PROPERTY TOKENIZATION DIGITAL FRAMEWORK FOR INCLUSIVE AND SUSTAINABLE ASSET MARKETS DEVELOPMENT

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Abstract

The real estate market is considered as a very promising sector for investments although, it blocks capitals in the short term then the investor can rely on an upgraded asset value in the long term. The concept of a "fractionable" asset can remove some barriers and burdens for owners, promoting liquidity and opening to actors with different financial or social backgrounds.

The univocal ownership of the asset shifts into a shared property freeing up financial resources for the main owner and the acquisition of value for small investors that can acquire a part of the asset defined by a NFT (non-fungible token). This NFT can be sold and bought in a fluid market. This is the core idea of the property tokenization, which can be additionally oriented to revalue the assets in an eco-sustainable way. The property market can be organized and automated through the registration in smart-contracts of a "property token".

The mechanism can be a disruptive financial booster and can renovate the asset exchange and the market using a digital environment. The idea is to connect the assets and the tokens (related to part of the assets) integrated to a new digital cadaster of the real estate assets, connecting the different scales by digital tools: urban scale managed by GIS, building scale defined by BIM models, certifying the exchanged consistencies in a unique and blockchained token.

The paper aims at depicting the framework for business innovation that can promote sustainability and social inclusion.

Introduction

The real estate market is experiencing an increase in investments worldwide and especially in Europe, after the crisis triggered by subprime mortgages in 2007 (Demyanyk and Van Hemert, 2008). Affordable housing and retrofitting challenges in Europe are additionally a crucial concern for social inclusion and progress in community upgrading. Real estate investments are coming not only from European financial institutions, but also from North American private funds and sovereign wealth funds from Middle and Far East countries.

Looking up to the national situation, it is worthy to note that the northern European countries are attracting ten times more investments than Italy (PWC, 2021). The reason for this gap relies in the inability of the housing market to be part of the investors' portfolio. In fact, they prefer a build to sell model, dissimilarly for other building uses. This inability is mainly caused by the poor protection provided by the regulations on lease contracts, which in case of insolvency does not guarantee the owner the repossession of the property (Dahlan, 2014).

Compared to the Italian situation, the German case is significant and antithetical. In Germany, only 45% of citizens own their house and to rent a house according to the flexible and variable needs of space in time is much more common (Bischoff, O., & Maennig, W. 2011). Accordingly, there is a wider supply of these rented properties on the market and a concentration of residential assets lay in the hands of large private real estate companies.

Italy and Germany represent the two extremes of ownership distribution in the real estate market in Europe, further underlining the consequent illiquidity related to the assets. The property tokenization aims to mitigate and make the market more fluid (Latifi et al., 2019, Konashevych, 2020a) which in this moment is a dichotomy: property or rental, with no options in between.

In addition to this ontological condition, there is a disproportionate complexity in the bureaucratic processes for exchanging assets. This is due on the one hand to protect both parties against frauds; nonetheless, on the other hand it represents a significant obstacle that in some cases can override investment opportunities.

Simplification and innovation of these processes guaranteed through asset tokenization can be an opportunity that has not been piloted to date even in the world of cryptocurrencies where non-fungible tokens (NFT) as example associated with the originality certification of works of art are emerging. This technology is transferable, with the due legal restraints, to the proposed tokenization process (Norta et al., 2018).

The "property token" represents a fraction of the asset that defines a new property with a secondary owner, submitted to the main one who maintains the possibility to sell the entire asset, if needed, repaying the property fragments in time. In the meanwhile, the secondary owner or owners can capitalize a reduced sum in a profitable investment. This has an important social outcome as it opens to small and weak investors (e.g. young people, seniors, persons with reduced purchasing power) that cannot afford the investment of a whole asset.

Market rigidity and problem statement

The proposed approach aims to create a new business model that includes aspects of environmental, economic and social sustainability, starting from an observation of the illiquidity created by real estate assets and market conditions. The indivisibility of a property, its high market value and its intrinsic rigidity make asset investment challenging, in case of both investment and disinvestment (Garcia-Teruel and Simón-Moreno, 2021). These issues define a stagnant situation and assets remain frozen, a guarantee handed down between generations, which still excludes the economically less privileged ones from the asset market, penalizing at the same time the older ones who cannot refurbish their assets due to reduced financial resources. These criticalities justify the Public intervention through tax incentives and super-bonuses to relaunch the stagnant market, and at the same time, the need for elasticity in the housing market has opened the way for innovative commercial operations such as Airb&b that removed the third parties between the owner and buyer.

The procedures for buying and selling assets contribute unavoidably to the rigidity of the market, even though for security reasons. Nevertheless, it is not possible fail to take into account the developments in the world of decentralized finance (De-Fi), which bases its strategies on the robustness of blockchain platforms, and towards which the traditional processes of notarization will necessarily have to switch in the future (Konashevych, 2020b).

Bridging the gap with "Property tokenization"

The paper proposes an innovative approach called "Property Tokenization" (PT) aimed at introducing a groundbreaking financial instrument, digital and legally effective, which allows the partial transfer of a real estate asset while maintaining ownership and exclusive use, capable of generating liquidity with an alternative and less absolute solution than the sale of the entire asset. The generated liquidity could be reinvested in the retrofitting and reconversion of buildings in an eco-sustainable direction, creating an additional market for this specific sector and environmentally improving the building stock. Moreover, it could be possible to achieve a social sustainability through the reinvestment of part of the liquidity in social innovation. The Property tokenization could lead to a financial revolution capable of generating important economic implications. This may lead to the creation of a dynamic property token exchange market much like the stock exchange market (Konashevych, 2020b)

The possibility of registering the fragmented and tokenized assets on a public blockchain, associating them with specific smart-contracts that guarantee contractual compliance and simplify the process of buying and selling, is a necessary however not a sufficient condition (Kalyuzhnova, 2018). The digital representation of the asset needs to be coherent with the current legal system, as currently the Registration on Property Register, which is the place where the acts and records related to real estate assets are kept, at present doesn't allow the registration of an asset by non-fungible tokens (NFT).

The process of Tokenization, that could be bound and connected to the asset through an extensive interpretation of the legal institution of bare ownership, can protect the lender against possible frauds through the digital technologies (Konashevych, 2020a). The concept will involve the Notary Council in representation of the notaries, which is now the unique assurance of the reliability of property rights for real estates.

Emerging opportunities with property tokenization could be expanded considering the followings processes that can become further possibilities:

- Fractional: by percentage, or even by architectural characteristics – owning the larger room, the room the a view to the city or the quite room etc;
- time-bound and time-share ownership arrangements for new and existing asset stock, which are difficult to operationalize.

The development of the presented framework also aims at promoting the digital transition of the cadaster towards the implementation of a platform adopting GIS (Geographical Information System) and BIM (Building Information Modeling) for the building units' location within a digital mapping at urban level with adequate levels of detail. This process can be also applicable and expandable beyond buildings though covering countless built environment assets.

Methodology

The technological chain proposed (GIS-BIM-Token - Blockchain-Smart Contract) for the Property Tokenization (PT) concept allows the creation of a transparent, digital and accessible chain, aligned with European policies (e.g. the Digital Europe Programme) and with the evolving management experiences of the built environment in Northern Europe (Heiskanen at al. 2017, Oros, 2016). For example, in the Netherlands, Estonia and Finland GIS and BIM systems are used for managing the regeneration developments of urban areas and projects as well as with respect to the implementation of digital authorization processes (i.e. Digital Building Permit) (Noardo et al., 2020).

The "Property Tokenization" project is based on the possibilities that blockchain platforms enable in terms of programming smart-contracts, i.e. contracts that incorporate the if-then type control functions and digital agreements between parties (Wang et al., 2019b). Their persistence, transparency and immutability is assured by the nature of these agreements, verified and recorded on a blockchain,. Blockchain platforms can be permissioned, if the owner is a single entity that acts as a guarantor of the operation, or permissionless, if the operation is guaranteed by a network of nodes peer-reviewing each transaction (Nawari and Ravindran, 2019).

Smart-contracts can take the form of exchangeable digital tokens in a marketplace if they are fungible in nature, and therefore divisible. On the other hand, if they represent a

unique asset, such as a work of art or a specific piece of real estate, they take the form of non-fungible tokens (NFT) and they can be auctioned or traded for their uniqueness. (Chirtoaca et al., 2020).

The design of a comprehensive platform will enable the storage and exchange of information between the digital tools adopted and their systemic interaction. As first step the GIS platform will define geometrically and geographically an asset in the digital environment. This digital representation of the asset can be associated to a BIM model for the detailed compliance definition required to guarantee the legal procedure of the asset validation for the possible transaction.

Then a digital fragment of the property can be associated to a token with a specific value defined in a smart contract and saved in the blockchain to pledge the validation and the legal contract between the involved parties (Figure 1).
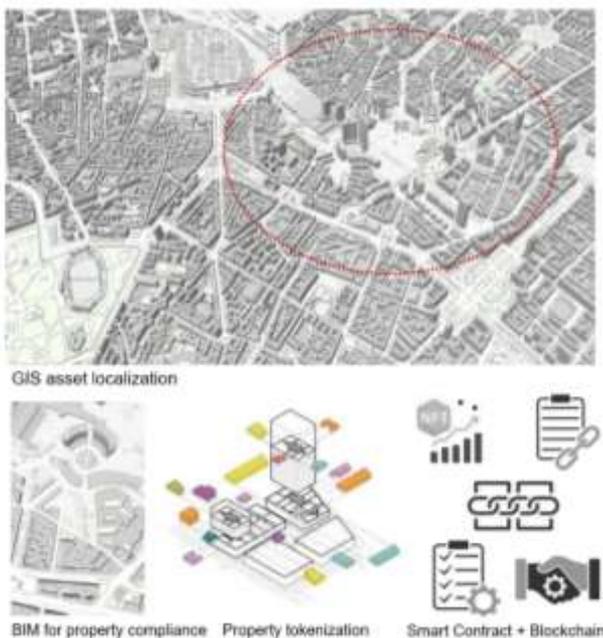

GIS asset localization

BIM for property compliance   Property tokenization   Smart Contract + Blockchain

Figure 1: Digital workflow for Property Tokenization process.

In the GIS model it is possible to associate alphanumeric information of several typologies based on location (Wang et al., 2019a). As an example, it is possible to double-check the rates of sale of real estate assets according to different urban areas, putting in topological relation spatial information.

In Figure 2 the geographical information of the central area of Porta Nuova in Milan, Italy, used as example in figure 1, is enriched with information related to the asset market cost used for the definition of the property specific value. The linked information is listed as follows: the typology of the buildings, the maintenance status (Centro Studi Confartigianato, 2015) the minimum and maximum sale values [€/m^2] for different building uses and the minimum and maximum lease value [€/m^2/month] (Agenzia delle Entrate, 2021). Moreover, the Property Tokenization process could involve areas with different market value increasing the attractiveness of areas with lower value that can be seen as a profitable investment.

Thus, the first step performed has been to connect the digital map of the territory with the building status and real estate value databases to create a system to facilitate the information backbone required to check the market value of the assets in different areas and define the property token values.
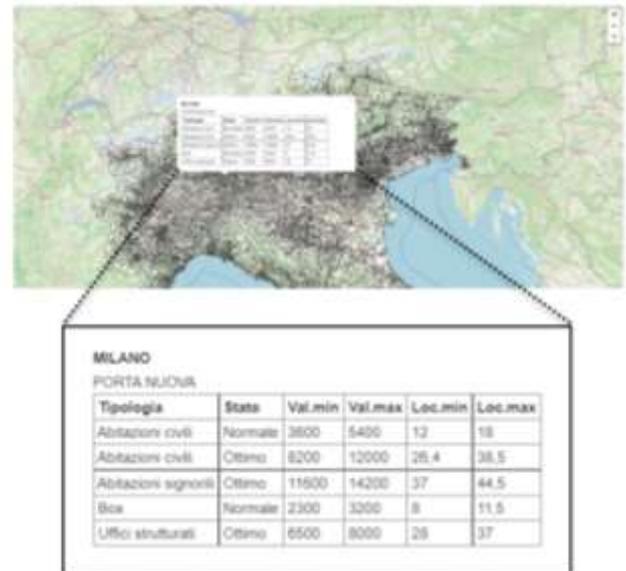

MILANO
PORTA NUOVA

Tipologia	Stato	Val.min	Val.max	Loc.min	Loc.max
Abitazioni civili	Normale	3600	5400	12	18
Abitazioni civili	Ottimo	8200	12000	26.4	38.5
Abitazioni signorili	Ottimo	11600	14200	37	44.5
Box	Normale	2300	3200	8	11.5
Uffici strutturati	Ottimo	6500	8000	26	37

Figure 2: Milan development in Porta Nuova, Italy, rates of sales [€/m^2] depending of the conservation status of the houses, offices and garages, and lease value [€/m^2/month].

The leap in scale from the urban context, where the relationships occur between constraints of the territory, to the building scale of the asset, can be chased by BIM modeling of buildings, allowing a definition of detail at the property unit level (Wang et al., 2019a). In this way, it is achievable to uniquely control the sizes and optionally proceed to an enrichment of the database with property related information (e.g., energy certification, building logbook, technical reports, ownership documents, state of the property, etc.).

The creation of the database of real estate units within the main properties for the subsequent tokenization and transactions by saving the current situation and the contractual conditions in a blockchain will ensure the data transparency and reliability, avoiding disputes or lack of information often affecting traditional procedures. This could disruptively introduce a paradigm shift in the actual management of the asset property exchange where are often discovered after years lacks and errors in property attribution and boundary definition.

The interoperability between GIS and BIM allows to control at the geographical and building level the properties and units creating a recorded land register in an immutable and accredited information chain (Ma and Ren, 2017). Similarly, the digital models permit defining new configurations of any space, optimizing them and verifying their compliance with regulations, regarding sizes, accessibility, air-lighting ratios, etc. through implementable procedures of code checking. In the real estate market is frequent to find properties for sales with significant non conformities that are sell to unconscious

clients. Moreover, during the notarization of the act of sale does not take place any control or assumption of responsibility of the selling party with respect to any unconformity that can be found later on.

The PT has a strong innovative and inclusive nature, proposing a revolution of the management processes in the real estate market in a delocalized way.

Digital innovation of PT

The digital innovation connected to the development of PT encompasses the outline of coordination steps of the technologies organized for the creation of a digital ecosystem that supports the phases of identification, document management and activation of the marketplace of tokenization defined for buying and selling properties.

The platform will offer a range of functionalities in order to guarantee maximum efficiency, transparency and trustworthiness throughout the procedure to endorse assistance for the parties of the transactions and to coordinate the digital cadaster.

The information related to the users participating in the network will be structured with a procedure of subjects accreditation, property documentation collection and verification of the provided data in order to increase transparency and truthfulness of the profiles and types of proposed properties for the service. In the PT platform, the following modules will be hence organized:

- *User master data*: creation of master data for the identification of participants and for access to the blockchain with identifiers and documents related to the ownership of the property;
- *Property master data*: definition of property master data with location, consistency and parceling for subsequent segmentation;
- *Digital enabler module*: connection of the properties to the GIS platform and BIM definition of the proposed consistencies and segmentations with possible analytics on conceivable fragmentation scenarios modulated with respect to the needs of the user and the marketplace, creation of the associated token, organization of the associated smart contract and preparation for the notarization in the blockchain;
- *Unit/product management*: verification and archiving of the document checklist, evolution of the statuses of the file (i.e. processing, verification, location, definition of compartments and sales units, association with the token and smart contract), statistical dashboard for analysis of the units, deeds of sale management of the parcels, acceptance\cession of the units, generation of the transfers details o, invoicing data generation and stocks data saving and transactions in blockchain;
- *Energy retrofit module*: check list of the energy efficiency measures to be implemented and detailed assessment of the units and funds for the re-investment of shares for the energy quality

implementation, using BIM-based interoperability processes for Building Energy Modeling (BEM).

- *Reporting*: possibility to operate punctual extractions from the different functionalities exportable in compatible formats;
- *Data Warehouse*: centralization of the data, daily extraction of the uploaded data in the platform, aggregation process, data verification and standardization, monitoring of Key Performance Indicators (KPIs) for statistical analysis, visualization of the properties in the territorial GIS tool for analytics on the involved urban areas and the territorial spread of the PT.

Product eco-innovation

The project PT intends to encourage investments in existing buildings by privileging them over new buildings and therefore supporting an extended building life cycle. In addition, the possibility of increasing the users' liquidity will allow raising resources to invest in energy efficiency retrofitting that will create cost savings during the operating life of the building reducing its environmental impact. The investments managed through the platform will facilitate the crucial purpose of promoting energy efficiency and monitoring these actions within the digital cadaster. The BIM support could be the basis for a data transfer to energy simulation models (Li et al., 2020) enabling the evaluation and validation of the proposed interventions, thus reducing performance gaps between design and implementation, and strengthening the return on investment economic analysis and the security of the investors.

Process eco-innovation

The PT project aims to use the paradigm of digital transition to increase the supply chain efficiency associated with green real estate investments. The process described above about the creation of the digital platform for the organization of geographical information such as the location, construction, and maintenance status of buildings supported by a shared data environment enables analytics from the financial and energy point of views. This will endorse and sustain the community of users to achieve a high level of economic, social and energy sustainability (Nguyen, 2016, Adams et al., 2018). According to this method, the buildings data becomes usable for different purposes related to the digitization of real estate assets, the energy efficiency retrofitting and will allow releasing investment capacity and supporting social inclusion. The participants in the blockchain arrangement will consequently create a community capable of changing the real estate market, leading the creation of sustainable districts also in disadvantages urban areas. The creation of a digital land register will also pave the way for an innovation at the public administrations level in a coordinated way with a public-private participation. The project proposes an inclusive and digital approach to buying and selling processes management linked to the refurbishment of the built environment, improving also the users' financial

conditions and the existing built environment management. The technologies for the acquisition, localization, modeling, enrichment of information content and data management permit to improve processes that have several criticalities and discrepancies considering transparency and inclusion. They can also guarantee the control of litigation. The driver of innovation is tokenization, which is one of the disruptive consequences of the blockchain technology. This process pledges to convert society towards a vision that encourages the process of dematerialization and commercialization in a positive sense, creating marketplaces where people can value and exchange any item based on a "peer-to-peer" trade. Alongside this, the attractiveness of tokens is their flexibility of denoting ownership (partial, time-bound, etc.) in the present concept of the built assets, helping in mitigating corruption, bribery, illegal activity etc. in the asset ownership. This system basically allows the transformation and representation of transactions of resources or objects within a chain of nodes linked to each other and unchangeable (Li et al., 2019). Once registered on a blockchain, the real estate lot or a part of it can be subsequently exchanged and traded. During this process, a token is assigned to the lot and registered in the blockchain. The tokenization of the real estate market will hence revolutionize today's logic and enable access to the market by an expanded share of users, improving security, adding transparency and traceability, and reducing costs for mediators (Li et al., 2019). The tokenization process is part of a digitalization agenda that expands the purposes and evolutionary possibilities of buildings and cities-related processes with information infrastructures. These permit linking real estate market information to the city's development plan, real estate costs in different urban areas, energy retrofit interventions that will be an integral part of the management of liquidity obtained by the users.

The proposed innovation is therefore disruptive and linked to eco-innovation by supporting efficiency processes with a highly inclusive financial instrument.

Technological and infrastructural assets

The needed resources that form the backbone of the PT project are skills on innovative technologies and sectors in the field of digital services, legal and business expertise as well as knowledge built in a long and continuous research and development on the listed topics of GIS, BIM and blockchain. The digital infrastructures to be used in the future are mainly cloud services, as well as software libraries and APIs. For the development of the prototype, it is envisioned that permissionless and public blockchain arrangements will be used. This adoption of open protocols is justified by the greater solidity guaranteed by a widespread and constant peer-review of software, a review that private producers, however authoritative, are not always able to guarantee. Moreover, these resources eliminate the risk of vendor lock-in by producers. They are the characteristics of blockchain that, in its ontological structure, makes its own: disintermediation, absence of an owner or, in any case, of a supreme manager capable of resetting the system with an absolute inviolability,

transparency of the code, diffusion, and impossibility to be scaled by a majority group of nodes (Perera et al., 2020, Li and Kassem, 2021).

Results

The theme of the renovation of the building stock is a real and compelling objective, not only to redevelop the built environment from an energy efficiency point of view in order to achieve the objectives of the Green Deal, but also to recover it, supporting the policy of net zero targets and zero land consumption (Sustainable Development Goals).

In Italy, real estate assets represent 80% of the investments of the families, for a capital exceeding 6,000 billion euros (Consob, 2020). The total number of real estate units in Italy is 64.5 million, for 12 million buildings, and according to the results of the last census, more than 2 million of these are in a state of poor or very poor conservation, a number that represents about 17% of the total building stock (Centro Studi Confartigianato, 2015). In the period 1998-2019, tax incentives for building renovation and energy retrofit activated about 21 million interventions, triggering investments of over 346 billion euros, with a burden on the State due to the mechanism of tax exemption of these works corresponding to 166 billion euros.

The tax exemption, until the approval of the public incentive for energy retrofitting Superbonus (Agenzia delle Entrate, 2020), was limited to a percentage lower than 100% of the costs, although with the Superbonus 110%, in addition to the coverage of all the costs, there is a percentage for the credit monetization to remunerate the advances given by financial institutions. This is a strong incentive for promoting renovation supporting the historical conjuncture marked by the pandemic; however, this mechanism objectively cannot be refinanced in the medium to long term. The injection of liquidity that the Superbonus entails in the real estate sector is encouraging an overall economic recovery, as it can be detected by looking at the national GDP forecasts.

Exploring new forms of financing based on the tokenization of real estate assets that can be scalable according to their age and that can reduce the government intervention is a necessary and potentially a high-impact area of research. The advantages for different parties can be:

- the owners can gain access to funds and credits without selling important assets, and they can sell a minor asset fragment, ensuring the ownership and full right of use;
- the weak investors that can benefit of new opportunities to improve their purchasing capacity on profitable investments progressing in future safety;
- private financial institutions, which, with different and more effective form of assurance on loans, could benefit from a review of the mortgage institution, helping to solve the critical issues arising from the stock of Non-Performing Loans (NPL) (Kasinger et al., 2021);

- the environment, for the common good where the existing building stock is renovated and revalued, reducing anthropic pressure.

Economic impact

The business model proposed by the PT project allows for a paradigm modification in real estate investments. In a country where the property ownership is at 73% and rental properties are at 27%, it is clear that the acquisition of a property is considered an investment of particular significance for the national residents (Consob. 2020). The requested properties are in the majority three-room apartments (35%), two-room apartments (24%), four-room apartments (24%), 5 or more rooms (23%) and studio apartments (5%) (Global Property Guide Europe, 2021). The main percentage of mortgage requests come from married couples (46-45%) and singles (43-35%) that invest on housing however they change their needs over time with an increasing request of cash liquidity and additional income when retired, creating situation of fragility of the investors or loan solvency incapacity.

An economic value analysis is presented in figure 3 where the value on of the properties in the northern Italy territory is elaborated and visualized on the geographical map giving a specific and consistent information about the highest value in dense cities. The granularity of the information can support the analysis to understand the attributable value to the tokens related to properties located in specific urban areas or moreover it could also enable governments/councils/municipalities to mandate and regulate the housing ownership prices through tokens.

Figure 3: Distribution of economic value [€/m²] in the northern Italy.

The project has an ambitious however attainableobjective, which is to allow the sale of a building portion of a maintaining the complete availability for the owner although increasing the liquidity and allowing safe investments for other actors with respect to the property value over time. The competitiveness of the concept also lies in the gross return of the investment, which for the residential sector is 7.6% (offices 8.6%, commercial 11.5%, garages 6.3%) and allows the seller to increase his purchasing power and the buyer to invest with a high rate of return.

In Table 1 an example of token value for partial disposal (20%) of a property by a 60 years old owner is hypothesized based on art. 14 and 17 D.Lgs n. 346 del 31/10/90 updated by DM 18/12/20 (Agenzia delle Entrate, 2020).

Table 1: Example of Property token: partial disposal

Input Parameters	Unit	Value
Asset value	€	300'000
Disposable percentage	%	20
Owner age	years	60
Annual revaluation	%	2
Years of ownership	Years	25
Output parameters	Unit	Value
Bare property value	€	24'000
Future property value	€	381'468
Revalued bare property	€	61'034
Estimated revenue	€	37'034
Annual income rate	%	9.12

The calculation shows, as the annual income rate is considerably high as investment and the possibility to trade partially the bare property and its value changes in percentage depending on the age of the owner (Figure 4).
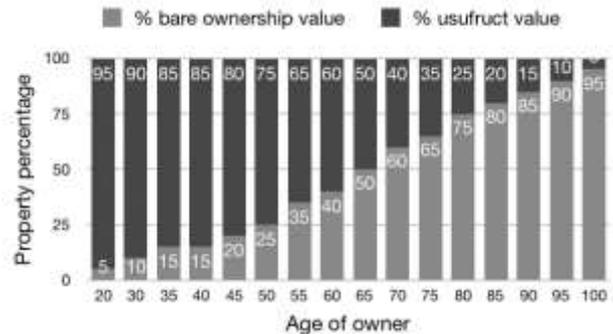

Figure 4: Distribution of bare property value and usufruct value related to owner age.

These assumptions hinged in an exchange platform based on GIS-BIM-blockchain technologies will increase the transparency of activities, permit the possibility to survey the real estate market directions ensuring the security of the investment over time and the opportunity to control and monitor in real-time the changes in the market by the users. Initiatives related to blockchain-based property virtual gaming in the US have shown the possibility of great involvement by users through digital access to homes with a collection of $18M and a valuation of $300M (Animoca, 2021), demonstrating a great expansion potential for this type of real estate transaction management even in a real context with actual social beneifts. The credibility of the process and the option of the relocated control can enable to implement the participation and inclusiveness of the initiative while the digitization of real estate will also have organizational and commercial spin-offs.

Conclusions

The paper outlines an initial concept involving tokenization of assets supported by GIS and BIM technologies from an Italian perspective. It is advocated that the tokenization of properties in a blockchain environment will facilitate the needed flexibility in asset ownership arrangements. This flexibility includes nonetheless is not limited to the fractional ownership of an asset with full rights, fractional ownership of an asset with limited ownership-rights, time-bound ownership and time-share ownership of an asset. It is envisioned that the realization of these arrangements will enable new business models to support communities financially, to raise funds for the refurbishment/retrofitting of the ageing asset stock in Europe, to mitigate the existing housing challenges, and to improve the current inclusivity in the asset market for disadvantaged groups. This will eventually lead to a more dynamic asset ownership and use modes catering to different needs and financial capabilities, and reliving councils/municipalities and governments of pressures for low-carbon retrofitting or affordable housing, tying the property tokenization idea well with key sustainability goals in the built environment.

GIS and BIM will be integrated and function simultaneously in the tokenization as the backbone of information needed at the urban and asset level. Their combined use will help configure the information to be blockchained and controlled in this arrangement to a finer detail. This high-level control will enable advanced ownership offerings. In time, with the rapid digitalization in the built environment, the tokenization idea can be expanded to elements other than buildings (e.g. parks, roads, trees etc.), where funds raised through tokens can be used for environmental, economic and social sustainability purposes. It is predicted that the current level of technology backbone and asset value knowledge is sufficient to operationalize and pilot the PT system.

With an increased level of control in market directions and data analytics enabled through BIM/GIS supported token exchange, authorities will be able to make informed decisions on the market trends for mandates, caps and incentives. This type of asset tokenization on blockchain will also provide guarantees against fraudulent and illegal activities in asset ownership. In time, a dynamic asset token-exchange market can be formed enabling spin-off businesses in this area.

Asset tokenization offers a promising yet disruptive alternative to the currently stagnant asset market. As with all disruptive arrangements, legal, social, technological and management readiness are key concerns to be tackled before a real-life implementation of this arrangement. Consequently, there is research needed in these directions on this promising arrangement of asset ownership and use. However, as discussed in the paper and shown in the exemplary token exchange scenario, there is the business case and socio-economic justification for asset tokenization arrangements.

Beyond the economic sustainability, two additional scenarios related to social and environmental sustainability by tokenization are proposed. Firstly, beyond creating new ways of ownership for the property market, it is possible to configure ultimately the use these arrangements to mitigate homelessness or housing problems, or to create extra income for low-income families as part of social sustainability programs. Secondly, the token sale can be used to create funds for refurbishment/retrofitting of older assets, for example for low-carbon emission, which is a major concern in Europe.

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