Gamified DAOs as Blockchain-Based Catalysts for Prosocial and Environmentally Oriented Cities

Arturs Bernovskis[1(✉)], Agnis Stibe[1,2,3], Deniss Sceulovs[1], Yan Zhang[4], and Jiajie Li[4]

[1] Riga Technical University, Riga, Latvia
arturs.bernovskis@rtu.lv
[2] INTERACT Research Unit, University of Oulu, Oulu, Finland
[3] Department of Informatics, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria, Pretoria, South Africa
[4] MIT Media Lab, Massachusetts Institute of Technology, Cambridge, USA

Abstract. This paper explores the role of gamification in decentralized autonomous organizations (DAOs) that are run through rules encoded as computer programs called smart contracts rather than being managed by people. DAOs operate on a decentralized blockchain network and allow for secure and transparent decision-making processes without the need for intermediaries. Token holders typically govern them with voting rights to make decisions and allocate resources within the organization. In the context of ever-growing cities, previous research has shown that prosocial behavior and a positive mental attitude toward the environment are not always related. People without motivation tend not to take meaningful and valuable actions for their societies. Over the past decade, gamification has offered new strategies and tactics for encouraging and sustaining positive change. More recently, advances in blockchain technology have enabled the rise of DAOs. Therefore, this research aims to review and discuss the potential of gamification to support DAOs aiming at prosocial and pro-environmental transformations in cities, as well as the role of blockchain as a technology that fosters such societal improvements and enables organizations to better align with sustainability goals.

Keywords: Decentralized Autonomous Organization · Gamification · Blockchain · Smart Cities · Prosocial · Ecology · Non-Fungible Token · NFT · DAO

1 Introduction

Nowadays, 55% of the world's population lives in cities, and this number is growing, expecting 80% of the population will live in urban areas by 2050 [38]. By that time, with the urban population, more than doubling its current size, nearly 7 of 10 people worldwide will live in cities [23]. Fast urbanization has brought about various urban issues – high traffic, density, pollution, and the overproduction of waste [29]. However,

M. Younas et al. (Eds.): MobiWIS 2023, LNCS 13977, pp. 38–51, 2023.
https://doi.org/10.1007/978-3-031-39764-6_3

as the city gets more, these issues become harder to be solved, centralized just with government laws. Not all citizens trust the government [10], and a lack of trust could be an issue in participating in sustainable activities [21]. Therefore, there is an urgent need to find additional solutions to motivate residents to choose pro-social and sustainable behaviors and not be satisfied only with solutions that rely on regulation. Blockchain technology can be a solution for decentralized actions.

The blockchain market is predicted to grow from USD 7,4 billion in 2022 to USD 94.0 billion by 2027 [22]. A key application of blockchain is to store financial data with a secure exchange; there have been attempts to explore and extend the applications of blockchain beyond payments like Blockchain 1.0 is generally associated with cryptocurrency and payment (Bitcoin, Ethereum), Blockchain 2.0 is associated with automated digital finance using smart contracts, and the more recent Blockchain 3.0 trend is focused on addressing the needs of the digital society, such as smart cities and Industry 4.0 [2].

Sustainable living is the answer to long-term city development [35], but how do motivate citizens to be prosocial? Prosocial behavior is defined as behavior through which people benefit others, including helping, cooperating, comforting, sharing, and donating [14]. According to research, prosocial behavior and positive mental attitude toward the environment are not related, from 97% of participants who declared they had the environment in mind, only 2% picked up garbage that had been left on the ground near a trash can [4]. Without motivation, most citizens will not be prosocially active and will not act with a sustainable mindset.

This paper presents a conceptual framework for utilizing gamification in DAOs to motivate residents toward pro-social and sustainable behaviors and to enhance international business operations. Specifically, the authors suggest that tokenizing assets within a blockchain could effectively incentivize such strategies. Our methodology involves a comprehensive literature review of research on DAOs, gamification, and blockchain. By proposing and elaborating on this framework, we contribute to the existing literature on blockchain technology and provide insights into the potential of DAOs and tokenization in promoting sustainability and enhancing social transformation [34].

2 Background Literature

Research [4] shows that prosocial behavior and a positive mental attitude to the environment are not related, and humans without motivation are not willing to pick up garbage that had been left on the ground near a trash can. Governments mostly use centralized *Stick* and *Carrot* motivation – give penalties or discounts to citizens to take care of the city environment.

In this obstacle arises a question: How can decentralized autonomous organizations effectively incorporate blockchain-based gamification into their operations to promote prosocial and environmental behavior?

The "Industry 4.0" initiative was launched by the German government in 2011 as part of its high-tech strategy to tackle new challenges and ensure the future competitiveness of the German manufacturing industry [19]. The new evolution of the production and industrial process called Industry 4.0, and its related technologies, such as the Internet of Things, big data analytics, and cyber–physical systems, among others, still have an unknown potential impact on sustainability and the environment [5].

A smart contract is a self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code. The code and the agreements contained therein exist across a distributed, decentralized blockchain network. The code controls the execution, and transactions are trackable and irreversible. Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without needing a central authority, legal system, or external enforcement mechanism. Thanks to the characteristics of running automatically on the blockchain, smart contracts have the advantages of being safe, fast, decentralized, and protecting the privacy of both parties involved.

Blockchain technologies are categorized as permissioned (*i.e.,* only authorized users can access the blockchain applications in private, consortium, or cloud-based settings) or permissionless (*i.e.,* publicly accessible for all users via the Internet) systems [32]. Data is stored in the form of cryptographically protected 'blocks' that are linked together in a 'chain.' Blockchain is a type of distributed database managed over peer-to-peer networks, with transaction data ledgers not stored in a centralized server but across multiple nodes all connected by blockchain networks [9].

Gamification has gained enormous popularity in recent years, and the idea has also moved into a broad discourse in policymaking and the public sphere [37], among other things, to promote sustainability in local authorities [30, 33]. The use of gamification makes it possible to design game elements in non-game contexts [11] to motivate desired behavior.

3 Research Methodology

The methodology of this research involves a comprehensive literature review of research on gamification, decentralized autonomous organizations (DAOs), and blockchain technology. Blockchain is a system of recording information that makes it difficult or impossible to change, hack, or cheat the system. A blockchain is the system's distributed and immutable electronic database – a ledger of all transactions that have ever occurred on the network.

The research focuses on understanding the potential of gamification in DAOs to motivate residents toward pro-social and sustainable behaviors. To achieve this, the authors first explored the concept of gamification and its impact on behavior, especially in the context of sustainable living and pro-social behavior. The study then examines the potential of DAOs and tokenization in promoting sustainability and enhancing environmentally oriented societies.

The research also highlights the types of DAOs, their governance and ownership structures, and how tokens play a crucial role in facilitating the exchange of value within DAOs. Finally, the authors propose the utilization of a Mixed DAO, which incorporates two or more DAO types, for sustainable DAO development in urban settings. The DAO Type map proposed by the authors serves as a framework for understanding different types of DAOs and their specific features, allowing researchers and practitioners to design and analyze DAOs more effectively. The proposed conceptual framework and methodology provide valuable insights into the potential of gamification in DAOs to promote sustainable behavior.

To identify gamification in DAOs, authors have researched this theory since it was developed over a decade ago. Since this field is relatively new most of the literature was selected from the last decade. Authors of the paper mainly searched the Web of Science and Scopus databases for targeted articles, using the keywords "gamification", "prosocial", "sustainable" and "blockchain".

4 Decentralized Autonomous Organizations

Bitcoin and Ethereum (a popular smart contract-supported platform) are, perhaps, the two most widely recognized implementations of blockchain. Ethereum founder Buterin and researchers [16] argue that Bitcoin is effectively the first DAO [8] and the Ethereum white paper defines a DAO as a virtual entity that has a certain set of members or shareholders and has the right to spend the entity's funds and modify its code [7].

However, Ethereum is not only a cryptocurrency; in fact, Ethereum introduces four main features in its system:

- Tokens: different currencies living in the blockchain,
- Smart Contracts: digital contracts where rules are stated through code,
- Smart Property: a way to assert the ownership of a real (non-digital) asset,
- DAO: a decentralized autonomous organization structured as a set of smart contracts that define the organization's tokens, properties, and government regulations [40].

The latter is a continuously growing cryptographically linked list of immutable data records. Within the blockchain, a (public) ledger is used to record each transaction's data and information. Information about each completed transaction is stored in a distributed ledger and shared across all the participating nodes of the blockchain network [2]. Blockchain can efficiently record transactions between two or more involved parties on a distributed peer-to-peer (P2P) network, with the stored data co-owned by all members of the network and permanently unmodifiable [25]. Although Bitcoin was the initial usage of blockchain, cryptocurrencies are only one of its numerous applications. Government record-keeping, tracking the flow of products and services along supply chains, voting, and validating citizens' identities are all examples of blockchain uses. Because blockchain technology employs algorithms to facilitate 'smart contracts,' it has powers much beyond those of any standard database. Self-executing code enables safe electronic cooperation techniques that do not rely on a central authority to mediate between transacting parties. These parties, who may or may not trust one other, may rely on the accuracy of the information stored in their shared databases. In a word, blockchain is a type of Distributed Ledger Technology (DLT) in which transactions are recorded with an immutable cryptographic signature.

Generally, DAOs are designed based on their founding members' vision and mission, and as such, have no canonical structure [39] and governance, and ownership structure could be established at the inception of the project or dependent on held utility, security, or governance tokens [1]:

A) *Utility tokens* is an asset based on cryptography that generates or is expected to generate future cash flows [24], serving as the medium of exchange in DAO platforms. These tokens are fungible and could be nonfungible, e.g., concert tickets.

B) Security tokens are tokens that represent ownership of an external tradeable asset, such as real estate and collectibles. They can be fungible or nonfungible, unique tokens used to prove asset ownership [3].
C) Governance tokens are fungible tokens that usually double as utility or security tokens; however, they can be minted separately [1].

An Initial Coin Offering (ICO) is an innovative way to raise funds and an opportunity to take part in a project or in a DAO [17].

Research papers have described several types of DAO like daostack, daohaus, aragon for dao operation systems, maker dao, compound uniswap as protocol dao to govern a decentralized protocol with voting, bitdao for investment, moloch dao for grants. Our research fund two more types of DAO - philanthropy dao like biggreendao and social dao like friendswithbenefits and flamingodao. The authors have created a map of DAO types in Fig. 1.

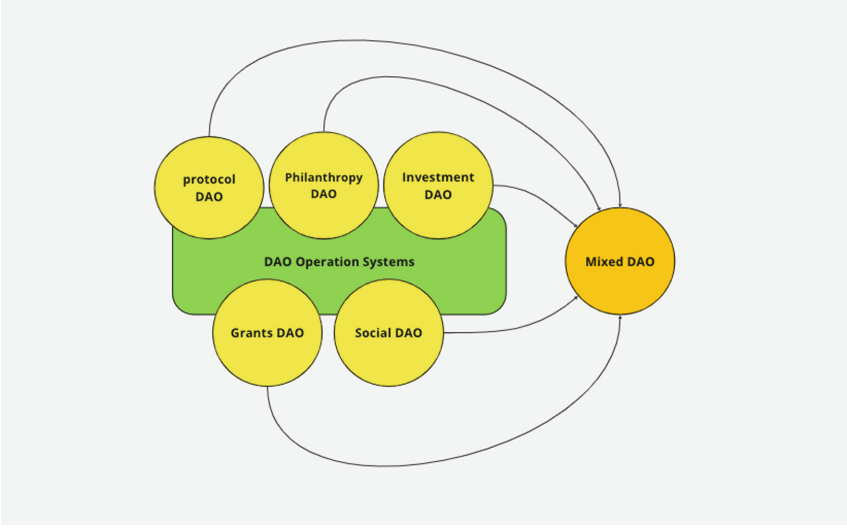

Fig. 1. Types of DAOs

The map of DAO types serves as a framework for understanding the different types of DAOs and their specific features, allowing researchers and practitioners to design and analyze DAOs more effectively. The authors propose the utilization of a Mixed DAO – with two or more DAO types – for sustainable DAO development in urban settings, given the existence of multiple DAO types.

DAOs can be structured in various ways, with governance and ownership structures established at inception or dependent on held utility, security, or governance tokens. Tokens facilitate value exchange within DAOs, represent external asset ownership, and enable governance. ICOs provide an innovative fundraising mechanism and a means to participate in a project or DAO. Researchers and practitioners can leverage the DAO types map as a framework for comprehending various DAO types and their specific

characteristics, which can aid in designing and analyzing DAOs more effectively. Furthermore, Mixed DAOs, which incorporate two or more DAO types, may be particularly useful for sustainable DAO development in urban settings, given the existence of various DAO types.

5 DAO Policy Design for Urban Contexts

Technologies like blockchain can help introduce access tracking and control, secure device discovery, prevention of spoofing, and data loss while ensuring that end-to-end encryption is also used [36]. Collaborating parties on blockchains can trust that transactions are recorded accurately and cannot be altered and that all participants follow the system's rules. Thus, the importance of the identity of collaborating parties in blockchains is less significant than in relational governance.

To establish a new paradigm for incentive policy to promote prosocial behaviors at an individual level, these four aspects are critical:

- It shall be capable of the quantification of diverse behaviors,
- Its incentive mechanism shall be user-driven,
- It shall have a distribution system of equity and equality,
- It shall operate with an ecosystem instead of input from a singular party.

The diagram in Fig. 2 shows how it works. The policy's design and decision-making will involve all participants' participation, collectively determining how the reward system operates. Once collectively designed, the reward system will incentivize each individual to make behavioral changes.

Individualized and Performance-Based Distribution of Incentives. DAOs utilize tokens as incentives to motivate intrinsic motivation for prosocial behaviors, providing extrinsic and reputational values. In this framework, incentive distribution is personalized based on individual behavior, departing from uniform or average-based approaches. The objective is to balance equity and equality by utilizing performance-based, individualized incentive distribution.

Collective Decision-Making. The decentralized voting mechanism in DAOs enables each participant to participate in policy and incentive decision-making, promoting consensus-building among participants. The voting power of each participant is based on their contributions and relevance to the issues being voted on. The decision-making process covers a wide range of topics, such as incentive distribution patterns, token values, token usage scenarios, and activities. In a decentralized decision-making process,

every stakeholder can be heard instead of limited to small groups of people. Thus, the decisions are:

More Fine-Grained and Contextual: A neighborhood's requirements can vary significantly due to the individuals living there, even if they share the same urban fabric.

Dynamic and Resilient: The decision made in such a decentralized way no longer relies on the opinions of a small group of people, thus avoiding bias and becoming more resilient.

Results of Consensus: The smart contract system, which all parties trust, enables secure sharing, storage, and data processing using blockchain technology.

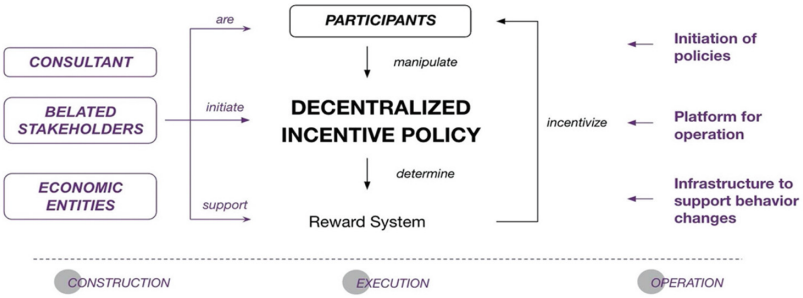

Fig. 2. Decentralized incentive policy

The blockchain market is expected to grow exponentially in the coming years, with the potential for use cases beyond payments and financial data storage. The Industry 4.0 initiative has led to the development of blockchain technologies that address the needs of the digital society, such as smart cities and sustainability. Smart contracts, which are self-executing agreements written in code and executed on a decentralized blockchain network, provide a trusted and efficient way for parties to carry out transactions and agreements without the need for a central authority.

The authors propose a new incentive policy paradigm that quantifies diverse behaviors, user-driven incentive mechanisms, distribution systems of equity and equality, and an ecosystem-based operation to promote prosocial behaviors at an individual level. A decentralized decision-making process, where every stakeholder can participate, leads to fine-grained and contextual decisions that are dynamic, resilient, and based on consensus. Furthermore, secure data and information management are provided using blockchain technology. By implementing these critical aspects, DAOs can effectively incentivize prosocial behaviors and promote sustainable practices in urban settings.

6 Application of Gamified DAOs in Cities

Gamification can help encourage residents to behave that care for the environment, thus creating more sustainable and durable cities [35]. Cities that use this way of intervention will be able to achieve sustainable behavior that is better for the environment and reduce

costs [27], much more than traditional methods such as the stick and carrot method [34]. The gamification works exceptionally well when it creates human and community interactions around it [6] and is, therefore, particularly suitable for use in cities and communities within cities.

Blockchain technologies with gamification elements could motivate city stakeholders to be more active in sustainable activities. A sustainable mindset is habit change, and stakeholders need to learn that gamification blockchain or GamiChain can help as it increases students' and teachers' motivation to build a more transparent, safe, and enjoyable educational environment [26]. On blockchain technology, stakeholders can create a cryptocurrency or NFT (Non-Fungible Token) as a motivational reward for sustainable choices and activities. Cryptocurrency is a decentralized tradable digital asset or digital form of money built on blockchain technology. Cryptocurrency uses encryption to verify and protect transactions without the need for monetary authority. A cryptocurrency wallet is a tool that can store, transfer and receive crypto. It accepts and sends cryptocurrency through interaction with the blockchain. Most cryptocurrencies are fungible assets, which is an important property, the same with currencies. One Bitcoin you receive from a buyer does not need to be the same one you send to the merchant, which means that each crypto unit has an equal market value.

6.1 Advantages of DAOs in Cities

An advantage of the NFT implementation is that it allows the seller of energy assets to set different prices for different tokens of the same token type. Similarly, this implementation permits the actor offering rewards to set different conditions for rewards of the same type. However, in cases where asset standardization is required, the FT implementation offers an advantage as it ensures uniformity between tokens of the same token type [18].

Gaming is the Future's language that can sensitize and stimulate a hypothetical world to the people giving them an immersive experience with the power to change the dynamics of the complex system. The players' decisions in the game self-organize the system's dynamics, making the consequences of connected choices visible to the player. This provides the best learning-by-doing experience to constantly observe and reflect upon an individual's role in the self-organizing complex systems. This experience can encourage people to participate in collective prosperity actively [13].

Gamification methods have shown good results in impacting human behavior and can be used to solve sustainable issues in cities. Blockchain technologies can bring trust and transparent solutions, thus making decentralized gamified motivational programs for municipalities. Decentralized autonomous systems with gamification based on Blockchain can bring an alternative environment for citizens to motivate prosocial behavior. What differentiates gamification from other persuasion techniques is its entertaining design, which makes users perceive a fun and entertaining action and thus creates a positive association with the activity [20, 33]. This is particularly important because previous studies have shown that prosocial behavior and a positive mental attitude toward the environment are not always related. Only motivated people tend to take actions that are meaningful and valuable to their society. Therefore, it is necessary to strengthen motivation in other ways.

The possibility of the community managing the game and learning the behavior distinguishes gamification use of Blockchain in DAO. It enables the management of the networks to promote a broad public value. The fact that everything is transparent and does not require central management (but a network) reduces the problem of distrust of the residents that exist in gamification that the municipality or the government entirely manages. In addition, it also involves the residents more cooperatively, giving them more responsibility and a "voice."

DAO builds a tokenomy that ensures a robust system both inside the platform DAO, as well as inside every initiative (if they use our modules), by the composition of different types of tokens, reasonable regulation of issuance and currency valuing, the ratio of circulation amount and reserve amount, and control of liquidity and fungibility. The potential healthy inter-initiative economic communications will also be built by the exchange with DAO tokens exchange, which will be the hard currency for all protocols in the DAO ecosystem, both platform DAO and initiatives.

6.2 Concerns for DAOs in Cities

Another criticism of this intervention, as in others, is the harmful effect of external rewards on internal motivation [28]. In such a case, where the community manages the game thanks to this technology of decentralized management, the internal motivation will increase.

The ethical implications of using gamification as a policy tool are also a concern. While gamification is often used to encourage pro-social behavior in cities that prioritize environmental sustainability, such initiatives are often implemented top-down, raising questions about who defines the criteria for "good" purposes. It is possible that citizens who are affected by the intervention will not always define "good" in the way that the policymakers will explain it. In authoritarian regimes, it may also lead to implementing government goals that do not align with the social goal [15]. The blockchain also offers excellent transparency, preventing ethical problems and misuse.

Another criticism of gamification is that sometimes the use of game elements may create a lack of seriousness [12]. We believe that the transparency and involvement of the community in this type of gamification will increase the sense of seriousness towards the social and environmental goal, even though it is a "game".

In addition, sometimes, there is an imbalance between the rewards and the "punishments," which motivates some users to circumvent the game's rules. Thus, they are rewarded for adopting habits opposite to the game's goal [12]. This technology saves all the moves, which are transparently presented to everyone, so there is less chance of circumventing the game's rules.

Finally, as in other ways of intervention, sometimes the creation of gamification requires resources of money and knowledge, which not every city and community has. Thus, instead of reducing gaps, it may widen them. And here is the place for the cities and the government to intervene in places where more help is needed with knowledge and financial resources.

6.3 Meaningful DAOs in Cities

Gamification possesses mechanics, dynamics, and aesthetics that share similarities with DAO features. The authors depict DAO as a gamified structure that exhibits resemblances with Ruhi's [31] gamification mechanics, such as challenges, opportunities, competition, cooperation, feedback, resource acquisition, rewards, transactions, shifts, win states, badges, levels, points, social interaction, as well as game dynamic elements including competition, collaboration, community, collection, achievements, and progress. Figure 3 illustrates a comparison of meaningful enterprise gamification with the DAO framework.

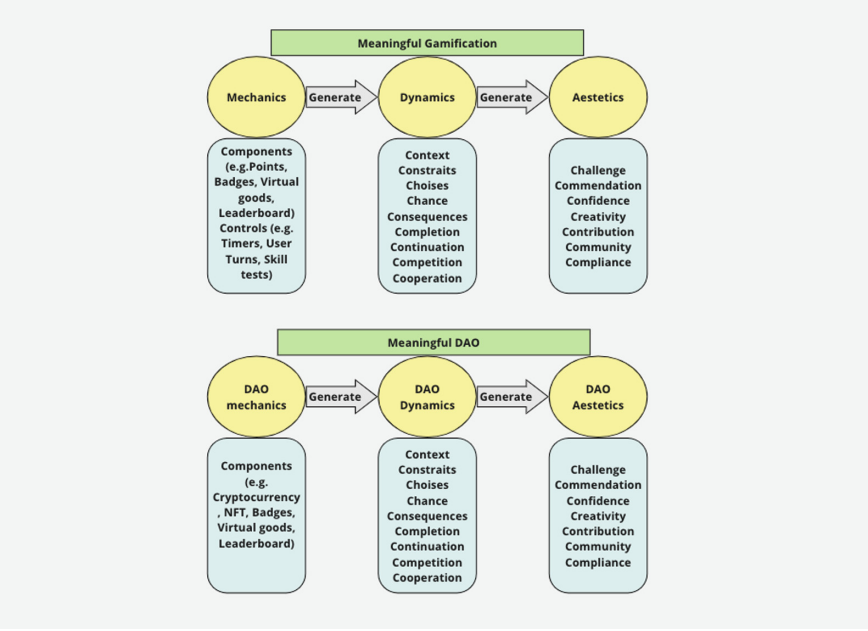

Fig. 3. Meaningful gamification vs meaningful DAO

DAO framework has many similarities with a meaningful enterprise gamification framework, and it could bring a more meaningful prosocial platform for citizens than a regular open government framework.

This paper argues that gamification, which involves using game elements in non-game contexts to motivate desired behavior, can be a powerful tool for promoting sustainability in cities. By combining gamification with blockchain technology, decentralized autonomous systems can be created to motivate prosocial behavior among residents, resulting in a more transparent and cooperative environment. The authors assert that such systems can also bring trust and transparency to solutions, making them more effective and less susceptible to problems of distrust that can occur when the government or municipality is solely responsible for the management of the game.

Furthermore, the transparency provided by the blockchain can help prevent ethical problems and misuse. However, the authors acknowledge that there are still some concerns and criticisms of gamification, such as the harmful effect of external rewards on internal motivation and the imbalance between rewards and punishments. Nonetheless, the authors believe this can be addressed by involving the community in gamification. The authors conclude that the combination of gamification and blockchain technology can create a more meaningful prosocial platform for citizens than a regular open government framework.

7 Results

The use of decentralized autonomous organizations (DAOs) in promoting sustainable and prosocial behavior in urban settings is a promising area of research. Tokens play a vital role in facilitating value exchange within DAOs and can be used to represent external asset ownership and enable governance. Initial Coin Offerings (ICOs) provide a novel fundraising mechanism for DAOs, and researchers can use DAO type maps as a framework to understand different DAO types and their specific characteristics.

Mixed DAOs, incorporating two or more DAO types, may be particularly useful in promoting sustainable DAO development in urban settings. The potential for blockchain technology to go beyond payments and financial data storage is significant, with smart contracts providing a trusted and efficient way for parties to carry out transactions and agreements without the need for a central authority. A new incentive policy paradigm is proposed to incentivize prosocial behavior at the individual level, which includes quantifying diverse behaviors, user-driven incentive mechanisms, distribution systems of equity and equality, and an ecosystem-based operation.

Decentralized decision-making processes lead to fine-grained and contextual decisions that are dynamic, resilient, and based on consensus, promoting sustainable practices in urban settings. Gamification has shown great potential in promoting sustainable behavior, and by combining gamification with blockchain technology, decentralized autonomous systems can be created to motivate prosocial behavior among residents. The community can be involved in the gamification process to address these concerns. International corporations can participate in city DAO token economies and use blockchain-based loyalty programs to reward customers and employees.

The platform can track the carbon impact of distribution channels. However, challenges such as greenwashing, limited resources for implementation, and ethical concerns must be considered. This paper provides insights and ideas for future research and implementation of DAOs in the sustainable development sectors. By creating more meaningful prosocial platforms for citizens, DAOs have the potential to promote sustainable practices and empower individuals and enterprises in sustainable activities.

8 Conclusions

In conclusion, accelerated urbanization has led to several environmental and social challenges. The conventional approaches, including regulations and laws, financial incentives, and carrot-and-stick methods, have proven insufficient to address these issues.

Even newer solutions, such as those based on behavioral economics and technologies like gamification, face criticism due to ethical concerns, issues of trust between residents and the government, and more. In this paper, we recommend integrating blockchain technology also into the urban realm.

The integration of blockchain technology can enable transparent and decentralized management by communities, under the guidance of the municipality, to promote pro-social and sustainable behaviors, which in turn can contribute to a better world for all. In the present times, with environmental and social challenges posing concerns for several cities worldwide, a method is required that can stimulate motivation and responsibility among all stakeholders. The authors contend that the utilization of gamification and Mixed DAO in cities, as recommended in this paper, can substantially aid in addressing these challenges.

DAOs can also offer opportunities for collaboration, innovation, and disruption of traditional business models. Moreover, DAOs can offer several benefits, such as cost savings, increased trust, and access to global markets. However, several challenges are associated with implementing DAOs in cities, including regulatory and legal barriers, issues of governance and decision-making, and potential security risks. Thus, further research is needed to develop best practices for implementing DAOs in cities and to address the challenges associated with their adoption.

References

1. Alao, O., Cuffe, P.: Structuring special purpose vehicles for financing renewable generators on a blockchain marketplace. IEEE Trans. Ind. Appl. **58**(2), 1478–1489 (2022). https://doi.org/10.1109/TIA.2021.3135252
2. Alladi, T., Chamola, V., Parizi, R., Choo, K.: Blockchain applications for industry 4.0 and industrial IoT: a review. IEEE Access **7**, 176935–176951 (2019). https://doi.org/10.1109/ACCESS.2019.2956748
3. Di Angelo, M., Salzer, G.: Towards the identification of security tokens on ethereum. In: Proceedings of the 11th IFIP International Conference New Technologies Mobility Security, pp. 1–5 (2021)
4. Bickman, L.: Environmental attitudes and actions. J. Soc. Psychol. **87**, 323–324 (1972). https://doi.org/10.1080/00224545.1972.9922533
5. Bonilla S., Silva H., Terra M., Franco R., Sacomano J.: Industry 4.0 and sustainability implications: a scenario-based analysis of the impacts and challenges. Sustainability **10**(10), 3740 (2018)
6. Buckley, P., Doyle, E.: Individualising gamification: an investigation of the impact of learning styles and personality traits on the efficacy of gamification using a prediction market. Comput. Educ. **106**, 43–55 (2017)
7. Buterin, V.: Ethereum whitepaper: A next-generation smart contract and decentralized application platform [White Paper] (2013).https://blockchainlab.com/pdf/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf
8. Buterin, V.: DAOs, DACs, DAs and More: An Incomplete Terminology Guide [Blog post]. Ethereum Foundation Blog (2014).https://blog.ethereum.org/2014/05/06/daos-dacs-das-and-more-an-incomplete-terminology-guide/
9. Choi, E., Choi, Y., Park, N.: Blockchain-centered educational program embodies and advances 2030 sustainable development goals. Sustainability **14**(7), 3761 (2022)

10. Dalton, R.J.: The social transformation of trust in government. Int. Rev. Sociol. **15**(1), 133–154 (2005)
11. Deterding, S., Sicart, M., Nacke, L., O'Hara, K., Dixon, D.: Gamification. using game-design elements in non-gaming contexts. In: Proceedings of the 2011 Conference on Human Factors in Computing Systems, ACM, 2011, pp. 2425–2428 (2011)
12. Diefenbach, S., Müssig, A.: Counterproductive effects of gamification: an analysis on the example of the gamified task manager Habitica. Int. J. Hum Comput Stud. **127**, 190–210 (2019)
13. Duke, R.D.: Toward a general theory of gaming. Simul. Games. **5**(2), 131–146 (1974). https://doi.org/10.1177/003755007452001
14. Eisenberg, N., Fabes, R.A.: Prosocial development. In: Damon, W., Eisenberg, N. (eds.) Handbook of Child Psychology, 5th edn, vol. 3, pp. 701–778. Wiley, New York (1998)
15. Harviainen, J.T., Hassan, L.: Governmental service gamification: central principles. Int. J. Innov. Digital Econ. (IJIDE) **10**(3), 1–12 (2019)
16. Hsieh, Y.-Y., Vergne, J.-P.: Bitcoin and the rise of decentralized autonomous organizations. J. Organ. Des. **7**(1), 1–16 (2018). https://doi.org/10.1186/s41469-018-0038-1
17. Ibba, S., Pinna, A., Baralla, G., Marchesi, M.: ICOs overview: should investors choose an ICO developed with the lean startup methodology? In: Garbajosa, J., Wang, X., Aguiar, A. (eds.) XP 2018. LNBIP, vol. 314, pp. 293–308. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-91602-6_21
18. Karandikar, N., Chakravorty, A., Rong, C.: Blockchain based transaction system with fungible and non-fungible tokens for a community-based energy infrastructure. Sensors. **21**(11), 3822 (2021). https://doi.org/10.3390/s21113822
19. Kagermann, H., Wahlster, W., Helbig, J.: Recommendations for Implementing the Strategic Initiative Industrie 4.0: Final Report of the Industrie 4.0 Working Group Forschungsunion, Berlin, Germany (2013)
20. Kurani, K.S., et al.: Plug-in hybrid electric vehicle (PHEV) demonstration and consumer education, outreach, and market research program: Volumes I and II. Plugin Hybrid Electric Vehicle Research Center. Institute of Transportation Studies, University of California, Davis (2010)
21. Liu, L., Bouman, T., Perlaviciute, G., Steg, L.: Effects of trust and public participation on acceptability of renewable energy projects in the Netherlands and China. Energy Res. Soc. Sci. **53**, 137–144 (2019)
22. MarketsandMarkets: Blockchain Market Analysis & Report (2023). https://www.marketsandmarkets.com/Market-Reports/blockchain-technology-market-90100890.html. Accessed 2 May 2023
23. Minovi S.: Shaping the future of transport and climate action with four words (2022). https://blogs.worldbank.org/transport/shaping-future-transport-and-climate-action-four-words. Accessed 10 June 2022
24. Pazos J.: Valuation of utility tokens based on the quantity theory of money. J. Br. Blockchain Assoc. **1**(2), 2516–3957 (2018). https://doi.org/10.31585/jbba-1-2-(2)2018. WOS: 000776575700001
25. Puthal, D., Malik, N., Mohanty, S., Kougianos, E., Das, G.: Everything you wanted to know about the blockchain: its promise component processes and problems. IEEE Consum. Electron. Mag. **7**, 6–14 (2018)
26. Qurotul, A., Nur, A., Rahmat, S., Nuke, S., Shofiyul, M.: iLearning education based on gamification blockchain. Indonesian J. Electr. Eng. Comput. Sci. **26**(1), 531–538 (2022)
27. Rajanen, M., Rajanen, D.: Usability benefits in gamification. In: GamiFIN, vol, 87, p. 95 (2017)
28. Rapp, A.: From games to gamification: a classification of rewards in world of Warcraft for the design of gamified systems. Simul. Gaming **48**(3), 381–401 (2017)

29. Ren, Y., Li, H., Shen, L., Zhang, Y., Chen, Y., Wang, J.: What is the efficiency of fast urbanization? A China study. Sustainability **10**(9), 3180 (2018)
30. Robson, K., Plangger, K., Kietzmann, J.H., McCarthy, I., Pitt, L.: Is it all a game? Understanding the principles of gamification. Bus. Horiz. **58**(4), 411–420 (2015). https://doi.org/10.1016/j.bushor.2015.03.006
31. Ruhi, U.: Level up your strategy: towards a descriptive framework for meaningful enterprise gamification. Technol. Innov. Manage. Rev. **5**, 5–16 (2015). https://doi.org/10.22215/timreview/918
32. Salah, K., Rehman, M.H.U., Nizamuddin, N., Al-Fuqaha, A.: Blockchain for AI: review and open research challenges. IEEE Access **7**, 10127–10149 (2019). https://doi.org/10.1109/ACCESS.2018.2890507
33. Spanellis, A., Harviainen, J.T.: Transforming Society and Organizations through Gamification. From the Sustainable Development Goals to Inclusive Workplaces. Springer, Cham (2021).https://doi.org/10.1007/978-3-030-68207-1
34. Stibe, A., Cugelman, B.: Social influence scale for technology design and transformation. In: Lamas, D., Loizides, F., Nacke, L., Petrie, H., Winckler, M., Zaphiris, P. (eds.) INTERACT 2019. LNCS, vol. 11748, pp. 561–577. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29387-1_33
35. Stibe, A., Larson, K.: Persuasive cities for sustainable wellbeing: quantified communities. In: Younas, M., Awan, I., Kryvinska, N., Strauss, C., Thanh, D.V. (eds.) MobiWIS 2016. LNCS, vol. 9847, pp. 271–282. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-44215-0_22
36. Syed, A., Sierra-Sosa, D., Kumar, A., Elmaghraby, A.: IoT in smart cities: a survey of technologies, practices and challenges. Smart Cities **4**(2), 429–475 (2021). https://doi.org/10.3390/smartcities4020024
37. Vanolo, A.: Cities and the politics of gamification. Cities **74**, 320–326 (2018)
38. Venditti, B.: United Nation, How Material Consumption is Calculated (2022). https://www.weforum.org/agenda/2022/04/global-urbanization-material-consumption/. Accessed 10 Jan 2023
39. Wang, S., Ding, W., Li, J., Yuan, Y., Ouyang, L., Wang, F.-Y.: Decentralized autonomous organizations: Concept model and applications. IEEE Trans. Comput. Soc. Syst. **6**(5), 870–878 (2019)
40. Zichichi, M., Contu, M., Ferretti, S., D'Angelo, G.: LikeStarter: a smart-contract based social DAO for crowdfunding, pp. 313–318 (2019). https://doi.org/10.1109/INFCOMW.2019.8845133