowledge, experience, and creativity, including ecological, cultural, and sociopolitical practices and institutions [63–66]. The main two pillars guiding the strategy have been implemented according to the expected outcomes of the project prioritizing the involvement of technical and public stakeholders interested in waste management and the involvement of young generations and education professionals (Section 2.3).

The following are the main phases and characteristics of the five key objectives of the strategy, conceptualized in Figure 6.

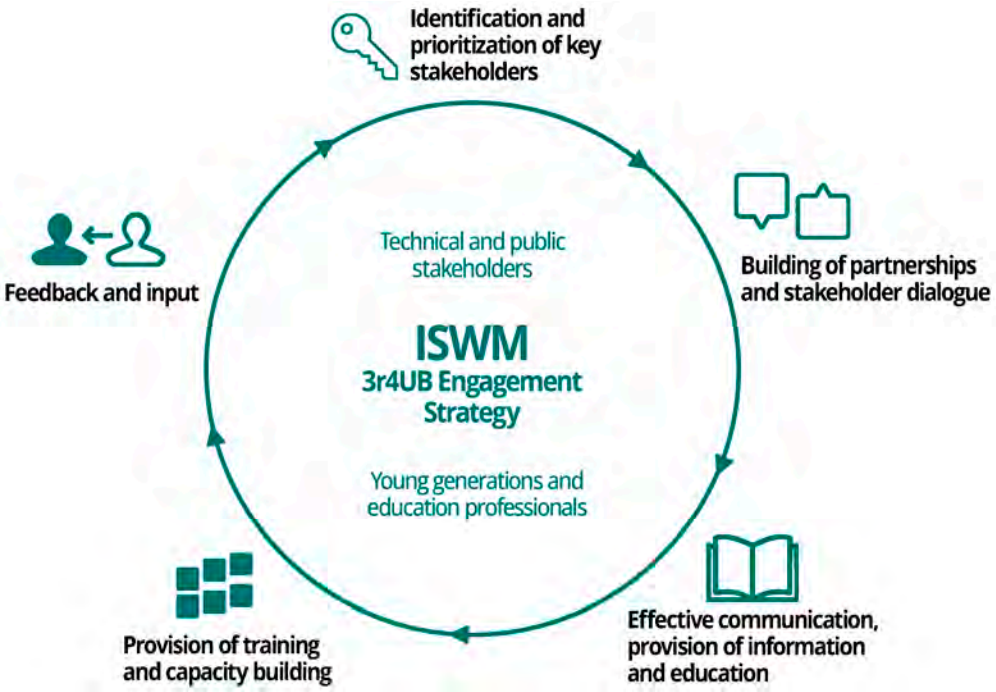

Figure 6. Conceptual diagram of the engagement strategy.

(1) Identification and prioritization of key stakeholders: The first step has been to identify the key stakeholders involved in waste management in Mongolia, such as national, state, and local governments, government agencies, waste management companies, research institutions, the private sector, funding agencies, NGOs, and community groups. At an early stage of the project, 3R4UB key stakeholders have been mapped based on their level of interest, influence, and potential impact on the waste management process (Figure 7). More specifically, stakeholders reached by project activities are as follows: local and national governments (notably Ulaanbaatar and Ministry of the Environment and Tourism, MET), MSMEs, financial institutions (Mongolian Banking Association, MBA), representatives from the private sector and industry (Mongolian National Chamber of Commerce and Industry, MNCCI), Government Environment Agency (FWRNCC), Universities and Research Centers (German-Mongolian Institute for Resources and Technology and Mongolian University of Science and Technology), NGOs (Mongolian National Recycling Association, MNRA, and Mongolian Environmental Civil Council, MECC), and educational institutions (15 schools engaged in the program).

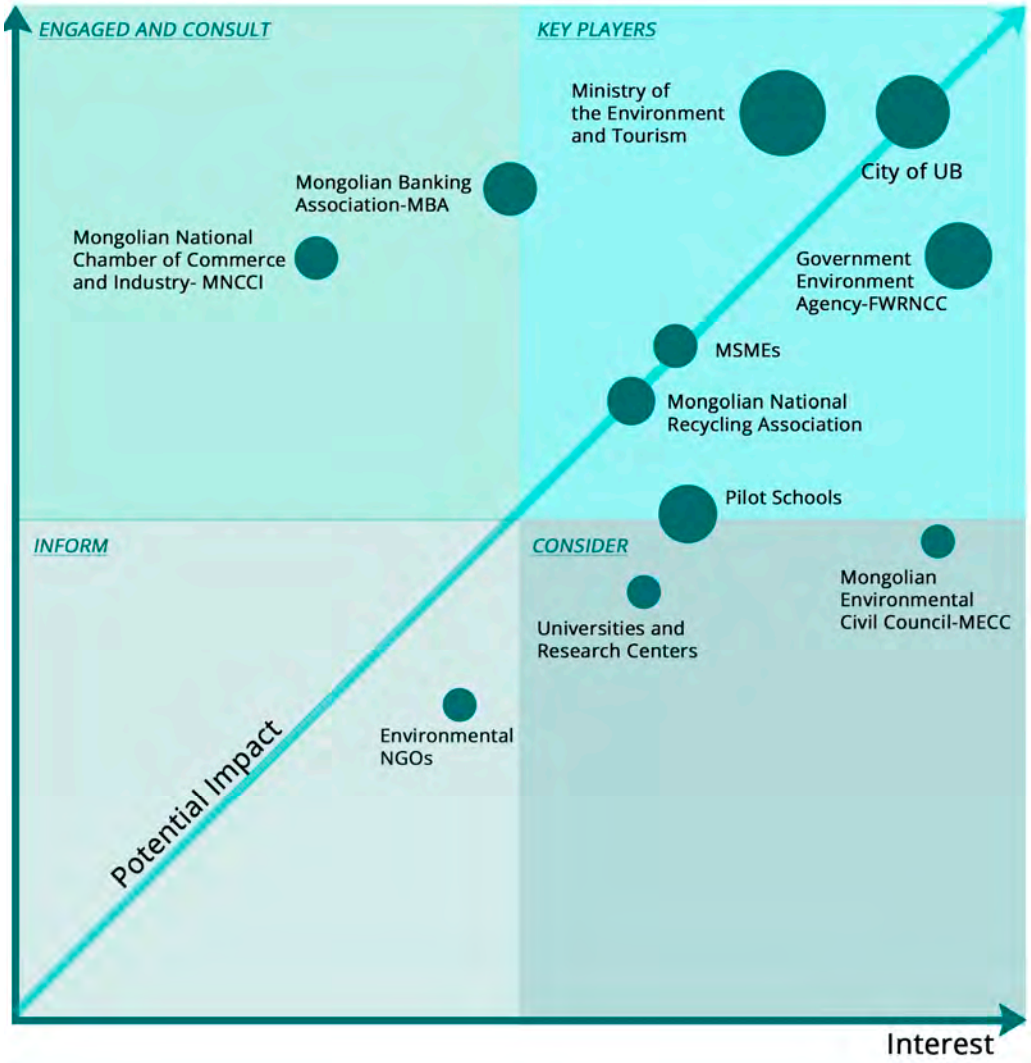

Figure 7. Stakeholder mapping based on interest, level of influence, and potential impact of the project.

(2) Building of partnerships and stakeholder dialogue: from the early phase of the project proposal, the identification of the main players in waste management at the local and national levels were brought to the establishment of a networking specifically triggered by the project implementation and opportunities in terms of financing, technical capacity, and communication activities. The integrated partnership model established by the project is based on the collaboration and cooperation of the Italian research institution CNR IRISS—National Research Council of Italy, Institute of Research on Innovation and Services for Development with local authorities—Municipality of Ulaanbaatar and FWRNCC—Mongolian Government Agency Fresh Water Resources and Nature Conservation Centre, supported by a technical Italian partner, Metellia Servizi, waste management service provider. The objective of this integrated partnership model has been the enlargement of the participation of all relevant stakeholders mapped to the project activities and the promotion of a platform oriented to share resources, expertise, and responsibilities. Roundtables, seminars, workshops, and steering committees jointly managed by the 3R4UB consortium have been promoted on a regular basis to encourage participation in the decision-making processes by the main Mongolian players in waste management. The dialogue triggered by these initiatives contributed to considering stakeholder perspectives, knowledge, and concerns and set operational procedures accordingly and to the establishment of a Stakeholder Agreement. Additionally, a participatory planning process for

the development of the waste management masterplan and of the pilot project have been carried on with the support of CNR researchers, Metellia technicians, and the technical staff of Ulaanbaatar and it has been opened to the participation of an enlarged stakeholder group composed of the private sector, NGOs, and educational actors. This action that is still under development will result in a Plan for a Smarter Consumption and a Plan for Waste Management for the city of Ulaanbaatar oriented to the reduction, reuse, and recycling of waste, and to the definition of a fee process for the Municipal Solid Waste management service according to the "polluter pays principle".

(3) Effective communication for citizen engagement, information, and education: a communication and visibility plan has been developed to deliver a communication program aiming at incentives to safeguard the environment through the adoption of the 3R approach (Reduce, Reuse, Recycle). The objectives of the plan have been individuated to communicate a long-term vision and a short and medium term one. The long-term vision focuses on the message that the actions undertaken by the residents of Ulaanbaatar, in relation to the principles of the 3Rs, will lead to an improvement in the city's environmental quality, making Ulaanbaatar a healthier city. Through increased awareness and conscious consumption, the citizens are the core players that actively contribute to the reduction of waste generation. The short- and medium-term vision is based on the message that sorting waste as an individual behavioral shift implies reconsidering waste as a resource triggering virtuous circular processes. The communication approach is being implemented to achieve such goals as the spread among the public of 3R principles and the building of a mindset regarding waste recycling and ecologically sustainable consumption habits. The main target for the communication strategy is individuated in pupils between 8 and 18 years old and university students, while secondary audiences are women in charge of household management, families, educational institutions, and single women and men, and additional audiences are universities, research centers, institutions, and MSMEs in the waste sector. A clear and transparent communication toolkit about the benefits of sustainable waste management and the impact of improper waste management has been created in order to help provide stakeholders and the general public with relevant information about waste management, including its impact on the environment, health, and economy. Information is delivered using several tools in particular training sessions and awareness campaigns, as well as by promoting education initiatives for communities on composting, recycling, and waste reduction practices. An education program is set for 15 schools that are actively engaged in the pilot. A first testing of the waste management masterplan is based on the collection of sorted waste from the pilot schools in which ecological points to recycle plastic, aluminum, paper, and cardboard are placed. Educational activities based on gamification have been co-designed by FWRNCC and CNR consulting education practitioners, teachers, and school directors to stimulate the engagement in recycling and to provide information about the beneficial impacts of this shifting habit.

(4) Training and capacity building: training and capacity building programs for stakeholders and Mongolian partners are being delivered to develop their skills and knowledge about sustainable waste management and 3R principles. This section of the project includes training professionals and local officers in managing the different issues related to the topic to achieve capacity building in terms of governance, management, and technical capacity. Specific activities for capacity building have been planned in order to ensure future compliance by stakeholders and to addresses current shortcomings in administrative capacity to implement and monitor solid waste management activities, especially at the local government level. Particular emphasis is given to improve technical capacity for waste sampling methodology, inventory assessment, and monitoring with attention to the potentializing use of sustainable technologies. The training of UB waste managers, technicians, and stakeholders (public and private ones such as recycler associations) is specifically oriented to cover the management of the Plan for Waste Management and of the pilot (waste sorting plant and collection of sorted waste in 15 schools). Furthermore, activities to improve institutional capacity building have been outlined specifically for

the UB municipality to improve their governance capacity to formulate, implement, and monitor effective policies to promote waste reduction and recycling. According to the goal of engaging young generations through education, a section of the project is dedicated to training education professionals for teaching 3Rs principles as part of the Education Program.

(5) Feedback and input: The project's activities related to the Plan for a Smarter Consumption, the Plan for Waste Management for the city of Ulaanbaatar, and the Pilot Project (waste sorting plant and waste collection from schools) are conducted in partnership with local actors with a collaborative model based on iterative interactions and activities oriented to collect feedback, information, and inputs on various project objectives.

The project adopts a participatory approach in order to maximize local ownership of the results, involving all decision-makers in the institutional capacity building process. A proactive collaboration between the Local Authority—Government Agency—Stakeholders is supported to evaluate the impact of the measures adopted on the sector and to raise awareness on the existing barriers in the waste sector and its needs.

The main progresses achieved by the project through the implementation of the five key objectives are synthetized in Table 2.

Table 2. Key objectives and project progresses.

Objectives		**Progresses**
1	Identification and prioritization of key stakeholders	Stakeholder mapping based on the levels of interest, influence, and potential impact on the waste management process
2	Building of partnerships and stakeholder dialogue	Integrated partnership model Establishment of a network triggered by the project implementation and opportunities in terms of financing, technical capacity, and communication activities
3	Effective communication for citizen engagement, information, and education	Communication and visibility plan Communication toolkit Communication campaigns Hackathon Preparation of the education program
4	Training and capacity building	Training of professionals and local officers in managing the different issues to achieve capacity building in terms of governance, management, and technical capacity
5	Feedback and input	Collaborative planning for the Plan for a Smarter Consumption, the Plan for Waste Management for the city of Ulaanbaatar, and the Pilot Project (waste sorting plant and waste collection from schools)

3.2. Players, Actions, and Activities

Table 3 explains the specific activities in relation to the players engaged and the lines of actions to operationalize the strands of the engagement strategy (1. Awareness raising; 2. Capacity Building; 3. Education; 4. Technical Support). The actions are conceived as intertwined to achieve several project goals and as transversal to the engagement strategy objectives. From the enlarged analysis of stakeholders during the first year of the project, key players have been individuated to downscale and define core activities based on the collaborative exchange of all actors involved grouped according to local authorities, NGOs and associations, waste sector practitioners, school communities (students, teachers, and directors), and academic institutions (universities). Results related to the actions developed are summarized as follows:

Table 3. Project's actions, activities conducted, and actors engaged.

Action		Activities	Local Players Engaged
1	Awareness raising	Communication Campaigns Competition for visual identity of the project Videos (promotional, institutional, and advertising) Media coverage (broadcast and digital platforms) Gadget for 3Rs (e.g., reusable ecological bags) Informative materials (e.g., flyers) Ecological days Organization of a hackathon for the proposal of an eco-point for recycling to be located in 15 pilot schools and a game about recycling	MET, Universities, FWRNCC, NGOs, Schools
2	Capacity building	Technical training course for city officials, technicians of municipalities, practitioners of waste sectors, NGO members Roundtables and stakeholder dedicated meetings Visiting of Italian recycling plants for knowledge exchange Informative materials (tutorials and training materials)	MET, FWRNCC, UB Municipality, MNRA, waste sector practitioners, NGO members
3	Education	Education program Training course for teachers about 3R principles and sustainability Design and deliver of 1000 ecological toolkits for schools Eco-points for sorting waste and informative materials on their use Organization of recycling games and delivery of an ecological game box Definition and promotion of a permanent school program about sustainability, environmental protection, and 3Rs	FWRNCC, NGO members, School teachers, and directors, Ministry of Education
4	Technical support	Development and co-design of a waste management masterplan and a waste sorting plant in Ulaanbaatar Roundtables Definition of a 3Rs permanent program to be offered in the school curricula	UB Municipality, MNRA, MSMEs, FWRNCC, Ministry of Education, School teachers and directors

1. Awareness raising: Campaigns have been realized on 3R topics tailored to Mongolian cultural values with the aim to create awareness about the potential benefits of waste reduction, recycle, reuse policies for environmental urban quality and on chain values related to the application of CE principles. A competition for the design of the visual identity of the project and for the definition of tailored communication messages has been launched to engage young local designers and communication practitioners. Communication activities such as videos and other informative materials have been promoted to reach the target audience estimated to be around 100,000 Ulaanbaatar citizens with a specific focus on youth and women. Moreover, in a second stage of the project development the outreach of the young generation has been triggered with the organization of a hackathon for the design of the eco-points for recycling to be located in 15 pilot schools, and for the organization of recycling games for students of the pilot schools. This activity has been outlined to enrich a participatory and collaborative model promoted by 3R4UB by implementing the co-production for the design of devices needed to support the piloting in the schools (eco-points for waste sorting and ecological toolkits for educational support). In the hackathon, 25 students from Mongolian universities have been engaged with the objective to develop ideas on how to realize the pilot action of recycling in schools. The results of this activity delivered two proposals for the ecological kit and four for the eco-points in which the participants were supported by experts responding to the challenge of design devices capable of triggering community engagement, acceptance, and behavioral shift, according to the cultural context. Participants were previously trained by international and local experts in a tutoring session about creative social design solutions, appropriate technology for community acceptance, management issues related to the sorting of waste, innovative materials and technologies, and design thinking for problem solving. Actors

involved in the definition and co-development of the awareness raising activities have included MET, Universities, FWRNCC, NGOs, and Schools.

2. Capacity Building: A technical training course about sustainable waste management has been instructed by experts from Metellia, both remotely and in-person, for a duration of 120 h while structured in four teaching modules. The purpose of this course is to transfer skills and to retrain MSME professional and technical staff and waste managers of Ulaanbaatar and FWRNCC. About 30 participants (city officials, technicians of municipalities, practitioners of waste sectors, NGO members) took part in this course. The methodology applied an engaging approach by using tools for briefing, problem-oriented learning, 'learning by doing', and team working.

In addition, as a compendium of the training activity, guidelines on sustainable waste management were created containing a series of best practices and practical cases. Extra training activities took place with a visiting field trip to Italian recycling plants to encourage knowledge exchange among Mongolian and Italian stakeholders.

Players involved in capacity building actions are MET, FWRNCC, UB Municipality, MNRA, waste sector practitioners, and NGO members.

3. Education: As part of the education program, a training course for teachers has been designed to promote education on the topic of 3R and sustainability and it will be carried out in the third phase of the project planned for the end of 2023 with the support of the FWRNCC. The target group for school education activities is 8-15 year-old pupils, and it is supported by digital materials (kit for tutors and video tutorial) and by a specific ecological school kit which contains materials that help to understand how to separate waste and protect the environment. It is proposed that after the piloting phase in 15 schools, a permanent program should be established in school curricula. The educational dimension of the engagement strategy will be further addressed with the organization of recycling games (based on an Olympics of waste separate collection format) which provides a series of awards for participating schools, and the delivery of an ecological game box. The educational tools which will include the co-designed proposals of the hackathon are conceived to create a positive competition and to stimulate the acquisition of knowledge while entertaining the students. Final users of the educational activities are estimated to be about 25,000 students contributing substantially to the pilot project testing. Indeed, is expected that through educational activities and raising awareness, students will be able to collect five tons per day of collection of separated waste such as plastic and paper that will be treated in the pilot waste sorting plant.

4. Technical support: A large effort of the 3RU4B project is dedicated to the technical support for the realization and implementation of the masterplan for waste management and the realization of a waste sorting plant to trigger and then upscale a ISWM model in Ulaanbaatar. CNR researchers and Metellia experts have been providing technical support through specific co-design sessions with major players such as UB city and private companies. The implementation of the Smart Consumption Plan and the Waste Management Plan and the management of the waste sorting plant are fostered through the co-development of operational steps for waste management, waste sampling methodology, inventory assessment, and monitoring. Activities to support the establishment of a 3Rs permanent school program have also been planned and they will engage the Ministry of Education, school teachers and directors, and educational practitioners.

4. Discussion

This section discusses the main results that emerged in terms of strategies, activities, and related levels of engagement. In particular, they are analyzed by referring to the project multi-level approach to the engagement of communities and stakeholders.

This has been articulated pivoting on the engagement continuum and taking into account the nature of participation mainly according to the direction of communication and information flows [67,68]. The ladder of reference is composed of six levels that represent the degree of engagement and the way stakeholders and communities are being involved

in the project actions and it has been structured accordingly with a literature review about stakeholder engagement [37,39,60,69–71]. In Table 4 are reported the engagement levels reached by the project actions relative to the strategies implemented considered as iterative and nonlinear [59]. Differential levels are coexisting in the same project action integrating a range of various involvements and strategies applied. Due to this variable configuration, the assessment of the levels of engagement reported in this paper reflects preliminary results as the project will achieve its complete implementation in 2025. Despite this limitation, levels of engagement currently accomplished by 3R4UB actions can offer insights into how collaborative approaches to trigger environmental awareness exceed this dimension to foster the establishment of more inclusive partnerships and participatory decision-making processes. The engagement levels of project actions are described as follows:

Table 4. Project's actions, levels of engagement, and strategies applied.

		Levels of Engagement		
	Action	**Level**	**Strategy Applied**	**Results**
1	Awareness raising	1/Outreach 2/Consultation	Communicate effectively Identify key stakeholders Build dialogue	Visibility and transparency to all actions, initiatives, and progresses Implementation of an effective communication for citizen engagement, provision of information 100,000 Ulaanbaatar citizens reached with specific focus on youth and women Outreach of young generation
2	Capacity building	1/Outreach 2/Consultation 3/Involvement	Build partnerships Provide training Feedback and input	Knowledge transfer about ISWM Technical skills improvement Enhancement of local capacity and governance
3	Education	1/Outreach 4/Collaboration	Provide training Build partnerships Communicate effectively Build dialogue	25,000 students engaged in the pilot project 30 teachers trained
4	Technical support	2/Consultation 3/Involvement 4/Collaboration 5/Shared leadership 6/Stakeholder leadership	Build partnerships Feedback and input Promote the use of sustainable technology	Co-design and co-development of the Smart Consumption Plan, Waste Management Plan, and the management of the waste sorting plant

1. Outreach: Involvement entails one-way communication flows aimed at providing information to the stakeholders and community without actively seeking their input or feedback. The outreach component of the project's actions is highly relevant as a first step for achieving awareness raising, educational aims, and capacity building. The project sought to give visibility and transparency to all actions, initiatives, and progresses made, implementing an effective communication for citizen engagement, provision of information, and education.

2. Consultation: Activities such as bilateral meetings and roundtables with relevant stakeholders are based on two-way communication. The flow of information is mutual and there is a reciprocity in the way knowledge is shared. At this stage of engagement, project activities (formal and informal ones) have been developed to gain feedback, input, and information by stakeholders and communities. In particular, consultation processes were conducted in the early phases of the project to collect necessary information and data on several aspects (e.g., waste management current practices, barriers, data of waste sampling, main stakeholders). The consultation occurred as a starting point for the definition of the specific actions of awareness raising, capacity building, and technical support.

3. Involvement: Stakeholders and community inputs are considered in the planning of further activities and in particular for the development of the pilot actions. Participation is encouraged to foster capacity building and make the technical support effective. This level has been achieved as preliminary to the co-design of the waste management masterplan and a pilot waste sorting plant. This stage can be understood as fundamental to ensure the compliance by major players in developing the necessary technical capacity and capacity building for the sustainability of the pilot and its upscale.

4. Collaboration: Involvement of stakeholders is more structured and implies active engagement in planning project activities for the pilot implementation. Partnerships have been formed with an identification of responsibilities for both the waste sorting plant and the pilot schools. This reflects the collaborative model fostered by 3R4UB in order to consolidate the local capacity for the complete implementation of the pilot and of the Smart Consumption plan that needs to be delivered by UB city in collaboration with the other key players.

5. Shared leadership: As the next stage of a collaborative relationship, the project seeks to build a bidirectional leadership for the project's activities. This level can be understood as transitional to allow stakeholders to achieve the complete leadership for the implementation of the pilot action. The bidirectional leadership has been intended as a way to operationalize the cooperation between Mongolian and Italian partners particularly addressing technical and knowledge transfer issues.

6. Stakeholders leadership: The final level of the engagement spectrum proposed is to consider the broader project goal as the shift from a knowledge transfer to a knowledge co-production allowing local stakeholders to spearhead the implementation of the pilot action and so lead the upscaling of an ISWM in Mongolia.

The results obtained highlight an approach that brings together science, communication, and technical capacity to effectively foster cooperation between citizens and government agencies [72]. The collective action dimension of the results discussed can be recognizable in the set of engagement tools developed that can significantly contribute to operationalize a collaborative waste management plan in which both key players and end-users are informed and involved. The core of the engagement strategy seeks to encourage people to collaborate together at multiple levels of interests and responsibilities needed for the development of the ISWM in Ulaanbaatar. The tools applied for the participation and the engagement assisted in clarifying and in settling communications and power relationships between stakeholders to construct as wide a consensus as possible [62,64]. Acknowledging that one of the main gaps in the literature for the implementation of ISWM is the lack of effective communication between various stakeholders [63], the preliminary results of 3R4UB show the project provided opportunities for the complex stakeholder ecosystem to collaborate and cooperate. The step-by step approach while fostering dynamic learning and iterative programming contributed to configurate a government-civil society partnership that was not existing in the Mongolian context of waste management.

5. Conclusions

This paper addresses environmental issues from a stakeholder networking perspective by developing a multilayer-circular-adaptive civic engagement model aimed at raising awareness and enhancing the efficiency and effectiveness of local policies within a waste management process project.

The EU SWITCH-Asia funded project 3R4UB by dealing with the waste management cycle offers the opportunity to develop and test a complex approach to environmental challenges in a territory in transition and in extreme meteorological conditions. The results of the model developed in Mongolia—although site-specific—could provide a generalization protocol to be applied in less explored geopolitical contexts to revise policies, governance models, and resource management toolkits.

- To achieve the 3R4UB expected results, along with the actions directly aimed at scaling and managing urban waste flows and supporting the pilot waste sorting

plant, a relevant role has been covered by communication and participation activities aimed at engaging different categories of local stakeholders. In so doing, the communication-exploitation plan, typically part of each research project to ensure visibility and marketability, has been completely remodelled to reach multidimensional results and to build a meaningful dialogue between the two continents involved in the cooperation process.

Useful insights come from the shift from a model of cooperation oriented for merely technology transfer and services provision to a co-produced roadmap in which the partnership between Mongolian and Italian institutions has been nurtured by local networking. This fruitful collaboration between the Italian and Mongolian partners and other local stakeholders has also been aimed at capturing demands, expectations, concerns, and perceptions. By combining the outsider perspective with the engaged fieldwork in Mongolia and with the open dialogue with locals, local traditions, settlement typologies, and household organizations, patterns regarding the waste cycle have been captured and interpreted. This tailor-made engagement approach has been developed and delivered based on transparent and effective communication, availability of technical support, and horizontal knowledge exchange to allow all parties to share information and to collaborate for the effective management and governance of the planned measures.

The research group fostered the building of long-term partnerships with key players to gain their support and encourage their participation in sustainable waste management initiatives beyond this project. This has been interpreted in terms of forming alliances with waste management companies, NGOs, and especially with local authorities to work collaboratively towards common goals. In this sense, the project activities are building an effective platform to achieve collaboration and local partnerships thus attempting to limit and overcome the difficulties related to the heterogeneity of the actors involved. The complex network established by the project can actively influence the upscaling of project pilots and their replicability.

In so doing, the project built consistent outcomes in terms of mutual learning and cultural and technical exchange, thus ensuring a long-term capacity building action that will foster upscaling in terms of management and financial mechanisms. The visibility aims have been achieved by developing public events and engagement activities. The open discussion with local scholars and research centres supported the efforts and the mutual learning process. Memorandums of understandings between the Italian research institutions involved in the project and the Mongolian universities and research centres based in Ulaanbaatar have been signed in order to further collaborations on the pedagogical and research initiatives, as well as for the 3R4UB exploitation phase.

- In terms of generalization purposes, the project is developing tools to be easily adapted to other contexts in the SWITCH-Asia Countries, regardless of the specificity of local conditions. By including territorial players and communities in the design process, both the exploitation of local resources, the capacity building, and the enhancement of environmental awareness can be achieved in waste management. Regarding this tailored participatory protocol, the project provided and tested an engagement toolkit that can be customized, addressing different environmental and societal challenges included within the SDGs, as well as reaching the specific needs of other Asian countries. To this aim, small-scale engagement tools such as the Hackathon offered an opportunity to address social innovation. Behavioral changes and social learning can only happen if the innovations empower people at local levels to collaboratively work, experiment, and prototype solutions for environmental and social challenges. In this perspective, several studies show that collaboration among universities, public administrations, and local communities is a major catalyst for local environmental, social, and economic innovation and development [36].
- In terms of impacts and successors, the effort in developing capacity building will provide expertise to local authorities and it will consolidate local management capacity. This process contributes to shaping local ownership, commitment, and accountability

in a significant way [64]. The expected results of the next phase of the project, regarding the business model and the green-funding scheme, will be integrated in terms of policy design perspectives within a proposal for an inclusive private-public (civic) partnership (PPP).

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