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Novel Technologies as Potential Catalyst for Democratizing Urban Heritage Preservation Practices: The Case of 3D Scanning and AI

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Abstract. The conflict between heritage protection and urban infrastructure development rationales creates a context for inclusion, participation and dialogue of different heritage-related communities. However, developed in the pre-computer age of administrative practice, are often incapable, partially or completely, to accommodate the 'new-era' community oriented participatory practices.

In this article, authors discuss the mutual effects of IT in the process of democratization of urban heritage preservation. The authors create and argue the conceptual model of distributed ledger technologies (DLT) in participatory UHP. The model demonstrates how technologies can become catalysts for democratization in situations when the regulatory and administrative change (on its own) is too inert. The article hypothesizes that novel technological developments which aim at or have the potential for increasing community involvement and democratization of administrative practice, exert their effects directly through technology-based participatory practices.

Keywords: urban heritage preservation; democratizing practices; participatory heritage; agent network theory; 3D and AI based technologies.

Naujos technologijos kaip galimas katalizatorius demokratizuojant miestų paveldo išsaugojimo praktiką: 3D skenavimo ir dirbtinio intelekto atvejis

Santrauka. Prieštaravimas tarp paveldosaugos ir miestų infrastruktūros plėtros sukuria ne tik įtampas, bet ir sąlygas įvairių su paveldu susijusių bendruomenių įtraukčiai, dalyvavimui ir dialogui. Tačiau dauguma paveldosaugos administravimo praktikų ir jas taikančių institucijų, atsiradę laikais, kai dar nebuvo kompiuterio,

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sunkiai prisitaiko prie skaitmeninių technologijų paskatintų pokyčių bei galimybių, orientuotų į bendruomenių dalyvavimą sprendimų priėmime.

Šiame straipsnyje autoriai aptaria abipusį IT poveikį miestų paveldo išsaugojimo demokratizavimo procese. Straipsnyje daroma prielaida, kad nauji technologiniai sprendimai, kuriais gali būti didinamas bendruomenės įsitraukimas yra svarbus įrankis demokratizuojant paveldosaugos administracines praktikas. Autoriai sukūrė ir pagrindžia koncepcinį paskirstytų duomenų technologijų modelį ir jo taikymą dalyvaujamajame miestų paveldo išsaugojime. Modelis parodo, kaip technologijos gali tapti demokratizacijos katalizatoriais tais atvejais, kai reguliavimo ir administraciniai pokyčiai (savaime) yra pernelyg inertiški.

Pagrindiniai žodžiai: miestų paveldo išsaugojimas; demokratizavimo praktika; dalyvaujamasis paveldas, veikėjo-tinklo teorija, 3D ir dirbtiniu intelektu pagrįstos technologijos.

Introduction

Urban heritage preservation (UHP) is concerned with the monitoring and management of various risks, which may vary from sudden and catastrophic events (such as major earthquakes, floods, fires, and armed conflict) to gradual and cumulative processes (such as chemical, physical, or biological degradation) and modern urban infrastructure development (cities, roads, railways, development of energy infrastructure, adaptation of buildings to modern needs, development of tourism services, etc.). Concentrating on the societal dimension, UHP can be seen as a paradox – an irreconcilable juxtaposition of two imperatives – the preservation of the heritage and the development of the city at the same time. However, the conflict between heritage protection and urban infrastructure development rationales creates a context for inclusion, participation and dialogue of different heritage-related communities. The problem of involvement and participation of communities in heritage protection processes is identified as one of the significant issues of modern heritage management (Li et al., 2020), the resolution of which often depends on whether or not the existing regulatory framework and technological tools permit the participation of other than responsible government units in the heritage protection administrative practice. This forms the background for democratization of UHP processes. The democratization of UHP in this paper is perceived as the dismantlement of authoritarian heritage preservation practices (related to the concentration of power in heritage preservation institutions and professionals with less responsibility to other heritage-related communities). Through this process, heritage preservation practices become democratic in the sense of participatory democracy as the model in which citizens are provided power to make heritage preservation-related decisions (Civil…, 2020). This model is closely related to deliberative democracy and authentic deliberation as decision-making practices (Bächtiger et al., 2018; Hammond, 2019), free from unequal power of one or few groups of the decision-makers or heritage-related communities among the power of the members of other groups or communities. The trend of democratizationof the government administration by building transparency into the practices with idiosyncratic decision making or by allowing consensus-based governance was sustained and reinforced by adaptation of supportive legislative norms, on the one hand, and the development of IT tools and services forming the broader e-government infrastructure (Pang et al., 2014). By the end of the first quarter of the 21st century, this trend has formed an understanding that contemporary regulatory frameworks must not only cater for transparency of and trust in government services (Tolbert & Mossberger, 2006; Warkentin et al., 2002), their effectiveness (Council…, 2002), but also permits broadening the degrees of inclusion of e-communities in various public discourses. Specifically, in the context of UHP, different participatory practices were emerging, building on such ideas and contexts as socially constructed heritage, 'contemporization' of heritage, participatory heritage, grassroots cultural heritage participation, and grassroots communities (Kelpšienė, 2021).

However, developed in the pre-computer age of administrative practice, today the Lithuanian UHP regulatory frameworks are defined as "...regulated by uncoordinated administrative legal norms…" and characterized by many duplications of functions and responsibilities (Dziegoraitienė, 2005). The UHP practice shows, that the legal norms defining those 'old-era' regulatory framework are often incapable, partially or completely, to accommodate the 'new-era' community oriented participatory practices, (Glemža, 2011). More to this, contrary to what was the policy-ascribed role of the IT as enabler and promoter of e-democracy, the technological tools used for UHP are often those based on Web 1.0 concept, without support for social networking, crowdsourcing or other UHP-relevant participatory practices. This problem is particularly salient in post-Soviet societies, whose UHP are based on inherited from the Soviet authoritarian control-and-punish governance system, which precluded pluralistic consensus-based decision making.

In this conceptual article, we discuss the mutual effects of IT in the process of democratization of UHP (as part of public administration). The object of this research is the mutually constitutive effects of IT-based developments within the context of (attempts of) democratization of heritage preservation practices. In this work, we create the conceptual model of distributed ledger technologies (DLT) in participatory UHP. We propose a model that demonstrates how technologies can become catalysts for democratization in situations when the regulatory and administrative change (on its own) is too inert. The article hypothesizes that novel technological developments which aim at or have the potential for increasing community involvement and democratization of administrative practice, exert their effects directly through technology-based participatory practices. In this work, we demonstrate how new advanced technologies, such as 3D scanning, mobile mapping, drone aerophotogrametry and AI (deep learning), shape new UHP models, which, in turn, have a capacity to engage the higher level of community participation in UHP.

Our work also identified possibilities for broader e-society development and the higher level of societal inclusion into the heritage monitoring process, in its shift from conceptualization of the heritage site as a physical complex of objects to that of virtual sets of imagery, making the heritage object accessible at any time, identifiable, traceable, explorable, crowdsoursable and participatory from different spatial and time perspectives at the same time.

Methodological approach

Methodologically, the conceptual modelling approach is applied to capture relevant aspects of the research topic and for understanding how technologies enable the growth of community involvement and participation in UHP processes. In our research, we understand "conceptual model" as "an abstract representation of something generalized from particular instances" (Borah, 2002) as "a simplified representation of the real system" (Liu et al., 2011). It works as "a kind of proto-theory <…> which can then be tested for validity [and] can often help in working through one's thinking about a subject of interest" (Bates, 2009).

The model presented in this paper was developed using the Agile engineering based methodological approach. The conceptualization process is realized incrementally using a five-stage Agile Modelling Method Engineering (AMME) lifecycle approach (Karagiannis, 2018). During the first – 'create' – stage, a selection of existing knowledge, UHP practices, the agency of UHP actors, patterns of knowledge acquisition, use and reuse by the members of different heritage-related communities, the impact of technology and requirements elicitation techniques are studied. The study results were represented in the report for Lithuanian Research Council and partially published (Laužikas et al., 2019). During the second stage ('design'), the first stage results were framed as modelling method building blocks that were formalized in the third stage. At the fourth ('develop') stage, the first conceptual model representing the basic notions of the domain, i.e. concepts and relationships among them, will be formed. For interoperability and integration issues, the model is constructed to adhere to the CIDOC-CRM cultural heritage and museum documentation standard (Brueseker et al., 2017). According to CIDOC-CRM, a conceptual model consists of two categories of informational elements: (i) classes, describing the concept for an entity as 'categories of items that share one or more common traits serving as criteria to identify the items belonging to the class'" 's and (ii) properties describing the concept for a process that 'serves to define a relationship of a specific kind between two classes' (Bekiari et al., 2021). This model was validated in the fifth stage ('Deploy/ Validate') using expert-based validation methods.

Theoretical framework

UHP as actor-network

Development and deployment of information technology (IT) tools for UHP is grounded in a complex web of administrative rules, technical tools, and the associated practices, which jointly establish a complex socio-technical system. The evolution of such socio-technical systems can be studied from a number of perspectives. Traditionally, three prominent approaches can be distinguished: technological, social determinist, and socio-constructivist. Depending on the approach each of these schools' advocates, the focus of analysis will be, for example, either the influence of technology on society, the social settings of technology development, or technological inflictions.

To model the UHP processes and the role of the technology in UHP work, we draw from the actor-network theory (ANT) perspective. The theoretical framework of this study is based on four general assumptions: (i) the UHP related complex socio-technical system could be perceived as the network of related agents; (ii) the societal values of urban heritage are created inside of this agent network; (iii) the creation of heritage-based societal values is higher in participatory agent networks in comparison with non-participatory agent networks; (iv) the use of the particular kind of technology enables a higher level of participatory inside of agent-network.

Understanding development processes as the network-building process is central to ANT. Although referred to as 'theory', ANT is merely a methodology for studying how social and technological actors form (or fail to do so) workable configurations of socio-technical systems – for example, such as a UHP.

The actor-network approach addresses the issue of the technological development process by looking at actors who possess enough power to change the direction in which the technology develops at critical points. The power of actors, however, is not something inherently individual in them but originates from the networks they may control (Callon & Latour 1981). Those actors who exert influence on a technology's trajectory are referred to as gatekeepers. The ontological position given to power in the actor-network approach makes it possible to break away from a traditional micro-macro division. The principle of symmetry, as a way to address the success or failure of a particular technology, is applied by actor-network theory by analyzing the human and non-human world in the same manner, and thus "the explanation of the development of socio-technical ensembles involves neither technical nor social reductionism" (Bijker, 1995, p.251). Callon's notion of translation (Callon 1986) is used to describe the changes that take place in socio-technical networks, as the negotiation process between the involved actors unfolds. A successful translation stabilizes the network of actors and creates a base and commitment to go ahead with innovation.

The idea of non-human actors is often met with resistance by those who are not acquainted with actor-network theory. Hughes (1986), gives an example of human and non-human actors by referring to Callon's case study on the French attempt to design an electric vehicle: "His actors include electrons, catalysts, accumulators, users, researchers, manufacturers, and ministerial departments defining and enforcing regulations affecting technology" (Hughes 1986, p.288). Non-human actors should not be thought of in terms of cognitive abilities; rather, what is central to the role of actor is the influence it exerts on other actors, the way it mandates other actors to behave in a certain way.

Another feature of addressing inanimate actors (or actants) in ANT is described by the terms "delegating" and "delegates". Humans "delegate" actions to other (nonhuman) actants that share our human existence. Our meanings and actions are translated into other kinds of expressions in such a way that an object becomes a delegate that can stand in for an actor and create an asymmetry between absent makers and occasional users. Through delegation actants are carrying past acts of the makers into the present and permit their "many investors to disappear while also remaining present" (Latour, 2005).

The notion of inscription helps us to understand how technology becomes an actant**.** Quoting Hanseth & Monteiro (1997, p.186), "the designer works out a scenario of the system together with the interaction between the users and the system. This scenario is inscribed into the system. The inscription includes programs of action for the users, and it delegates roles and competences to the users as well as the components of the system." Inscriptions impose programs of action on the artifacts' users, and by so doing give a technology the active role of an actor (Hanseth &Monteiro, 1997).

Actor networks can be understood as a web of "individuals, groups, objects, artefacts and intangibles that combine to make a field of activity around their conjunctions" (Waterton & Watson, 2013, pp. 553). By providing a methodological base on 'what to study', ANT becomes a viable tool for studies featuring a diversity of involved actors affecting or being affected by the system. Actor networks can now be understood as any array of individuals, groups, objects, artefacts and intangibles that combine to make a field of activity around their conjunctions (Waterton & Watson, 2013). For such a network to stabilize, the interests of these actants must be aligned.

Recently, ANT was gaining popularity in heritage studies (Tait & While, 2009; Arnaboldi & Spiller, 2011; Kefi & Pallud, 2011; Wang & Xiao, 2020; Bagiński, 2020). Looking at UHP through the prism of ANT, the UHP can be seen as (building) a sustained actor-network of actors representing public administration staff, owners or heritage objects, relevant stakeholder groups, delivering the UHP practice (Waterton & Watson, 2013, pp. 553–554, Van der Duim et al. 2012) - the preservation, risk assessment, monitoring. The application of ANT in the heritage preservation practices also creates the relationship between heritage preservation and the other concepts of growth of "stakeholder's agency", like stakeholders' management (Hajialikhani, 2008), community heritage (Crooke, 2010), public heritage (Labrador & Silberman, 2018), participatory heritage (Roued-Cunliffe & Copeland, 2017), and grassroots heritage (Liu, 2010).

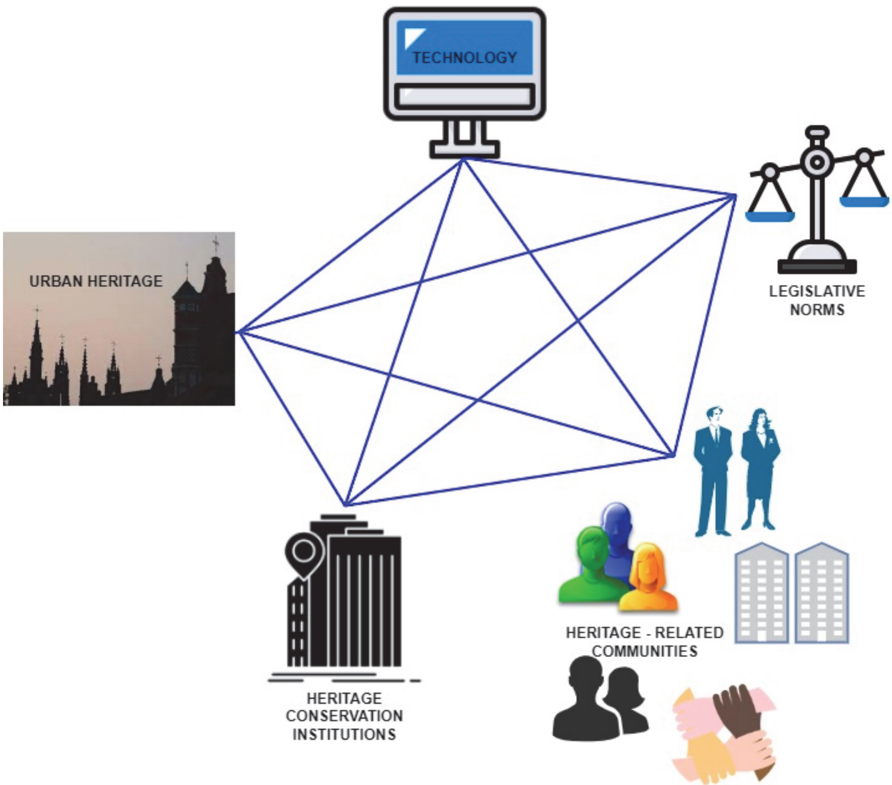

Fig. 1. **Actor network diagram illustrates the connections between actors at UHP**

Specifically, in UHP research, the main actors can be identified as: (i) the urban heritage objects, (ii) the heritage conservation institutions, (iii) the different heritage-related communities, (iv) the advanced computer-based technologies, and (v) the legislative norms and rules. Interaction between actors within the actor-network is embodied in the intermediaries that actors themselves put into circulation. Callon (1992) states, that an intermediary is anything that passes from one actor to another, and which constitutes the form and the substance of the relation set up between them – scientific articles, software, technological artefacts, instruments, contracts, money (Fig. 1).

The members of UHP actor network can be defined as:

- The urban heritage conceptually is rooted in the concept of the city, the urban way of life, and the specific culture of the city. Different concepts of urban heritage are known in modern scholarly literature. They differ not only in historical contexts but also in their connections with different professional and regulatory communities, involved in contemporary heritage preservation activities. The landscape, architectural, anthropological, historical, and systemic concepts of urban heritage can be distinguished (Laužikas et al., 2019). In this paper, we adopt the definition of urban heritage as a systemic concept consisting of (i) spatial structures that express the evolution of a society and of its cultural identity; (ii) made up of tangible and intangible elements; (iii) living evidence of the past that formed them, but also, (iv) forming part of daily [contemporary] human life (Charter…, 1987).
- The heritage conservation organizations include all public sector institutions with a particular purpose of heritage management. In the context of our study, several organizations are responsible for the administration of Vilnius urban heritage sites: the Department of Cultural Heritage under the Ministry of Culture of Lithuania, Vilnius municipality, and the Vilnius Old Town Renewal Agency financed by Vilnius municipality.
- The different heritage-related communities most broadly mean "heritage-related "people with all possible public interests and relationships to heritage (the urban heritage in the case of this study). There are people whose material interests are affected by urban heritage (e.g., real estate owners of heritage buildings, city infrastructure developers), or whose contemporary identity and life is entangled with the meaning of urban heritage (e.g., members of town or town quarters communities). These individuals and groups do not normally describe themselves as "intentionally interested" in urban heritage, as they do not see urban heritage, at least primarily, from a heritage study disciplinary perspective. In other cases (e.g., tour operators who work with urban tourism, or publishers), people are related to urban heritage because their work draws on its conduct and outcomes.
- The legislative norms and rules defining the roles of and relationships between different actors are described as regulatory frameworks, which provide the statutory basis for defining specific institutional and societal roles in a UHP and explain how formal relationships between actors are formed. Under the existing regulatory framework based on the control-and-punish governance paradigm, there are different degrees of recognition (or different possibilities for inclusion) for different

heritage-related communities, meaning that there are unequal terms on which those actors enter the process of forming an actor-network.

- The advanced computer-based technologies cover the area of technological (hardware and software) tools used or have the potential to use in the process of monitoring of urban heritage. Introduction of novel advanced technologies, such as 3D scanning of urban landscapes and AI-based processing of the collected imagery could contribute to boosting the efficiency and effectiveness of UHP risk monitoring practices and thus create public value in terms of transitioning of public administration to e-services (Jansson & Erlingsson, 2014) and the broader context of societal inclusion, participatory heritage and the Network Society (Castells, 2009; van Dijk, 2012).

Understanding the actor's relationships is necessary to define that humans are not privileged in this AN. The second important is the principle of irreduction - there is no essence within or beyond any assemblage process. Actors are concrete; there is no "potential" other than their actions at the moment. Entities are nothing more than an effect of assemblage. Third, the concept of translation and its mediation processes transform objects when they encounter one another. Finally, the principle of the alliance. Actants gain strength only through their alliances. These propositions have specific implications for data generation, analysis, and reporting.

The technology and the participation

Most contemporary technological solutions created by heritage preservation institutions (in our case "The register of Cultural heritage in Lithuania" or the "Database for monitoring the condition of the old town buildings, their environment and public spaces") are based on an authoritarian ("top-down") curatorial approach, according to which the creators of the technological solution are perceived as an expert who knows the public's needs and creates the product meant for them. Therefore, here suppliers and customers are in strongly fixed positions, where system creators are active suppliers and members of the heritage-related non-professional communities are passive consumers, without the possibility of use of participatory tools, reuse and co-creation of digital content. The case presented in our article proposes another model, based on the sharing and participatory presumptions. Participatory models need to use democratic ("bottom-up"), open, crowdsourced technology platforms. In this case, the process itself of relating between the actors (in actor-network) is different. In the first kind of (authoritarian) systems, the hierarchy between the actors can be a priory discovered. That means the privileged (*a priory*) situation of one actor - the heritage conservation institutions, and the destruction of ontological symmetry of all actors, and - in general - the destruction of agent-network at all. The technological solutions (systems) work there as the engagement tool for deliberative democracy (Fishkin & Laslett, 2008; Olson, 2011; Habermas, 2015; Bächtiger et al., 2018; Hammond, 2019), breaking the limitation of authoritarian (unequal power) practices and bringing more direct participation and more equality for the members of different urban heritage-related communities. In participatory AN the power also exist, but is constructed differently. The actor's social/hierarchical power is "lost" when actor is entering the network, but the "network" power comes from the translation process. One or another "equal" actor can yield the enormous power. This depends from how many other actors it will associate with oneself and how many will "speak" in the name of the given one (a social media is a good example of this) (Faik et al., 2013). But this kind power is temporal and fluid in sense of hierarchical stability of authoritarian systems.

Democratizing technology-based systems are designed using the participatory approach: (i) will work as an open service system with equality of all users to use the data and services (Elabd et al., 2021); (ii) the use of the system is based on the quality in use methodological principles (ISO/IEC 25022..., 2016); (iii) the system administrator is positioned as moderator and supporting person (Yifan et al., 2021); (iv) the preserved data sets and analysis results are intended to use/reuse, with high level of immersivity (Condell et al., 2021), and involvement to volunteering (Humphrey-Taylor et al., 2020); (v) the system user, depending on the situation, could choose the different roles; (vi) the system will work in networked, participatory, crowdsourced, sharing modes, enabling the participatory monitoring (Nasrolahi et al., 2021); (vii) the different monitoring cases enable creating the multi-interpretative messages (Tait, 2020); (viii) the system follow the open-source and open access principles; (ix) the system really enable application of the principles of the deliberative democracy (AlDajani, 2020). This approach, and "...co-design activities and infrastructuring strategies in relation to a broader interest in advocating not only the preservation of and access to digital cultural heritage, but, more importantly, enabling collaboration, to support the emerging practices of diverse user groups, and to contribute to cultural commons…" (Martilla & Botero, 2017), and strength the pluralistic consensus-based governance paradigm in UHP sector.

Results

The novel technological bundle description

This paper reports on the case of a university-led initiative of development of an automated solution for 3D spatial scanning and AI-based urban heritage monitoring practices in Vilnius old town (Žižiūnas & Amilevičius, 2020). The created technology product is Windows desktop-based software operating in 3 main ES languages. Software for monitoring and analysis of its results based on the theoretical approach of using artificial intelligence technology to identify accurately the differences in the same cultural heritage object and two 3D point clouds / 2D photos and 360 degrees views photos of different periods, which represent changes that have occurred during the relevant period. The main outcome of the software is an interactive report wherein every change in the analyzed heritage area is identified in photos or point cloud, and alteration's address, coordinates, and other information are included. The software not only identifies alterations but also calculates the difference and reveals a situation "before" and a situation "after". This functionality enables heritage-related community members and heritage professionals for double-checking alterations in a fast and easy manner. With this product, only one person is required to perform digital monitoring. The software is installed on powerful computers (requirements will be included in the user manual), but not on workstation-type computers only. User interface (UI) and user experience (UX) are developed for simplifying the usability of the software. Hence average computer users are able to adopt these technologies into everyday work agendas successfully. This monitoring step will be based on the report which will be accessible to as many heritage interested people as needed by using medium-level smart mobile devices (tablets, smartphones, laptops).

Creating the software was performed the (i) selection of the valuable properties of urban heritage to be captured and monitored, and separation of valuable features; (ii) identification of damage factors destroying valuable properties; (iii) linking of specific valuable features of urban heritage to specific damaging factors in order to use further this matrix for automatic heritage monitoring; (iv) determination of mathematical indicators applicable to the measurement of change; (v) exclusion of sets of valuable properties that are specific to a group of specific heritage objects and their description by algorithms; (vi) verification of data reliability by available satellite or LIDAR data or by real-time detection; (vii) application of artificial intelligence technology to the monitoring of urban cultural heritage (Laužikas et al, 2019).

The general concept of the tool is based on the idea to (i) bring digital world objects of heritage sites (2D, 3D) into an IT system (ii) in recognizable formats for (iii) further imagery data processing using AI tools to (iv) recognize, record and compare changes in physical heritage objects based on the digital world objects. The digital object is obtained in the field measurement stage by capturing 2D images and performing 3D laser scanning of a physical shape of the urban heritage area. AI image processing is used to identify relevant objects on 2D images. The AI-identified objects can be algorithmically linked to their 3D geometry in the 3D point cloud data. Using those processes, field measurements of heritage valuables at different time periods allow identification of changes in the valuable heritage objects – the valuables (doors, windows, gates, the height of the building, the volume of the building, roof elements (e.g. new skylights and volumetric skylights), old town urban structure (e.g. streets plan structure) and the old town panoramas (landscape views, looking from the particular points of observation). To enable (automated) evaluation of the evolution of the object, relevant imagery data has to be converted into a database structure, where each valuable heritage object has attributes defining the object's location in real-world, time of digital image capture and the actual mathematical geometric shape of the object. The combination of AI-powered imagery object identification and algorithmic object geometry analysis allows to fully automate the process leading to the first level interpretation: i.e., information on geometrical changes. Using logical operators and simple terminology, such as "status quo unchanged" or "increase of area/volume by x%", identified changes in heritage valuables are presented to human experts in a simple way to understand the report in plain text or by combining graphical and textual information. Information presented in the automatically generated reports is likely to require human expertise (Lyytinen et al., 2020) for further evaluation of risks to urban heritage valuables. For example, the identified changes must be evaluated against particular legal status and local legislation for specific valuables, or other factors.

The conceptual model of distributed ledger technologies (DLT) in participatory UHP

The agency of technologies is crucially important for UHP practises, because they create the environment, supporting the control-and-punish or pluralistic consensus-based governance paradigms. The old technologies, which are in use in UHP today, are problematic, because they are not supportive of participatory practises, so even if the legislation/rules were changed to allow consensus-based practises, the old technology tools would not permit that. We have studies reporting that when tools are designed to support participatory practises, these do emerge. Studies show that "...when projects are designed with a human-centred computing focus and a community-oriented foundation, there is evidence of deeper engagement and sustained participation…" (Chern et al., 2020). New technologies enables to create of the sharing heritage socio-economic ecosystem built around the sharing of heritage information in a broader sense (raw data, structured information, knowledge and experience, interpretations and etc.); includes the shared creation / co-creation of heritage information and information services by members of the different communities; and create additional social value more not through ownership, but through sharing and more not by experts, but by "crowds" using the participatory, reconciliation and dialogue ways. Lastly, European Union, separate EU countries calls for such actions, welcomes these activities and this is highly anticipated in "analysis and recommendations" documents (Community…, 2012; Leidulf & Grahn, 2012; Shackel, 2011).

In the context of the topic of this article, the DLT-based approach can be used as the background of the modelling. In this case, UHP can be perceived as an iterative process – the set of urban heritage monitoring activities - as actions intentionally carried out by actors that result in changes of state in the cultural, social, or physical systems documented (Bekiari et al., 2021). The informative results of iterations are documented in the blocks - as identifiable immaterial items that make propositions about reality (Bekiari et al., 2021). The blocks are related to the chain and in this mode form the information structure of UHP. The conceptual model of one iteration (monitoring event) is represented in Fig. 2. The letters "E" (e.g. E73) and "P" (e.g. P67) refer to the corresponding CIDOC-CRM classes and properties.

The iteration (monitoring event) connects UHP related actor's as members of the described agent-network system. The iteration begins by adding urban heritage data (2D, 3D, 360°) into our IT system (virtual computer-based technological solution, described above as the novel technological bundle). Our IT system works as the space of consensus-making in this case, whereas the different interests of heritage conservation institutions and heritage-related communities are represented on one table. The mentioned framework enables us to develop a hypothesis about the compromise mechanism as an informative and communicative process sharing of information (about the interests) and exchanging of meanings, happening in a particular spatiotemporal dimension (monitoring event). And, the monitoring event there works as a resonance trigger, which initiates the actor's participation and possibility of further consensus-making between two or more actor's groups of interest.

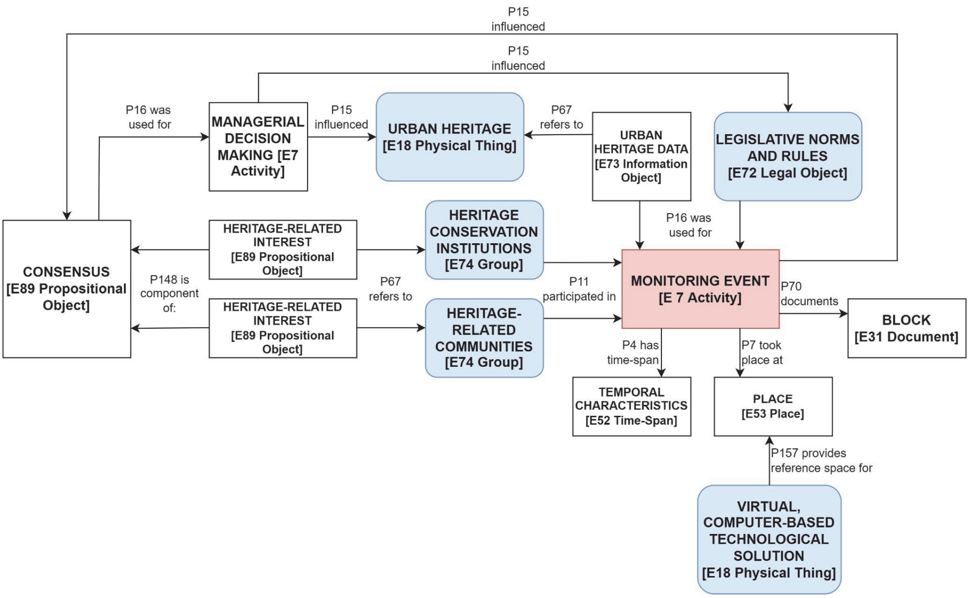

Fig. 2. **The conceptual model of one iteration (monitoring event) in UHP process**

For participatory UHP is important that the use of a central, validating authority can be avoided because in a blockchain, as transactions are added, the identities of the parties conducting those transactions are verified, and the transactions are verified as they are added to the ledger as a block of transactions (Jaikaran, 2018). This feature of blockchain prevents authoritarian heritage practises and enables the equal possibilities of participation of all related communities members without dominating heritage professionals and heritage institutions. The openness and flexibility of monitoring events enable the compromises between the different professional and non-professional urban heritage-related groups. In the conceptual model, the compromises of interests are realized as no less than two-level interaction between members of different groups: by broadcasting to members of "other" groups through participating in the monitoring event and by means of the neighbourhood inside the particular group of actors. It should also be noted that people tend to interact with other people similar to them (neighbourhood based on interests similarity). These interactions are different in duration and functional mechanisms. The broadcasting as interaction is shorter, performed during the event (in time-span equal to monitoring event), when a member of one group communicates and shares interests with a member of another group, thus changing the understanding of interests for both sides (Plikynas et al., 2022). Meanwhile, members of groups can discuss the compromises through the neighbourhood, communicating with the people inside of their own group. In comparison, broadcasting has a much faster and stronger effect on compromise-making, but sharing the compromise results through neighbourhood interaction (longer, less intensive and functionally decrement in time) is the important thing in acceptance or declining of the compromises. The efficiency of sharing depends on: (i) group members interest coherence with the features of monitoring events (did event will touch the interests of the group); (ii) coherence between two or more groups interests (the interests with the bigger difference are hardly going to compromise). If the members of some heritage-related group don't participate in monitoring events, the interest of the members of this group is fixed on the same level of compromise.

This process creates some level of consensus, which could be used for managerial decision making. And this managerial decision making directly impacts the state of urban heritage and - probably - the legislative norms and rules. And, finally, the results of the monitoring event are documented in a specific spatiotemporal information structure – block – related to the prior and the next block in the blockchain (Huang & Dai, 2019; Vacchio & Bifulco, 2022; Lvping, 2021; Mucchi et al., 2022).

This conceptual framework suggests a possible ecosystem (Fig. 3) of: different groups of interests, different incentives of acting, new possibilities to come up to consensus and new ways of managing difficult, diverse and highly interconnected cultural heritage areas such as oldtowns. This ecosystem (Fig. 4) implies ordinary parts, agencies or elements where some interests are the same between almost all and some are directly opposite. Hence the heritage field is well known for having everlasting conflict where one side wants stability and preservation of status quo and another part- wants new constructions and reshaping the status quo which always bring tensions or losses.

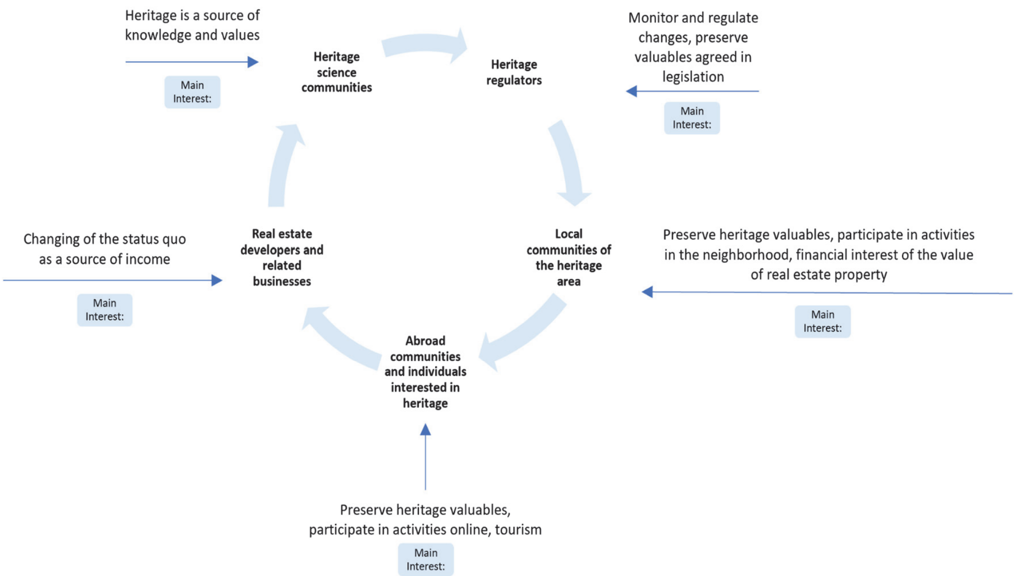

Fig 3. **Participating agents and its main interest in cultural heritage. Inherent tensions on approach to status quo.**

Local communities are often lacking the ability to participate in their interest in the heritage place or object and on the other hand heritage areas and sites are always facing some danger of illegal activities, poor governance and economic priorities coming from real estate developers and builders (Mergos & Patsavos, 2016; The UNESCO…, 2019). Lastly, a broader context of the cultural sphere and on-going digital transformation leads to Culture 3.0 (Sacco, 2011) which is "blurring the boundaries between producers and users" and paradigm shift is already here: "there is a suboptimal promotion of the idea that digital cultural resources can be reapplied to directly influence community building, targeted knowledge sharing, political decision-making and/or to rescue specific heritage in danger of disappearing" (Drabczyk et al., 2021). We state (Laužikas et al., 2019) that 3D technologies together with AI can redo how heritage monitoring can be performed, blockchain technologies like Smart Contracts could lead to a real community engagement (Perlman, 2020) constantly declared broadly like Faro convention and alike (The Faro…, 2021), but no real tools for such "button-up" policy, citizenship, and real democratic governance was created. Also, some power in between these two poles could emerge, meaning various public data generations and usability can be financially incentivized via crypto ecosystems.

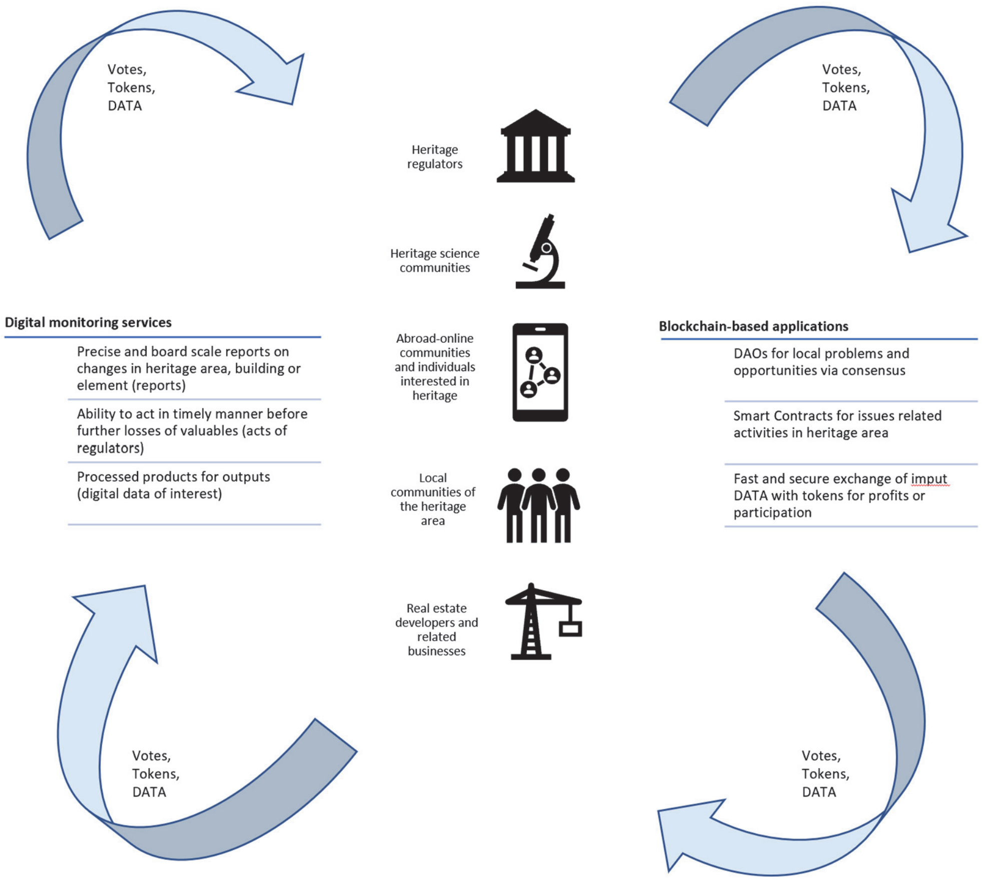

Fig. 4. **Actors and ecosystem within a proposed technological solution for heritage monitoring and participation where DATA, crypto tokens and votes are main powers to act.**

Last 3-5 years, financial institutions, regulators and policy makers all around the globe are trying to grasp and elaborate how to safely adopt and use distributed ledger technologies (DLT/blockchain) (Blockchain…, 2019). Today almost all central banks in the world is working, researching or already developing Central bank digital currency (CBDC), steadily growing number of crypto users (Number…, 2021), high promises and fast adoption of Decentralized Finance (DeFi) protocol trying to solve Centralized Finances (CeFi) fundamental problems (Harvey at al., 2021), record number of developers joined WEB 3.0 (Shen, 2021) - all of that signals that crypto is a positively disruptive technologies (Trček, 2022) and that is here to stay by creating a crypto economy (Perlman, 2020). Smart contracts and decentralized autonomous organizations (DAO) could lead to a completely new way for a governance (voting) of the communities and incentivize their will and actions in related heritage places within blockchain technologies (Faqir-Rhazoui et al., 2021). This project argues that it is possible to create a potentially powerful methodology which would dramatically increase engagement of local and foreign communities in heritage preservation and development actions. There is no lack of data driven, scientifically proven and technology sound blockchains with Smart Contract functionality (like Cardano, Avalanche, Ethereum, Cosmos, Algorand, etc) on which heritage related practises could be developed and proposed around the world. DLT being one of the biggest disruptive technologies still waiting to be deployed into the cultural heritage area (Trček, 2022).

Communities with a new way for participation could emerge with an incentivized dialogue between (Fig. 3): regulators, real estate developers, business, local communities and international communities (if that heritage area is a matter for all, like objects in the World Heritage List of UNESCO). Proposed ecosystem could be described as decentralized governance through blockchains dAPPs or Smart Contracts where every part could participate by voting for projects, ideas and activities in the place of interest. Another powerful idea is to give the community an active way of preserving heritage and taking actions like collecting 2D photos, drone surveying or, if available, 3D scanning in exchange of crypto tokens. Collected and revised data is useful for performing digital monitoring procedures with a proposed software, and tokens could be further exchanged in fiat currency, buy some virtual products or services, or give votes with converted governance tokens. Real financial incentives, safety and knowing that indeed your vote can make a difference is all it needs to make these ideas work in real life scenarios of active communities in heritage.

Example of how such an ecosystem (Fig. 4) could potentially work is as follows. Firstly, all described acting actors or groups of interest exchange value propositions between each other (Thwaites & Pailthorpe, 2019; Lidell, 2021). These are votes, crypto tokens and DATA. Communities - local and international - could decide to offer some DATA (2D pictures of some buildings or collection of these on some old town part, 3D data, etc.) for monitoring services where DATA is a key competent for robust and fully scaled functioning of monitoring acts. In exchange, some tokens are uploaded to these communities or individual members automatically. Later these can be used for governance tokens, further exchange with fiat currency, investments or oven donations for the same heritage place, object or particular activities. Communities can also use Smart Contracts or some dApps for creating virtual pools of crypto tokens and voting on some ongoing or future event in that particular heritage area or even participate, for example in Rome's local community actions for or against some, for example, constructions which potentially could go for worse. Communities could fastly, securely (blockchain irreversibility meaning anti-fraudulent nature) and almost seamlessly emerge with "louder voice" for actions, or maybe crowdfunding for legal procedures, or creating a treasury for enhancing collaboration and acting (Anta et al., 2021; Zhang et al., 2018). DLT enables such possibilities like nothing else in the past, because by using DLT there is no need to trust any coordinator, central entity, middle-man or organization for your vote, money or intention to be treated securely, fairly and objectively. That empowers communities to participate in a way that was never really possible. Heritage regulators intention is to have up to date situation view of the protected area, buildings and elements, hence such monitoring software is a key tool for need to work properly. For using digital monitoring services heritage regulators transfer crypto tokens, or in combination with importing some DATA there could be a mixed balance sheet where both ways of using these services can work accordingly. Hence there is a possibility to use public data on behalf of regulators and use services in exchange of that, where only cypro tokens and data are in use - no fiat currency involved here and long procedures when institution is buying some services are no longer needed. That will encourage institutions to share data, exchange it and use it in a most effective way. Lastly, there could be a local community donation by sending some tokens for heritage regulators in order to process some in-depth monitoring analysis and have up to date reports. These tokens could be programmed to be used just for such purposes, hence crypto tokens through Smart Contract is a trustless way of donating when communities would have a guarantee of how their money will be used. Heritage scientist institutions like universities and research laboratories could act in a very similar manner by bringing its own share to an ecosystem. WEB 3.0 will empower individuals to own digital property on the decentralized, more secure and privacy-oriented internet (as opposite to recent WEB 2.0 where big corporations rule and own the majority not to mention governmental online surveillance, etc.), that is why similar actions could be applied with general public goods and ability to really participate in decisions, acts, processes and ideas how heritage, in this case, could be used, reused, transformed (Fuchs, 2011; Caviglione & Coccoli, 2011; Child…, 2017). Real estate developers and related businesses, in essence, have a completely different approach (Fig. 4) to heritage areas, where the main interest is not to analyze, preserve, but rather transform and change the *status quo* in exchange for financial benefits. This creates usual conflict between communities, regulations and scientific aspects of heritage, but participating in the proposed ecosystem situation could go for better mainly because of the broad, open and interconnected participatory nature of all working agents in the field. DLT is irreversible blocks of information and exchange of values (Fig. 4) where all agents know for a fact that it is almost impossible to disrupt or corrupt documented processes, votings, regulations and so forth. Hence DLT could mean new era of dissemination and voting taking the fact that everybody anytime could check what was proposed in the, for example, new construction plan or what exact regulations are on the project and this leds to open, irreversible tracking for the processes, potentially preventing some illegal activities and elements to be present in the heritage area, building or it elements (Dhillon et al., 2020; Heiberg et al., 2019; Ben Ayed, 2017). On the other hand, for business it is a "safe playing" mode where anytime it could demonstrate that everything was open and agreed (if agreed) between all agents in the ecosystem. As a result it is always better to take time for effective discussions rather than dealing with bad discussions and the already changed landscape in the old town which is against a law or community's will, not to mention that such on-chain governance could potentially save money for all. Lastly, for example, if a company wants to reconstruct an old building or develop a new one, there is need for 3D, 2D DATA about that case for preparing documentation, architectural drawings, BIM (building information modelling) projects and visualizing ideas for regulators and community (Building…, 2019; Nawari & Shriraam, 2019). Hence monitoring service can provide needed data for that company and in exchange receive some tokens which closes up the entire ecosystem and theoretically demonstrates a real-world need and incentives working in the proposed model.

On the other hand, there are always some risks of adopting new technology versus alternatives. Crypto space itself now is in its infancy and there is whole taxonomy of possible threats from "51% attack" to "DNS hijack" (Ramos et al., 2021) not to mention inherited operation problems in standard blockchain systems like nodes shutting down in participation or oracles feeding false information for smart contract decision making (Perlman, 2020, Table 1).

Rapidly growing number of scientific approaches to DLT comes with exploding interest reflected in research papers during last 6 years (Fig. 5) and more practical, in-depth analysis and pipiles how to introduce DLT in traditional systems are coming (Anta et al., 2021).

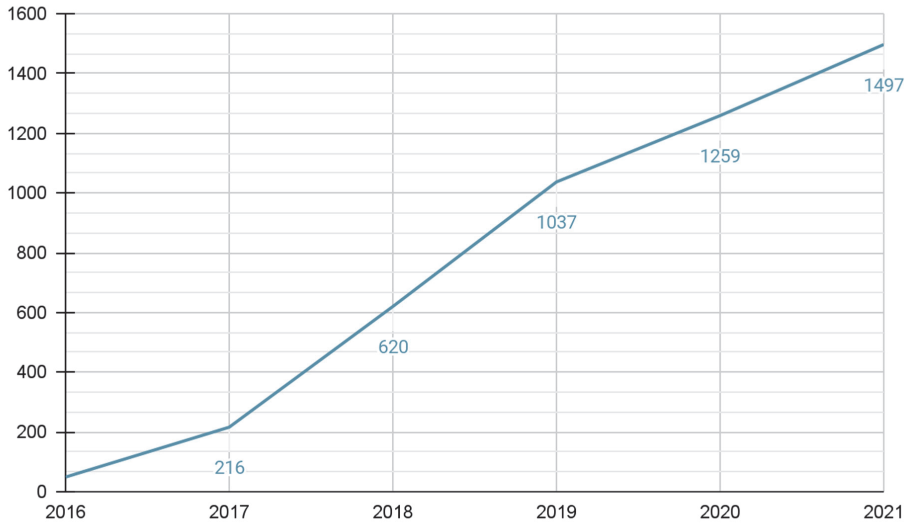

Fig. 5. **Published scientific papers on DLT topic (2016–2021). In the search articles, proceedings, chapters, preprints, edited books and monographs were counted.**

Hence it is clear, that "the distributed ledger technology has the potential of being a game-changer in many domains, its recent developments being triggered not only by technology expectations but also by social ones" (Anta et al., 2021, p. 27), but various steps and processes must be cross checked building a robust finished model of DLT in heritage

Conclusion

In this conceptual paper, the authors develop the model of the ecosystem applying distributed ledger technologies (DLT) in participatory UHP. In a broader sense, the authors perceive the application of DLT as the possibility to democratize the UHP processes to avoid cases of authoritarian practices. The model of the ecosystem also illuminated possibilities for broader e-society development and a higher level of societal inclusion into UHP process, in its shift from conceptualization of the heritage site as a physical complex of objects to that of virtual sets of imagery, making the heritage object accessible at any time, identifiable, traceable, explorable, crowdsoursable and participatory from different spatial and time perspective at the same time. The proposed ecosystem can potentially transform all heritage preservation and research fields by giving a totally new approach with an effective tool for non-destructive, non-invasive, remote and precise monitoring within an economically incentivized governance and participatory blockchain usability of digital monitoring tool (for governments and scientific researchers) and economical aspect of participating with public data in exchange of crypto tokens (for communities and businesses). This ecosystem can outperform established ways of dealing with errorious, illegal, damaging factors which, as it was stated in the beginning of the paper, usually leads to losing heritage valuables which can be lost forever and cannot be redone (Main factors…, 2008). That would drastically increase the level of preservation of usually highly economically appreciated real estate in oldtowns and surroundings (UK Heritage…, 2020). As fundamental literature review of economical cultural heritage aspects concludes: "as confirmed by multiple studies, heritage, if properly managed (bolded by authors), can be instrumental in enhancing social inclusion, developing intercultural dialogue, shaping identity of a territory, improving quality of the environment, providing social cohesion and – on the economic side – stimulating tourism development, creating jobs and enhancing investment climate. In other words, investment in heritage can generate a return in the form of social benefits and economic growth. This has been shown by many authors in theoretical discourse supported by numerous case studies" (Dümcke & Gnedovsky, 2013). It is clear that establishing and spreading such a technological bundle would benefit not only the governance of cultural heritage but will create positive economic outcomes for society who is the end-owner of this culturally and financially sound property. Lastly, heritage sector is a 3% of EU GDP (around 500 billions in 2021) where almost 6 000 000 people are working at the field alone, and the heritage sector is the most important source for tourism, which is highly linked with heritage conservation, and every year generates more than 335 billion euros (Mergos & Patsavos, 2016; Trček, 2022). Moreover, conservation market alone is estimated about 5 billion per year (Mergos & Patsavos, 2016). All in all, these arguments imples, that the proposed model, working in a real life environment, could potentially bring real financial benefits as well.

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