Blockchain for citizens' participation in urban planning: The case of the city of Berlin. A value sensitive design approach

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Abstract:	The aim of the paper is to investigate how a blockchain-based platform for citizens' participation in urban planning should be developed adopting a Value Sensitive Design approach (VSD). VSD can be considered as an methodological framework for technologies development which considers moral and human values of all the direct and indirect stakeholders which are impacted by the technology. By considering the perspectives of the different involved stakeholders, the paper specifically addresses the call for more research about blockchain-based services which adopts a human-centred approach instead of technocentric The paper is based on the empirical analysis of a DApp called BBBlockchain which was specifically created with the purpose to improve citizens participation in urban planning decisions in two major residential development projects in Berlin, Germany. BBBlockchain is a proof of concept which is currently running on its own in-house test network but it can run on every EVM compatible blockchain. For testing and development purposes we decided to use Ethereum. From the analysis of the information layer of participation, it can be argued that the most important values include transparency, inclusiveness and confidentiality.
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I also certify that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in the journal Cities.

Dear Editor,

We are pleased to submit an original research article entitled “Blockchain for citizens’ participation in urban planning: the case of the city of Berlin. A value sensitive design approach” for consideration for publication in Cities.

The aim of the paper is to investigate the adoption of blockchain technologies for the development of an e-participation platform for urban planning adopting a Value Sensitive Design approach. By considering the human values of the different involved stakeholders, the paper presents indeed a novel approach to the analysis of blockchain-based services which, so far, has taken a rather technocentric approach, mostly focusing on technical and infrastructural challenges.

Furthermore, the paper is the result of the empirical analysis of BBBlockchain (bbblockchain.de) which has been developed in 2019 with the purpose to improve citizens participation in urban planning decisions and it’s currently being tested in two major residential development projects in Berlin. BBBlockchain is a cross disciplinary research project of the Einstein Center Digital Future (Berlin) supported by the six municipal housing associations in Berlin and conducted by a multidisciplinary research team which integrates varied competences and background including urban resilience and digitization, distributed security infrastructures, management and marketing.

Regards

The Authors.

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Federica Pascucci: conceptualization, supervision, methodology, writing original draft, visualization

- Value Sensitive Design is proved to be a good approach to develop a blockchain-based platform for citizens' participation in urban planning.
- The most important values include transparency, inclusiveness and confidentiality.
- Taking the perspective of the different involved stakeholders, the paper adopts a human-centred approach instead of technocentric.
- The value of inclusiveness can be enhanced at an infrastructural level through a public and permissionless blockchain.
- Stakeholders' values should be incorporated into the design of the platform to enhance stakeholders' adoption.
- Conflicts among stakeholders' values have emerged and they have been addressed through platform's design and implementation.

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Abstract

The aim of the paper is to investigate how a blockchain-based platform for citizens' participation in urban planning should be developed adopting a Value Sensitive Design approach (VSD). VSD can be considered as an overarching methodological 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. By considering the perspectives of the different involved stakeholders, the paper specifically addresses the call for more research about blockchain-based services which adopts a human-centred approach instead of technocentric.

The paper is based on the empirical analysis of a DApp called BBBlockchain which was specifically created with the purpose to improve citizens participation in urban planning decisions in two major residential development projects in Berlin, Germany. BBBlockchain is a proof of concept which is currently running on its own in-house test network but it can run on every EVM compatible blockchain. From the analysis of 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

1. Introduction

Citizens' participation in public decision making has recently become one of the most important topics in open government (Welch, 2012). Digital technologies have allowed citizens to demand a new type of relationships with public administration, founded on greater transparency and more participatory systems through the development of e-platforms which enable a more interactive and engaging participation (Linder, 2012; Benitez-Martinez et al., 2021; Naranjo-Zolotov et al., 2019). Nonetheless, governments lack behind in stimulating and maintaining productive engagement in participation initiatives and feel pressured to identify efficient solutions (Horizon 2020).

So far, a concurring lack of citizens participation has been associated with platforms' disengaging design, failure to keep citizens' motivation high, citizens' scarce knowledge on the topics and lack of trust (Rana et al., 2019).

Due to the peculiarities of decentralisation, traceability, and immutability, blockchain technologies have recently grabbed governments' attention as an attractive opportunity to improve public engagement in urban planning processes (Bagloee et al., 2021; Li et al., 2020). For governments, some of the most important blockchain promises include: a move toward decentralised, transparent, and accountable processes through data integrity and immutability; a way to empower citizens through technical means; a vision of cutting out government and third-party middlemen through automatic trust (Benitez-Martinez et al., 2021).

Nonetheless, so far, research on blockchain technologies has either been focusing on cryptocurrencies or on technical and infrastructural challenges (Elsden et al., 2018; Subramanian, 2019). In fact, the prevailing attitude toward blockchain technologies, mostly driven by technology enthusiasts such as developers, has been rather technocentric and focused on the belief that, if a technology is better, its technical superiority would automatically lead to users' adoption (Foth, 2017). Such an assumption might inevitably lead to several problems. First, developers are very different from the final average users which are generally only considered at later stages of the development process of a technology. This might lead many blockchain-based services to not meet the expectations and objectives they were intended to achieve (Cila et al., 2020; Husain et al., 2020; Elsden et al., 2018).
Secondly, the majority of available blockchain reports and white papers, are distributing information about blockchain experiments which are boosting the hype around it but, in fact, do not consider the actual deployment for the end users of the service (Lindman et al, 2020). Furthermore, although blockchain is increasingly becoming part of mainstream knowledge, blockchain-based government initiatives that have actual users are still rare and many projects end up fading into the background (Lindman et al., 2020). The EU Joint Research Centre has reported that the identification of empirical use cases of the use of blockchain technologies in the public sector is scarce (Du et al., 2019; Rieger et al., 2019). There are almost no published scientific evaluations of the proposed public sector blockchain use cases or ideas (Labazova, 2019; Allessie et al, 2019). More specifically, it seems that the research has fallen short in considering the importance of the socio-cultural context in which the technology is applied, including the perspectives of the different involved stakeholders (Jang et al., 2020).
In fact, e-participation platforms usually involve very different types of users, as they bring together institutions, businesses, citizens, and other indirect stakeholders. As different stakeholders are likely to have different interests and preferences, their perceived benefits in using the platform are likely to diverge, causing tensions or conflicts (Elsden et al, 2018).
To prevent that such tensions might hold off the platform from achieving the main purposes it was created for, several researchers suggest identifying and solve such tensions before they manifest, during the platform conceptualization and development phases (Ølnes and Jansen, 2017; Elsden et al., 2018; Foth, 2017). Therefore, Foth (2017) calls for further research on blockchain-based platforms development which take into account the different interests and perspectives of all the direct and indirect stakeholders which might be impacted by the technology (publics, businesses, governmental bodies).
Based on these premises, the paper takes on Foth's suggestion (2017) and analyzes how a blockchain-based platform should be developed and implemented to improve engagement in urban planning contexts. Urban planning is one of those public sectors in which future developments affect citizens' lives and wellbeing. Therefore, it becomes essential to embrace all the stakeholders' opinions as an ongoing input into decision making processes (Xie et al., 2019).
In relation to urban planning, researchers argue that governments can use blockchain to make citizens better understand their decisions by improving transparency, accountability and trust in often lengthy and controversial urban development processes (Centobelli et al., 2021; Ølnes and Jansen, 2017).

More specifically, the paper considers the perspectives of all the direct and indirect stakeholders by focusing on their values, through the adoption of the VSD approach. VSD is a framework developed by Friedman and Henry (2019) for new technologies development which considers moral and human values. VSD assumes that any given technology is more likely to support certain stakeholders' values while hindering others. Therefore, to favour a technology's acceptance and adoption, these values need to be considered prior and during the

development and implementation of the technology. Accordingly, a technology can be developed in a way that accounts for values which are important for those who use the technology and is implemented in a way that such values are promoted through the structure and/or capabilities of the technology Wynsberghe (2013).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 (Longo et al., 2020).

Accordingly, the paper wants to answer the following questions:

RQ1: What are the most important stakeholders' values that should drive the design of a blockchain-based participation platform for urban planning?

RQ2: How can such values be incorporated into the design of the platform to enhance stakeholders' adoption?

RQ3: What conflicts among stakeholders' values can emerge and how can they be addressed through the platform design and implementation?

Through the analysis of the case study of BBBlockchain, the paper aims to demonstrate how the different stakeholders involved in the project hold different, and often conflicting, values, which further complicate the conceptualization and development of the platform. In fact, blockchain-based platforms usually involve an ecosystem of different stakeholders that must cooperate to achieve the desired platforms objectives. In the case of BBBlockchain the direct stakeholders include: the research team which developed the technical infrastructure and the user interface design of the DApp; two Housing Associations, founders of the project, in charge of taking managerial decisions on the objectives and financial viability of the project but also decide on the platform functionalities together with the research team; two Berlin municipalities, the tenants' representatives and tenants as final users of the platform. The indirect stakeholders included experts whose role was to give their opinion on different e-participation contexts which could benefit from blockchain technologies. Differences in stakeholders' values might hinder cooperation, cause tensions and, ultimately, lead to poor stakeholders' participation and contribution to the platform, causing a poor platform performance (Randma-Liiv, 2021).
Ultimately, the paper wants to provide some recommendations on how to address these conflicts so that the platform delivery of its objectives can be maximised. In fact, blockchain technologies are 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 (Cila et al., 2020; Gaggioli et al., 2019). Based on the above premises, the paper follows the blueprint of the tripartite methodology approach suggested by Friedman and Hendry (2019).
The theoretical background section sets the foundation of the conceptual investigation phase of VSD. Drawing on the extant literature on e-government and blockchain technologies, the starting point of the conceptual investigation is to identify which are the most important e-government values that blockchain technologies can support. The research design section discusses the methodological approach of case study analysis and, by providing a thorough description of BBBlockchain, it sets the basis of the technical investigation (Friedman and Hendry, 2019). Specifically, this part retrospectively looks at the current design and technical features of BBBlockchain and it tries to identify which stakeholders' values are likely to be supported or hindered by the platform current infrastructure and design.

Finally, the data collection and analysis section detailed the different data sources used for the analysis and how they were collected. The collected data are then analysed following an inductive approach through a theme analysis (Gioia et al., 2013). This part sets the foundation of the empirical conceptualization as, through primary data analysis, it identifies what are the most important values for each stakeholder. This part also identifies possible values' conflicts among stakeholders. The paper will conclude with some implications about blockchain-based e-participation platforms' design, governance and policy in the context of urban planning.

2. Theoretical background

2.1. Citizen participation: the main values of e-government initiatives

Citizen participation has recently become one of the most important topics in public government and it relates to citizen engagement in decision making and public affairs (Welch, 2012). Research on citizens participation focuses on identifying approaches to motivate, engage and involve citizens to achieve strong public participation in decision making processes, promoting a more efficient society and government support (Elsden et al., 2018; Pina and Avellaneda, 2019).

In relation to urban development, attempts to engage citizens in a dialogue about planning projects are becoming increasingly common and citizens participation has become key to successful implementation of development plans (Horizon, 2020).

In 1969, Arnstein introduced the ladder of participation, arguing for an increased and meaningful involvement of the civil society in decision making. For Arnstein, citizens participation can be presented as a ladder with multiple steps which progressively moves from more ‘‘passive” roles linked to information access and transparency to more ‘‘active” ones based on consultation, decision-making and co-creation (Rozas et al., 2018). A more recent and currently widely used model by governments in planning and reporting on public consultation initiatives is the International Association for Public Participation (IAP2)'s spectrum of public participation (2018). The IAP2 framework emulates Arnstein's Ladder of Citizen Participation: 'inform' pairs with 'informing', 'consult' with 'consultation', 'involve' with 'partnership', 'collaborate' with 'delegated power', and 'empower' with 'citizen control'. According to the IAP2 model, the definition of participation starts with purely informing the public about ongoing planning processes. The next step is defined as consulting the public by listening to concerns and asking for their input and feedback. The next level is to actively involving them throughout planning processes. Collaboration refers to the joint development of solutions between the government and citizens. The ultimate is empowerment where decision-making power is handed over to the public.

Although public participation in decision making is an old topic, more recently, digital technology has profoundly disrupted this area bringing about unquestionable benefits but also some new challenges (Macintosh and Whyte, 2008; Johnson, 2019).

In fact, over the last two decades, several digital platforms, ranging from web-based systems, mobile participation apps, and digital participation games, have been developed to facilitate the participation of citizens and other stakeholders (Desouza and Bhagwatwar 2014).

Researchers seem to concur that the major goal of e-government initiatives is the inclusiveness of every citizen by the removal of barriers which might prevent them from fully participating in the processes that directly affect them. In fact, digital technologies might bring about several benefits including better tools to reach a wider audience, facilitate citizens communication as well as a more efficient access to information which enables citizens to make more informed contributions. Such benefits should improve citizens' inclusion in decision making processes (Raikov, 2018; Van Schalkwyk et al. 2015; Garrido-Rodríguez et al., 2019).

Similarly, in the context of urban planning, e-participation initiatives are used for urban development to make processes more inclusive and participatory, making sure that governments make information accessible so that citizens' rights to access it are preserved (Kitchin, 2014).
Accessibility can be achieved by sharing the information through e-platforms which are easy to use by all the involved actors. Furthermore, information should be found easily and, most importantly, they should be presented in ways and language which are understandable by all the users, including non-experts (Friedman and Hendry, 2019; Detlor et al., 2013; Kitchin, 2014; Macintosh and Whyte, 2008).
Another important objective of e-government for urban planning is related to the value of trust. In fact, as participation processes have historically suffered from an underlying mistrust as well as a negative image of corruption, governments need to reinfuse trust in urban planning through an open access strategy (La Dantec, 2016). Enabling citizens to access information about the urban development steps and the decisions taken, helps to make the planning and design processes more trustworthy. It also prevents speculations and misunderstandings that might undermine the process. Such open access strategy to urban information seeks to combat the negative image of urban planning conducive to corruption (Rodriguez, Alcaide & Lopez, 2010).
Strictly related to the value of trust, transparency has also been considered as a key tool of good governance as supposed to increase trust and reduce corruption (Cila et a., 2020). Transparency can be broadly defined as the availability of information about government organisations, so that they can monitor their functioning (Horizon, 2020; Cila et al., 2020; Husain et al., 2020).
In terms of e-government literature, transparency is recognized as a public value that requires citizens to be informed on how and why decisions are made, including procedures, criteria applied by decision makers, evidence used to reach decisions and results. Transparency is usually associated with comprehensiveness meant as access to information on how the project unfolds and the actual decision-making processes, i.e., what decisions are made, how they are made, why, by whom and what are the outcomes of the decision. The interests of all the involved stakeholders should also be disclosed (Friedman and Hendry, 2019). Governments have, in fact, obligations to provide clarity on the rules and results of urban planning processes and to reveal any secondary interest that might influence such decisions. Transparency has also been associated with information quality meant as relevance, accuracy, completeness, timeliness, and reliability of information (Friedman and Hendry, 2019).
Transparency is also related to how to share information, and with whom. This helps achieve trust of the stakeholders and it ensures government accountability (Tshering and Gao; 2019).
Transparency is, in fact, considered a necessary but not sufficient condition for accountability. The greater the transparency, the more space for government officials to be held accountable for their actions (Zuboff, 2015).
To conclude, this section has identified inclusiveness, trust, transparency and accountability as the most important values which government initiatives should take into account when developing new forms of e-participation.

2.2. Blockchain technologies for improving citizens participation in e-government initiatives

Blockchain technologies have recently positioned themselves at the top of policy agenda, research and public discourse especially with regard to their promise to provide more decentralised information management solutions in government and make digital platforms more transparent and efficient.
Zheng et al. (2018) identified the key characteristics of blockchain as being decentralised, traceable, immutable, anonymous and auditable. Although these characteristics have initially sustained cryptocurrencies, they are also relatable to a wider variety of scenarios in which a

number of different stakeholders need a reliable system to manage their interrelationships (Baudier et al., 2021).
Muth et al. (2019) argued that the utilisation of blockchain technology could improve transparency, trust and accountability of the urban planning process in the five layers of the public participation spectrum including co-decision making and empowerment, therefore, also improving inclusiveness.
First of all, blockchain is a distributed ledger technology which records data in a way that is very difficult to modify retroactively. Such immutable storage of information in a sequential and decentralised manner makes blockchain systems reliable in registering and storing information (Centobelli et al., 2021). As all the data in the blockchain are "hashed" and linked to the hash of the previous block, even minimal changes in the data will result in major changes in the hash value. Therefore, as data are unlikely to be manipulated, blockchain can provide good data integrity which positively impacts on information quality by ensuring reliability, hence, transparency (Gaggioli et al., 2019; Kitchin, 2014; Detlor et al., 2013).
As the record is visible to anyone, can be traced back and it must be approved by the network to ensure integrity (consensus algorithm), citizens and other stakeholders can monitor and verify the information put forth (Johnson, 2019; Tapscott and Tapscott, 2016). This makes blockchain useful for tracking processes of urban development, preventing corruption as well as providing a transparent basis for discussion (Centobelli et al., 2021; Cila et al., 2020; Muth et al, 2019; Rozas et al., 2018), especially in those situations where governments' decisions are likely to be lengthier and more controversial (Elsden et al., 2018; Longo et al., 2020), thus, providing a transparent basis for conflict management (Macintosh and Whyte, 2008).
Traceability becomes, then, an important feature to enhance the availability of information as all transactions remain permanently visible to anyone at any point of time and all data can be traced back (Gaggioli et al., 2019; Kitchin, 2014).
Blockchain also eliminates the need for trust among the relevant stakeholders as all the completed transactions are kept in a distributed ledger which is not controlled by a central authority (Le Dantec, 2016). In fact, one of the key arguments sustained by blockchain enthusiasts is its capacity to conduct transactions without relying on trust as they are carried out in a peer-to-peer network which provides technical trust mechanisms to the users. This means that actors would not need to trust a centralised computing entity but would instead trust the network that carries out the transactions in a transparent and immutable way.
By contrast, blockchain is also considered as a complex and hard-to-understand technology and only people with adequate technical knowledge might be able to understand all relevant details (Harrison and Sayogo, 2014). For example, Egberts (2017) argues how existing blockchain-based systems have shown significant obstacles, limiting its widespread use, such as a lack of digital (blockchain) literacy and technical know-how among citizens, public officials and civil society. Such complexity might negatively impact information accessibility and, accordingly, reduce inclusiveness.

3. Value Sensitive Design: the methodological framework

3.1. *The VSD methodology: the aims of the conceptual, the technical and the empirical investigation*

VSD is a grounded design methodology that starts with the assumption that technologies are value-laden and that human values are continually implemented during and after the design of the technology (Friedman and Henry, 2019). VSD considers the values which are important for all the stakeholders that are both directly and indirectly involved with the technology. VSD assumes that, to favour a technology's acceptance and adoption, stakeholders' values need to

be considered prior and during the development and implementation of the technology. Once identified, values are translated into design requirements. Generally speaking, VSD adopts the position that a given technology is more likely to support certain values while hindering others. More specifically, VSD can be considered as a value-led participatory design approach where all the involved stakeholders' values, including developers and researchers, inform the design process (Iversen et al., 2010). Stakeholders do not usually state their values openly but they express them implicitly in the way how they engage with the design process, in the decisions made during design activities, in their goals as well as in the frameworks of funding bodies and in the scientific cultures in which project operates (Kautz, 2011).
Identifying the values reflected in design decisions, even when decisions are not made collectively, for example, because the stakeholder group cannot be expected to contribute at this level, tracing values from all the users input to design decision is still important. In the case of BBBlockchain were considered as users the Housing Associations and the Berlin municipalities as they commissioned the platform and funded its development as well as deployed its operationalisation. Tenants and their representative were also considered as users as they were directly engaging with the platform. Therefore, although the research team totally controlled the process of design and development of BBBlockchain, and the other stakeholders did not participate in the actual design activities of the platform, their input and feedback, obtained through meetings, workshops and surveys were taken into account. Specifically, while the Housing Associations played both a consultative and participatory role as, during meetings and workshops, they were asked to comment on design solutions, in some instances, they also had decision-making power on some design solutions (Kautz, 2011). On the other side, tenants played more an informative role as they were object of some observation on how they engaged with the platform. The role of the development and design team was to keep the Housing Associations informed on the development of the platform and, although they developed many requirements at their own discretion, they still tried to take into account the other stakeholders' requirements and preferences according to their importance and prioritization. However, as stakeholders might hold different values or have different perceptions of their importance, potential value conflicts and approaches to overcome them were also taken into account (Friedman and Henry, 2019).

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 (Longo et al., 2019).
Friedman and Hendry (2019) conceive VSD as a tripartite methodology which consists of conceptual, empirical and technical investigations.
Through an analysis of the extant literature (this might include white papers, official documents, technical reports, etc..), the *conceptual investigation* identifies the most important values supported by the technology under investigation, how they translate into technical requirements, who are the involved stakeholders, their interests and reasons to adopt the platform.
The *technical investigation* identifies the main design characteristics of the technology and translates them into stakeholders' values.
The *empirical investigation* involves the analysis of the human context in which the technology is situated by surveying stakeholders through primary research. Following a bottom-up approach, empirical investigations identify values priorities for each stakeholder, identify trade-offs among conflicting values and between values and usability. Interestingly, values emerging from the empirical phase might be different from the conceptualisation phase (Friedman and Hendry, 2019).
The three types of investigation can be executed simultaneously and in an integrated fashion

(Friedman and Hendry, 2019).

3.2. The conceptual investigation: the values for the design of a blockchain-based platform
Based on the previous review of the extant literature on citizens participation and blockchain technologies, the most important values which should inspire the conceptualization and development of a blockchain-based platform for citizens participation in urban planning decisions have been identified. Drawing on the literature, Table 1 shows how the identified values are translated into norms which are then translated into technical requirements.

Values	***Norms***	***Design/technical features***
Inclusiveness	Information should be openly available to anyone who wants to access them at any time.	Blockchain provides an historical record of all the transactions and by default it is openly accessible to all the participants in the network. Transactions remain permanently visible to anyone at any point of time and all data can be traced back
	Communication and interaction among stakeholders should be efficient Platform should be easy to navigate and information should be easy to find and understand by all the users, including non-experts	Blockchain access and transactions verification might require high levels of technical knowledge, reducing information accessibility
Trust	Information not to be held by a central power	Completed transactions are kept in a distributed ledger which is not controlled by a central authority Transactions are carried out in a peer-to-peer network (with a global consensus mechanism) which provides technical trust mechanisms to the users.
	Information should have an open access	Public blockchains are openly accessible to anyone who joins the network
	Information should be reliable	Blockchain ensures data cannot be manipulated through hash values therefore it ensures data integrity, hence information reliability
Transparency	Information comprehensiveness: Citizens must be kept informed on the project, on decision-making processes, on the interests of all the involved stakeholders	Blockchain infrastructures might have a negative impact on information comprehensiveness as its complexity might be a hindering factor to publish information
	Information should be of good quality: accurate, reliable, relevant and timely	Blockchain ensures data cannot be manipulated through hash values therefore it ensures data integrity, hence information reliability

Accountability	Citizens should monitor processes to hold other stakeholders accountable for not complying to plans. Conflict situations should be solved in a fair way.	Historical record is openly accessible and traceable through timestamping and proof of content of origin everyone can monitor and verify information put forth Consensus algorithm does not allow data to be manipulated unnoticed once they have been published, providing a transparent basis to manage conflicts

Table 1 The conceptual investigation: main values, norms and design features

4. Research context and the technical investigation

As the investigation of the inspiring values for the design of a blockchain-based e-participation platform has not been sufficiently studied yet, the paper employed a case study approach as a qualitative methodology to perform an exploratory analysis (Eisenhardt, 1989). Case studies are particularly useful because they provide in-depth information to answer the "how" and "why" research questions and enable a holistic, comprehensive, and realistic understanding of the studied phenomenon (Yin, 2009). In our context, the case study methodology was particularly suitable since it allowed to ground the findings in the empirical evidence collected from the case. Therefore, it also addressed the research gap of a lack of empirical cases as well as it helped to better uncover stakeholders' perception of blockchain and what values they consider as important (Johnson, 2019).

The investigated case relates to a platform for improving citizens participation in urban planning decisions in two major residential development projects in Berlin: BBBlockchain.

The BBBlockchain app was deployed as an underlying digital participation tool and since the second half of 2019 is being tested in two a real-life urban development projects (400+ residential units densification) in Berlin, Germany. One of the Berlin state-owned housing associations, as the landlord and developer, decided to create a blockchain-based participation platform designed to increase trust, transparency and participation in urban planning processes. BBBlockchain was developed in close collaboration with professionals and an experienced user interface design studio. An iterative design process was conducted during the pilot project as well as usability tests.

Following the IAP's layers of participation (2018), BBBlockchain provides three main functionalities developed around three main use cases: information, co-decision and the issuing of tokens. In the information use case, citizens have access to various documents on the current state of the urban development project whose integrity can be verified directly on the blockchain. In the co-decision use case, citizens can vote on several urban planning matters and, since the voting is executed on-chain, voters can directly verify that the process was executed correctly, preventing any stakeholder from exercising dominance over the voting process. Finally, voters are rewarded with a token, created in a smart contract, which assigns a personal credit to all users. To ensure security for participants, tokens were created as non-fungible tokens (NFTs). Although this paper focuses on the information layer of participation and decentralised networks like Nostr would have probably been more suitable, nonetheless, the other use cases of co-decision and issuing of tokens heavily rely on blockchain technologies for their functioning. Therefore, in order to maintain consistency in the choice of the technology, Ethereum blockchain was adopted since the beginning.

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 building information.
Technically speaking, BBBlockchain is a decentralised application 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.
BBBlockchain provides information in a strictly chronological order to allow users to view the newest updates in the urban development projects. The app interface therefore revolves around a timeline view, as shown in Figure 1, and it is intended to remind users of a calendar. It also ensures that users are confronted with blockchain details as little as possible. Nonetheless, users can access blockchain details for each entry and utilise cryptographic hash values to verify data integrity. Accordingly, BBBlockchain, by incorporating such verification in the user interface, can ensure information reliability. 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.

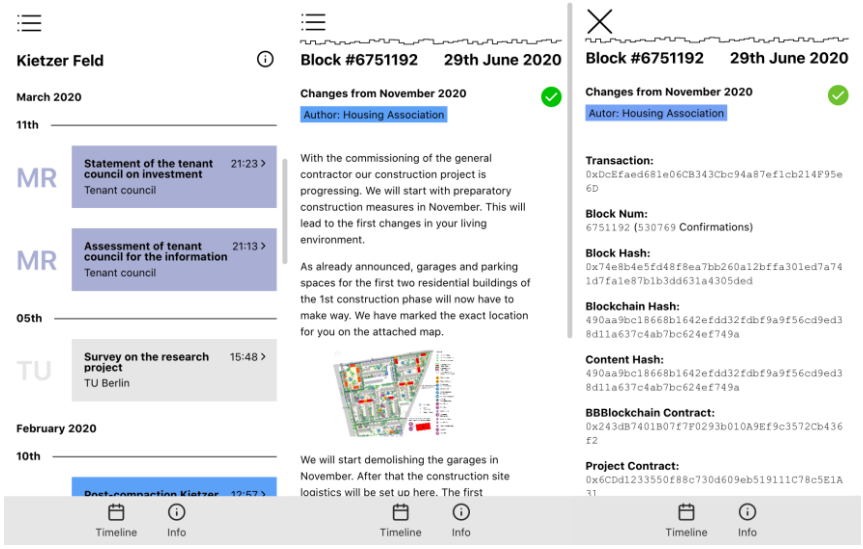

Fig. 1. Screenshots of BBBlockchain interface

BBBlockchain was designed as an Ethereum DApp for mobile devices (i.e., Android and iOS) and desktop browsers, however, in practice, it can run on any network and, if the testing phase will bring positive outcomes, we might consider porting it to Bitcoin RSK.

Figure 2 shows the basic technical infrastructure of BBBlockchain and underlying technologies. BBBlockchain is therefore built as a decentralized application (DApp) with Ethereum as the underlying blockchain platform because it offered more technical capabilities than other blockchains at the beginning of the development. With the next-generation Web3 in mind, we developed all program logic for participation in a smart contract. Thus, BBBlockchain can be used directly by any Ethereum user, e.g., with Metamask. However, less technical experienced users may be discouraged, which is why we also offer an optional graphical user interface on an external server. Future technical advances could make this technical dependency obsolete.

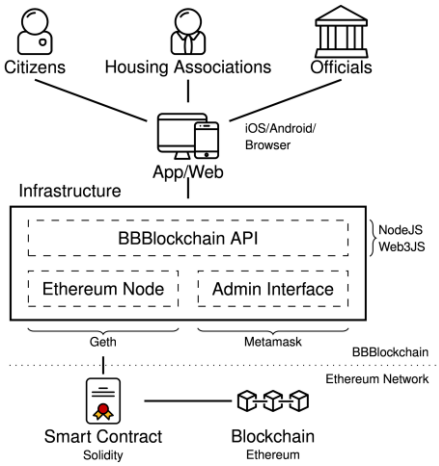

Fig. 2. BBBlockchain technical infrastructure

The Ethereum nodes, which store and execute the smart contracts, are mirrored into an API interface which provides access to the Ethereum node and also verifies data integrity through hash values which can be visualised on the App to convey a secured information transfer in a comprehensible manner.

BBBlockchain was developed as a public permissionless infrastructure as the characteristics of this type of blockchain best fit with needs of state storage, multiple writers and the absence of a central Trusted Third Party (TTP) (Wüst and Gervais, 2017). Since the involved stakeholders do not trust each other, no one was eligible to be designated as a TTP and, accordingly, host a cloud-based participation platform. To this end, BBBlockchain functions as a communication platform where the participating housing associations (HAs), local authorities, and residents' representatives were given access for publishing contents on BBBlockchain. Stakeholders can direct access the smart contracts or, instead, use a blogging content management system that was purposefully installed for easier usage (Fig. 2). An editor interface allows non-experts to create and publish content without the need to know blockchain frameworks. Nonetheless, as the content created through the editor is added to the blockchain by an external monitoring tool (oracle), data integrity is still retained as changes to the planning project need to be uploaded as new information.

Although most blockchain-based financial applications are incentivized to process accurate data to avoid financial penalties, BBBlockchain exclusively relies on the accuracy of the data provided by its stakeholders. However, to retain accuracy, organizational measures such as legal participation rules and imposed restrictions on trusted sources have been implemented. Nonetheless, even if BBBlockchain cannot overcome the oracle problem (i.e., verifying the ground truth), it is reliable for data timestamping, secure documentation and accountability. Therefore, it provides a reliable data verification source for citizens and a trustful base to held other stakeholders accountable.

Design/Technical Features	***Norms***	***Values***
BBBlockchain is a DApp for mobiles and desktop browsers Information can be entered via editor tool Intuitive and minimal design: content is visualised in a chronological way and colour coded according to the publishing stakeholder. Entries are designed in three layers - blockchain details on the third layer and remain hidden Functionality of Blockchain is explained. Transaction fees for users are covered within BBBlockchain.	Easy to access, use and understand by non-expert users (Interface design).	Inclusiveness

Data are stored in a decentralised open network and are available to everyone from multiple servers. Public and permissionless design.	No one has control on the data (Infrastructure design).	Inclusiveness/ Trust
Users can run their own blockchain client and verify transactions. All data are stored openly for read-only access. Everyone has access to all files and can mirror these files on their own infrastructure. Accordingly, network failures and maintenance issues would no longer affect the verification of BBBlockchain entries. Information can only be posted by defined contact persons of HAs, tenant council, and district	Data Reliability Prevent misuse	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. Information are presented as brief contributions about updates on construction progress, explanation of changes in documents. PDFs of documents (construction plans/drafts/notices) or newsfeed Contents in the app can be tracked and analysed by anybody in the blockchain network, even without the BBBlockchain app user front-end	Once published, data cannot be modified unnoticed 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
Changes to the project must be entered as new entries Modified entries marked in red.	Data cannot be manipulated	Accountability

Table 2 – Technical Investigation

5. The empirical investigation: data collection and analysis

The empirical investigation of BBBlockchain was conducted during the implementation of the pilot phase of the project. Following a bottom-up approach, as suggested by Friedman and Hendry (2019), such evaluations are based on an exploratory analysis of direct and indirect stakeholders.

The data used for the analysis were collected from four different sources: in-depth interviews with direct and indirect stakeholders, recordings of direct stakeholders' meetings, content published on BBBlockchain platform and a preliminary citizen survey of 25 respondents.

The most important source of empirical data collected from the case consisted of 10 semi-structured interviews with key direct and indirect stakeholders of BBBlockchain. Specifically, 5 interviews were conducted with experts (indirect stakeholders), two interviews were conducted with the HAs, two with the development team and one interview with a member of the advisory board. The scope of the interviews with the development team, the HAs and the advisory board was to gain insights on what values informed the conceptualization of BBBlockchain as well as to what extent other stakeholders' requirements and preferences were taken into account for the technical and infrastructural development of the platform.

The rationale of including experts as indirect stakeholders is related to the fact that, being blockchain an emerging technology associated with a high degree of technical complexity and uncertainties, experts could have been considered as guides who possess contextual, and more specialised knowledge, as they inform researchers with valid information which are unknown to them (Tapscott and Tapscott, 2016). Experts were selected based on their involvement on e-government start-ups, their knowledge on blockchain technologies and the provision of different viewpoints from different e-participation contexts which could benefit from blockchain technologies (Rozas et al., 2018).

The decision to rely on semi-structured interviews suited the exploratory approach of the study as they keep a structured approach but also enable some openness and the investigator must ensure sufficient space for the interviewees to disclose their experiences, opinions and knowledge (Yin, 2009). The interview script was carefully designed considering the literature previously analysed. Specifically, a semi-structured interview guideline was developed to obtain explorative insights on the values which emerged in the conceptual investigation. Although keeping a common set of questions, the interviewees were able to elaborate and expand on their answers, allowing the researcher to ask additional probing questions (Kim and Laskowski, 2018). Interviews lasted between 30-45 mins and participants were asked to test BBBlockchain before the interview so that their impressions could be recorded.

The second source of data is represented by the recordings of two direct stakeholders meeting whose scope was to discuss how BBBlockchain functionalities, believed to be important by the HA and Government, could be developed and implemented by the project team. The purpose of the analysis of the stakeholders' meetings was to get further insights on each stakeholder' objectives, which values were considered as important and, since stakeholders might pursue different objectives, some potential value conflicts. Table 3 summarises in-depth interviews and stakeholders' meetings details.

Identification	***Type of Informant***	***Role in the project***	***Rationale***
E-1	Expert - Co-founder of digital tools for spatial planning	Express opinion on the added value of blockchain technologies for citizens participation in urban development	Provide general opinion on BBBlockchain potential benefits for citizens participation in urban development.
E-2	Expert – CEO of Funding Program to develop open-source applications in the areas of Civic Tech		
E-3	Expert – Founder of No-profit organisation developing innovative solutions for more democratic decision making		
E-4	Expert – Founder of Open-source software firm developing solutions for agile administration		
E-5	Expert – Executive Director of urban development firm		
E-6	Expert – Executive Director and partner of urban development firm		
D-1	CEO of Housing Association		

D-2	CEO of Housing Association	Managerial decision power on objectives and financial viability of the project Finance the project Set the project purpose and objectives Decide on the technical features of BBBlockchain together with developers Check on the legal compliance Check on the financial viability Liaise with tenants and tenants representatives Marketing and communication of BBBlockchain Upload content on the platform Reply to citizens questions (not implemented yet)	Get insights into their values and preferences, objectives they want to achieve with the project
D-3	Member of BBBlockchain Advisory Board	Provide feedback on BBlockchain design and objectives during the conceptualisation phase	To understand the most important values and features that BBBlockchain should deliver
D-4	Developer of BBBlockchain	Develop technical infrastructure and design features, maintenance of the platform	To understand what values informed the project team and get insights into to what extent other stakeholders' requirements were taken into account for the technical and infrastructural features
D-5	Project Coordinator of BBBlockchain	Manage and coordinate the project planning, coordinate interaction among stakeholders	
Stakeholders Meeting Details			
Identification	***Date and Participants of the meeting***	***Objective of the Meeting***	***Rationale***
M-1	29/11/2021 Project team Representatives of the two Housing Associations	Monthly update of the state of the development of the project Discussion on the implementation of tokens	Get insights into their values and preferences, objectives stakeholders want to achieve with the project, what potential conflicts might emerge
M-2	16/12/2021 Project team Representatives of the two Housing Associations	Monthly update of the state of the development of the project Discussion on user journey for token implementation, legal issues	

Table 3 Summary of in-depth interviews and stakeholders' meetings

The third source of data consisted of the content analysis of BBBlockchain. The scope was to have an initial understanding on the amount and type of information that stakeholders published on the platform. This analysis was relevant to gain insights on how BBBlockchain currently supports the value of transparency. Since transparency has been associated with information availability and quality, the analysis of the information already published on BBBlockchain can help to gain a more in-depth understanding of the level of information comprehensiveness and accuracy achieved so far. From September 2019 to September 2021 a total of 37 entries were made by three main stakeholders: two HAs (33 entries), the involved municipalities (2 entries) and the tenant council (2 entries).

Table 4 summarises the type of content of the entries, according to its corresponding category and publishing stakeholder group. From a preliminary content analysis, it emerges that most of the entries (12) concerned administrative information, like time and location of physical events, invitations, welcomes, etc. and they were mostly posted by the HAs. Five entries posted by the HAs discussed the future development steps of the project, including a timeline from the beginning till completion and maps of the construction plan. Nine entries were about decisions already made such as the appointment of a new contractor, trees cutting, permits, etc. As for information on the decision-making process, like, for example, how decisions were made and by whom, were absent. Finally, six entries involved citizens by asking their opinions or votes for the potential establishment of facilities such as a roof garden or a laundry room. Nonetheless, it was not made clear how their contribution would have been used. Overall, as shown in Table 4, the 2 HAs were the most active participating stakeholders' group with a total of 33 entries. Municipalities and Tenant Council contribution to the content platform was more limited, with only 2 entries each.

Type of Content	**Direct Stakeholders**		
	Housing Associations	***Municipalities***	***Tenant Council***
Administrative information (physical events location, how to, etc..)	11 entries	1 entry	
Future planning steps	5 entries		
Steps of the planning process already accomplished	9 entries		
Tenants FAQ	1 entry	1 entry	
General Opinion on the planning	1 entry		2 entries
Tenants Voting	2 entries		
Tenants Survey	4 entries		

Table 4 Summary of Content Analysis of BBBlockchain

The final data source is represented by a preliminary citizens survey (n=25) conducted during the end of the first phase of the pilot project. The scope of the survey was to have a preliminary understanding of the overall level of engagement of citizens with BBBlockchain, specifically focusing on how the platform might have improved citizens inclusiveness into the decision making process, how citizens perceived the quality of the information made available on BBBlockchain, how easy it was for them to access such information and if they truly felt that the platform could have made their opinion taken into account in decision making processes.
Such a variety of data sources is recommended for theory building, as it can provide greater reliability, less dependency on a particular context, and better generalizability of the findings (Zheng et al., 2018). Following a grounded approach (Locke, 2002), the data were entered into NVivo12 software and inductively coded from empirical to conceptual so that related concepts could be merged into more abstract themes following the subjective interpretation of the researcher.

6 . Findings of empirical investigation

6.1. Blockchain for Inclusiveness

The empirical results confirmed the importance of inclusiveness as one of the inspiring values and objectives of BBBlockchain. First, BBBlockchain project team considered inclusiveness as one of the key inspiring values of the platform design.

"*We wanted to build a service where multiple stakeholders can all communicate within the same platform in the most easy and efficient way possible*" (D-4).

Inclusiveness was also a main objective that HAs and the government wanted to achieve by adopting BBBlockchain. Specifically, both stakeholders expressed their willingness to participate in the BBBlockchain to demonstrate government engagement with digital innovation, achieve open government and increase citizens involvement in urban planning decisions.

"As a HA, for us it's important to involve citizens, hear their opinions, questions, interact with them at an early stage of the development project. We want to empower people to make decisions which directly impact their living. For us is important to assess how blockchain can support this kind of interaction" (M-1, HA)

Although not strictly related to blockchain technical features, experts perceived 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' inclusiveness, they acknowledged the importance of platform and information accessibility by making the use of BBBlockchain very simple and the understanding of complex planning processes, as clear as possible. The citizens survey also confirmed that BBBlockchain was somehow fostering inclusiveness as the 70% of the respondents said that they never attended citizens events before. Nonetheless, most of the respondents was unsure if BBBlockchain was making them feel more involved in the participation process.
In terms of information accessibility, the findings emphasised the importance of making the information openly accessible and easy to understand by all the users, including non-experts. In this case, blockchain can have a positive impact on accessibility as its permissionless and open-source features allow anyone to access information.

"*The complexities of the planning processes need to be presented in a simpler way as I think distrust does not come from not trusting others but more from the fear of not understanding the information*" (E1).

Furthermore, for experts, accessibility meant that all the stakeholders should clearly understand what BBBlockchain does and why it is needed, especially since it is a very different tool from what they might be used to operate with. In fact, for the HAs blockchain technical complexities might hinder adoption as they still do not clearly understand what it does. This is particularly true for people who are not technology experts.

"*Just because blockchain can do something, it doesn't mean that it will then be understood, seen and recognized for that*" (D-1).

In fact, all interviewees were stressing the fact that blockchain 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 blockchain 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 blockchain unique value to non-experts becomes then a rather critical factor.
As emphasised by another expert, the problem of non-experts struggling with the understanding of the value of blockchain technology is because, being an emerging technology, there are not yet enough practical use cases that could be used to make people understand how the technology might work in real life situations.
Nonetheless, developers pointed that, to preserve inclusiveness, BBBlockchain interface was designed to make access as simple and easy as possible like, for example, not requiring users to set up an Ethereum wallet to access smart contracts.

"*We put a lot of thoughts on how we designed the App.. if you look at it, in the first layer you do not see the blockchain details. To see them you need to dig deeper*" (D-4).

Developers also recognized the importance of creating an App interface which is predictable and intuitive, with a similar navigation of other Apps that users already know how to use.

"*As BBBlockchain is a research project, we hired an agency that conducted research on how a blockchain-based App could look like to teach people how to use blockchain. It turned out they had some nice idea and working insights for the visualisation of the hash value .. this comes from them and it is something that usually blockchain doesn't have ..but still the interface should look like an app interface.. they did too much ..*" (D-4).

Interface familiarity is crucial for improving inclusiveness and citizens participation. Nonetheless, the App interface should also allow the HAs and the government to upload information efficiently as, to make citizens participate, content must be made available first.

Interestingly the data confirmed that blockchain technical complexity, its immutability and traceability were, somehow, holding HAs off to share some content as they feared to 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).

The fact that blockchain could have a negative impact on information accessibility was also confirmed by the low level of citizens participation during pilot phase 1 and by the documentation of the 1st tenant information event on the construction project which states that "*most of the tenants' contributions to these stands were questions of understanding and questions about the details of the construction project*".

6.2. Blockchain for transparency vs. accountability

Overall, the empirical investigation confirmed that transparency is an important and inspiring value of BBBlockchain design.

"*We wanted a platform which would communicate information in the more transparent way as possible. Therefore, we designed blockchain as an open and permissionless system which can track changes and detect manipulation. Although we had the feeling that immutability might have hold stakeholders back from publishing content, we refused to compromise on that*" (D-4).

Transparency was also a deeply embedded value into all the other direct stakeholders' values' systems. HAs, for example, confirmed its importance by acknowledging their duty to inform people about construction processes. "*We want to make sure that they know what we are doing, why we are doing it and how we are doing it"* (D-2).

In fact, urban planning processes have historically been known to be complex, very long, and very likely to diverge from how they were initially thought out.
Experts too considered transparency as the most important benefit of blockchain. Considering the complexities of urban development, blockchain allows to clearly monitor the frequent changes to planning projects.

"*Currently there are no ways to see who made what changes or who uploaded at what time, etc.. with blockchain this problem could be overcome*" (E-6).

Therefore, BBBlockchain, through the provision of an open and immutable historical record of all the decisions ever made, can improve transparency in relation to information availability.

"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 this case, BBBlockchain was also considered particularly relevant to increase government and HAs accountability as it could be used as a reliable basis to manage and solve potential conflicts which could emerge among stakeholders.
In practice, though, such an increase in accountability might produce undesirable effects on the very same information availability which is supposed to enhance. Because blockchain makes published information traceable and immutable, experts believed that key stakeholders might be reluctant to make available a substantial amount of data on the planning project as, eventually, they could be held accountable for it.
Therefore, in relation to information availability, if, on one hand, blockchain might improve transparency by ensuring information reliability, on the other, it can reduce information comprehensiveness, as stakeholders might refrain from making information public on BBBlockchain for fear of increased accountability. This was also partially confirmed by the low level of engagement on BBBlockchain from government and HAs which, during pilot phase 1, did post a total of 35 entries out of which only 14 regarded the actual development plan. The citizens survey also seemed to confirm such a point as most of the respondents did not feel sufficiently informed on the development of the urban planning process.
Such findings seem to suggest that blockchain technologies do not have an impact on information comprehensiveness as, ultimately, this entirely relies upon the willingness and commitment of those actors who are in charge of providing information. In fact, in some circumstances, blockchain technologies might even hinder stakeholders from participating and, accordingly, have a negative impact on transparency.
Therefore, the empirical findings showed how stakeholders believed that blockchain technologies do not have any impact on information comprehensiveness, relevance, and

accuracy as ultimately information quality and availability also rely on how much effort and commitment stakeholders are prepared to put into the whole process (Sotoudehnia, 2021).

In terms of information availability experts confirmed the importance of including information on the actual decision-making process including what decisions need to be made, why they are made and who makes them. Ideally, the interests of all the involved parties should also be disclosed:

"Transparency to me means communicating content but also processes in an understandable way." (E4)

Experts believed that the more comprehensive are the information provided, the more citizens would feel motivate in participating as they would have a better understanding on how their contribution might impact on the project:

"*If I have received the context information then I would be able to find my way around completely. What is still unclear to me at the moment is where is it going? What is the timeline in the future? What is the resolution or what is at the end of the process? If I am not given the information, then I cannot make a qualified decision. That's why it's always a prerequisite for participation processes that I have access to information."* (E4)

E4 suggests that providing citizens with context, can assist them in making more informed decisions and, accordingly, make their contribution more meaningful. In fact, when citizens don't understand how their contribution will be used, or they perceive that it has not been valuable, they might feel a sense of frustration and lose motivation to participate, especially if they were also required to put effort by informing themselves beforehand.

"*I don't want to be permanently in the situation where I have to say and have the feeling that nothing comes out*" (E2).

Therefore, in this instance, transparency in terms of information availability is important to improve citizens engagement but blockchain does not have any influence on this aspect.
In relation to information quality, although blockchain has a positive impact by improving reliability, this is not sufficient to make the information of good quality. It is essential that any input data is accurate before processing into the blockchain. Blockchain infrastructures cannot, in fact, assess the quality of the data which are inserted by stakeholders in terms of how relevant and exhaustive they might be (Rozas et al., 2018).
This relates to the problem of "garbage in–garbage out", which is often associated to blockchain systems (Kim and Laskowski, 2018). If the inserted data are of poor quality, their assessment cannot be automated and blockchain immutability is even going to extend their longevity.
Stakeholders' hesitation to publish information on BBBlockchain was seen by experts as a need to protect more sensitive and confidential information. In fact, experts supported the idea that an optimal level of transparency could also be achieved without reaching maximum levels of disclosure:

"*I don't think that 100% 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).

Experts suggested that if all the actors involved would decide and agree upon on what information to publish on BBBlockchain, this problem might be overcome:

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

This point was also confirmed by BBBlockchain developers which, during the conceptualization phase, tried to establish some "rules of participation" which do establish in advance how often HAs and government commit to publish information as well as what information they want to keep confidential, like, for example, financial data.
According to the E3, an optimal level of transparency can indeed be achieved without reaching maximum levels of disclosure but by establishing an "*adequate level of transparency*", which considers the need of government confidentiality, public officials fear of overexposure and citizens need of open access. The point was also confirmed by the other experts which stressed the importance of keeping private information on costs, calculations, and tender documents. For example, copyrighted material, personal data, licensed material, communication logs and recordings, should not be included for legal reasons or without the permission of the involved parties.
Finally, transparency might also introduce what (Sotoudehnia, 2021) calls operational risks as, for the HAs and government, increased transparency might introduce higher degrees of interference 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.

"It is important to find a good balance between transparency and still allowing all parties to contribute without coming under pressure, because you also have to look at who is exposing themselves., in the end, no one will participate if they are afraid that they will somehow come under fire, from whomever" (M-1, HA).

6.3. Synthesis of Empirical Investigation

Based on the above findings, Table 5 summarises the main values, with associated norms and design features, which have emerged from the empirical investigation.

Values	***Norms***	***Technical/Design Features***
Transparency	Information availability in terms of comprehensiveness (should include decision making processes, interests' disclosure, overall vision of the entire process)	Blockchain immutability and traceability might have a negative impact
	Information should be comprehensive in terms of availability of the historical record of all the transaction ever made	Blockchain has a positive impact through timestamping and proof of content origin.
	Information should be of good quality in terms of reliability	Blockchain immutability ensures data integrity

	Information should be of good quality in terms of relevance and timeliness	Blockchain has not impact on that as it depends on HAs and Government commitment and willingness to make information publicly available
Inclusiveness	Open access to information. Simple design to facilitate usability and, therefore, platform accessibility. Information should be accessible Value should be perceived by non-experts Motivate citizens' contribution. Give a sense of community to all the stakeholders, including the neighbourhood	Decentralised system through a distributed ledger. Use an interface design that hides blockchain details Urban planning process explained using clear and simple language Clearly explain how citizens contribution will impact on the planning process. Voting and consulting functionalities might allow more interaction
Accountability	Government and HA should become more accountable Government and HAs confidentiality should be protected	BBBlocckchain provides a reliable basis to manage and solve potential conflicts Establish in advance "rules of participation" Establish in advance an "adequate level of transparency"

Table 5 Values, norms and technical/design features emerged from empirical investigation

7. Implications for platform design and development

The paper analysed how a multi-stakeholder blockchain-based platform for citizens' involvement in urban planning should be developed by considering the most important values for each group of stakeholders and how potential values' conflicts could be addressed through the platform design. Overall, the analysis has shown that the most important values to improve stakeholders' engagement and participation, in relation to the information layer, include transparency, inclusiveness and accountability. The paper also demonstrated how values conflicts among stakeholders further complicate the conceptualization and development of the platform.

This part provides some design and development implications for developers on how stakeholders values and potential conflicts should be addressed so that stakeholders' adoption of the platform can be enhanced, and the platform can succeed in the delivery of its objectives. The conceptual investigation argued that one of the main values that should be supported by e-government platforms for citizens participation in urban planning is *inclusiveness*, meant as a more efficient and easy access to information by the largest possible amount of all the relevant stakeholders. Although blockchain-based platforms, which are built with a public and permissionless design, are available to every participant in the network, and, therefore, support

inclusivity, its technical complexities might constitute a barrier for those who are not technology savvy. Nonetheless, the technical investigation has shown how BBBlockchain was built using an API interface design so that non-expert users are confronted with blockchain complexities as little as possible. The empirical investigation confirmed that inclusiveness can be associated with platform and information accessibility, achievable by making BBBlockchain easy to use through a simple design and information on the urban planning project, easy to understand, by using a clear and simple language. Accessibility was also associated with making the entire historical record of the urban planning decision openly available to anyone at any time. This last instance is supported by blockchain traceability and immutability and by creating an underlying technical infrastructure which is permissionless, with smart contracts stored open-source. Nonetheless, due to its technological complexities and novelty, blockchain might constitute a hindering factor to inclusiveness, especially for non-expert users. Though, the empirical analysis has reinforced the belief that technical complexities can be overcome through an interface design which hides blockchain details through an API. Furthermore, the empirical findings highlighted the importance for the App to retain, as much as possible, a design with characteristics that users expect from traditional Apps. Yet, how to design a blockchain-based platform to best present blockchain features is an area of research that, so far, has not been sufficiently investigated and, currently, there are no clear guidelines on how to design the platform based on the context of application. Another critical factor related to inclusiveness is the importance of clearly communicating blockchain added value to non-experts. In such instances, practical use cases might be useful to make stakeholders, such as governments or HAs, understand how blockchain works in real case scenarios and, therefore, better understand its unique benefits and how to make an efficient use of it.

On the other hand, citizens' inclusiveness can be improved by making clear how their contribution will be considered and it will practically impact on the urban development project. Rewards could also be implemented, especially to involve those people that are usually more difficult to engage. In this case, blockchain might be particularly useful through its unique feature of token issuing. Nonetheless, the implementation of tokens might come with additional technical, financial and legal issues that need to be addressed.

Secondly, the conceptual investigation identified *transparency* as a further key value specifically associated with information quality and availability. The technical investigation showed that blockchain technologies can partially support transparency by improving the quality of information by ensuring the reliability of the data through immutability. Blockchain can also partially improve information availability by making the historical record of all the past transactions openly accessible to anyone at any time.

The empirical investigation confirmed the association of transparency with information availability and quality. According to the empirical analysis, information availability is achieved through information comprehensiveness in terms of making publicly available all the data on the entire decision-making process as well as providing citizens with an overall vision of the project so that they might feel more motivated to participate. Nonetheless, blockchain technologies might also have a negative impact on information availability as, because of immutability and traceability, some stakeholders might be reluctant in sharing a large amount of information for fear of being held accountable for it in the future.

In terms of information quality, blockchain has a positive impact on information reliability but no impact on information accuracy, relevance or timeliness as it suffers from the previously discussed problem of "garbage in-garbage out".

Therefore, if on one hand BBBlockchain can potentially provide a continuous overview of verified information across a range of data about urban development projects, including planning and approval processes (e.g., land-use plans, urban development contracts and general

building information and specifications), on the other hand, the very same structural immutability of blockchain, might hinder stakeholders from disclosing information as changes to already published urban planning processes must be communicated as new entries, increasing their accountability. Accordingly, blockchain can foster and hinder transparency at the same time. This aspect is rather critical as, if on one side, citizens' acceptance and adoption of the platform are crucial, it is equally important that the HAs and the government proactively and consistently engage with the platform through regular and comprehensive information updates.

In strict complementarity with the value of transparency is the value of *accountability* since, the higher the levels of transparency, the more stakeholders such as HAs or government can be held accountable for the information they share. The empirical findings have shown that citizens' need for transparency might, in fact, conflict with HAs and government' needs to minimise their accountability and retain confidentiality, especially in regards the disclosure of more sensitive data, such as financial information like purchase prices, building costs, expected rents and so on.

Such concerns of increased accountability can, therefore, lead these stakeholders to rethink their communication protocols and drastically reduce the information they are willing to share. Furthermore, the fact that HAs and the government often face several operational difficulties as well as inflexible legislation, might lead to an additional institutional and cultural resistance which further limit their contribution. In fact, although HAs acknowledged that transparency was one of the main reasons they got involved with BBBlockchain, the findings showed that, at this point in time, the levels of transparency achieved by BBBlockchain are not satisfactory.

8. Implication for platform governance policy in urban planning

In relation to urban planning processes, the findings suggest that, although blockchain technologies represent a good opportunity to improve citizens' engagement, their development and implementation should be accompanied by governance decisions to maximise their potential. Blockchain itself only plays a partial role in improving citizens' participation. There are several other aspects such as platform acceptability, information quality, legal and regulation support that also need to be considered in addition to the development of the technology.

Urban development is indeed a social process tightly controlled by institutions and procedures shaped by a diversity of stakeholders with heterogeneous interests. Therefore, policymakers cover a prominent role by ensuring that the values of all the involved stakeholders'are considered during the design and governance of blockchain-based platforms (Ølnes, Jansen, 2017).

First, policymakers could foster inclusiveness by addressing those technological barriers, such as institutional and cultural resistance, which have emerged throughout the paper. For example, information accessibility by non-expert users could be improved with the provision of guidelines on how to develop knowledge of the technology through trainings and tutorials for each of the involved stakeholders. Clear protocols on how citizens' input is taken into account by planners should also be developed and made publicly available. If citizens do not feel that their contribution is considered, they will lack motivation to participate.

This is a rather critical and recurring topic in urban planning as, historically, development processes have always been criticised of being vague about to what extent citizens' opinions are considered (Parvin 2018; Monno and Khakee 2012). Establishing clear guidelines on how citizens input will be used and make them accessible to all the involved stakeholders might, therefore, improve inclusiveness.

In relation to the value of transparency, although blockchain technologies prevent data manipulation, it is important that input data are accurate before processing onto the blockchain to prevent the issue of "garbage in – garbage out". As blockchain cannot assess the reliability of the input, standardised data validation procedures should be established to guarantee information quality. Ultimately, although blockchain technologies can store official records of the planning process, still some stakeholders, usually the government or the HAs, must operate as administrator, maintain the system, ensure proper functioning of the platform and, eventually, be held accountable for problems. Therefore, platform development should be integrated by clear guidelines which govern its use to ensure information quality and clearly outline the role and responsibilities of its governing actors.

Furthermore, as previously discussed, tensions between transparency and accountability can be addressed through an a-priori establishment of standards about the expected level of transparency and corresponding monitoring processes. In this case, policymakers could develop common "rules of participation" which clearly define in advance what information will be shared by whom and how often. In fact, the analysis seemed to suggest that the optimum level of transparency to maximise the engagement of all the involved stakeholders does not necessarily correspond to its maximum level. Policymakers should define the "expected level of transparency" which makes transparent what information will not be disclosed and the reason behind it. This should be supported by proper mechanisms that ensure stakeholders' compliance to it.

It is also important to consider that blockchain technologies are implemented within the existing legal framework of urban planning, therefore, for legal reasons, information such as copyrighted material, personal data, licensed material, communication logs and recordings should not be disclosed without the permission of the involved parties.

Privacy, data ownership, platform control and access are all equally important governance elements whose planification should occur according to standardised protocols based on the socio-cultural and legal context of application. Nonetheless, blockchain-based platforms still suffer of an unclear legal and regulatory support in relation to many aspects including stakeholders' responsibilities, dispute resolution, enforcement and so on (Ølnes and Jansen, 2017). Therefore, although policy could facilitate the development of governance processes that can be specifically re-engineered for blockchain-based services in the context of urban planning, there are still many uncertainties that will need to be addressed as the technology becomes more mature.

9. Research limits and future research directions

To conclude, the analysis has shown that values and possible values' tensions can either be addressed at an infrastructural level, through platform design or through the establishment of governance guidelines which manage how the information will be shared.

For example, the analysis has revealed that inclusiveness can be enhanced at an infrastructural level through a public and permissionless blockchain, at a design level by developing an App which is easy and intuitive to use as well as at an informational level by keeping a clear and simple language. Indeed, this is an important issue in urban planning participation as planning proposals and urban design are rather complex and ways to communicate them to non-experts must be found. Currently, almost all participatory platforms, including blockchain-based solutions, fall shorts in conveying such information in more simple ways. Therefore, future research might investigate more advanced solutions which integrate blockchain-based participatory platforms with advanced urban co-design applications which are specifically

tailored to communicate existing planning ideas and decisions in a comprehensible manner and gather tangible opinions from the public.
Transparency too can either be enhanced at an 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 accuracy which cannot be proved by the blockchain itself but should be addressed at an informational level. Blockchain systems are particularly exposed to the latter problem since immutability extends information longevity, even if the data are of poor quality and its assessment cannot be automated by blockchain. Alternatively, the technical investigation has shown that the relevance of the data can be partially 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, inclusiveness. Ultimately, the development of a more human-centred blockchain-based system depends on the specific context of application as well as on the synergies created among the infrastructural blockchain layer, the App design layer and the informational layer through content decisions.
Blockchain has without doubt some potential but, an effective implementation requires a careful evaluation of the context of application. A close cooperation between blockchain experts and policymakers is, therefore, necessary to develop a blockchain platform which ensures compliance with all the involved stakeholders' values and needs through the provision of clear guidelines and procedures for its governance. The analysis also suggests that the problem of improving citizen participation cannot only be solved through better technology. Technology is only one dimension to effectively design and implement a citizen participation platform. Effective e-participation systems need to be conceptualised considering the broader socio-cultural context of application and blockchain technologies should be seen as an additional component which might be used to address some of the current issues in participatory processes. In conclusion, the paper shows that the development of blockchain-based platforms might benefit from a value sensitive design approach as it distances itself from the highly functional and technological approaches which, so far, have been dominant in blockchain research but which have failed to consider the broader socio-cultural context of application.
In terms of future research directions, as the paper is based on the first layer of participation, that is information, more research should be conducted in relation to the other use cases of consultation, collaboration and empowerment, in which citizens cover a more active role. For these use cases new blockchain functionalities such as voting and token issuing need to be implemented. Accordingly, as new values are likely to emerge, they might need to be investigated in relation to how they can be supported by blockchain technologies and to what extent they might generate additional values' conflicts among stakeholders.

Finally, it is important to acknowledge that BBBlockchain is a research-driven project whose infrastructure developed for the pilot phase was initially based on the Ethereum test network Rinkeby and eventually forked to our own in-house public, proof-of-authority blockchain network with three miner authorities: the two Housing Associations and the university. Therefore, every transaction and its value are transparent to the entire network through a central consensus ledger mirrored across every participating node in the network (i.e., a public blockchain). However, manipulations on past transactions are only possible if more than half of the authorities conspire. Running BBBlockchain on our network, which has no monetary exchange value, allowed us to experiment during the initial development phase without financial pressure. If BBBlockchain will prove to be successful, we might consider to port it to the Bitcoin RSK network. However, moving BBBlockchain to networks that use Proof-of-

Work as the consensus mechanism for validating transactions would require miners to solve complex mathematical problems to create blocks, consuming very high levels of computing power and electricity (Cao et al., 2020). Such high levels of energy consumption currently represent a very common blockchain adoption challenge, as the environmental footprint of blockchain mining is another important value that must be taken into account in the broader socio-economic blockchain-related discourses. For a more detailed discussion of BBBlockchain infrastructure development, see Muth et al. (2022).

The paper also presents a major limitation since it is based on qualitative analysis and citizens opinions have only been taken into account through a small sample survey. Therefore, as citizens represent a key stakeholder of blockchain-based participation platforms, in the future, it is important to collect more data about their preferences and opinions by conducting in-depth interviews and focus groups.

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Blockchain for citizens' participation in urban planning: the case of the city of Berlin. A value sensitive design approach

Dear Editor and Reviewer,

thank you again for your further comments and feedback. As the editor required, we meticulously followed the reviewer's critical comments and below we address each comment and issues raised by the reviewer explaining the changes we made, which have been highlighted in yellow on the manuscript.

Sincerely,
The authors

Reviewer #1

In P2P networks like Bitcoin, validators are rewarded for providing accurate data, which creates a strong incentive to ensure the data's accuracy. However, in other use cases like healthcare, participation or supply chain management, the incentives may be less clear, and validators may have different motivations that could compromise the integrity of the data. Finally, many non-financial applications of blockchain require the integration of multiple data sources, which makes it even more challenging to solve the oracle problem. For example, a supply chain management system may require data from multiple parties, including suppliers, manufacturers, logistics providers, and retailers. Ensuring the accuracy and consistency of this data across all parties can be a significant challenge.
In summary, the oracle problem remains a significant challenge in implementing blockchain solutions for non-financial applications due to the subjective nature of real-world data, differing incentives for validators, and the complexity of integrating multiple data sources.

We'd like to emphasize that we agree with the reviewer and thank him/her for pointing out the missing aspects. On page 11 of the manuscript, we have now included two additional paragraphs where we address the blockchain-related issues regarding data accuracy and oracles and how we have tried to minimize them on BBBlockchain.

In reviewing the paper, it is not clear how these challenges are addressed in detail in elections or participatory processes. Possible methods for data storage:

1) To manage data efficiently at a trust authority: Uses databases or cloud applications

As in Wüst and Gervais (2017) "Do you need a blockchain?", blockchains are shown to be suitable for our use case. According to their decision tree for our participation use case,

we have multiple information hosts (cf. ”writers"), but we do not have a trusted third party (TTP) because all our stakeholders do not trust each other (i.e. citizens, government, housing associations). There is no TTP we could trust to host a cloud service.
On page 11, we have now added an explanation of why BBBlockchain uses a permissionless blockchain, based on the decision tree.

2) To distribute data censorship resistant in the network: uses e.g. P2P protocols like Nostr

We thank the reviewer for pointing out Nostr. From our understanding of Nostr, it would be a very good fit for information-based participation use cases, thanks to decentralization, but it does not provide token and cryptocurrency capabilities. However, the BBBlockchain DApp implements tokenization (for participation rewards) and participation budgets (for future use cases) that require such cryptocurrency capabilities. Therefore, in order to maintain consistency in our technology stack and prepare for future use cases (e.g., participation incentives and budgets), we chose the Ethereum blockchain from the beginning. On page 9 we have further explained such point.

Blockchain for citizens' participation in urban planning: the case of the city of Berlin. A value sensitive design approach

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