CIRCULAR ECONOMIES AND DIGITAL TOOLS FOR SUSTAINABILITY IN URBAN LOCAL ECOSYSTEMS

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ABSTRACT:

This article provides an exploratory overview of selected projects that promote circular and participatory models to facilitate the circulation of resources and value – both monetary and non-monetary – with a particular focus on projects that utilise digital tools. By further focusing on digital platforms that support community-based circular economy initiatives in an urban context, our aim was to investigate how technology can effectively address challenges in the field of social and environmental sustainability. We examine circular economies in sharing economy and collaborative economy projects that focus on the reuse of items as well as on circular processes for the repair and upcycling of materials. These initiatives, which are based on participatory principles, represent models of mutual exchange designed to promote sustainability and community relations. A diverse range of social actors and community-based organisations are involved in the projects under investigation. We consider two types of instruments: firstly, instruments that facilitate the management and exchange of goods and services, as well as the tracking of trade, flows and transactions. Secondly, instruments that facilitate behavioural change, particularly those that provide incentives for circular and participatory behaviour. The main aim of this study is to examine the digital dimension within the context of diverse economic systems, community currencies and non-monetary exchange processes, with a focus on participatory dynamics and socio-ecological challenges in urban settings. The paper also seeks to explore whether and how these initiatives establish relationships with institutional actors, examining the dynamics of interaction between grassroots movements and formal institutions. The study investigates how technological, economic and institutional dimensions are intertwined, thereby creating dynamics of sustainability and participation in local community contexts.

KEYWORDS:

Circular Economy, Environmental sustainability, Digital Participation, Blockchain Technology, Local Communities

1. INTRODUCTION

Rapid changes and problems related to the global economic system—scarcity of natural resources, fragile ecosystems and waste management etc.—are challenging the established linear economic model (Ghisellini, Cialani and Ulgiati, 2016) with its traditional "take-make-dispose" sequence of production and consumption.

In recent decades, many scholars have tried to address these problems by developing different concepts that provide alternatives to the established economic system. These include recycling and reusing, which are seen as fundamental steps towards achieving a sustainable economic system. From this context has emerged the concept of circular economy as a sustainable development paradigm, and it has gained increasing attention over the years.

This paper is an exploratory analysis of a set of case studies investigating how digital tools are used to tackle problems of social and environmental sustainability. Among the many ways of achieving circular economies, we focus on the promotion of reuse, repair and upcycling in the context of community-based initiatives and participatory models of monetary and non-monetary exchanges. The spatial and geographical context is urban, as it is characterised by high population density and more exchanges of goods and services. In what follows, we refer to such practices as community-based initiatives of circular economy in urban contexts.

Community currencies systems (CCS) are often created and used with objectives related to sustainability issues (both environmental and social), whether explicitly integrated into the design of these currencies or emerging later as an effect of the practices involving them (Seyfang, 2012).

For this reason, one of our goals is to explore the role that CCS play in facilitating these kinds of collaborative and sustainable exchanges and practices.

One of the key characteristics of community currencies systems, as highlighted by Seyfang and Longhurst (2012), is their emphasis on supporting local economic circuits and encouraging local production in order to minimise environmental impacts (see, e.g., the work of Norberg-Hodge (2002)). CCS promote sustainable behaviours that help to reduce ecological footprints and contribute to the development of informal economies, which operate outside the conventional monetised labour market (see, e.g., the work of Williams and Round (2008)). This fosters mutual support within communities and the recognition of goods and services typically excluded from the market economy (Scott-Cato (2006)). For these reasons, they are regarded as one of the key elements in this investigation.

A second aspect that we explore is the material dimension of these kinds of collaborative and sustainable exchanges and practices, represented by the digital devices increasingly involved. By considering the materiality of these devices and objects, we can move beyond the assumption that their technical dimension is neutral or passive. These devices assume relevance because they enable participants to engage in socio-economic processes, extending their impact beyond mere technical functions and becoming active elements that take part in participation dimension (Marres, 2016).

Particular attention is given to the use of blockchain technology in this context. Blockchains are essentially distributed digital ledgers that record ownership of valuable assets and track the history of transactions made on the blockchain. Transactions proposed by users are grouped in blocks of data and posted on the network. After being validated, they are timestamped and added to a new block. A distributed consensus mechanism enables the network to automatically accept or reject transactions while cryptography ensures the security, integrity, and immutability of the data. The processes mentioned above allow the blockchain to provide a transparent, shared, and verifiable version of an immutable ledger, eliminating the need for a central authority or intermediary to manage the flow and storage of information (Urban and Pineda, 2018).

We analyse some blockchain applications classified as "blockchain for social impact" or "blockchain for social good", including initiatives focused on the co-creation of services to meet social needs (Cagigas, 2021). Specifically, in the context of blockchain for social good, we focus on the concept of civic blockchain (Viano, 2023), which refers to systems designed to facilitate civic participation and develop alternative models of value circulation in local economies. These civic blockchain applications aim to support various types of exchanges, including non-monetary ones, and promote resource sharing within communities. Unlike the speculative and financial mechanisms typical of cryptocurrencies and mainstream uses of blockchain, these systems prioritise community-driven models and local engagement.

Having clarified the focus of our investigation (community-based initiatives of circular economy in urban contexts) and some core functional aspects that we explore it is essential to establish a deeper interpretative framework for situating these phenomena. We therefore aim to explore the socio-technical imaginaries underlying the experiences and concepts analysed. This exploration serves a dual purpose. First, we identify the assumptions behind these realities since they intersect relational, economic, and technical dimensions. Second, we outline future research directions that will enable the design of new models to address the needs and visions identified.

Building on this premise and the research focus on exploring technology-supported value creation within communities, this paper aims to address the following research questions:

1. What types of transactions and exchanges are enabled by circular economies set in urban-scale community settings?
2. How do digital technologies influence participatory processes and through what tools?
3. What underlying imaginaries shape these socio-technical systems and how can they enhance our understanding of the needs expressed.

In order to answer these research questions, we carried out an analysis of selected projects in the domain of urban-scale circular economies in community settings. This analysis was exploratory and non-systematic in its scope as it took place at an early stage of our research. The initiatives considered were selected on the basis of some common key elements: urban community settings, the participatory nature of the practices enabled by the exchange systems, and the digital aspect of the tools adopted.

Given the strong multidimensional (social, economic and digital) components of these experiences and their innovative nature, an additional level of analysis is necessary to identify a common framework for understanding their principles and trajectories. To achieve this, the concept of socio-technical imaginaries was introduced as a potential interpretive tool to better analyse and understand these initiatives.

This paper is organised as follows. Section 2 provides basic definitions of imaginaries and the circular economy as well as a description of some key concepts from which we built the exploratory analysis, namely taxonomies concerning community currency systems and digital platforms. Section 3 describes the methodology we employed and provides an extensive description of our analysis of the selected projects. Section 4 contains a discussion with a particular focus on the role of digital dimensions and imaginaries. Section 5 concludes the paper by addressing the aforementioned research questions.

2. BACKGROUND

2.1. Circular Economy

The concept of circularity in material flows was first proposed in the book The Economics of the Coming Spaceship Earth (Boulding, 1966). It claimed that without circular systems, the global economy cannot guarantee human life on Earth in the long term.

After Boulding's polemic, many scholars have added other elements in support of circular systems. Pearce and Turner (1989), for example, agreed that the traditional linear economy is not sustainable without recycling processes. In the context of waste management, one of the first and most important contributions that helped spread the concept of circular systems was Germany's 1972 waste disposal act, which also developed the concept of "extended producer responsibility".

Coming to this day, the concept of circular economy (CE) has spread widely across the scientific community and is one of the most discussed terms among environmental economic scholars. Despite different conceptions, the term generally refers to the prevalent and commonly referenced 3R principles (reduce, reuse and recycle).

Reduce refers to enhancing eco-efficiency in both production and consumption (DeSimone and Popoff, 2000), while reuse involves designing products to facilitate a cycle of disassembling and repurposing. Recycling encompasses any process where waste materials are reprocessed into new products, materials, or substances, as per their original use or for alternative purposes. This includes reprocessing organic materials but excludes energy recovery and using reprocessed materials as fuel or for backfilling (European Union, 2008).

Nevertheless, some scholars like Ghisellini argue that, in some cases, this definition is too narrow. They suggest that while circular economies incorporate material recovery aspects, they are often mistakenly viewed as "an approach to more appropriate waste management" (Ghisellini et al., 2016) while neglecting the fact that achieving circular economies requires broader, systemic transformation (Kirkhherr et al., 2017).

In general, we can refer to CE as a "closed-loop economy". This term, introduced by Walther Stahel, suggests that in order to achieve a sustainable economic system, the life of products has to be extended (Stahel, 1982), and recycling and reusing are some of the most important parts of that process. Generally speaking, an economy that "does not generate excessive waste and whereby any waste becomes a resource" (Wysokinska, 2016) is an economy where outputs do not become waste but rather inputs in new transformation processes. The European Union has contributed significant definitions in the EU Action Plan for the Circular Economy: "in a circular economy the value of products and materials is maintained for as long as possible; waste and resource use are minimised, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value" (European Commission, 2015).

However, all of these definitions may be somewhat ambiguous on the concept of waste. The question arises whether waste should be minimised or entirely avoided. In a circular economy framework, the concept of "waste" might differ from its conventional meaning of residuals that are discarded or processed; instead, it could refer to materials that are intended to be reused. The emphasis on minimising waste could be seen as a push for greater efficiency rather than a fundamental change in how we see waste.

Finally, there is a widely accepted definition of circular economy (CE) originating from grey literature and is provided by the Ellen MacArthur Foundation (2016): "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles."

Therefore, it is fundamental that we recognise that the concept of CE is very broad, and that we always specify which conception of circular economy we are referring to.

In the context of this paper, we selected a set of projects that focus mainly on addressing environmental issues. This includes reducing traditional waste management practices, promoting reusing and recycling, or enabling the creation of circular products and services at the local community level.

These projects are principally located in the EU, with the exception of some projects in Australia and the USA. They are mainly focused on urban and local levels, where they try to address various local environmental problems and, in some cases, social ones. Alongside the environmental and social dimension, the projects under consideration have strong digital and collaborative components intended to help address these problems.

2.2. *Exchange systems and CCS*

Given that both monetary and non-monetary exchange models were analysed, and one of the objectives is to explore the role of CCSs in enabling collaborative and sustainable practices, it was crucial to have a framework for considering those systems that operate without the use of a national currency. For this reason, we adopted Blanc's (2011) classification of complementary and community currencies. This framework identifies three ideal types of currency schemes: local currencies, community currencies, and complementary currencies. This distinction is based on the type of project underlying the monetary system used, and consequently on its ultimate objective. A brief description of the framework follows.

Local currencies are implemented as part of territorial projects that are typically aimed at defining and supporting a specific region. They usually coexist with the national currency and facilitate the redistribution of money and resources within that particular territorial context.

Community currencies pursue community-oriented objectives and are mainly situated in the social sphere with the intent of promoting the exchange of services for: the wellbeing of the community, mutual assistance, individual empowerment, and strengthening the social network.

Finally, complementary currencies have a primarily economic goal and are oriented towards market exchange. However, they are not necessarily adopted for profit; in fact, they are often used by non-profit organisations.

Another work by Blanc and Fare (2013) that has been considered is their taxonomy, which classifies community currency experiences into four generational groups. While this taxonomy was not applied exactly as the author proposed—since the main focus was on circular economies and some of the projects did not use a community currency—it still provided valuable insights for understanding the relationship between the projects and institutional partners. Notably, the characteristics associated with fourth-generation schemes were particularly useful in connecting the projects to the underlying imaginaries being explored.

The first generation is characterised by non-convertible currencies with limited economic partnerships. Local governments play little to no role in their implementation.

Second-generation schemes involve nonconvertible, time-based currencies used primarily for exchange of services, with the accounts tracked in terms of the time spent providing services. These currencies are often linked to social policies aimed at strengthening community ties and they often involve partnerships with local governments.

Third-generation programmes provide convertible currencies pegged to the national currency, backed by reserves. These schemes aim to have greater local economic impact by engaging local producers and retailers and promoting micro-entrepreneurship so that they are integrated into the local socio-economic landscape.

Fourth-generation schemes, which emerged in the early 2000s, are characterised by multiple objectives, including environmental concerns. They involve complex partnerships between local governments, economic actors and national or European organisations.

2.3.   Digital Platforms

Diniz et al.'s (2018) digital platforms taxonomy was taken as a starting point for understanding the technological aspects of community currency systems. The taxonomy defines the following key dimensions.

Platform Architecture: This dimension categorises platforms as either standard or dynamic. Standard platforms include digital devices that do not use the Internet, such as cards or point of sale (POS) systems. Dynamic platforms, on the other hand, leverage the Internet and emerging technologies like blockchain.

Platform Governance: A central issue for community currency systems is governance, particularly as regards the decision-making process for issuance rules and overall system functionality. Governance is considered 'shared' when decisions are made collectively through grassroots or cooperative processes. Conversely, it is 'centralised' when these decisions are made by a local entity or authority.

 Platform Transactionality: This dimension identifies the types of actors involved in transactions. A one-sided platform indicates transactions between the same type of actors, such as peer-to-peer (P2P) exchanges. A two-sided platform involves two different types of actors, as seen in business-to-consumer (B2C) transactions. Multi-sided platforms involve more than two types of actors, such as when an institution distributes a CCS that beneficiaries can use at local merchants.

Platform Virtuality: This dimension distinguishes between fully virtual and less virtual platforms. Fully virtual platforms refer to community currencies that are not convertible to fiat currency and do not require physical proximity for transactions. A lower level of virtuality implies that the currency is convertible to fiat currency and that transactions require physical interaction between parties.

2.4.   Imaginaries

Analysing the underlying narratives and imaginaries is fundamental to understanding how different visions of the economy and the environment, which are associated with different technical solutions, can significantly change societal behaviours and functional processes.

Sheila Jasanoff defined socio-technical imaginaries as "collectively held, institutionally stabilised, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff, 2015).

The importance of imaginaries behind circular-economy-related concepts resides in their performative character and their capacity to turn speculative plans into reality. Imaginaries operate in the interstitial space between discourse and decision, between imagination and action, and "between inchoate public opinion and instrumental state policy" (Jasonaff and Kim, 2015). They are able to make plans feasible and are able to operate as transformative forces because they are, by their nature, intended to be embedded and incorporated into the design of policies and material structures.

While narratives can be defined as stories that allow experiences to acquire form, stories that help people understand reality (Wittmayer et al., 2019), social imaginaries are the focal point around which narratives are built. Their role is to provide people with a logical or emotional structure for their known expectations and to justify their actions. Indeed, imaginaries are shaped by societal values and are connected to ethical considerations. They often reflect visions of ideal societies or potential dystopias that could emerge from social changes in the future.

In a dynamic society, diverse and conflicting imaginaries often coexist, engaging in a dialectic interplay or even coming into direct conflict. These imaginaries hold significant power. They not only envision possible futures but also underpin norms and principles on which life should be based (Jasanoff, 2015).

Of particular relevance for this research are imaginaries concerning social innovation (SI), which today reflect the deep integration of technology, material elements and social change. Such imaginaries have played a crucial role in societal transformation since the 19th century, initially through revolutionary movements linked to radical ideas for social change. Over time, the role of innovation has become central to not only the proposal of new methods and organisational structures but also how to actively shape reality by introducing new ways of framing and understanding (Wittermayer et al., 2019).

In the past few decades, interest in social innovation has grown, with the rise of digital technology leading to widespread adoption of digital tools and systems. And that has led to SI initiatives having such greater efficiency, dissemination, and impact that digital tools are now broadly recognised, by academic and non-academic communities, as crucial enablers of SI processes (Maglavera et al., 2019).

Scholars and practitioners have identified a set of principles for shaping the functioning and structures of society with digital social innovation (DSI), thanks to the intrinsic properties of digital technologies (Certomà, 2021). DSI denotes a form of social and collaborative innovation in which innovators, users and communities work together using digital technologies to co-create knowledge and solutions for a variety of social needs. Urban areas are the main contexts for DSI initiatives due to the higher density and flows of population, resources and goods (JPI, 2015).

As for the application of DSI over the past few years, we could not fail to note their attempt to address probably the most important challenge of our time: the environment. When we shift the focus onto possible solutions for achieving circular economies, it is important to unveil the imaginaries and narratives behind this concept in order to better understand what the desirable futures are they are trying to achieve.

2.5.   Deriving a framework for the exploratory analysis

Overall, the exploratory analysis conducted in this study integrates selected elements from the taxonomies and perspectives reviewed in the previous subsections, each chosen for its relevance to understanding community-level, environmentally oriented, and digitally mediated initiatives. From the literature on circular economies, the dimensions related to reduce, reuse, and recycle were incorporated to capture the environmental missions of the selected projects, as these categories provide a clear basis for distinguishing how each initiative addresses material

flows and ecological impact. Blanc's (2011) classification of complementary and community currencies was used to assess whether each project employs a community or complementary currency and to identify the type of medium of exchange involved. In addition, the generational taxonomy proposed by Blanc and Fare (2013) offered valuable insights for defining the initiator of each project—clarifying its relationship with institutional actors—and for identifying the range of stakeholders involved, aspects that are essential for evaluating participation dynamics. Diniz et al.'s (2018) digital platform taxonomy informed the digital dimension of the analysis—referred to here as "platform"—by contributing categories related to technological architecture, governance arrangements, and virtuality, all necessary for systematically evaluating the digital infrastructures that enable coordination and transactions. Finally, although the literature on digital imaginaries did not directly shape the analytical dimensions, it guided the selection of cases by helping to ensure that the initiatives analyzed are representative of digital social innovation and grounded in collaborative, community-oriented values. Together, these elements form a coherent and multidimensional analytical lens that captures environmental intent, socio-economic organization, technological design, and the broader innovation ethos underlying the initiatives studied.

3.   METHODOLOGY

3.1.   *Selected projects*

This research emerges from the EU-funded CORPUS project, which explores how communities can reimagine and regenerate public urban spaces through circular practices and civic-oriented digital technologies. At the heart of this work is an interest in how digital platforms—and blockchain-based systems in particular—can support new forms of decentralized value exchange and encourage more sustainable behaviors within local neighborhoods. While related research within the project focuses on participatory methods and Urban Living Labs, this contribution turns specifically to the role of digital tools in enabling Circular Urban Economies (CUE). It examines a range of community-level initiatives, from municipal programs to grassroots experiments, that promote practices such as reuse, repair, and recycling, while also embracing alternative models of urban digitalization. These are initiatives that challenge mainstream, technology-driven smart city narratives by advocating more participatory, human-centered, and socially grounded uses of digital technologies. Of particular relevance are digitally enabled sharing and collaborative economies, where online platforms help local actors exchange resources—material or immaterial—and activate new forms of both monetary and non-monetary micro-economies. This narrative provides the context for analyzing how such experiments can contribute to circularity and community empowerment within contemporary urban environments.

We referred to databases and reports as our main sources of information on the selected blockchain-based projects addressing sustainability-related issues (Galen et al., 2018 and 2019; Polvora et al., 2020; Voshmgir et al., 2019; Fines Schlumberger, 2022). Additional insights were drawn from academic literature on circular, collaborative, and sharing economies (Ertz and Boily, 2019; Lampinen et al., 2022; Santala and McGuirk, 2022).

Most of the projects we analysed are still active and based in EU countries, primarily operating at urban and local levels. Only a few projects are located in the USA and Australia.

The primary issues addressed by these projects are environmental concerns such as reducing waste, promoting reuse and recycling, or enabling the creation of circular products and services at the local community level. However, in some cases, sustainability and circular economy initiatives are tied to broader goals like socio-economic inclusion, social cohesion, community care, or supporting self-organised communities.

To analyse the selected projects, we decided to use existing taxonomies and analytical tools related to: community currencies systems (CCS), the digital platforms that implement them, and circular economies systems. These frameworks served as a foundation for our analysis.

In order to answer the research questions, the analysis involved the following dimensions: exchange system, participation and platform. These dimensions were selected as the key criteria for analysis because they provide a comprehensive framework for examining different aspects of these complex systems. The exchange system dimension explored various forms of transactions and their contribution to socio-economic sustainability. The framework described above considers the goal of the project underpinning the adopted monetary system as central. For this reason, it is particularly useful for considering the dimension referred to as the exchange system, especially for

understanding how systems that include the use of tokens, which we see in various projects, can be read within the framework of monetary instruments different from national currencies.

The participation dimension focused on the relational aspect, examining how social dynamics within the community fosters collaboration, trust, and shared responsibility among participants. With regard to the dimension defined as participation, we looked at relationships with possible institutional entities and the kind of actors involved. Here, it was helpful to refer to further work by Blanc and Fare (2013) analysing experiences with CCS and placing them on a time axis with specific characteristics associated with each generation.

The platform dimension addresses the material aspects of the tools embedding the technological mediation. It looks at the role of digital tools and platforms in facilitating exchanges and how the technological infrastructure shapes the overall functioning and accessibility of these systems. Together, these dimensions offer a well-rounded approach to understanding the multifaceted nature of collaborative practices and sustainable exchanges in urban community contexts.

3.2.   Project Analysis

Table 1 provides an overview of the projects analysed, highlighting their key dimensions and parameters. The first two columns contain links to the projects along with brief descriptions.

In the column addressing the exchange system dimension, the projects are categorised on the basis of their economic model, i.e. whether they align with a sharing economy or a circular economy.

A sharing economy refers to local systems that connect the demand for items with the availability of unused resources, and this fosters the exchange or lending of goods within a community. This model emphasises communication and information sharing to meet unmet needs through direct interaction between participants.

In contrast, circular economies focus on promoting specific behaviours within a broader system of resource reuse and recycling, particularly in urban and local contexts. Unlike traditional digital tools that merely track information, these projects aim to encourage actions that contribute to the continuous flow of objects and materials. To achieve this, they often incorporate incentive mechanisms, and in some cases, gamification elements.

Among the projects analysed, four fall into the sharing economy category (CeloCelo, the Inner West Tool Library, Peerby and COSO), while five belong to the circular economy category (InvolveMint, Empower, Plastic Bank, Plastic App, and Pop Machina). One project, the Reuse Wall - Junker app, supports both sharing and circular economy models.

Another important parameter examined is the type of currency used for transactions, including non-monetary exchanges, fiat currency, and complementary currencies (CCs). Tokens used in blockchain-based projects were classified based on the aforementioned Blanc CCS taxonomy. Three projects facilitate non-monetary exchanges without involving any form of currency (Celo Celo, Reuse Wall - Junker app, the Inner West Tool Library). Four projects utilise national currency (the Reuse Wall - Junker app, Peerby, the Inner West Tool Library, and Plastic Bank). In the first two, national currency is used directly for transactions, while in the latter two, it is required only for membership fees. Six projects rely on CCs for transactions (InvolveMint, Empower, Plastic Bank, Plastic App, Pop Machina, and COSO).

Lastly, the types of transactions supported by the systems analysed are summarised in Table 1. They include donations, bartering, lending, renting, buying/selling, certification, rewards, and tracking. A notable trend is observed. Projects not utilising blockchain technology (Celo Celo, the Reuse Wall - Junker app, Peerby, and the Inner West Tool Library) tend to focus on donations, lending, and renting. In contrast, blockchain-based projects (InvolveMint, Empower, Plastic Bank, Plastic App, Pop Machina, and COSO CommonsHood) frequently emphasise reward-based and tracking-related transactions.

The second dimension analysed is participation, with the first subgroup of parameters exploring who initiated the project. The initiators can be categorised as research organisations, the community itself, private associations, institutions, or nonprofits. The findings indicate that three projects were initiated by private organisations (the Reuse Wall - Junker app, Empower, Plastic Bank), four originated from grassroots efforts by community members

(the Inner West Tool Library, Peerby, Plastic App, COSO), two stemmed from research institutions (Pop Machina, COSO), and one was launched by a nonprofit (Celo Celo). For one project, no information on its origins is available. Additionally, three projects (Empower, Pop Machina, and COSO) received recognition and funding from European programmes.

Another parameter we analysed is the mode of participant engagement, which reflects how users interact with and access the system. The resource sharing mode was found in five projects (Celo Celo, the Reuse Wall - Junker app, the Inner West Tool Library, Peerby, and COSO). Marketplace features were offered by two projects (the Reuse Wall - Junker app and Pop Machina). Incentives mechanisms are present in six projects (InvolveMint, Empower, Plastik Bank, Plastic App, Pop Machina, and COSO). Gamification mechanisms are included in two projects (Empower and Plastic App). Since tokenized systems depend heavily on incentives for their functionality and sustainability, mechanisms of incentive and gamification are more commonly associated with blockchain-based projects.

The final aspect considered in this dimension is the involvement of different actors. While all projects target private citizens, six also engage local associations (Celo Celo, the Inner West Tool Library, InvolveMint, Empower, Plastik Bank, and COSO). Additionally, four projects involve municipalities (Celo Celo, the Reuse Wall - Junker app, Pop Machina, and COSO), and four involve commercial organisations (InvolveMint, Empower, Plastik Bank, and Plastic App). Furthermore, both InvolveMint and COSO involve research organisations such as universities. It is notable that institutional entities such as municipalities are involved in all these projects regardless of whether blockchain technology is used.

With regard to the platform dimension, we used Diniz et al.'s (2018) taxonomy to examine the technological aspects of the projects. In four cases, a website or app serves as a bulletin board to match resource supply with demand, thus facilitating exchanges (Celo Celo, the Reuse Wall - Junker app, the Inner West Tool Library, and Peerby). One project, InvolveMint, uses a website and an app to document impact and manage transactions. Five projects utilise blockchain-based platforms (Empower, Plastik Bank, Plastic App, Pop Machina and COSO). According to Diniz et. al.'s (2018) taxonomy, these platforms fall under the category of "dynamic platforms" as they leverage the use of the Internet and innovative technologies like blockchain.

The issue of governance usually relates to the platform's openness, meaning how decisions about its operation are made. Governance is considered shared if the platform relies on open standards and its ownership is distributed among multiple actors. In contrast, it is called proprietary when a single entity holds ownership. In our analysis, the focus shifts to centralised versus decentralised governance, referring to the decision-making processes regarding exchange rules, rather than the platform's ownership. Our analysis reveals that five projects exhibit centralised governance (Celo Celo, the Reuse Wall - Junker app, the Inner West Tool Library, Peerby, and Plastik Bank), while five others display decentralised governance (InvolveMint, Empower, Plastic App, Pop Machina, and COSO). Notably, decentralised governance is a common feature of projects utilising blockchain-based platforms.

Finally, virtuality refers to whether transactions occur digitally or physically. Three projects involve physical exchanges exclusively (Celo Celo, the Reuse Wall - Junker app, the Inner West Tool Library), while three projects operate solely in the digital realm (Involvemint, Empower, Plastic App). Four projects combine digital transactions with physical exchanges of resources (Peerby, Plastik Bank, Pop Machina, and COSO). In the context of sharing and circular economies, it is evident that the digital aspect does not replace or diminish the relational dimension because it is often the case that resource sharing and exchange still requires physical interactions between participants.

The aspect of transactionality—whether different types of actors use the platform—was not explored in this analysis. It would have been redundant given that actor involvement is already covered under the participation dimension.

4. DISCUSSION

In response to the first research question, which regards what types of transactions and exchanges are enabled by circular economies in urban-scale community settings, the analysis shows that circular urban economies support a wide range of resource circulation practices, including donations, bartering, lending, renting, buying and selling, as well as certification, reward, and tracking mechanisms. In terms of the means of exchange, projects that rely on non-monetary transactions predominantly align with sharing-economy models, enabling access-based and community-

driven forms of collaboration. At the same time, six of the analysed initiatives employ complementary currencies (CCs), confirming that CCs constitute an effective exchange mechanism for advancing sustainability objectives and supporting more structured, incentive-based circular practices within urban communities.

Regarding the answer to the second research question, which asked how digital technologies influence participatory processes and through what tools, we reflected on the specific role of blockchain technology. Our analysis of the selected projects shows that digital tools are often used to encourage behaviours that have a positive impact on circular processes, mainly through various forms of incentives, both monetary and nonmonetary, material and immaterial. Given the central role of incentives in promoting these behaviours, blockchain technology emerges as a very effective tool in these initiatives. In particular, blockchain-based platforms are used to make tokens the digital representation of the value generated by circular processes. Blockchain's ability to provide transparent, secure and decentralised incentive systems makes it a key component in advancing circularity.

We also observe a correlation between the adoption of this technology and the implementation of more decentralised governance models, as compared to projects that do not utilise it. This is particularly significant in terms of the governance processes considered, specifically decision-making on token issuance, circulation, and incentive design. In this context, technological tools not only facilitate collaboration but also emerge as the product of the participatory processes themselves, both in their design and implementation. These tools thus enter the public space as active, non-neutral elements, enabling individuals to engage as communities and act collectively (Marres, 2016).

From a broader perspective, independent of blockchain technology, the participatory processes reveal a wide range of actors, not only self-organized citizens but also institutional entities such as municipalities are involved in all these projects regardless of whether blockchain technology is used.

The last research question is about What underlying imaginaries shape these socio-technical systems and how they enhance our understanding of the needs expressed. The answer to this research question is necessarily extensive as it first establishes the crucial contextual understanding required to ground the subsequent work. This detailed contextual analysis then serves as the essential foundation for the future development of the framework, which will ultimately be used to support the design of collaborative systems enabled by digital technologies.

In the first section, we introduced the concepts of circularity and circular economy, the latter considered to be a viable alternative to the linear economic model. It was also stated that the circular economy concept originates from a bigger and more widespread paradigm: sustainable development.

Over the decades, the environmental issue has gradually gained legitimacy. Starting as demands from grassroots social movements from the 1960s, it has been recognised over the years by institutions around the world as a real global problem. Since the United Nations conferences in Stockholm in 1972 and Rio in 1992, the environmental problem has been the subject of public debate and has gained relevance internationally. Since then, environmental concerns have been gradually integrated into the international political agenda, and environmental thinking is now mainstream. The institutionalisation of environmental thinking has depowered the early and radical claims of grassroots movements that had immediately recognised the oxymoron of the concept of "sustainable development". That concept first appeared in the Brundtland Report "Our Common Future" (1987) which announced an attempt to combine economic growth and protect the ecosystem's balance.

Following this process of depoliticising environmental thinking, the next conferences promoted by the UN has progressively diluted the revolutionary potential of the early movements and has invented new principles and tools such as "carrying capacity" and "ecological footprint" — concepts that, while effective in guiding international policies, have had little practical effect.

This process of normalisation has allowed the business community to take an interest in the environmental issue, with the change from early anti-capitalist values into recognition of investment opportunities. It is in this context that ecological transition theory was born, and it has gained more and more space in the public debate.

This theory is part of the "realist" and institutional positions. It therefore identifies the industrial sector and business private companies as the key actors involved in developing new sustainable industrial supply chains or

transforming existing ones, thanks also to the creation of favourable regulatory frameworks by public institutions (Köhler et al., 2019).

In parallel, social innovation has re-emerged as a dominant paradigm in European environmental governance, highlighting the importance of community-driven initiatives.

The projects we analysed reflect this shift. They represent social innovation experiments that introduce new models of participation where communities take responsibility for addressing their own needs. When mediated by technology, these models fall under the concept of digital social innovation (DSI). The primary goals of DSI generally include empowering citizens, sharing knowledge and resources, enhancing the transparency and accountability of institutional processes, and promoting collaborative and sustainable models.

DSI is distinguished by the "peculiar capacity of digital technologies to infiltrate society and change the ontology of socio-technological assemblages; the way in which knowledge is produced and science is elaborated; and the political forms, the ends and the processes digital technologies are entangled with" (Certomà, 2021).

In this context, we reflected on the specific role of blockchain technology. Our analysis of the selected projects shows that digital tools are often used to encourage behaviours that have a positive impact on circular processes, mainly through various forms of incentives, both monetary and nonmonetary, material and immaterial. Given the central role of incentives in promoting these behaviours, blockchain technology emerges as a very effective tool in these initiatives. In particular, blockchain-based platforms are used to make tokens the digital representation of the value generated by circular processes. Blockchain's ability to provide transparent, secure and decentralised incentive systems makes it a key component in advancing circularity.

While we've established that the analysed projects fall within the category of digital social innovation, there remains the need to assess the various forms of social innovation and understand the often ambiguous and nuanced relationship between social innovation and the current economic system.

In some cases, social innovation may be co-opted to serve neoliberal agendas, potentially contributing to processes of depoliticisation that justify neoliberal public policies (Moulaert, 2013; Swyngedouw, 2005; Fougère et al., 2017; Jessop et al., 2013; Schubert, 2018). For these reasons, it is important to detect the imaginaries behind social innovation initiatives. These imaginaries can be categorised into three types. (Certomà 2021)

Initiatives that aim to enhance existing socio-political and economic processes by making them faster, more efficient, or more effective, without fundamentally altering the underlying systems of social reproduction or their conceptual frameworks, are categorised as functionalist. These functionalist social innovation processes aim to reshape market structures and governance models to address needs that the state is unable to fulfil, leveraging the creativity and entrepreneurial skills of private actors. They often involve technological advancements designed to automate tasks and enhance both the quality and efficiency of business processes. As a result, functionalist social innovation initiatives often align seamlessly with the smart city paradigm and are frequently endorsed or co-opted by neoliberal institutions.

Moving along the spectrum from functionalist to revolutionary approaches, we encounter a reformist perspective that characterises many social innovation initiatives as more inclusive, participatory, and citizen-friendly compared to functionalist models. These reformist efforts, often promoted by civil society organisations (CSOs) and public administrations, aim to create collaborative platforms where citizens can engage with both public administrations and a potentially non-exploitative private sector. By directly addressing and transforming socio-spatial structures, reformist initiatives utilise existing digital technologies to foster institutional reform through co-creation and broad participation. On the other end of the spectrum, revolutionary social innovation initiatives spearheaded by cyber-activists, hackers and e-makers seek to disrupt and reconfigure the rules and tools of the digital realm. They aim to challenge the extensive flows of economic, financial, material, and symbolic power that is characteristic of digital capitalism.

5. CONCLUSION

This paper sought to explore some examples of forms of collaborative practices and sustainable exchanges in urban-scale community projects that rely on digital tools. Ten projects were selected and analysed based on three core

dimensions: the exchange system, participation, and platform. These dimensions were chosen as analytical criteria because they reflect key aspects of these complex systems: socio-economic sustainability, community interaction, and the technological mediation of transactions. Our analysis revealed that the projects focus on circular and sharing economies, addressing both environmental concerns—such as waste reduction, reuse, and recycling—and socio-economic objectives, including community care, socio-economic inclusion, and supporting self-organised communities. The use of community currencies (CCs) and the incorporation of incentive mechanisms are expected to promote environmentally sustainable behaviours while strengthening the relational dynamics within communities.

The digital dimension and the technological tools used to facilitate relevant processes are another focus of this research. With regard to the role of digital technologies in these contexts, one important consideration that is worth repeating is that blockchain technology holds significant potential for advancing circular economy initiatives, as highlighted by expert analyses (Caldarelli, 2024). It can incentivise sustainable behaviours by means of tokens or badges that reward individuals and businesses for actions that promote circularity. Blockchain can also enhance transparency and accountability. The authenticated and verified participation of multiple actors can aid with the selection of eco-friendly suppliers and can facilitate reverse logistics for safe disposal or recycling. Moreover, blockchain can support decentralised governance models such as decentralised autonomous organisations (DAOs) in managing sustainability projects. The technology also plays a key role in tokenizing environmental benefits like carbon credits, thus providing verifiable proof of green practices.

Finally, we observed that the underlying imaginaries of these realities align with the digital social innovation paradigm. Specifically, while the projects we analysed fall within the spectrum of reformist to revolutionary, they predominantly occupy a nuanced position closer to reformism. That's because these forms of collaborative and exchange processes engage in partnerships with institutional and public entities while focusing on co-creating new models of participation with the aim of empowering communities.

The following issue remains. Once the underlying imaginaries of these initiatives have been identified, it is essential to determine which operational mechanisms (in terms of tools and design of the exchange system these tools enable) can most effectively support the development of socio-technical systems aligned with their core principles. Although these initiatives are generally classified as social innovation, the predominant tendency towards reformism may limit the scope of some experiments. While the focus on reformism may enhance project sustainability, it could potentially undermine the disruptive potential of the models and tools they aim to implement.

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APPENDIX: TABLE 1 - SHORT DESCRIPTION OF SELECTED PROJECTS

NAME	LINK	SHORT DESCRIPTION
Celo Celo	https://celocelo.it/	Online platform for the donation of unused objects (e.g. clothes, furnitures) and services (e.g. volunteering) to disadvantaged people. Individual users and associations can both offer and ask for object/services.
Bacheca del Riuso (Reuse Wall - Junker App)	https://junker.app/junker-per-le-amministrazioni/bacheca-del-riuso/	*Junker app:* support to the citizen for separate waste: material recognition, mapping of services, etc... on a municipal basis. *Bacheca del Riuso:* additional functionality for a fee (Institution/Municipality side) for reports of objects to be reused, by municipalities and citizens
The Inner West Tool Library	https://innerwesttoollibrary.myturn.com/library/	Digitally mediated "Library of things" for borrowing/lending objects at a neighborhood/urban level.
Peerby	https://www.peerby.com/en-nl	Digitally mediated "Library of things" for borrowing/lending/renting objects at a neighborhood/urban level.
InvolveMint	https://involvemint.io/	Environmental and social care actions in community projects are documented (POI - proof of impact) and rewarded with tokens to be used as local currency for shops and goods
Empower	https://www.empowerchain.io/	Waste tracking; Plastic waste collection and recycling are rewarded with "plastic credits" and customizable deposit schemes, to be used as monetary or gamified incentives
Plastik Bank	https://plasticbank.com/	Collection of plastic waste by vulnerable communities is tracked and generate financial and social benefits, supported by credits purchased by supporting companies
PlasticApp	https://plasticapp.io/	App with games (tokens, challenges, geolocation) for rewarding individual plastic waste sorting
POP-MACHINA	https://cordis.europa.eu/project/id/821479	Within a broader "Social platform" for Makers communities, blockchain-based functionalities enable: P2P marketplace of circular material and services via project tokens, or other crypto and fiat currency; tracking and collectively- or self-certifying the circularity of products/services
COSO	https://www.progettocoso.org/	Decentralized lending system for everyday objects that aims to Incentivize sustainable exchanges and support relationships within the community. The application allows people to book and regulate exchanges of items. For each action, the platform generates community tokens that can be used to borrow objects

APPENDIX: TABLE 2 - OVERVIEW OF THE PROJECTS ANALYSIS

Name	Exchange system			Participation			Platform		
	Economy	CCs	Transaction	Initiator	Engagement	Actors	Architecture	Governance	Virtuality
Celo Celo	Sharing Economy	Non-monetary exchanges	Donations	No profit organization	Resource sharing	Local associations Private citizens Municipality	Wall (website) for matching demand and offer + P2P lending	Centralized	Phisical transaction
Bacheca del Riuso (Reuse Wall - Junker App)	Circular Economy and Sharing Economy	Non-monetary exchanges or National currency	Donations Barter Sale	Private association / Business	Resource sharing. Market place	Private citizens Municipality	Wall (app) for offering and make donations + Customized information and learning.	Centralized	Phisical transaction
The Inner West Tool Library	Sharing Economy	Non-monetary exchanges and National currency	Lending	Grassroot / Community based	resource sharing	Private citizens Local Association	Wall (website) for matching demand and offer + P2P lending	Centralized	Phisical transaction
Peerby	Sharing Economy	National currency	Lending Renting	Grassroot / Community based	resource sharing	Private citizens Peerby organization	Wall (website) for matching demand and offer + P2P lending	Centralized	Phisical exchange for objects Digital transaction for payments

Name	Exchange system			Participation			Platform		
	Economy	CCs	Transaction	Initiator	Engagement	Actors	Architecture	Governance	Virtuality
InvolveMint	Circular Economy	Local Currency	Donation. Reward	NA	Incentives	Private citizens. Local Associations. Universities. Business	Mobile and web app to document and proof actions + generate tokens to be used as local currency.	Decentralize d	Digital
Empower	Circular Economy	Token Complementary currency	Reward. Tracking	Private association / Business recogniction/fund from EU	Incentives. Gamification	Private citizens. Local Associations. Business	Blockchain-based platform (website) that generates and alllows to exchange tokens as monetary or gamified incentives to behaviours, or as credits.	Decentralized	Digital
Plastik Bank	Circular Economy	Token Community currency and National currency	Reward. Tracking	Private association / Business	Incentives	Private citizens. Local Associations. Business	Blockchain-based platform that generate and alllow to exchange tokens to be used as rewards/payments to plastic collectors	Centralized	Phisical exchange for objects. Digital transaction for payments
PlasticApp	Circular Economy	Token Community currency	Reward. Tracking	Grassroot / Community based	Incentives. Gamification	Private citizens. Business	Blockchain-based app leveraging tokenization and gamification + behavioural incentives	Decentralized	Digital

Name	Exchange system			Participation			Platform		
	Economy	CCs	Transaction	Initiator	Engagement	Actors	Architecture	Governance	Virtuality
POP-MACHINA	Circular Economy	Token Community currency	Reward. Traking	Research project Recogniction/fund from EU	Marketplace. Incentives	EU and National Authorities. Municipalities. Urban planners. Circular Makers.	Blockchain-based platform (website) for marketplace of circular material and services + trackcing and certification of the circularity of products and services	Decentralize d	Phisical exchange for objects. Digital transaction for payments
COSO	Sharing Economy	Token Community currency	Reward. Lending. Renting	Grassroot / Community based + Research project Recogniction/fund from EU	Incentives. Resource Sharing	Private citizens. Municipalities. University. Local Association	Blockchain-based platform (web app) for a decentralized lending system for everyday items	Decentralize d	Phisical exchange for objects Digital transaction for payments

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