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FULL PAPER

Urban Living Labs, Circular Economy and Nature-Based Solutions: Ideation and Testing of a *New Soil* in the City of Turin Using a Multi-stakeholder Perspective

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Abstract
In the attempt to foster circular economy (CE), cities are increasingly adopting urban living labs (ULLs) as sites of co-production aimed at testing alternative solutions based on the reuse of products, reduction of consumption and recycling of materials. Taking this perspective, our study adopts an exploratory research design to discover the pragmatic implications emerging from a case study. The City of Turin joined proGIreg, a European project that entails the regeneration of former industrial districts by means of nature-based solutions (NBS). Ranging from aquaponics to green roofs, seven NBS have been experimented in Turin, which rely on the use of natural systems to tackle social, economic and environmental challenges efficiently and sustainably. Among them, the most promising is related to the production and test of the '*new soil*', a blend obtained by mixing earth materials coming from construction sites with compost, zeolites and mycorrhizae. The case herein presented is interesting to analyse for the multi-stakeholder management setting used, where public institutions, private companies, research institutions, citizens and associations collaborated in the co-creation and testing phase of the NBS. Consequently, the data collected through participant observation and direct interviews allow researchers to describe multi-stakeholders' dynamics and how they work. Thus, this paper narrates a micro-contextual experience while providing a critique. Results include an analysis of the unique combination of different stakeholders, which strongly impacted on the management and the effectiveness of the entire project. By consequence, the paper offers both theoretical contributions to the relational branch of stakeholder theory and practical evidence in demonstrating the importance of the relational branch of the theory over a more traditional transactional view.

Keywords Circular economy · Urban living lab · Nature-based solutions · *New soil* · Sustainable transition · Turin

Introduction

Urban living labs (ULLs) are deemed to be innovative policy processes developed around the concept of multi-stakeholder engagement, where co-producers explore, examine, experiment,

test and evaluate innovative ideas and alternative solutions in a real urban setting. ULLs can be, in fact, unusual sites where stakeholders can cooperate and collaborate to test innovations designed to tackle the grand challenges that affect cities and megalopolis worldwide, such as soil consumption and erosion, food access, social policies and assistance to vulnerable populations [1]. Adopting a similar viewpoint, nature-based solutions (NBS) are technologies, actions and business settings developed to preserve sustainability through a recovering process of resources based on natural production systems [2]. Acting on a larger scale, the circular economy (CE) paradigm proposes to revise the traditional model of development and consumption, promoting the reuse of products, the recovery of materials and the recycling of waste [3].

CE policies and business ideas have in common with NBS the need for spaces to test their reliability, scalability and future sustainability [4]. The literature recognises in the ULLs potential arenas of experimentation [5]. For instance, according to Doherty [6], ULLs are good examples of ways through which local farmers can collaborate with scientific institutions to develop a resilient urban food system. Despite the fact that the research on CE and NBS is proliferating in a wide range of disciplines, the matches between ULLs to test CE and NBS solutions are somehow limited. At the same time, due to the specific features of each urban environment, the stakeholders populating a ULL can be different, and arriving at a shared consensus into a ULL is not always a linear process.

ULLs, NBS and CE might be complementary in promoting policies and actions to regenerate and redesign the urban environment, but to be effective, they should be designed and tested to reach a shared consensus among the actors involved. Prioritisation and salience are usually two fundamental principles applied by scholars of stakeholder theory [6]. Unfortunately, when stakeholders are deeply bonded in a territory and among themselves, like in the case of a dynamic and critical urban environment, such principles lose their applicability, as they are thought to work when relationships are transactional [7]. Transactional perspectives of the stakeholder theory are usually designed for the normativism branch of the theory itself, entailing that a particular stake is owned by a well-identified party [8]. As recently supported by Casalegno et al. [8], in analysing the dynamics of actors towards a CE problem, the transactional approach fails, because CE requires to extend the analysis including the relationships among stakeholders and the reallocation of stakeholder roles. The presence of multi-stakeholder dynamics, in a context related to CE in urban spaces, is recognised by scholars as one of the most intriguing research problems of modern stakeholder theory [9].

In our paper, we present a case study of a systemic experience where a *'new soil'* (artificial ground or technogenic soil) is tested as one of the most promising NBS for the urban requalification projects of the City of Turin (Italy), where the ULL is placed. The new soil presented in our paper is a blend obtained by mixing earth materials coming from construction sites with compost, zeolites and mycorrhizae and developed in the context of the proGIreg European project (productive Green Infrastructures for urban regeneration). ProGIreg is an initiative planned and funded by the European Commission (EC), which proposes the experimentation of NBS in suburbs with a relevant industrial past. The 5-year project (2018–2023) is part of the wider Horizon 2020 funding programme, and it is based on the collaboration between four front-runner cities, which lead directly to the NBS experimentation: Dortmund (Germany), Turin (Italy), Zagreb (Croatia) and Ningbo (China). The City of Turin focused its efforts on building a ULL composed by seven different NBS in the neighbourhood: new regenerated soil (NBS 2), community-based urban farms and gardens (NBS 3), aquaponics (NBS 4), green wall and roofs (NBS 5), accessible greenway and cycling corridors bordered by autochthonous tree species (NBS 6), local environmental

compensation of big events processes (NBS 7); activities of pollinator biodiversity defence aimed at monitoring the life conditions of bees and butterflies to assess the pollinator friendliness of the urban area (NBS 8).

In this framework, the new soil case study could represent a starting point for future investigation about the potential overlapping of ULLs, CE and NBS. Thus, we aim to shed light on how to examine the interplay between ULLs, CE and NBS, identifying in a multi-stakeholder approach a key driver of success and, lastly, providing a critique of the case tested. The paper is divided into four main sections. In 'Theoretical Framework', we briefly introduce how urban living labs, nature-based solutions and circular economy concepts are reciprocally interconnected. 'Methods' presents a methodological focus and the background of the case with technical insights, while 'Results and Discussion' provides the multi-stakeholder analysis and the critique. 'Conclusion' offers final remarks and future research avenues.

Theoretical Framework

As pointed out by the Sustainable Development Goals (SDGs) of the United Nations [10], the creation of partnerships (represented by the SDG 17) is one of the most critical suggestions, as it gives the key operating guidelines. As SDGs are by nature interconnected, the involvement of different stakeholders can be helpful in providing different perspectives about the same issue. In this paper, ULLs, CE and NBS are concepts reciprocally interlinked, representing an example of *where* partnerships can take place (the local innovation ecosystem), *how* in the sense of what adopted principles should support and, lastly, the content of such experiments (*what*).

ULLs: Where

ULLs, inspired by the traditional living lab definition of MIT of a 'living laboratory' [11], transpose its logic to an urban scale with a specific multi-stakeholder and participatory nature [12]. Co-creating innovations and testing them in a real-life context is one of the main aims of this study [13]. A recent study on ULL sees the existence of similarities between ULL and forms of open innovations, like the ones of n-tuples helix, where a wide range of actors, including public institutions and citizens, are simultaneously engaged in a collaborative practice of co-production [14, 15].

ULLs are characterised by a strong presence of municipalities and public actors who act like principal leaders and coordinators, handling social challenges that are peculiar to that specific area [16]. At a city scale, ULL initiatives are engines for urban regeneration and requalification, especially in those areas that are polluted and where the social fabric might be compromised by the industrial downturn [17]. In such vulnerable areas, ULLs can generate social and sustainable transformations that can also be developed in line with CE principles [18]. Consequently, multi-stakeholder partnerships should be created to engage actors in the process of designing, developing, implementing, testing and evaluating an innovation [19].

Circular Economy: How

Circular economy has proven to be an innovative yet multidisciplinary paradigm, despite raising many questions about the feasibility of technological innovations, changes in regulations and the need of starting new alliances [20, 21]. To boost European economies towards a

more circular one, the European Commission has recently published its Circular Economy Action Plan, where it calls all the actors of the economic system to work together under its guidance [22]. The transition from the 'take-make-dispose' linear principle to 'reuse-reduce-recycle' of resources requires investments to test and prototype innovations and business models [23]. ULLs could be used as a fertile ground for circular economy innovations and experiments [23]. Today, and more in the near future, cities and megalopolis will be called to solve pressing social issues, such as supporting vulnerable and poor populations, guaranteeing food access and food security to everyone [24]. For this reason, ULLs can be identified as the right physical places where citizens and end-users actively look for solutions, closing the loops in terms of resources and energy, enacting virtuous partnerships between public and private actors [25, 26].

Moreover, the European Union set its goal to zeroing the soil consumption by 2050. Looking forward to this ambitious goal, recovering abandoned areas might be a step in the right direction [27]. Notwithstanding the costs and high risks involved in regeneration processes, implementing circular economy processes could help in reducing costs in terms of virgin soil use, generating at the same time positive externalities regarding social and environmental impacts [28, 29]. The circular approach allows the creation of a 'community of relationship', which, along with reactivating and recovering resources already in the system, might help in exploiting unexpressed potential [30]. Indeed, circularity might be identified as a feasible option to increase efficiency and achieve synergies among different stakeholders in the cities, thus being a key driver for urban regeneration processes [31]. The ultimate goal would be the rise of a circular city, where the consumption of virgin natural resources would be reduced.

Several studies acknowledge the importance of the relationship between urban regeneration, stakeholders' consideration and circular processes [31–33]; however, to our knowledge, no research links the idea of soil recovery with circular practices in the context of an urban regeneration process. To this end, this research presents the case study of the City of Turin. We discuss the results of new soil experimentation as an example of circular practice, aimed at the urban regeneration of the dismissed area of Mirafiori Sud.

NBS: What

NBS can be defined as 'any transition to using ecosystem services with decreased input of non-renewable natural capital and increased investment in renewable natural processes' [34]. Several NBS applications have been developed during the last years in a wide range of fields, from agriculture to urban management [35, 36]. Recent literature in environmental studies looks at NBS as key leverages to underpin sustainable and circular activities in modern cities [37]. In that sense, green infrastructure can increase the green coverage in the urban environment and create new synergies within city ecosystems, coupling humans and the environment.

Financially supported by the European Union, NBS can play a pivotal role in assisting cities during the sustainable transition, and this journey can start from ULLs [38]. Hence, ULLs' strength lies in the integrated perspective in tackling social challenges [39]. In this effort, NBS are deemed to be open innovation systems based on the engagement of multiple actors, capable of proposing unconventional solutions to stimulate new green economies and green jobs in urban areas [40]. When looking at soil management, NBS usage is not mainstream. However, NBS can be critical factors in reaching sustainability in soil management, considering they use the natural flow of matter and energy often exploiting local

solutions at the same time. Therefore, NBS could help in restoring ecosystems, with an eye on both sustainability and cost-effectiveness [41]. This is possible because using NBS would entail less need for maintenance, while usually traditional infrastructures require high-maintenance strategies, relying on external sources of inputs and capital [42].

The process of urban deindustrialisation took place in thousands of cities around the world, leaving many brownfield sites abandoned due to the high recovery costs [43]. According to Song et al. [43], in such situations, NBS might represent a feasible solution, providing at the same time social, economic and environmental benefits as, for instance, improving living conditions for people living in these areas while increasing real estate value through the recreation of the ecological habitat lacking in brownfields. In the case study presented in this research, new soil represents a NBS aimed at directly improving the condition of a post-industrialised brownfield area of Turin, named Mirafiori.

The Potentialities of Multi-stakeholder Management Perspective in ULLs

Scholars of stakeholder management theory are stressing the importance of a multi-stakeholder management perspective by public institutions [9]. According to the recent work of Wicks et al. [9], the involvement of different actors is a prerogative to create a democratic and collaborative process in creating public policies. According to this view, the relational perspective of stakeholder management is opposed to the transactional one, widely used by private institutions. Freeman et al. [44] clarify that the relationships among stakeholders play a vital role in aligning all the stakeholders' interests around a purpose, and its importance increases in the case of public values and public policies. The result is to move away from the pure analysis of the nature of the transaction and to devote more attention to the narrative on the relationships. The quality of the relationships, the interactions and the values that ground such relationships are fundamental.

Unfortunately, studies involving multi-stakeholder value creation in implementing a public policy around a CE issue are scarce [8, 9]. Studies involving public institutions are usually narrowed towards a stakeholder analysis to orient processes of communications, while less frequently the analysis has the strategic intent of interpreting relationships between actors to better frame future policies for co-management or co-design public initiatives. Nevertheless, cases of effective participation for the so-called new public governance are emerging [45]. According to the new public governance paradigm, scholars emphasise the role of public institutions as leader of open innovation and collaboration, with the attempt of eliminating the command-and-control approaches to policy [46].

Wicks et al. [9] link this shift to the participatory democracy literature, especially for the need of involving multi-stakeholder partnerships in the formation of a policy process, with collaborative solutions and with an increase of civic engagement. According to the authors, the study of multi-stakeholders' dynamics in localised systems deserves more attention, especially regarding policies that affect the sustainability of the natural environment. Citizens, public managers, practitioners, academics, companies and investors are among the stakeholders that can be involved in the design of a ULL, where the ULL is a localised system [6]. In a ULL, the knowledge-generating process takes place through several rounds of co-design sessions, and it outputs a business model that aims to guarantee the long-term sustainability of the project itself while simultaneously guaranteeing proper levels of environmental preservation of resources.

The novelty of the application of CE principles is that the entire business model can be concretely co-designed with the intent of reducing costs, hence improving the economic

sustainability of the whole ULL by retrieving returned and recycled material [7]. Orchestrating an effective multi-stakeholder management model for CE in public policies is of paramount importance also for the growing interest of stakeholder management researchers. As clarified by the team of Freeman in one of his recent papers, 'when stakeholders stop being treated and seen as abstract entities and they become individuals with common and integrated goals, the value created has higher chances of being recaptured in a CE system' (p. 160). With this study, we want to contribute to narrowing the gap presented in stakeholder theory, offering a valid example of multi-stakeholder management of an NBS. In the following section, the NBS will be in-depth presented within the research design.

Methods

Case research enriches the understanding of emerging phenomena through a multifaceted perspective [47]. Specifically, the research design applied in our study privileges a mixed method where data collection is based on interviews conducted during field observations and document analysis. According to Bergvall [48], case studies based on mixed methods apply content analysis on primary and secondary data sources. Moreover, case studies should be privileged in the context of living lab analysis, as through them, the researchers can offer a comprehensive analysis of fieldwork data.

As argued by Smith [49], a mixed method research applied in urban studies offers flexibility that best suits the research object and provides the advantages of a predefined structure without excessive rigidity. For instance, the narrative required to account for the process of testing a new soil can be different from the research methodology required to demonstrate the feasibility of other NBS solutions. Specifically, the research design applied in our case is an exploratory mixed method, a technique that is suitable in pragmatic cases where sustainability real-world practices are explored [50]. In addition, case studies serve the purpose of offering a pragmatic view of the multi-stakeholder management problem in a pluralistic context of the ULL where the new soil is tested.

Formulation of the Artificial Ground New Soil

This paper shows the micro-context of a ULL where the development and testing of a new soil composite have been experienced. Specifically, the testing of such new soil has been selected among the other experiments for being in an advanced level of development and execution. In the proGIreg framework, the artificial ground new soil has been formulated according to the following general composition:

- Building earth materials resulting from construction sites (particles with a diameter lower than 2 cm);
- Compost obtained from organic waste, in particular, plant waste;
- Natural zeolites, mainly chabazite;
- Natural mycorrhizae.

Mycorrhizae are composed of *Glomus* sp. GB67, *Glomus mosseae* GP11 and *Glomus viscosum* GC11. Mycorrhizae are inoculated in plants after planting as a microbial inoculation associated with a diversity of organisms, among which there are rhizosphere bacteria such as

Bacillus amyloliquefaciens BA41 and *Agrobacterium radiobacter* AR3; actinomycetes such as *Streptomyces* sp. SB14; saprophyte fungi such as *Trichoderma harzianum* TH01 and *Pochonia chlamydosporia* PC50 and ascomycetes such as *Pichia pastoris* PP59.

This new soil fits with the definition of NBS reported in the literature [34] as this mixture has been generated decreasing input of non-renewable natural capital, the virgin soil, as well as being consistent with the CE paradigm of reusing (soil already used in construction sites), reducing (the exploitation of virgin soil) and recycling (processing soil from excavation sites adding elements to create soil that can be redeployed).

It is important to notice that the composition of the inert soil recovered from the excavations depends on its origin. The mixture of excavated earth, compost and zeolites, impacts specifically on the top 15 cm of the land, while the mycorrhizae can highly vary in terms of quality and quantity, depending on the type of vegetation present in the area. Moreover, the final application affects the final formulation of the technogenic soil new soil. Hence, it is not possible to have a fixed mix respecting perfectly the same percentage of the component. On the contrary, the final composition must be tuned to meet all the necessary chemical and physical properties, to allow both a proper plant growth and compliance with regulations (presented in 'The Context of New Soil'). While tunability can be considered a constraint for the patentability of new soil, the customisation represents a solid market opportunity in providing the proper formulation for the final applications (i.e. geographical areas, biodiversity rate and climate variables shape the profile of the final application).

The Context of New Soil

The ULL of Turin has taken place in Mirafiori Sud, one of the most important post-industrial districts of the city, characterised both by large disused spaces and a meaningful cultural and environmental heritage. The site of the experimentation of the new soil has been an industrial area for years, placed along the southern border of the city, where buildings and plants of the automotive industries were established. In the last 30 years, Mirafiori Sud has been highly impacted by the deep economic downturn, which has forced one of the primary automotive manufacturers (former FIAT, now Fiat Chrysler Automobile Group) to dismiss most of the industrial sites located in the area. Therefore, most of the citizens of Mirafiori Sud employed in the automotive poles have gradually been laid off from the company, leading to a vacuum in employment and social terms. Nowadays, the historical and essential link between the Mirafiori Sud dwellers and the automotive sector has been radically weakened, leaving the district looking for a new economic and environmental identity.

Since the turbulent phase of industrial sites dismissal, the City of Turin has planned to regenerate and transform that area, getting inspired and following principles of the circular economy for cities [3]. Specifically, during proGIreg, the area has been identified by the public managers to be the best available space to test innovative solutions within a ULL. By means of the 7 NBS foreseen by proGIreg, the ULL has been trying to transform discarded buildings and brownfields into attractive spaces open to co-production and sustainable development processes (Fig. 1). The idea to carry out the experimentation on soil arose from the interest of the City to solve a significant environmental problem that affects most of Europe, namely, soil and land erosion [51] because soil is considered the 'most complex biomaterial on the planet' [25].

To build or restore urban green areas, one of the most implemented techniques is to use brownfield or excavating soil from the greenfield. This technique is, of course, unsustainable as tons of virgin terrain are removed from one place to recover those areas where the soil is

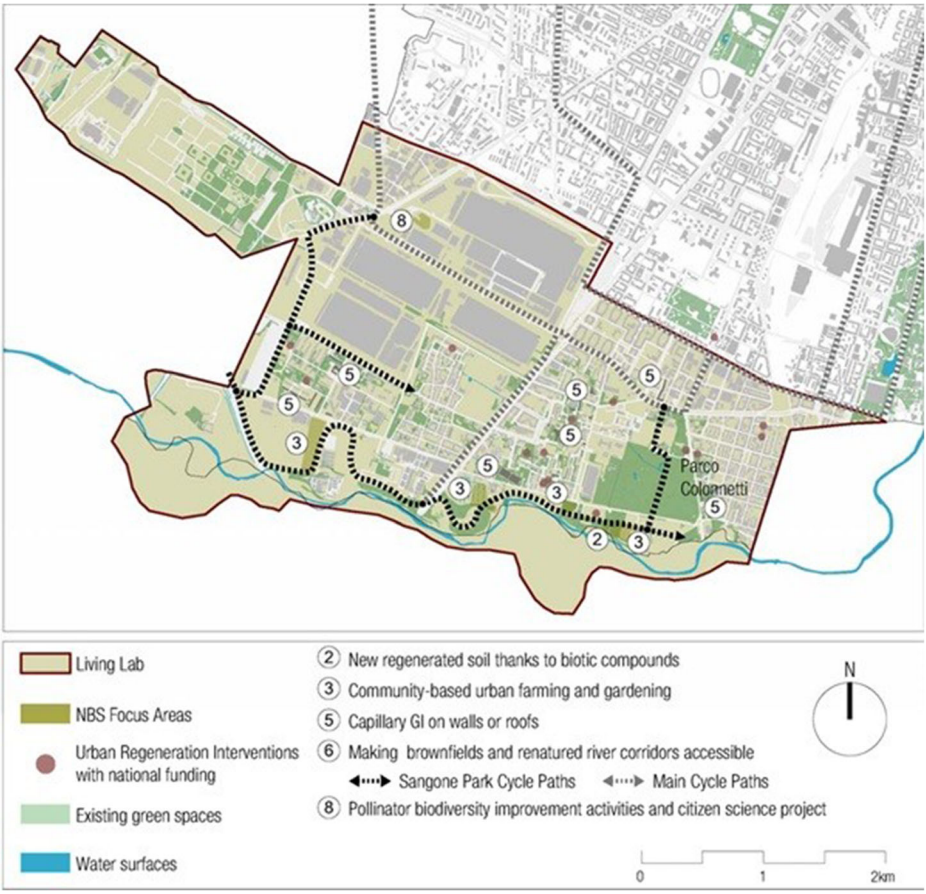

Fig. 1 The proGIreg Living Lab in Turin (source: RWTH Aachen University, Institute of Landscape Architecture). This image shows the proGIreg NBS collocation in one district of the City of Turin

inert because it has been for long years cemented. On the other side, such inert soil can become a resource mainly because it represents a vast area of the city grounds. However, according to the Italian regulation on earth materials (mainly regulated by the no. 161/2012 Decree of the Italian Ministry of the Environment and the no.120/2017 Decree of the President of the Republic), every new public green area, as well as every restorative initiative, must be carried out using high-quality soil in full compliance with certain parameters concerning the content of heavy metals.

Due to those regulatory constraints, the City of Turin has always struggled to implement and enable initiatives concerning the reuse of soil for the construction or renovation of urban green areas. Because the high relevancy of the topic about the use of excavated earth and rocks is crucial, starting from July 2019 onwards, all the regional environmental agencies have edited precise guidelines to identify excavated earth as a by-product excluded from the waste regulation, which has been formally introduced by the Law 128 of 2 November 2019 [43].

These guidelines help organisations define processes for the verification of environmental requirements, determine the percentages of anthropic material and determine the background values that are needed to reuse excavated earth and rocks [52]. Therefore, inside the proGIreg

project, the innovative new soil has been tested in the ULL where an area of 2000 m^2, near the course of the Sangone River, has been dedicated to such an experiment. For the first time, researchers and public managers have started mixing up inert soil coming from construction sites with compost, zeolites and mycorrhizae, able to abide by the regulations and creating a new mixture that can be used to create new urban green areas.

Data Collection

In our case, field observations have been fundamental. Three phases compose the data collection. First, we conducted an extended content analysis of the scientific literature and material focused on ULLs, NBS, circular economy and proGIreg project. Moreover, to better frame the existent dynamics between the stakeholders involved in the project, we have analysed 24 official documents (proposals, reports and deliverables) provided by the City of Turin regarding the experiments and their strategic intent. Second, we did an in-depth participatory observation of 15 meetings organised by the City of Turin and proGIreg stakeholders, which allowed the researchers to observe and assist in the governance and stakeholder relationships from a privileged viewpoint [53, 54]. Third, we collected primary data through 12 semi-structured interviews that have enabled us to further explore the difficulties and barriers of the operational process. The total number of the interviews carried out conforms with the criteria of theoretical saturation laid out by Guest [55], and it allows us to start identifying meta-themes related to multi-stakeholder management, as theorised by Grafton et al. [56].

Interviews have been conducted from June 2019 to March 2020 and have involved a wide range of stakeholders and representatives (five civil servants, two representatives of the company and six technical experts). A summary of the interviews is reported in Table 1. Data resulting from the interviews have been used in interpreting those collected during the participant observation, where researchers were passively involved. Interviews have been conducted by means of non-directive questions, in order to unravel underlying multi-stakeholder dynamics. Meta-themes have been subsequently identified triangulating the different data sources. Examples of meta-themes that emerged during the interviews have been reported in Table 1.

Stakeholder Identification and Dynamics

Several actors have been involved in the ULL ecosystem where the new soil has been tested. First, the City of Turin with its personnel, public managers and civil servants has played the role of the orchestrator managing most of the legal concerns and bureaucratic implications. The city was also in charge of a study aimed at testing the possibility of effectively commercialising the new soil, given the legal requirements in terms of proprietorship. Only through the collaboration with ARPA Piemonte, the regional agency in charge of preventing damages and protecting the environment, the city had the opportunity to point out how the regulations and laws about the reuse of soil in urban areas should be changed to allow an extensive application of the new soil after the experiment.

In terms of public value and democratic participation, the geographical area identified for the ULL and its proximity to the Sangone river has been strategic to involve citizens in repopulating and living the park with its new urban gardens. During the public meeting organised with a representative of the citizens and local associations, it emerged that the area

Table 1 Summary of the interviews run during the period of observation

Interviewee	Gender	Organisation	Mode of interview	Date and length	Focus of the interview
Civil servant 1	F	City of Turin—Innovation and Smart Area	Face-to-face	04/02/2020 35 min	ULL framework Administrative barriers Stakeholders' dynamics
Civil servant 2	F	City of Turin—Innovation and Smart Area	Face-to-face	07/03/2020 60 min	ULL framework Administrative barriers Stakeholders' dynamics
Civil servant 3	M	City of Turin—Green and Public Space Area	Face-to-face	07/03/2020 40 min	Characteristics and aims of proGIreg Administrative barriers Stakeholders' dynamics
Geologist consultant	M	DUAL srl	Face-to-face	20/04/2020 60 min	Composition of the new soil Potentials and
Company administrator	M	DUAL srl	Face-to-face	16/05/2020 30 min	weaknesses of the new soil Scope of the experimentation Market opportunities of
Company administrator	M	DUAL srl	Virtual	10/06/2020 50 min	the new soil Scope of the experimentation Market opportunities
Citizen of Mirafiori 1	F	Resident of the area of Mirafiori Sud	Face-to-face	30/06/2020 35 min	History and social change of the neighbourhood Environmental issues
Citizen of Mirafiori 2	M	Resident of the area of Mirafiori Sud	Face-to-face	30/06/2020 35 min	History and social change of the neighbourhood Environmental issues
Citizen of Mirafiori 3	M	Resident of the area of Mirafiori Sud	Virtual	24/07/2020 40 min	History and social change of the neighbourhood Environmental issues
Associate professor of systemic design	M	Polytechnic of Turin	Virtual	14/08/2019 60 min	Value of the reuse of materials in the building sector Local issues in the regeneration of green areas
PhD student of systemic design	F	Polytechnic of Turin	Face-to-face	02/10/2020 30 min	Value of the reuse of materials in the building sector Local issues in the regeneration of green areas
Area manager	F	Environment Park	Face-to-face	05/10/2020 45 min	Market opportunities

was identified as one of the most proper locations to test the potential benefit of such regenerative intervention and also that the district is highly populated by elders and families with babies, which will would take advantage of the new gardens created with the new soil.

Three private companies have been involved to provide technical support. DUAL was the company responsible for the provision of the inert soil coming from its construction sites,

which is usually discarded and not reused for any economic purpose. DUAL is already producing a technogenic soil similar to one created during the project. However, disregarding the environmental regulations hampers its placement on the market [57], and the convenience in the project lays in the possibility to correct the formula with the support of scientific stakeholders (i.e. universities). With the support of the laboratories, the development of a product that can comply with the environmental regulations is guaranteed.

Another company, ACEA, a local multi-utility company, has specific expertise in waste processing, and its role has been crucial in providing the mix of its compost with the earth materials, upgrading the quality of the inert one and turning it into a fertile mixture. Besides, ACEA has previous experience in commercialising composite and compost through specific distribution channels. One of the aims of the testing has been to evaluate the commercial power of such a mixture in terms of financial flows. Moreover, the conversion of the organic fraction of municipal solid waste in certified compost, to be applied as fertiliser in the new soil application, contributes to lowering the greenhouse gas emissions as it replaces fossil-based chemical fertilisers with compost.

Lastly, the company CCS Aosta has been involved as a provider of the mycorrhizae, a symbiotic association between a fungus and a plant [58] capable of increasing nutrient absorption and plant resistance. CCS studied a specific mixture to foster the growth of mycorrhizae on the plant roots for the new soil. In particular, CCS Aosta supplied a microbial inoculation composed of fungi, bacteria and yeasts listed in the 'Formulation of the Artificial Ground New Soil' section. The market of natural additives and the knowledge exchange about the use of mycorrhizae are opening new market segments, mostly linked to CE services. In addition, Bal-co Spa provided the natural zeolites, mainly chabasite, used as a fertiliser.

The scientific stakeholders were mainly the University of Turin, with its Department of Chemistry, which has been involved in the quality control of the soil, and it has played a role in managing specific tasks in business model evaluation, as well as collecting data to test the reliability and replicability of the experiment (with the Department of Economics). The Polytechnic of Turin played the role in supervising the coherence of the new soil experiment with the overall research project with many NBS and developing knowledge exchange dynamics between actors involved. Environment Park (EnviPark), a sort of local business incubator for green technologies, had a role in identifying, analysing and overcoming the technical barriers during the development of the new soil. Among its duties, EnviPark has been deeply involved in creating new knowledge and training materials linked to the development of the new soil, through training events and the creation of Massive Open Online Courses (MOOCs).

Figure 2 shows the stakeholders involved grouped by their specific area of intervention in the project: economic, social and environmental and innovation. Inside the red circle, there are the actors with a specific economic interest; in blue, there are public actors along with the civil society who hold a social and environmental interest in restoring and preserving the local area. At the same time, in orange, there are those institutions responsible for generating knowledge and innovation during the project.

Results and Discussion

The Development of the New Soil Business Model: Multi-stakeholder Implications

During the interviews, researchers collected data about the future opportunities or constraints of new soil with the intent of developing a business model. As suggested by Nesti [59],

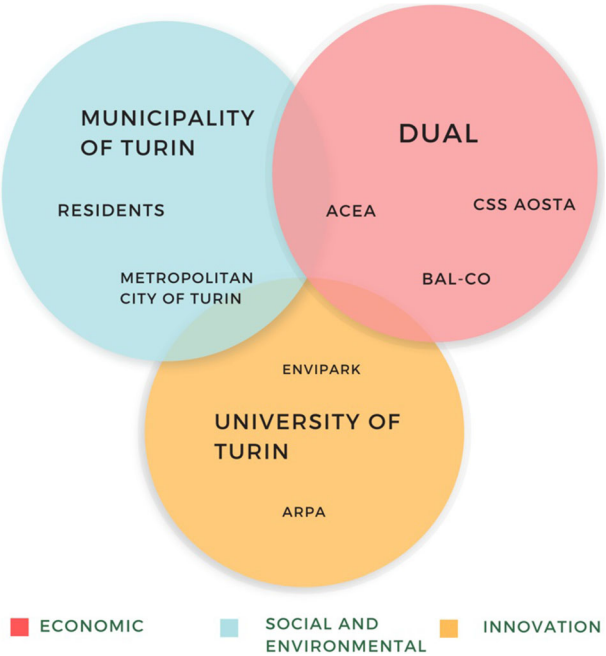

Fig. 2 Stakeholder divided by the area of interest (source: authors' elaboration)

experiencing a ULL could be a driver to help public administration and governments to innovate existent regulations and overcome bureaucratic barriers that can be a constraint for the scalability of sustainable solutions. In the case study of new soil, one of the most significant barriers in the development of a scalable business model has been the presence of strict environmental regulations that fix some limits in the presence of earth compounds when someone develops an earth composite.

The involvement of an actor responsible for revising and adopting the new regulations, ARPA Piemonte, has been of paramount importance in guaranteeing effective results of the NBS. Its involvement has been essential in letting the new soil be included as a regional best practice that, in turn, can represent a valid base to the development of less restrictive new regulations. In addition, the companies involved during the market validation phase have been advantaged by the presence of ARPA Piemonte because a change in the existent regulation can positively alter how the entire market works towards new products like new soil [52].

To guarantee that the outcome of the ULL for the NBS is effective, the business model of the new soil must be resilient, scalable and profitable. Scalability and profitability are usually seen as a prerogative of private and profit-oriented stakeholders and less in the case of environmental and social innovations [59]. Thanks to the multi-stakeholder perspective, indeed, scalability and profitability have been matched with the shared purpose of decreasing land consumption, reusing damaged soils and giving back to the community a post-industrial site. As such, the ULL of Mirafiori has been the place where actors have envisioned the future development of an innovation, understanding that scalability and profitability had to be matched with the interests of the citizens, communities and the public value [17, 60]. As stressed by DUAL interviewees, new soil turned out to be an 'up-cycled' product

economically feasible as it offers the opportunity of reintroducing into the market earth and rock materials from construction sites usually used as filler materials or discarded in landfills.

As an example, in establishing its market price, private companies suggested that the new soil could be priced less than a virgin soil when sold to public institutions. This decision is justified by budget constraints that usually a public institution must stick to in renovating public and urban gardens. On the other side, the new soil is designed to be a highly customisable product, and as such, its market price for private companies and users could be increased. In the future, the new soil could become a versatile product, as the mixture of additives could be patented, and tailored consulting services can be developed around the concept of product-as-a-service logic. Besides, the collaboration with research centres could be vital in obtaining a sort of certification that could guarantee the high quality of the product. A niche market of low-impact buildings and green architectures could be targeted by new soil.

It is worthy to note that all the economic convenience calculus has been made by the public managers of the city, in collaboration with the University of Turin. Specifically, the power of the ULL here narrated is the match of different stakes with a specific purpose, that is, to let the experiment of new soil become/be beneficial to all the parties involved. In the next section, a critical perspective in terms of theoretical implications for stakeholder theory is provided.

Critical perspective on Multi-stakeholder Management During the New Soil Experiment

The collaborative design applied to the case of the new soil has been realised inside the boundaries of a ULL. As clarified by Jonas [45], new public governance implies that public institutions are deeply involved in an intricate net of relationships with a wide range of stakeholders, sharing a precise intent. In the project herein described, the ULL has incentivised the collaboration between different public and private actors, facilitating dialogue and the exchange of knowledge about the creation of a practical innovation for the CE.

With the help of universities and research centres, the city, through its public managers, has developed a pivotal role in connecting different actors with different needs and different inter-organisational dynamics [59]. As confirmed by Annessi-Pessina [46], the co-creation of public policy and the co-management of resources, among which there are natural resources, push the public institution to overcome the traditional command-and-control model to play a more active role. In our case, we find exactly a strong evidence of what Casalegno et al. [8] describe as real actors, and not abstract entities, with a specific purpose of collaborating into a CE system. With its multi-stakeholder model, the ULL has increased the level of trust and cooperation between the actors, and this could be an advantage for the future development of a concrete business plan, because it is possible to include different stakeholders' perspectives, ranging from suppliers to customers and final users.

In our case, the relational approach recently supported by the scholars of stakeholder theory aims to be more appropriate than Mitchell's model of salience [6]. For instance, in our case, there is not a prioritisation of the stakeholders' interest but instead a democratic and collaborative process that puts at the core of the project a common good (the soil protection). Moreover, instead of having fixed categories and fixed stakes, in our example, stakeholders' relationships have been built and will be strengthened in the future to guarantee that an experiment will be turned into an effective business model. With a pragmatic intent, the relational stakeholders' view of the theory does not discriminate stakeholders as fixed

categories, but it focuses more on the nature of the relationships that could be fluid over time and on a specific geographical space.

Finally, our study shows how multi-stakeholders' dynamics happened into a localised system (the ULL) that, according to Wicks et al. [9], represent the unique settings through which a public institution can innovate its policies on the sustainability of the natural environment. This inclusive and democratic approach here discussed contributes directly to stakeholder theory, by providing an example of establishing relationships of value, even when a subject does not have any institutional power or interest in affirming its authority [7]. To sum up, in the case herein presented, we give evidence to the fact that the relational view of stakeholder theory is playing and will play a pivotal role for the CE, and sooner or later, whoever wants to operate in developing sustainability innovation will not be exempted from adopting a multi-stakeholder management model.

Conclusion

This paper presented the development of new soil, a new type of circular product that uses recycled terrain (a portion of brownfield already exhausted and excavated) to convert it into fertile ground that can be used for public green areas. The pilot project presented here is an example of a NBS developed within the European project proGIreg, aimed at supporting the experimentations of circular economy solutions in urban areas. Specifically, our study provides pragmatic insights of the experience tested in the ULL coordinated by the City of Turin (Italy).

While the literature on the practical experience of NBS tested in ULL is currently not vast, our paper has been designed to narrate a micro-contextual experience while providing a critique. The experience here described shows that a unique combination of different stakeholders has strongly impacted on the management and the effectiveness of the entire project. By consequence, our study adds value to stakeholder theory and especially in demonstrating the importance of the relational branch of the theory over a more traditional transactional view.

In our case, for instance, actors representing different stakes are not described as abstract entities but as dynamic protagonists collaborating together. In the respect of the new public governance role, the City of Turin has been pivotal in reconciling diverse interests, from private ones (like in the case of making pressure to change regulations) to public and common goods as well. Specifically, in our case, the recycled terrain of the post-industrial sites is turned into high-quality soil, which could represent a potential solution for the growing concern about the issue of soil scarcity. While matching the interest of opening new market opportunities for the private sectors, the city guarantees the stewardship of the citizens' rights to live in a more sustainable urban area. Nevertheless, more tests and interviews are needed to determine the exact economic convenience of the new soil, in relation to the need of complying with the national and local regulation while being competitive on the market.

The new soil illustrated here might represent an example of the co-creation of a CE innovation, but there is more. The city, through a multi-stakeholder management setting, has guaranteed a public and democratic participation of a wide range of interests. Moreover, with the ULL, the city has reinvigorated the public interest towards the purpose of limiting the depletion of scarce resources, and it has played an active role in promoting a factual change in the regulation not only for the benefit of the project but also for all the private actors operating in the backfilling soil market. Nonetheless, new soil is characterised by a varying composition, according to the building earth materials combined for its creation. This entails that the new

soil's composition is flexible so that it can be modulated according to specific needs; on the other hand, the possibility of exact replication is hampered by both chemical features of the earth materials and the requirements of diverse contexts of urban experimentation.

While our study suffers from the classical limitations of a single case study, it offers a pragmatic perspective on stakeholders' dynamics in ULL. With the hype of CE projects and ULL, experts of stakeholder theory and sustainability experts need to engage in studies that narrate how multi-stakeholder's arrangement happens in practice. Future work is needed to explore the presence of critical issues, controversies, mission's drifts and organisational orchestrations of multi-stakeholders' partnership at a different developmental stage of ULL and in a different geographical context and apply to a wide range of NBS.

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Availability of Data and Material The interview track is available by sending an email to the authors.

Code Availability Not applicable

Declarations

Conflict of Interest The authors declare no competing interests.

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