Citizens' engagement in urban development through blockchain: a human-centered design approach

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***Abstract*— The aim of the paper is to investigate how a BC-based platform for citizens' involvement in urban planning should be developed taking a human-centered perspective. Specifically, the paper adopts a Value Sensitive Design (VSD) approach to identify the key values driving the technological infrastructure development and design of a blockchain-based participation platform for urban planning. The study is empirical and based BBBlockchain: an App specifically conceived to improve citizens participation in urban planning decisions in two major residential development projects in Berlin. From a preliminary investigation on the information layer of participation, it can be argued that the most important values include transparency, inclusiveness and confidentiality.**

Keywords*— *blockchain, blockchain-based systems, value sensitive design, human-centeredness, citizen participation, open government

I. INTRODUCTION

Citizens' participation in public decision making and affairs has recently become one of the most important topics in open government [1]. Advancements in digital technologies have set the scene for a complete transformation of citizens experience through the development of e-platforms which enable participation in public decisions through an interactive engagement [2][3][4]. Urban planning is one of those public sectors in which future developments affect citizens' lives and wellbeing. Therefore, embracing citizens opinions, as an ongoing input into decision making processes, is essential [5]. Nonetheless, governments seem to struggle to stimulate and maintain productive engagement in participation initiatives and feel pressure to identify new solutions [6]. The lack of citizens participation has been associated to problems of the current e-participation platforms, including, citizens lack of motivation, scarce knowledge on the topics, distrust, platforms' disengaging design [7].

Due to the attractive peculiarities of decentralization, traceability, and immutability, blockchain (BC) technologies have been on the spotlight as a great opportunity for governments to improve public engagement in urban planning [2]. Researchers argue that governments can use BC to improve transparency, accountability and, most importantly, trust in lengthy, and controversial, urban development processes so that citizens can better understand governments' decisions [8][9]. Drawing on Arnstein's ladder of participation [10], Muth et al. [11] argue that BC can improve citizens' engagement in all the five layers of the participation spectrum: inform, consult, involve, collaborate, and empower. Transparency, accountability, and trust are, in fact, considered the most important elements to foster citizens participation [5][12]. So far, research on BC has been focusing either on cryptocurrencies or on technical and infrastructural challenges [14] [15], resulting in a rather technocentric approach to study BC which often underestimate the importance that BC might have on the final users, causing many BC-based platforms to underperform [16][17][14]. In fact, BC can be used as the underlying technical infrastructure of systems with different purposes, created for different users and contexts. Therefore, [18] calls for further research on human-centered approaches to study BC-based systems development and adoption. Furthermore, e-participation platforms usually involve very different types of users, as they bring together institutions, businesses, citizens, and other stakeholders. As different stakeholders are likely to have different interests, their perceived benefits in using the platform are likely to diverge, causing tensions or conflicts [14]. To prevent that such tensions undermine the e-platform effectiveness, several researchers suggest identifying and solving them before they manifest, during the platform development phase [9][14][18].

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Value Sensitive Design (VSD) can be considered as an overarching framework for new technologies development which takes into account moral and human values of all the direct and indirect stakeholders which might be impacted by the technology (publics, businesses, governmental bodies)[19]. VSD assumes that any given technology is more likely to support certain stakeholders' values while hindering others, therefore, to favor a technology's acceptance and adoption, these values need to be considered prior and during the development and implementation of the technology. VSD adopts the position that values are translated into design requirements through norms. Norms are transition points between values and design requirements; they can be understood as design objectives of any given project [20].

Based on these premises, the paper takes on Foth's suggestion [18] and adopts a human-centered perspective to analyze how BC can improve engagement in urban planning contexts, through the adoption of the VSD approach. Accordingly, the paper wants to answer the following questions: what are the most important values that should drive the design of a BC-based participation platform for urban planning? How such values can be incorporated into the design of the platform to enhance stakeholders' adoption? Ultimately, the broader scope it would be to identify a conceptual framework to develop BC-based platforms through which the platform is developed according to human-centered principles. As most developers focus on functional and technical aspects of the BC underlying infrastructure, there is still very little guidance on how to create BC-based systems which also consider more socio-technical matters, such as interface design and users' values, ensuring that BC benefits are clearly communicated and perceived [14]. In fact, BC technology is underpinned by a wide range of supporting hardware and software components that can be differently combined as design features that support stakeholders' values across a range of user-applications [14][16] [21]. The study adopts an empirical approach through a case study analysis of BBBlockchain: An app for citizens participation in urban planning decisions based on BC technology. As the study is currently on its second development and testing phase, the analysis will provide preliminary insights based on 4 experts interviews and two interviews with the Housing Association (HA).

The structure of the paper follows the tri-partite methodology approach of VSD, as suggested by [19] which establishes the following three different investigations.

1. Conceptual investigation, which draws on the extant literature on e-government and blockchain technologies to identify what are the most important e-government values that BC can support and how they translate into technical requirements.
2. Technical investigation, which analyses the current design features of BBBlockchain and translates them into stakeholders' values.
3. Empirical investigation, which, following a bottom-up approach, analyses stakeholders through primary research. Specifically, it seeks to identify what are the main benefits and harms for each stakeholder and associate them to specific values. This part also identifies possible values' conflicts among stakeholders (for an exhaustive explanation of VSD see [19].

II. Conceptual Investigation

One of the main objectives of e-government initiatives in urban planning is to make the process more inclusive by fostering citizens' engagement through their involvement in decision-making [22] [23] and by improving the accessibility to information in terms of platform usability and information easiness of understanding [24]. As participation processes have historically suffered from an underlying mistrust as well as a negative image of corruption, reinfusing *trust* in urban planning, through an open access strategy, has been a government priority [25]. Strictly related to the value of trust, transparency has also been considered another key government objective, conceived as the availability of information concerning government organizations. More specifically transparency has been associated to information quality in terms of clarity, reliability, relevance, and comprehensiveness [26][27].

Blockchain technologies have been considered as particularly suitable to improve participation processes because they can act upon inclusivity, trust, and transparency [17][28]. First, utilizing a distributed ledger and a consensus algorithm, BC provides an historical record of all the past transactions which is permanently stored and cannot be changed. As the record is visible to anyone, can be traced back and it must be approved by the network to ensure integrity, citizens and other stakeholders can monitor and verify the information put forth, data are unlikely to be manipulated [28][29]. Hence, transparency improves so that possible speculations on corruption in urban planning can be prevented [8] [16] [30]. The immutability also makes BC useful for tracking processes of urban development, especially if conflicts arise, thus, providing a transparent basis for discussion [11].

Nonetheless, BC is a complex and hard-to-understand technology and only people with adequate technical knowledge can appreciate its value [33]. Accordingly, it might impact on

TABLE I. CONCEPTUAL INVESTIGATION

Values	***Norms***	***Design/technical features***
Trust	Information not to be held by a central power. Information should retain integrity.	BC builds a decentralized system through a distributed ledger of nodes. BC validates and records transactions in a p2p network (consensus mechanism).
Transparency	Information should be accurate, reliable, relevant, comprehensive. Citizens should monitor processes to hold other stakeholders accountable for not complying to plans. Conflicts situation should be solved in a fair way.	Consensus algorithm ensures data integrity, therefore, information reliability. Historical record can be traced back through timestamping and proof of content origin. Consensus algorithm does not allow data manipulation to published data.
	Information should be easy to access	BC provides immutable record of all the transactions and by default makes them

Inclusiveness	by everyone at any time. Information should be understandable by non-experts Information should be openly available and easy to find.	visible to all the participants in the network. BC transactions verification might require high levels of technical knowledge. Decentralized system through a distributed ledger.

inclusivity. Table I summarizes the conceptual investigation of BC-based participation platforms.

III Technical Investigation

BBBlockchain was developed in the 2nd half of 2019 with the purpose of improving citizens participation in urban planning processes. The use cases analysed in the paper are timestamping and document management that serve to address the first layer of participation which is information [10]. Specifically, BBBlockchain provides an ongoing overview of the urban development process through the management and secured storage of various documents such as land-use plans, approval processes, contracts and general buildings information.

Technically speaking, BBBlockchain is a decentralized application (DApp) which verifies the integrity of the blockchain-secured contents on the users' devices through a simple user interface which conveys complex blockchain concepts on a visual level. The interface evolves around a timeline view and ensures that users are confronted with blockchain details as little as possible. Nonetheless, if in doubt, users can access blockchain details for each entry's transaction and utilize cryptographic hash values to verify data integrity. Accordingly, BBBlockchain, by incorporating such verification in the user interface, can ensure the reliability of the information in a comprehensible manner. As urban planning processes are likely to change as they develop, such changes will need to be communicated as new information due to blockchain's immutability. Table II summarizes the main technical features with associated norms and values in relation to the "inform" layer of participation.

IV Empirical Investigation

A. Data Collection and Analysis

A preliminary empirical investigation was conducted by collecting the following primary data:

- n. 2 semi-structured interviews with the HAs involved in the project;
- n. 4 semi-structured expert interviews;
- informal discussions with all the relevant stakeholders (HAs, municipalities, and tenants' representatives).

The scope of the interviews with the HAs was to understand their opinions on BBBlockchain, why they decided to get involved, perceived benefits and limits. In addition, as BC is a technology still at its nascent stage and with a high degree of technical complexity, expert interviews, considered as indirect stakeholders, also resulted to be a suitable complement as they could provide a more informed view on BC for civic participation in urban planning. Experts were selected based on their knowledge of blockchain as well as making sure to provide different viewpoints from different industries for whom blockchain can be relevant [34][1].

Table III summarizes interviews details. Following [35] grounded approach, the interviews[2] were eventually inductively coded from empirical to conceptual so that related concepts could be merged into more abstract themes following the subjective interpretation of the researcher.

TABLE II. Technical Investigation

Design/Technical Features	***Norms***	***Values***
BBBlockchain is a DApp for mobiles and desktop browsers Information entered via WordPress Intuitive and minimal design: content is visualized in a chronological way and color coded according to the publishing stakeholder. Entries are designed in three layers - blockchain details on the third. Functionality of Blockchain is explained. Transaction fees for users are covered within BBBlockchain.	Easy to access and understand by a larger non-expert audience (Interface design).	Inclusiveness
Data are stored in a decentralized open network and are available to everyone from multiple servers. Public and permissionless design.	No one has control on the data (BC infrastructure design).	Inclusiveness
Files are stored in a cloud storage and hash value in the blockchain. New functionalities can be developed and added any time.	Minimizing costs. Flexible design.	Efficiency
Users can run their own node and verify transactions. All data are stored openly for read-only access.	Data Integrity.	Trust
App features implemented as smart contracts. Publicly available transaction log. Blockchain records transactions via a verification process that users cannot reverse or remove from the blockchain. Permissionless blockchain on Ethereum. Modified entries marked in red.	Once published, data cannot be modified unnoticedly. Citizens can monitor urban planning decisions over time.	Transparency
Managing the smart contract is only allowed for a closed user-group representing the key stakeholders	Prevent poor or irrelevant information	Transparency
No identification for using app. Personal data from individuals, copyrighted material, documents that aren't wanted to be made public in purpose by relevant stakeholders, might not be included.	Pseudo-anonymity of users	Confidentiality/ Privacy

[1] Interviews lasted between 45-60 mins and participants were asked to test BBBlockchain before the interview so that their impressions on it could be recorded.

[2] All the collected data was entered into NVivo12 software for manual coding and analysed through a thematic content analysis.

B. Preliminary Findings

a) Blockchain for transparency

Transparency, recognized as a key value for citizens participation, was mostly associated with information quality in terms of relevance and comprehensiveness. Information on the decision-making processes, the disclosure of all the parties' interests, an overall vision of the project, were all considered as very important topic citizens would expect to be made available.

Interestingly, although BC can ensure data integrity, it cannot assess the quality of the data in terms of how relevant and exhaustive they might be [36]. By contrast, BC was considered relevant to increase government accountability since, the openly available immutable historical record of all the past transactions, it creates a transparent basis for conflict management:

"*If all the decisions are stored and they are also verified, bindingness can be established, and decisions can be tracked in retrospect as you can look up exactly what the actual decision was*" (E3).

In practice, though, an increase of accountability can result in undesirable effects such as the reluctance of key stakeholders to publish additional information as BC makes them traceable and immutable.

"*I don't think that maximum level of transparency is important or even right in every step and that a certain level of secrecy in some points is not wrong and is also important to protect the stakeholders*" (E2).

Therefore, in this instance, BC causes a value conflict between citizens need of transparency and other stakeholders' confidentiality protection. As suggested by E3, a solution could be to establish in advance an "*adequate level of transparency*" which juggles in between governmental confidentiality, fear of over exposure and open access.

"*Communication of the limits of transparency is important; what do I publish and what not"* (E3).

Furthermore, transparency might also introduce what [36] calls operational risks as, for the HAs and government,

TABLE III. INTERVIEWS INFORMATION

Interviews	***Type of stakeholder***	***Organisation***	***Position of interviewee***
E1	Indirect (expert)	Developer of digital tools for spatial planning	Co-founder
E2		Funding Program to develop open-source applications in the areas of Civic Tech	CEO
E3		No-profit organization developing innovative solutions for more democratic decision making	Founder
E4		Open-source software firm developing solutions for agile administration	Founder
E5	Direct	Housing Association	CEO
E6		Housing Association	CEO

increased transparency might introduce higher degrees of interferences in the development process. Maintaining adequate levels of transparency also requires a substantial commitment which might not be sustainable in the long term, especially if the involved stakeholders are not legally bound to its compliance.

b) Blockchain for inclusiveness

Overall, both HAs expressed their willingness to participate in the BBBlockchain project in very abstract terms to demonstrate government engagement with digital innovation, achieve open government and increase citizens involvement in urban planning decisions. Although not strictly related to BC peculiarities, E5 envisions BBBlockchain as an asynchronous community platform to reach more people, "*for neighbour from neighbourhood",* where direct interaction with tenants could be established and where their opinions are not influenced by others' opinions, as it would happen during in-person events. However, to improve citizens inclusion, they acknowledged the importance of platform and information accessibility by making the use of BBBlockchain very simple and the understanding of the, often complex, planning process, as clear as possible.

In fact, interviewees were stressing the fact that BC is a complex technology whose benefits are valued only by a small minority of tech savvy users. Therefore, not understanding the actual added value that BC might bring to participation platforms, because of its complexity, might be a hindering factor for inclusiveness. This was also confirmed by the low level of citizens participation during pilot phase 1. The identification of communication strategies to best communicate BC unique value to non-experts becomes a rather critical factor. The findings also revealed the importance of clearly communicating to citizens how their contribution will be considered, or they might feel that their effort has not being valued and lose motivation to participate.

"*Sometimes what I've read is that people feel that even if they put effort into something, then it's likely that they're not too sure how their opinion is taken into account*" (E5).

BC capabilities might also hinder stakeholders' participation as immutability and traceability might increase their accountability in relation to issues beyond their control.

"*As a housing association, we don't really know if we are able to do it in a way that citizens are thinking. We need to talk with our lawyers, our builders, etc. We are dependent on many government rules and decisions. So the questions we are willing to consider are also depending of what we are able to control. Even if we ask if you prefer the playground for your kids or fitness area outside, it could be that for one reason or the other we are not allowed to create that. At that point you also must deal with the social and psychological side. This is one of the biggest barriers on our side*" (E5). I understand this is a quote but this can clearly be pre-assessed by professionals

Although the above findings need to be further explored by conducting more empirical investigation and analysis, Table IV summarizes the main values, with associated norms and design features, which have emerged from the empirical investigation.

TABLE IV. EMPIRICAL INVESTIGATION

Values	*Norms*	*Technical/Design Features*
Transparency	Information should be comprehensive.	Information should include decision making process, interests' disclosure, overall vision of the entire process.
	Information should be accessible to manage potential conflicts.	BBBlockchain infrastructure design should ensure immutability, traceability.
	Government and HA should become more accountable	"Rules of game" can be established, and all stakeholders agree on it.
Inclusiveness	Open access to information.	BC decentralized system through a distributed ledger.
	Simple design to facilitate usability.	BC infrastructure complexity might be difficult to use and non-valued.
	BC value should be perceived by non-experts	
	Information should be accessible.	Urban planning process explained so that non-experts can understand
	Motivate citizens' contribution.	Clearly explain how citizens contribution will impact on the planning process.
	Give a sense of community to all the stakeholders, including the neighborhood	Voting and consulting functionalities might allow more interaction
Confidentiality	Sensitive Information or information which are beyond control of key stakeholders should not be shared.	"A*dequate level of transparency*" should be established and agreed upon all the stakeholders.

CONCLUSIONS

The paper analyses how a BC-based platform for citizens' involvement in urban planning should be developed taking a human-centered perspective. From a preliminary investigation on the information layer of participation, it can be argued that the most important values include transparency, inclusiveness and confidentiality.

Transparency can be associated with information comprehensiveness and information accessibility, both relevant to increase stakeholders' accountability and manage potential conflicts. Comprehensiveness can be achieved through the content published on BBBlockchain so it's beyond the control of the BC underlying infrastructure. Accessibility relies on BC characteristics of traceability and immutability. Specifically, the technical investigation shows that accessibility can be achieved through the development of a BC infrastructure which is permissionless so that data and smart contracts are stored open-source and can be accessed by anyone. Nonetheless, transparency might conflict with the value of confidentiality which resulted to be particularly relevant for HAs and government as it would make them more accountable for the information, they post on BBBlockchain. In fact, government and HAs face several operational difficulties and an inflexible legislation which cause an institutional and cultural resistance which hinder the adoption of BBBlockchain. Such conflict can't be managed at an infrastructural level but instead at an informational level by defining an "*expected level of transparen*cy" in advance, explicitly including what information will not be disclosed, the reasons and, eventually, make stakeholders to commit to it. Still, as this would go beyond both stakeholders' habitual communication protocol and their legal requirements, it remains the issue of ensuring that the relevant parties will comply. In this case, further research will be conducted during pilot phase 2 to investigate how BC might be implemented to overcome the problem, for example, through the issue of tokens.

Inclusiveness has been associated with accessibility, making the platform easy to use through a simple design and the information on the urban planning project, easy to understand. In this case, BC, due to its technological complexity, might constitute a hindering factor for non-expert users. However, the technical investigation has shown that through the interface design it is possible to keep BC details hidden through an API. Still, as suggested by [18], more investigation will be conducted during pilot phase 2 on how platforms should be developed to best present the complexity of BC features, according to the domain of application. Further research also needs to be conducted on how to best communicate BC added value to non-expert's users as well as on how to best motivate citizens to contribute either through rewards or by making clear how their contribution will impact on the urban development plan.

Finally, the empirical investigation has revealed an interesting result about the importance of create a sense of community and inclusion in the whole neighbourhood. This is also something that will be further investigated when new functionalities of collaboration and empowerment will be developed on BBBlockchain.

To conclude, it is important to emphasize that, to develop human-centered BC-based platforms, specific technical and design features, which take into account stakeholders' values, should be considered. Although the analysis is at a very early stage, it clearly emerges that values and possible value tensions can be addressed at the infrastructural, design or information level. For example, inclusivity can be fostered with a public BC design but also with platform usability and information understandability. Transparency is achieved at the infrastructural level through a permissionless design and transactions records with cryptographic hash values which ensure data integrity. Still, the empirical analysis has shown that transparency requires information quality in terms of relevance and comprehensiveness which cannot be proved by the BC itself. BC systems are particularly exposed to this problem because immutability extends information longevity even if the data are poor quality and data quality assessment cannot be automated by BC. In fact, the analysis shows that immutability might deter key stakeholders to enter data as they could be held accountable for wrong entries. The technical investigation shows that information relevance can be addressed by granting writing rights only to key stakeholders so that the publication of undesired information can be prevented. Nonetheless, this is a form of control and discrimination as it affects the openness of the platform and therefore, inclusivity. Alternatively, the

empirical investigation suggests that by establishing in advance "*adequate levels of transparency*", might affect information comprehensiveness. Ultimately, human-centeredness should be achieved through a combination of governance, design and information decisions, to be taken based on the specific context of application.

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