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Closing the City Cycle: An Approach for Defining Cross-Sectoral Circular Actions to Be Included in a Circular Urban Plan

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Abstract: The topic of the circular economy and its potential applications to urban areas is currently widely discussed as it is seen as a possible solution to the state of environmental, economic, and social unsustainability resulting from the previous consumption model. However, although many contributions focus on one or more key sectors affecting the urban environment (Mobility, Waste, Built Environment, Water, Energy, and Food), few attempts address the topic comprehensively, promoting a broad vision that encompasses all sectors and evaluates their interrelation. This paper aims to meet this need by first providing an overview of the topic of circular cities, best practices, and circular actions, and subsequently defining a synergistic methodological framework of intersectoral circular actions that considers the interrelation of the various key sectors and that can be used as a tool to contribute to the overall closure of the urban cycle of a city. The city of Genoa is proposed as a case study for a first application. This research should be incorporated into a possible Urban Circular Action Plan aimed at implementing current international strategies.

Keywords: circular actions; closing the loop; Urban Circular Action Plan

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1. Introduction

Today primarily the ecological transition involves cities due to the key role they play in many of the environmental challenges of our time: climate change, the shift from a linear to a circular economy, and the crisis in the human-environment relationship. Moreover, urbanization is one of the main global trends of the 21st century: over 55% of the world's population lives in urban areas, a percentage that could reach about 70% by 2050, with predictable environmental impacts in terms of pollution, waste production, and land consumption [1]. Currently, cities have become protagonists in the transition towards a circular economy, especially since the paradigm shift in contemporary planning towards circularity could facilitate cities' adaptability [2]. Additionally, circular development creates more resource-efficient, adaptive, and ecologically healthier cities, producing various ecological, social, and economic benefits [3]. Cities are also important centers for generating waste flows across key urban sectors (mobility, waste, built environment, water, energy, and food). As centers of innovation, investment, and culture, they will necessarily be affected by the success or failure of the circular economy. The concept of a circular economy was introduced into the European political arena in 2014; while not new to science, it was new to policymakers who are still attempting to adapt it to the urban scale. This concept has since spread among governments and institutions, intergovernmental bodies, influential forums, think tanks, and leading corporations [4]. Recently, this model has been and continues to be implemented by some city administrations and urban programs in various European cities (e.g., Amsterdam, Paris, London, ...). However, despite the growing importance the concept is gradually acquiring in the urban field, research on what a circular city might be and how to achieve it is still in its infancy [5–8]. The concept of 'circularity' is gaining prominence in urban environments when it comes to 'sustainability', but there is still a lack of shared understanding of what 'circular' features actually are (or can be), and their applications to urban systems are still being explored [6,8–10].

The transformation towards the circular model will necessarily involve radical changes in land management and governance, planning and construction phases, and citizens' living habits.

The transition to a circular economy is beneficial from a global point of view only if its environmental footprint is smaller than the CO_2 savings achieved by operating in the new model in the foreseeable future.

In September 2015, the United Nations adopted the 2030 Agenda for Sustainable Development [11], defining 17 Sustainable Development Goals (SDGs). Goal 11 specifically aims to "Make cities and human settlements inclusive, safe, resilient, and sustainable" and introduces the concept of a circular approach to a city. Subsequently, almost eighty European local administrations signed the Circular City Declaration, which aims to accelerate the transition from a linear to a circular economy in Europe, creating a resource-efficient, low-carbon, and socially responsible society.

The emergence of the circular economy and its various applications to urban issues has led to the need to identify key priority sectors to study their supply chains and define closed and regenerative cycles. This is carried out with a sustainable vision, addressing "the needs of the present without compromising the ability of future generations to meet their own" [12] and realizing "circular cities." According to the Circular City Declaration [13], a "Circular City" must adhere to all the principles of the circular economy, namely reduction, reuse, and recycling of resources. Generally, a circular city is characterized by the following elements:

- Buildings designed to be modular and flexible;
- An accessible, economical, clean, and effective urban mobility system;
- Resilient, renewable, distributed energy systems that enable effective energy use;
- Balance in the urban bio-economy, where nutrients are returned to the soil;
- Production systems that encourage "local value loops" and minimize waste.

Therefore, planning a city sustainably becomes the real challenge [14–16], not only for proper urban growth but also concerning climate change [17,18]. Today, various strategies and studies in the scientific literature address circular cities [8,19–21]. The focus has largely been on creating circular economies, resource flows of individual supply chains, or specific circular economy projects. However, there are few examples related to the process of creating circular cities and the concept of "urban cycle closure" [22,23]. Recent studies have shown that contemporary challenges require integrated and transformative approaches, such as scenario planning, which considers intersectoral interventions [24–26].

A circular city can and should be considered an ecosystem associated with the concept of urban metabolism. The latter views cities and all the resources flowing within them as complex networks of interconnected social and physical infrastructures ("material flows") [27]. Following major urbanization processes, in fact, cities today are configured as complex metabolisms in which the concentration of numerous material and immaterial resources represents a threat to the liveability of urban spaces due to the use of these resources in unsustainable development models, and at the same time, an opportunity for the development of circular scenarios and solutions [28–31]. Urban metabolism is seen as a pillar of the circular economy to be applied at the city scale in a socio-ecological perspective beyond boundaries [2,32]. The framework referred to for circular urban metabolism results from applying the concept of a circular economy to the context of urban metabolism. This framework can help planners and policymakers rethink urban activities, such as transport or food production, within the urban and rural space and over time [33]. Generally, "for the urban environment, a comprehensive vision is needed to address urban metabolism as a whole and create not only specific circular economy systems but also a global resource management system for the urban biosphere" [34]. Therefore, intersectoral interrelation is crucial for urban cycle closure. Currently, however, many cities call themselves circular because they have promoted or are promoting individual circular actions. This paper aims to present initial research to address the need for a general vision to achieve urban circularity. The research starts with a survey of circular actions promoted at international and national levels and then develops an approach aimed at using these actions to close the life cycle of individual priority themes while considering their intersectorality to close the city's life cycle.

This research aims to fit into this context, with the research questions being as follows: #1 How can the relationships between the various key themes be systematized to simplify planning aimed at urban cycle closure? #2 How might this tool work within a real case study? Thus, starting from an initial phase where circular actions are defined, the definition of a framework of intersectoral circular actions is proposed to achieve the overall closure of a city's urban cycle. The actions to be defined should in fact be integrated into a synergetic framework which in turn should be incorporated into a possible Urban Circular Action Plan aimed at the implementation of current international strategies and aimed at the creation of an effective circular urban system addressing all key sectors.

In particular, the following section presents the materials and methods used. Section 2.1 provides the definition of circular action and best practices and some examples of platforms that collect them. Section 2.2 then defines the methodology used to structure the framework of intersectoral circular actions, and Section 2.3 presents the case study, contextualizing it with the help of studies carried out in some strategic documents or previous research by the authors. Finally, Section 3 applies the proposed framework to an initial case study: the city of Genoa. It should be noted that, for illustrative purposes, the application will be provided only concerning the water theme.

2. Materials and Methods

2.1. Circular Actions

A circular action is an action aimed at achieving circularity. It is a best practice, meaning "...an action, exportable to other realities, that allows a municipality, a community, or any local administration to move towards sustainable local management" [10]. It is defined as "good" when it can meet "...the needs of the present without compromising the ability of future generations to meet their own" [12]. In general, a best practice must meet four requirements: relevance, transferability and durability, involvement (participation), and innovation (expressing new methodological approaches different from those usually practiced). It should also be noted that every best practice is "a product of its territory"; thus, it cannot always be replicated exactly the same in another territorial context, but it can be adapted considering the different culture, tradition, and local development and by evaluating scope; economic, social, and environmental feasibility thresholds; the morphological conformation of the territory; existence of agreements between neighboring municipalities; reasons that led to that choice; what incentivizes/disincentivizes such action type and burdens. The utility of disseminating and sharing best practices is widely recognized and proposed as a model for local administrations pursuing sustainability. Since local administrations' task is to intervene and respond to environmental, economic, and social problems through immediate and concrete actions, it is necessary to inform and disseminate everyone's experiences so they may be useful to others' work. Moreover, the availability of this information offers the opportunity to create partnerships between cities with common policies and objectives and to foster alliances among local actors regarding the implementation of specific projects. However, the literature on knowledge transfer and related concepts, such as policy transfer, policy mobility, or lesson-drawing, highlights the limitations of this process, especially when transferring best practices from one place to another. Such transfer can lead to suboptimal solutions, particularly when imported practices address complex phenomena, involve networks of multiple actors, and rely on specific local dynamics [35]. To overcome these issues, co-creation processes of knowledge are needed, involving stakeholders from both places to identify barriers in this knowledge transfer, which makes solutions transferable to different contexts, and how solutions can be adapted from one place to another [36]. The adoption of these best practices indeed requires collaboration among local authorities, businesses, citizens, and other stakeholders. The participatory approach is essential for the successful transformation of a city into a circular reality.

In general, the set of best practices should represent a comprehensive array of project initiatives related to various actually implemented activities, representative of experiences, fields, and levels of intervention (local, regional, national, or community), territorial areas, different executive bodies (public and private), and beneficiaries of the measure [37].

Best practices in the context of circular cities are essential when considering the environmental, social, and economic challenges cities face. Furthermore, activating best practices can foster the development of a circular economy, a necessary condition for moving towards a circular city [38,39]. Generally, the transition to a circular city model implies adopting sustainable and innovative practices—circular actions to manage resources efficiently, reduce waste, promote reuse and recycling of materials, contribute to preserving natural resources, reduce the environmental impact of human activities, and improve citizens' quality of life.

Today, various best practices/actions are promoted in waste management, sustainable mobility, or projects that promote social events. Best practices can involve various stages of the production cycle: procurement, design, production, distribution, consumption, collection, and recycling. Examples of best practices/circular actions for waste management include recycling, implementing separate collection systems, promoting awareness of proper waste management, and investing in advanced recycling and material recovery technologies. In terms of sustainable mobility, promoted actions include developing infrastructure for efficient public transport, promoting cycling and walking, and implementing car-sharing and bike-sharing systems. For renewable energy, actions include investments in renewable energy sources such as solar and wind, promoting energy efficiency in buildings and infrastructure, and developing community renewable energy projects. For water and water resources, actions include implementing water resource management technologies and reducing water waste through efficient irrigation systems, etc. [40].

Over the years, platforms for collecting best practices have been developed, for example, the catalog of best practices from the Italian Circular Economy Stakeholders Platform and that provided by the European Commission [41,42].

The first is a platform for collecting circular economy best practices developed by Italian actors (companies, associations, institutions) aimed at promoting the knowledge and dissemination of these realities and promoting their replicability. The second is a collection of best practices promoted by the European Commission to highlight virtuous experiences in Green Public Procurement, including examples of circular economy and sustainable innovation.

In general, these platforms aim to converge initiatives, share experiences, highlight critical issues and indicate perspectives to propose virtuous examples in sustainability and the circular economy and promote their development.

2.2. Proposed Methodology

The developed research aims to define a strategic framework for identifying intersectoral circular actions to achieve the overall closure of the urban cycle of a city. The defined actions need to be integrated into a synergistic framework to create an effective circular urban system addressing all key sectors. For instance, rainwater recovery can be used to irrigate green areas, which in turn can help foster a local market, reduce air pollution, and improve air quality. To close the urban life cycle, it is necessary first to close the cycle of individual priority sectors in a city (Mobility, Waste, Built Environment, Water, Energy, Food) and then propose interrelations among them. However, it should be noted that to achieve the closure of the urban cycle, this framework of circular actions must generally be included in a broader strategic framework, such as an Urban Circular Action Plan [43].

Figure 1 shows the dependency cycle of six systems identified as key urban sectors and the framework in which best practices and actions are positioned concerning the 10R model (Refuse, Rethink, Reduce, Reuse, Recontain, Repair, Recondition/Regenerate, Repurpose, Recycle, and Recover) [44].

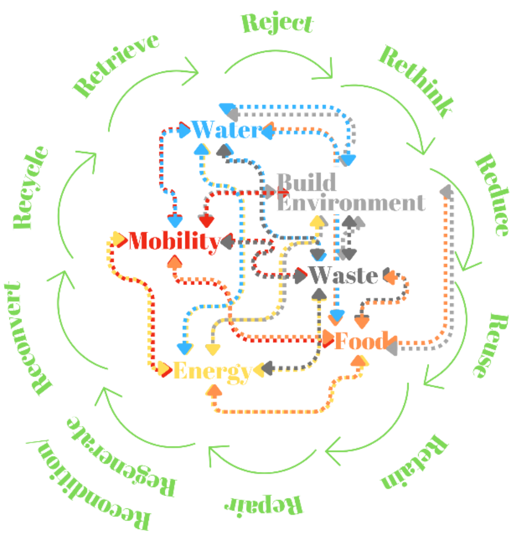

Figure 1. Interrelation of key sectors.

After identifying the six priority sectors in a city, the corresponding macro-objectives are shown in Figure 2.

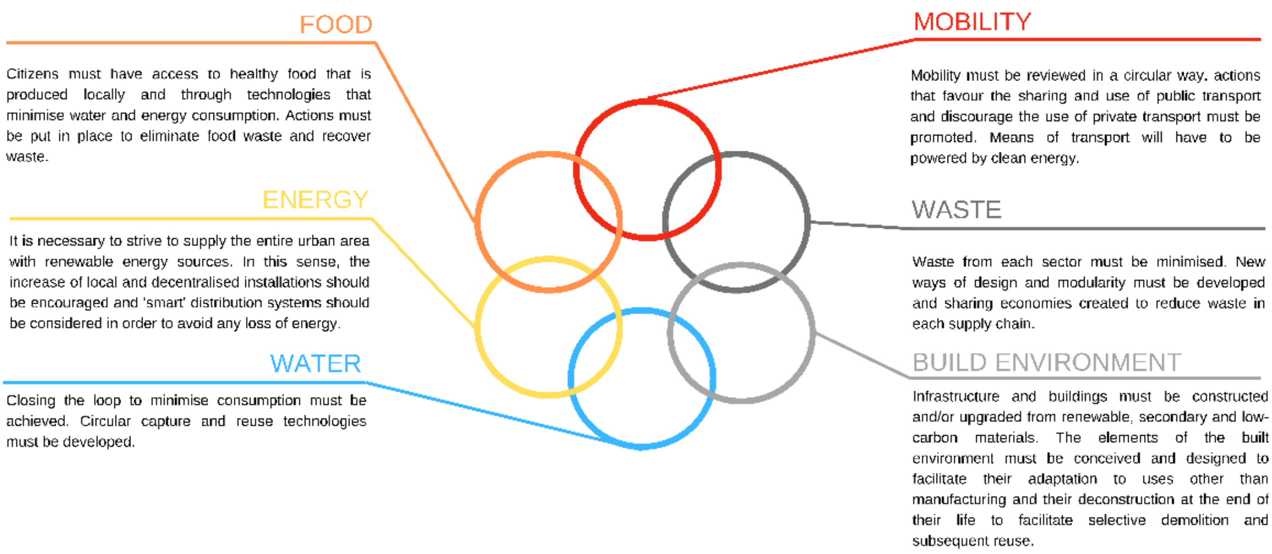

Figure 2. Macro-objectives of key sectors.

In a circular city, material productivity is maximized by eliminating waste and reducing costs. For example, decentralized production and service centers create new business opportunities, bring jobs to neighborhoods, and create incentives for the development of new skills. Green infrastructure and restored natural ecosystems in cities improve urban air quality, reduce carbon emissions, and enhance human health and well-being. Leveraging local productive capacity increases city resilience. These principles can be applied to all urban resource flows, including construction materials, goods, and food, but must be evaluated in terms of their correlations across various sectors [45]. When circular actions are implemented in one sector, a circular output is produced. There are many circular outputs due to the high number of goods and products in a city and the number of circular actions and best practices. For example, the circular action "reuse" can be applied to water resource reuse at the city level, where water is purified and reused. Similarly, the circular action "repurpose" can be applied to public spaces. A public square can be used as a public gathering place and for various artistic events and festivals. Waste such as bottles, metal, footwear, and plastic cups could be separated into compostable and non-compostable; non-compostable items could be sold to scrap dealers and compostable items to farmers (recycling and reuse). Clearly, there are many combinations of circular actions/best practices and city goods and products that can be used to close the urban cycle.

In the developed research, various circular actions related to the six identified sectors were collected from the scientific literature, existing documents from international experiences, and the existing platforms mentioned above. These actions lead to the sustainability of each considered issue and often to its life cycle closure. A catalog was prepared from research conducted in the scientific literature and found platforms, where, for each best practice/circular action, the following are reported: the considered issue, the title of the best practice/action, a brief description, the type of best practice/action, the state/city where it was proposed, and the source from which the information was obtained. This tool is intended to support concretizing urban circularity strategies within a broader strategic framework designed for local administrations (e.g., Urban Circular Action Plan). This database was designed to be implemented in Office 365 or Excel 16, making it an updatable and expandable tool.

Thanks to this catalog, it is possible to have a strategic framework not only of actions necessary to close the life cycle of a single sector but also of possible interactions between the various sectors to close the life cycle of the entire city. Figure 3 shows the following: in the first column, the six considered sectors; in the second column, the prepared catalog; in the third column, the symbols of the six sectors that need to be closed (characterized by different colors); and in the last column, the schematic representation of the strategic framework of actions aimed at the intersectoral closure of the involved sectors and thus for closing the urban cycle. This method works according to the 10R model and the interaction between minimizing resource demand and maximizing an efficient and renewable supply of materials, energy, water, and food. For example, in examining the Water issue, it is possible to find, in the respective row and column, the intersectoral actions related to the other sectors, and the same applies to each issue.

Table A1 in Appendix A shows an excerpt from the strategic framework of intersectoral actions provided in the methodology and prepared in Excel, while Figure 4 shows a focus on the Water key sector that will later be used in the application of the methodology to a first case study.

Finally, it is specified that this framework of actions can also be supplemented with information regarding potential specific actions/good practices existing in the study area to which the methodology is intended to be applied, and which have not been included in the database.

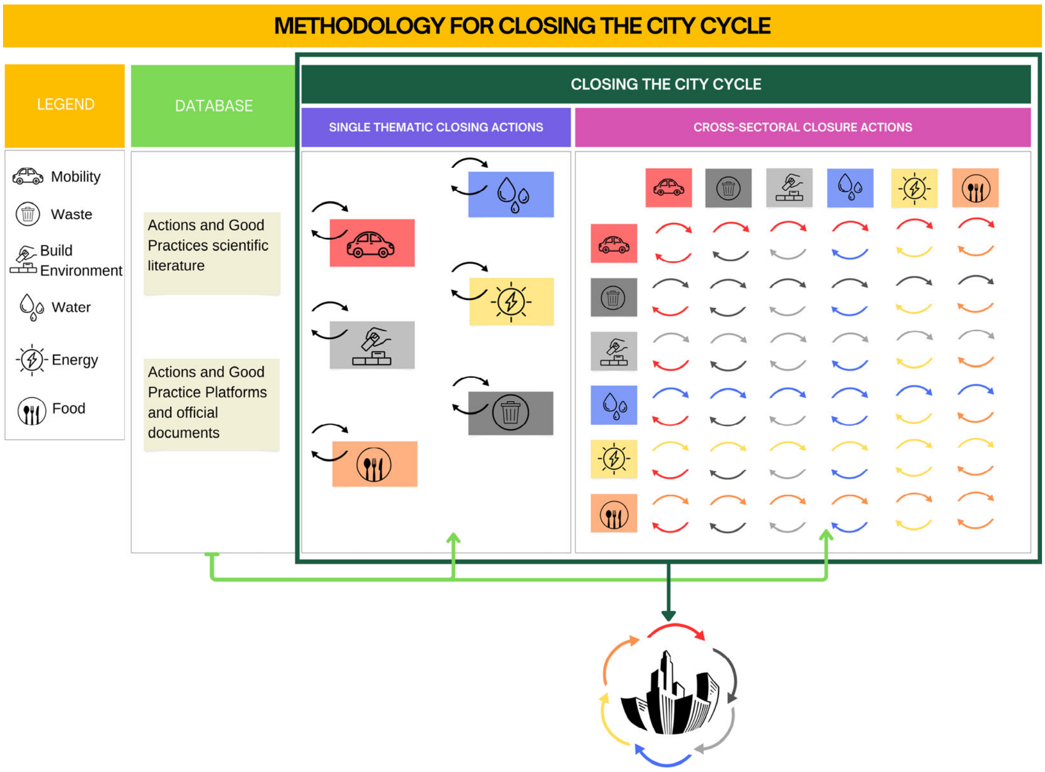

Figure 3. Proposed methodology for defining intersectoral actions aimed at closing the city cycle.

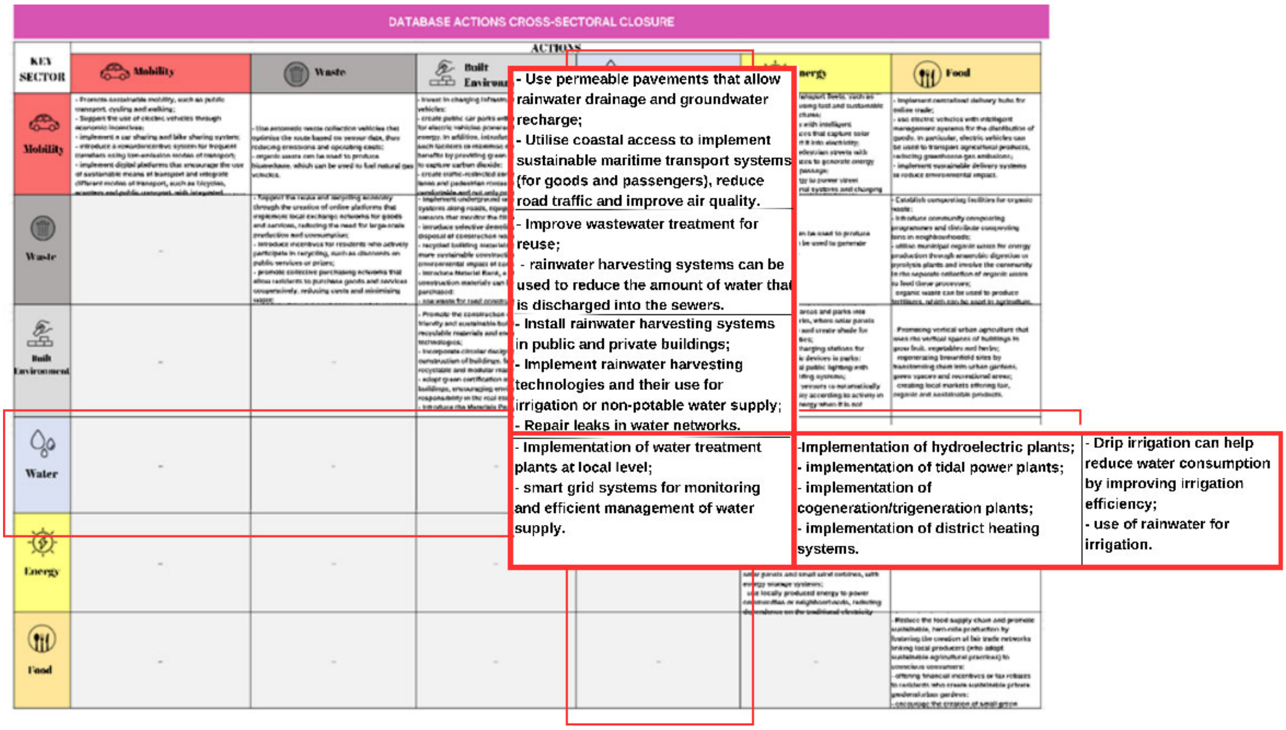

Figure 4. Catalog of intersectoral circular actions—focus on Water key sectors.

2.3. Case Study: The City of Genoa and Circularity

The case study of the research is Genoa. This is because the paper is part of a broader collaboration with the Genoa municipal administration on issues related to sustainability. For a first application, data and information are important, which sometimes become difficult to obtain outside of an existing collaboration between institutions. Furthermore, as described in the paragraph, Genoa has in itself all the potential characteristics and is somewhat already on the path toward circularity.

Now, a brief analysis of the context is presented to provide a general overview of the area under study and to deepen its path toward circularity. The city has a territorial area of 240.3 km^2 and presents very peculiar territorial characteristics. This is due both to the existence of multiple centers, each with its own physical and social identity, around which settlements have grown in successive expansions, and to its geographical conformation, squeezed between the sea and the mountainous reliefs where the municipalities of the metropolitan area are located. The city stretches along the coastline for a length of about 30 km and along two major valleys perpendicular to the coast, Val Polcevera and Val Bisagno.

Regarding the resident population, it amounts to 561,191 inhabitants (31 December 2022). After a drastic decline in the number of inhabitants, with a resizing of the resident population by about 250,000 inhabitants compared to the maximum size reached in the first half of the 1970s, there is currently still a slight decrease.

Regarding the transition strategies towards a circular economy, Genoa aims to become carbon neutral by 2050. At the heart of this process is the sustainable development strategy proposed by the Authority, called Genoa Lighthouse (DGC-2019-340 of 13/11/2019) [46]. Within this strategy, divided into three pillars (innovative infrastructure design, urban regeneration, and community business) and six strategic sectors (livability, development, attractiveness, inclusivity, and sustainability), twelve priority lines are planned to pursue the overall goal of making the city more livable (ensuring greater safety and healthiness, providing a good supply of public spaces and green areas, appreciable air quality, and satisfactory services), more competitive (implementing economic sectors and improving quality of life), more attractive (for residents, tourists, and businesses), and more inclusive (offering equal opportunities to all). One of these lines, "C-City," is directly linked to the circularity path that the city intends to undertake. With it, a long-term program has been launched aiming to adopt key principles of the circular economy to achieve goals of economic, social, and environmental well-being. This line aims to enhance progress in the field of green and bioeconomy technological innovation and in energy sector circularity and to transition the city from a consumer to a prosumer.

Genoa, already a signatory to the European Circular City Declaration, "therefore intends to study and apply a new business model aimed at promoting, within the waste management sector, prevention and up-cycling, improving collection schemes, incentivizing reuse, working at the neighborhood scale to foster social circularity and strengthen the stakeholder network; in the field of bioeconomy, encouraging experimentation with the conversion of some current production lines into new circular ones that can attract international funding applied to sustainability of production processes and marketing of products and services. Finally, in the field of circularity and energy positivity, the city will explore the potential of energy communities at the neighborhood scale" [42]. Outputs expected include:

- Preliminary report on city circular economy initiatives (short term);
- Development of a flexible circular economy strategy (short term);
- Research and innovation projects on new sustainable and circular product chains (short term);
- Identification and characterization of potential experimentation sites (short term);
- Implementation of new circular economy initiatives (medium term);
- Experimentation of a circular district (Circular Hub and idea laboratory) (medium term);
- Partnership agreements on technologies in the bio-economy field (medium term).

Regarding long-term impacts and benefits for the city, the strategy aims at decarbonizing the traditional economy and initiating a new type of production focusing on green technologies through the conversion of company production lines. In doing so, Genoa adheres to international policies and the National Plan for the Circular Economy, enhancing the city's positioning and visibility in the field of green innovation technology and increasing attractiveness for researchers and investors.

According to the Integrated Evaluation Document of Urban Environmental Quality 2022 "Cities in Transition: Italian Capitals towards Environmental Sustainability" from the National System for the Protection of the Environment (SNPA) [47], Genoa has implemented several improvements in terms of circularity, particularly in waste management, mobility and transportation, and partially in terms of water.

Regarding the latter, over the seven years from 2012 to 2018, the per capita water supply registered a continuous decline, dropping to 216 L per capita per day in 2018 (from 276 L per capita per day in 2012). However, despite this value being lower than the sample of municipalities analyzed, during the considered period (2012–2018), total water losses in the distribution area increased significantly, reaching the highest value of the series (39.0%), although still below the national total recorded in the same year (42.0%).

These analyses, which constitute one of the most important challenges in urban policies, highlight Genoa's commitment to ecological transition.

3. Results

3.1. Applying the Methodology to the Case Study: Towards the Closure of the Genoa Cycle

This paragraph presents an initial application of the described methodology with reference to the water issue alone (schematization: Figure 5). The choice to describe this topic as an example stems from the fact that Genoa, as seen in the previous paragraph, has implemented only partial improvements in this sector in terms of circularity.

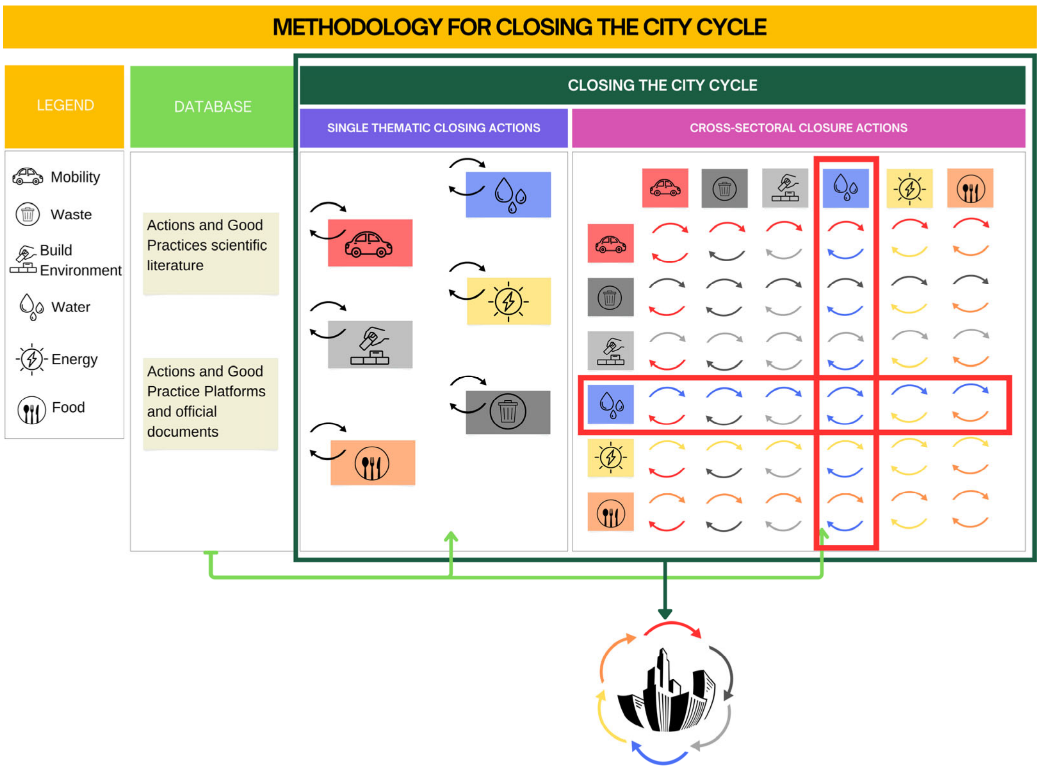

Figure 5. Application of the proposed methodology for defining intersectoral actions aimed at closing the urban cycle—Water sector.

Table A2 in Appendix A shows the existing actions in Genoa for this sector that were studied through reconnaissance of best practices at the municipal level in terms of sustainability and circularity [48]. These specific local actions will be used to expand the catalog of actions developed from the literature research and existing documents. Of particular interest are two landfill projects related to leachate treatment and groundwater, the "viAmare" project aimed at increasing urban mobility by sea, and the project for the construction of a new water treatment plant.

The management of surface runoff in urban areas has several significant consequences for sustainability (environmental, social, and economic), especially given the increasing challenges posed by climate change. In this context, sustainable management of stormwater is crucial and involves various solutions such as retention or infiltration basins, floodable ditches, partially floodable urban public spaces (rain gardens, green parking lots, rain squares), and private spaces (gardens, green roofs). These solutions aim to control surface runoff, conserve or restore permeable areas, and restore the natural filtering function of soils [49]. Such solutions should be evaluated based on specific site characteristics and land use purposes, particularly in line with predefined macro-objectives, starting from the analysis of available data and the proposed methodology related to the framework of intersectoral circular actions.

As anticipated in Figure 2, achieving water cycle closure is essential to minimize consumption. Genoa's current wastewater treatment system consists of numerous facilities distributed throughout the municipal territory in a manner closely tied to the local urban and morphological structure. Over time, the location of these facilities and the aging of infrastructure have led to administrative and operational challenges that can only be resolved through a comprehensive reorganization of the entire urban wastewater treatment system. The Municipal Urban Plan (P.U.C.) includes plans for a new plant capable of receiving all sludge produced by Genoa's treatment system, thereby simplifying management and making available the areas of sludge lines from other progressively decommissioned plants for potential upgrades [50]. Within this framework, the research proposes the introduction of smart networks for monitoring and efficiently managing water supply, and the enhancement and implementation of local water treatment plants. Establishing community-level water treatment plants can recycle and purify wastewater for non-potable uses such as irrigation or industrial processes.

Considering the municipal territory of Genoa, and since the Municipal Urban Plan was recently created, the research referred to the P.U.C. of Genoa. Naturally, when talking about a topic such as water, it is necessary to also refer to other sectoral planning tools, given that the reference scale is certainly broader.

For example, the Basin Plan is fundamental for the management of surface and underground waters. In Genoa, there are several hydrographic basins and related plans drawn up (for example, the Basin Plan for the hydrogeological structure of Bisagno, Polcevera, etc.) linked precisely to soil protection (aimed in particular at water remediation and soil protection), which, in a broader perspective, are certainly necessary to analyze and systematize. Furthermore, always for sectoral planning in Liguria, and therefore in Genoa, it should be noted that for the case study, there is the Territorial Coast Coordination Plan of Liguria Region, which among the various purposes deals with the specific defense of the coastline from marine erosion.

It should be noted that the urban planning tools mentioned and the related actions are certainly aimed at sustainability criteria but do not consider the issue of circularity.

In addition to water cycle closure, it is crucial to consider the intersectoral nature of various issues to achieve overall urban cycle closure, as mentioned earlier. The following actions are proposed to meet this requirement, summarized schematically (Figure 6, actions already planned in green frames), investigating and proposing actions related to intersectoral issues: Water–Mobility, Water–Waste, Water–Built Environment, and Water–Energy.

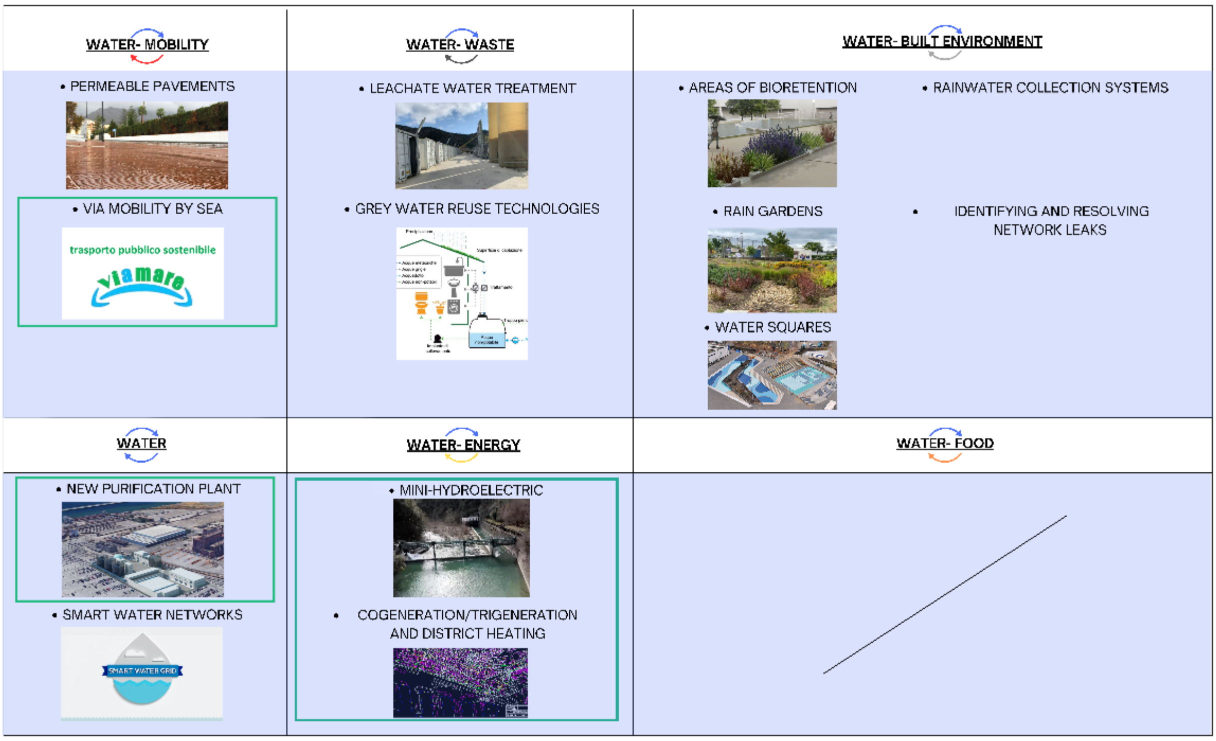

Figure 6. Intersectoral actions in the Water sector and urban cycle closure.

Regarding Water–Mobility, one proposal is to use permeable pavements for draining rainwater and recharging groundwater, particularly in high-flood-risk areas. These types of pavements facilitate surface water drainage and infiltration into the ground through modular elements characterized by voids or joints made of permeable materials. Such pavements can be used to drain pedestrian or lightly trafficked vehicular streets, driveways, bicycle and pedestrian paths, residential avenues, parking lots, and rest areas. Among various available technologies, the LIFE CERSUDS Sustainable Urban Drainage System in ceramics can reduce surface runoff of rainwater by almost 90%, making it available for irrigation, reducing pollutant dispersion, and improving water quality [41]. Another ongoing action is the "viAmare" project, aimed at increasing coastal access to implement sustainable maritime transport systems (for goods and passengers), reducing road traffic, and improving air quality.

Regarding the Water–Waste intersectorality, the first proposed action involves improving wastewater treatment for reuse. Two important ongoing projects concerning Genoa's landfill are suggested. The first project aims to optimize water resource use by modifying groundwater extraction well systems to intercept groundwater and reduce its contact with landfill leachate, thereby preventing an increase in leachate production by lowering the intercepted groundwater level. Additionally, the extracted water is used for industrial purposes such as dampening internal landfill tracks or other landfill management purposes, leading to significant water savings. The second project directly addresses leachate, a pollutant formed when rainwater passes through and collects waste and chemical components. The leachate is collected by a capillary system of pipes and wells, transporting it to two large tanks at the base of the landfill. From there, it is sent to the treatment plant, where it undergoes treatment through reverse osmosis purification systems and is eventually discharged into sewers. During the 2019 test campaign, a process was developed for treating concentrate from leachate, resulting in a marketable solution for formulating agricultural fertilizers. This solution offers a dual economic and environmental benefit: eliminating the need for sludge transfer by tankers to other plants, reducing transport costs and CO_2 emissions, and reducing water consumption, using less than 1 m^3 per day of water withdrawn from the aqueduct thanks to the reuse of permeate as industrial water [51]. Although urban wastewater treatment has consistently met emission standards, with more than 99% of urban wastewater treated from 2009 to 2018 [42], the research also proposes incentivizing the installation of greywater reuse technologies, linked to actions related to Water–Built Environment, to further reduce the amount of water discharged into sewers.

Regarding Water–Built Environment synergy, the first proposed intervention involves implementing technologies for collecting and managing rainwater and its subsequent reuse for irrigation or non-potable water supply. Based on floodplain mapping from the Basin Plan, areas are identified for intervention, with particular attention to high-flood-risk areas. Due to high urbanization levels, the research proposes interventions suitable for densely built residential neighborhoods with high impermeable surface ratios, as well as industrial areas and wide or one-way road sections: bioretention beds. Bioretention beds are small green areas positioned lower than surrounding pavements and enclosed by vertical walls that contain both the water collection basin and the substrate for vegetation growth [52–56]. They are designed to collect and temporarily retain water from surrounding surfaces, allowing it to infiltrate into the substrate and, if open-ended, into the ground, purifying it through plant and substrate action [52,56]. Additionally, where space allows, the research proposes creating "rain gardens". These too are small-scale solutions [52,55,57,58], preferably located away from buildings to avoid potential infiltration [52,54,59]. Lastly, an innovative solution is the installation of rainwater collection and greywater recycling systems in public and private buildings, drawing from the example of London's Millennium Dome [60]. Overall, rainwater is a renewable and local resource. Rainwater can be used for external uses such as irrigating green areas, lawns, gardens, and orchards; washing external areas (roads, yards, parking lots, balconies) and cars; technological uses (e.g., cooling water); and feeding fire protection systems.

Finally, based on the data examined, repairing leaks in water networks is necessary; total water losses in distribution, starting from 29.2% in 2012, reached 39.0% in 2018, the highest value in the series [47]. Smart monitoring systems are proposed to identify and resolve water losses in water networks. Lastly, concerning the Water–Energy relationship, the research proposes valorizing the restart of an existing mini-hydroelectric plant in Genoa, outlined in the current SEAP and SECAP tools. The plant utilizes water from an existing reservoir, with plans to install a new turbine alternator unit by 2030, potentially reducing CO_2 emissions by 279 tons [61]. Such plants generate electricity using small elevation drops and low flow rates, suitable for placement along city aqueduct distribution lines. The research recommends implementing this technology by leveraging Genoa's geomorphology to use previously untapped elevation drops or reactivate decommissioned plants over time. Another significant action involves cogeneration/trigeneration plants and their respective district heating networks. Cogeneration plants produce secondary forms of energy (electricity and heat) from a single source, fossil or renewable, in an integrated system. Trigeneration plants also produce cooling in addition to thermal energy for heating. When applied to individual buildings or complexes, they are referred to as "micro-cogeneration" or "micro-trigeneration" plants. These systems increase overall energy efficiency in energy conversion systems and save primary energy, thereby reducing CO_2 emissions into the atmosphere. The City of Genoa intends to continue supporting and monitoring the spread of such technologies in residential and tertiary sectors. By 2030, the number of "micro-cogeneration/trigeneration" plants in the municipal area is expected to double compared to data collected up to 2015 (from 80 to 160 plants). Notably, a cogeneration plant is currently under construction in Genoa [61]. The proposal is to expand the district heating network with activities distributing heat through underground pipes in city streets.

4. Discussion and Conclusions

The research aims to highlight existing intersectoral connections among key themes to outline a synergistic framework of actions. The study addresses a current, yet complex and evolving theme that, to become more operational, must be incorporated within the framework of city planning and management tools, such as a potential Urban Circular Action Plan aimed at closing the urban cycle and implementing sustainable planning.

The development of an urban circularity tool that addresses and integrates priority themes through circular actions would, indeed, contribute to transitioning our cities towards sustainability in accordance with Agenda 2030. "It is therefore necessary to develop a regulatory-level plan that integrates and communicates various circular themes, which must integrate and coordinate with each other. In general, this action plan must define a forward-looking agenda co-designed with economic actors, consumers, citizens, and civil society organizations. Furthermore, it must present a series of interconnected initiatives aimed at establishing a strategic and coherent framework where sustainable products, services, and business models will be the norm and transform consumption patterns to avoid high-output production in the first place (waste, emissions, ...)" [43].

The core contribution is a methodological and synergistic framework designed to assist municipal administrations in conceptualizing integrated circularity and moderating intersectoral activities. While the paper advances a conceptual framework for a relational and circular city, its primary utility lies in its application, proposing the framework as a tool for integrated planning.

In this way, thanks to the research and its first application, it was possible to answer the following initial questions:

"How can the relationships between various key themes be systematized to simplify planning aimed at urban cycle closure?" and "How might this tool function within a real case study?"

The scientific innovation of the research is in the definition of a general tool, the Urban Circular Action Plan, which does not currently exist at an international level aimed at defining a general framework of circularity for the entire urban level. Often, in fact, as already expressed, thanks to good practices, there is a tendency to carry out interesting interventions but specific only to one sector. It is necessary to no longer think in terms of individual sectors but of the entire city; only in this way could we talk about circular cities and not circular actions. Naturally, it is a very complex topic, given that cities are very complex organisms and certainly the research itself needs further development and in-depth analysis.

A topic that has not been the subject of research (in the field of urban planning) is the one related to the costs of the transition to a circular economy at the city level if we really want to achieve sustainability, not only environmental but also social and economic. The actions proposed in the research must of course be economically feasible and therefore require specific analyses, for example cost–benefit. Creating the necessary conditions (e.g., buying technology, building infrastructure) is not only financially demanding but can also have a significant environmental footprint.

The new tool, the Circular Action Plan, was proposed at the municipal level, because in the research, the urban scale was considered the most effective and operational for the topic discussed, a point of reference, not only for the Municipal Urban Plan but also for other tools at the municipal level (where they exist), for example, the Mobility Plan, the Tourism Plan, the Waste Plan, etc.

Furthermore, to complete the research, more detailed insights into the mechanisms of sectoral collaboration and the principles that support their interaction, with the other sectoral urban planning tools, are certainly recommended.

Finally, synergies with large-scale urban planning tools, such as the Provincial Plan and Regional Plan, are necessary for correct governance.

For example, for the case study of Genoa treated in the research, and for the theme of water considered, it is certainly important to also analyze the supra-municipal context, i.e., the provincial and regional one and the related urban planning tools.

Such a plan should also be participatory; only through real cooperation and engagement of the public administration, citizens, civil society organizations, economic actors, and consumers can we build open governance and implement the radical transformations necessary to foster economic, political, and technological development towards circular and sustainable cities.

Additionally, besides the technical actions identified in the Catalog of Intersectoral Circular Actions, it is crucial to include other types of actions essential for an administration embarking on a path of circularity within its municipality. These include participatory and educational actions (e.g., supporting the creation of research networks among various local stakeholders, developing applications or online platforms to gather feedback and suggestions from the community, participating in sustainable city networks to share best practices, implementing education and training programs for citizens, etc.) and actions related to the industrial economic landscape (e.g., supporting and incentivizing industrial symbiosis, supporting local businesses adopting circular models, creating technological and innovation parks, etc.).

Currently, the international scenario is still far from the desired landscape for several reasons. Among the main challenges requiring immediate and prioritized intervention, in addition to the lack of strategic plans and multilevel governance, are cultural and financial disparities. On one hand, there is often no established culture regarding circularity.

We find that cultural barriers, particularly a lack of consumer interest and awareness as well as a hesitant company culture, are considered the main circular economy barriers by businesses and policymakers. These are driven by market barriers which, in turn, are induced by a lack of synergistic governmental interventions to accelerate the transition towards a circular economy [62].

In this logic, the intersectoral good practices proposed in the research in Genoa are even more important, also as an example of possible recommendations/guidelines that can be replicated in other urban contexts.

It is often too closely tied to its application in a single theme or specific field (e.g., industrial symbiosis), whereas achieving the lifecycle closure of a city requires starting to consider the interrelationships between various themes and sectors in which a city operates, including aspects such as best practices and participation. Even now, the concept of circularity is often solely understood as a different waste management approach and must still be explained and embraced administratively and by the population.

On the other hand, addressing the economic availability of significant public funds and/or private financing is crucial when discussing circularity. A circular city needs to introduce new, initially seemingly unsustainable, smart technologies from an economic standpoint. A long-term rather than short-term vision is required to achieve a genuine balance across environmental, social, and economic fields. In this context, urban planning plays a crucial role in directing the transformation of current cities into circular realities, as it provides a starting point to radically rethink the current ways of thinking, describing, and shaping cities and landscapes. However, more integrative approaches are necessary to navigate complexity, learn to manage complex, interdisciplinary, and potentially large-scale processes, and fully realize the circularity goal [3].

Today, there are several references in the scientific literature for the closing of the cycle, for example, for the issue of waste, but not for the closing of the urban cycle. Each sector remains too disconnected and there is no framework, no tool, that gives overall indications for the global circularity policy at the urban level. Furthermore, the creation of a specific circularity tool, proposed in the research, would lead to harmonization and guidelines in our cities in this field aimed at transforming our cities into truly circular cities.

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Appendix A

In this section, the implemented tables presented in Sections 2.2 and 3.1 are shown.

Table A1. Catalog of intersectoral circular actions.

DATABASE ACTIONS CROSS-SECTORAL CLOSURE						
KEY SECTOR	**Mobility**	**Waste**	**Built Environment**	**Water**	**Energy**	**Food**
Mobility	- Promote sustainable mobility, such as public transport, cycling and walking; - Support the use of electric vehicles through economic incentives; - implement a car sharing and bike sharing system; - introduce a reward/incentive system for frequent travellers using low-emission modes of transport; - implement digital platforms that encourage the use of sustainable means of transport and integrate different modes of transport, such as bicycles, scooters and public transport, with integrated	- Use automatic waste collection vehicles that optimize the route based on sensor data, thus reducing emissions and operating costs; - organic waste can be used to produce biomethane, which can be used to fuel natural gas vehicles.	- Invest in charging infrastructure for electric vehicles; - create public car parks with charging stations for electric vehicles powered by solar or wind energy. In addition, introduce green roofs on such facilities to maximize environmental benefits by providing green space and helping to capture carbon dioxide; - create traffic-restricted zones (ZTLs), bicycle lanes and pedestrian routes that are safer, more comfortable and not only promote sustainable mobility, but also incorporate elements of	- Use permeable pavements that allow rainwater drainage and groundwater recharge; - Utilize coastal access to implement sustainable maritime transport systems (for goods and passengers), reduce road traffic and improve air quality.	- Electrify public transport fleets, such as buses and trains, using fast and sustainable charging infrastructures; - Developing roads with intelligent photovoltaic surfaces that capture solar energy and convert it into electricity; - creating smart pedestrian streets with piezoelectric surfaces to generate energy from pedestrians' passage; - using green energy to power street lighting, traffic signal systems and	- Implement centralized delivery hubs for online trade; - use electric vehicles with intelligent management systems for the distribution of goods. In particular, electric vehicles can be used to transport agricultural products, reducing greenhouse gas emissions; - implement sustainable delivery systems to reduce environmental impact.

	payment systems; - implement intelligent mobile applications for traffic management, providing real-time information on peak times, suggestions for alternative routes and public transport options; - promote cycling through bicycle-sharing programmes; - improve public transport by increasing the frequency of electric vehicles and facilitating access to stations; - electrify public transport fleets, such as buses and trains, using fast and sustainable charging infrastructure.		vegetation and green areas; - integrate online booking systems and smart sensors to optimize the use of spaces and reduce waiting time.		charging stations for electric vehicles; - create smart pedestrian paths with photovoltaic pavements, solar LED lighting and benches equipped with solar USB chargers. And use technology to detect footfall and dynamically adapt lighting and other services as needed.	
Waste		- Support the reuse- and recycling economy through the creation of online platforms that implement local exchange networks for goods and services, reducing the need for large-scale production and consumption; - Introduce incentives for residents who actively participate in recycling, such as discounts on public services or prizes; - promote collective purchasing networks that allow residents to	Implement underground waste collection systems along roads, equipped with intelligent sensors that monitor the fill level; - introduce selective demolition for the proper disposal of construction waste; - recycled building materials can be used for more sustainable construction, reducing the environmental impact of construction; - introduce Material Bank, a place where waste	- Improve wastewater treatment for reuse; - - rainwater harvesting systems can be used to reduce the amount of water that is discharged into the sewers.	- - Organic waste can be used to produce biogas, which can be used to generate electricity or heat.	- Establish composting facilities for organic waste; - Introduce community composting programmes and distribute composting bins in neighbourhoods; - utilize municipal organic waste for energy production through anaerobic digestion or pyrolysis plants and involve the community in the

	purchase goods and services cooperatively, reducing costs and minimizing waste; - create 'tool libraries' where the community can borrow tools and equipment instead of buying them; - create a recycling and reuse center where the community can donate or purchase used goods; - work with local businesses to reduce unnecessary packaging and promote sustainable packaging solutions; - install accessible recycling stations throughout the city to incentivize recycling collection and using technology such as computer vision to facilitate the proper separation of recyclable materials.	construction materials can be deposited or purchased; - use waste for road construction.			separate collection of organic waste to feed these processes; - organic waste can be used to produce fertilizers, which can be used in agriculture.
Built Environment		- Promote the construction of environmentally friendly and sustainable buildings, using recyclable materials and energy-saving technologies; - incorporate circular design principles in the construction of buildings, favouring recyclable and modular materials; and - adopt green certification standards for	- Install rainwater harvesting systems in public and private buildings; - implement rainwater harvesting technologies and their use for irrigation or- non-potable water supply; - - repair leaks in water networks.	- Transform green areas and parks into multi-use solar parks, where solar panels provide electricity and create shade for recreational activities; introduce solar charging stations for personal electronic devices in parks;	- Promoting vertical urban agriculture that uses the vertical spaces of buildings to grow fruit, vegetables and herbs; - regenerating brownfield sites by transformin g them into urban gardens, green spaces and recreational areas;

	buildings, encouraging environmental responsibility in the real estate sector; - introduce the Materials Passport.		- replace traditional public lighting with solar-powered lighting systems; - integrate motion sensors to automatically adjust light intensity according to activity in the area, saving energy when it is not needed; - initiate energy rehabilitation programmes for historic buildings, preserving their cultural heritage; - - install solar panels on the roofs of public and private buildings.	- creating local markets offering fair, organic and sustainable products.
Water		- Implementation of water treatment plants at local level; - smart grid systems for monitoring and efficient management of water supply.	- Implementation of hydroelectric plants; - implementation of tidal power plants; - implementation of cogeneration/trigeneration plants; - implementation of district heating systems.	- Drip irrigation can help reduce water consumption by improving irrigation efficiency; - use of rainwater for irrigation.
Energy			- Implement economic incentive programmes for households and	/

		businesses that reduce energy consumption; - promote the use of renewable energy; - create local energy microgrids that combine renewable energy sources, such as solar panels and small wind turbines, with energy storage systems; - use locally produced energy to power communities or neighborhoods, reducing dependence on the traditional electricity grid; - implement a smart energy network that enables the efficient distribution of locally produced energy; - initiating community energy programmes that involve the community in the production, sharing and consumption of renewable energy	
Food			- Reduce the food supply chain and

promote sustainable, zero-mile production by fostering the creation of fair trade networks linking local producers (who adopt sustainable agricultural practices) to conscious consumers; - offering financial incentives or tax rebates to residents who create sustainable private gardens/urban gardens; - encourage the creation of small green oases in urban residential areas; - develop urban ‘farm-to-table’ programmes that connect local farmers with restaurants and communities; - introduce fair-trade food products in public and community canteens; - creating communal kitchens where residents can share food resources and cook communal meals.

Table A2. Best Practices/Actions for Circularity in the City of Genoa—Water sector.

GOOD PRACTICES/ACTIONS—WATER	DESCRIPTION
Initiative/Event	
Blue Economy Summit	The Summit's overall objective was to create awareness of the opportunities deriving from the 'Blue Economy', or 'Economy of the Sea', by involving all the main institutional and entrepreneurial players in the area that use the sea as a resource for industrial activities and the development of services, placing them in a context of sustainability. Several targets were reached during the Summit, including: International, European and Italian institutions, academic and research institutions, international and national associations, Italian and European local authorities bearers of case-histories, public and private companies, local institutions representing sectors related to infrastructure, smart cities, environment, energy, mobility, culture, tourism and local, national and international media. The themes addressed during these editions are: - Port, infrastructure, new markets, intermodality -High tech, training 4.0, new professions, start-ups in the sector—in - Tourism, cruises, boating, port as motorway of the sea, waterfront of Levante - Fishing, ichthyic tourism, fish farming, protection of the marine environment -Genoa, Capital of the Blue Economy: development prospects for the Waterfront and the Port - The economic and maritime dynamics of the Mediterranean, between Europe and China. Where Italy is positioned and what development opportunities there are - Cruise tourism - Technological evolution - The Protagonists of the Blue Economy: development paths and new professions in the sea economy The three editions of this event have reaffirmed both the centrality of Genoa in the Italian maritime economy and the extent to which the blue economy is primary in the programmatic lines for the development of our city. With this in mind, the objective is to work on a long-term strategy involving all local institutions in order to find the right balance between the development of the blue economy and that of professions related to the sea economy so that young people from other areas can come to specialize here and then find a favorable working environment.
TheOcean Race—Genoa Grand Finale 2022—2023	The Ocean Race, (formerly Whitbread Round the World Race), is the most prestigious, longest and toughest round-the-world sailing competition for professional crews, held every three years. The city of Genoa has allowed Italy to be present and protagonist of this epic event for the first time, through the organization of the Grand Finale of the 2022—2023 edition. The event, articulated in 10 international stages: Alicante—Cape Verde—Cape Town—Shenzhen—Auckland—Itajai—Newport—Aarhus—The Hague—Genoa, represented first and foremost an extraordinary opportunity for Genoa and Sistema Italia to promote and develop social, cultural, scientific and economic development. The sea and the port and all the related activities represent one of the fundamental assets for the economic development of the city and, therefore, The Ocean Race was a fundamental driving force to exploit every opportunity to reaffirm and promote Genoa as the European capital of the blue economy (sustainability, Maritime Transport, Marine Waste Management, Renewable Energies, Tourism, Oceans and Climate Change) and the centrality of the port of Genoa and its role in the Mediterranean. Founding elements of a new great season for the city of Genoa at the service of Italy and Europe.
Place	
Genoa Blue District	The blue economy represents one of the Administration's main drivers. Given the territorial conformation and the specialization of the supply chain that is intended to be strengthened in the area, an aggregation and facilitation project linked to the blue economy has been launched, with the establishment of the Genoa Blue District as its highest expression. The Warehouses of Abundance (or Palazzo Verde) have been identified as the physical configuration space of this project. The geographical location in the area of the old port represents the incipit of a path of identity creation around the theme of the Blue Economy in terms of business innovation, as well as economic development and networking. The Genoa Blue District is a modular project that brings together a heterogeneity of actions gravitating around 3 main themes 1. the financial aspect and the catalyzing of resources to be allocated to the 'Blue driver'. An attempt will therefore be made to make various funding lines converge around this project (European funds, national funds, private funds). 2. The element of process facilitation. Networking, also by means of the schedule of well-established events, will provide for the concentration of multi-level aggregation processes (communication of projects in progress or being presented, sectoral events, focal points, focus groups) both institutional and private. 3. The activation of services that may be outlined in information and open innovation actions. To this end, an agreement was signed between Job Centre s.r.l. and the Municipality of Genoa to assign the management of the 'Magazzini dell'Abbondanza' building to the in-house company, in which Job Centre s.r.l., Hub2work and the start-up of the new Genova Blue District will be located. The inauguration of the Genova Blue District was on 19 November 2020.
Implementation project	
SIMAM2—Leachate and groundwater purification	The substance called leachate, produced in any landfill, is a polluting liquid also containing ammonia, nitrogen and metals that is formed when rainwater runs through the waste and, as it flows, collects the waste and chemical components present. The leachate produced in this way is collected by a capillary system of pipes and wells, which

	conveys it into two large tanks located at the foot of the landfill. From there it is sent to the 'SIMAM2' treatment plant, where, thanks to the reverse osmosis purification system, it is treated and finally discharged into the sewage system. During the experimental campaign in the spring of 2019, in agreement with the company Simam, a specially designed process was developed for the treatment of the leachate concentrate, which makes it possible to obtain a concentrated solution of ammonium sulphate, which can be valorized on the market for the formulation of fertilizers for agricultural use. The estimated annual production of ammonium sulphate is around 3700 tons. In January 2020, AMIU filed an application to introduce improvements to the SIMAM2 plant's purification cycle. Pending the issuance of the permit, work was carried out to adapt the plant to the new configuration, through the installation of specific equipment. In addition, in December 2021, AMIU was granted the possibility of disposing of sludge from leachate treatment operations directly in the landfill. This solution will provide a double economic and environmental advantage: it will no longer be necessary to transfer the sludge by tanker trucks to other plants, with a consequent reduction in transport costs and CO_2 produced. From the point of view of water consumption, in the new configuration the consumption of water taken from the aqueduct will be less than 1 m^3/day. This reduction was also possible thanks to the reuse of permeate (the main product of the purification process) as industrial water.
viAmare	The 'viAmare' project derives from the strategy of the Genoa Metropolitan City's Sustainable Mobility Plan to strengthen local public transport complementary to LPT and as an alternative to the use of private cars and is integrated with soft mobility systems (urban cycle paths and cycle-tourist routes) . It is also a project for the sustainable enhancement of the territory since the viAmare service can support the tourist offer. In fact, the service, in addition to providing stopovers at the main tourist resorts on the Rivieras, is designed to integrate with the Tyrrhenian national tourist cycle route and connect with the interchange nodes at Cristoforo Colombo Airport and the new waterfront in Genoa. The service addresses the challenge of the transport sector's energy transition by incentivizing the transfer from private cars to LPT, with a consequent annual reduction in private journeys, and proposes—depending on the scenario considered basic or congested—an annual reduction in CO_2 emissions from road traffic, thanks also to the green propulsion systems of the innovative, low-input prototype ships, which are also the subject of the project. On the basis of a sample survey, a project was carried out to demonstrate the feasibility of a segmented transport service on three lines: Linea Centro da Prà a Nervi—con approdo a Pegli, Aeroporto, Porto Antico e Fiera, Linea Ponente si svilupperà invece dall'Aeroporto a Savona con scalo ad Arenzano e Varazze Linea Levante, infine, partirà dalla Fiera, con approdo a Recco, Santa Margherita Ligure, Rapallo, Chiavari e Sestri Levante.
Central Area Water Purifier	A large "Depuratore area centrale" (D.A.C.) is being built in the disused areas of Genoa's "Ex Ilva" steel mill, which will rise at the mouth of the Polcevera River, on the right bank in the former Ilva area, thus creating one of the largest sewage treatment plants in Italy and Europe. The operation, under an Integrated Contract won by the consortium Consorzio Integra, Veolia Water Technologies Italia and Suez Trattamento Acque and carried out by the company ICI.COOP SpA, will cost about 60 million euros and is considered a Strategic intervention in the Plan of Program Interventions approved by the Metropolitan Council: in fact, it will also allow the redevelopment of Via Rolla in the Campi area of Cornigliano, in accordance with the Metropolitan City's P.U.C. Genoa's current sewage system in fact consists of numerous plants, distributed throughout the territory following the particular local morphological and urban conformation, some of which are obsolete, causing a series of management and functional criticalities that can only be overcome through a general reorganization of the city's sewage system. The new D.A.C., in addition to treating wastewater generated by the Polcevera Valley basin, will be able to receive sludge from the entire city's sewage treatment system (with a design pollutant load amounting to 250,000 A.E), simplifying its management and making possible upgrades of other plants. Its construction is functional in the pursuit of the following objectives, which are of particular importance for the current historical moment of energy efficiency and environmental impact: - Improve the livability of neighboring city neighborhoods; - Utilize modern technologies for the treatment of pollutant loads associated with wastewater and sludge generated by the urban area; - Increase the production of biogas obtained from the anaerobic digestion of sludge, using it for the combined production of electricity and heat that will provide the plant with a better energy balance; - Facilitate the operation and maintenance of the plant.
European/supranational Project	
EcoeFISHent	EcoeFISHent is the Horizon 2020 project coordinated by FILSE—Finanziaria Ligure per lo Sviluppo Economico—which involves no less than 35 Italian and European entities, including AMIU and its affiliate GEAM. EcoeFISHent will support the growth of the local fishing sector through innovative development models based on circular economy principles. Among the main objectives are: the creation of sustainable packaging for fishing; the production of alternative fertilizers for agriculture from waste, biodiesel oil for the food, cosmetic, biomedical and pharmaceutical industries; and the reduction of the amount of plastic marine waste; the initiation of actions to preserve biodiversity and the balance and health of the ecosystem. Other objectives are to use better and cutting-edge technologies, optimize logistics and the impact of transport, all supported by an app (SeAPP) that allows the monitoring of vehicles, goods, materials and financial flows within the relevant territory.

INFUSION	Funded under the LIFE Programme, the main objective of the INFUSION project is to improve the current treatment of wastewater from the treatment of municipal waste through a series of technological processes that do not destroy the nutrients contained in this water. The project aims to close the loop between waste and resources in landfills and waste management plants by reducing their social, economic and environmental impact (recovering energy, nutrients and water from landfill leachate and liquid digestate from the organic fraction of municipal solid waste; reducing the environmental impact of liquid FORSU digestate and landfill leachate generated in municipal solid waste treatment plants; and disseminating the project results to other regions by extending it to other sectors with similar effluents). To achieve these objectives, the technology will be implemented in two pilot plants: at the Europarc2 plant in Besòs (Montcada i Reixac, Barcelona) and at the Cogersa plants in Gijón (Asturias). In 2021, the technology design was successfully completed and tested on a laboratory scale.

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