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DIGITAL ENVIRONMENT DEFINITION FOR PROPERTY TOKENIZATION UPTAKE IN ITALY

Paolo Mistrangelo[1], Lavinia Chiara Tagliabue[2], and Algan Tezel[3]
[1]Smartmoover Srl, Milan, Italy
[2]University of Turin, Turin, Italy
[3]University of Nottingham, Nottingham, United Kingdom

Abstract

The real estate market can be streamlined by smart contracts that register a "real estate token" on blockchain creating an increased financial liquidity and socio-economic opportunities extended to vulnerable groups. This mechanisms has the potential to be a financial catalyst and to revolutionize property exchange. However, most of the existing discussions are conceptual in this domain or lack integration with other relevant technologies. The contributions of this paper are threefold: (i) discussion on the feasibility of the application of the property tokenization at national level based on the literature; (ii) envisioning an application of a blockchain-GIS and BIM integrated property tokenization model, and (iii) a real-life property economic evaluation example for the tokens made possible by the model's linked data.

Introduction

One of the opportunities made possible by the popular distributed ledger blockchain is tokenization. The property tokenization introduces the use of digital tokens for denoting ownership and property rights in the case of asset market, which holds a great potential in increasing financial liquidity, investment and value exchange opportunities in the real estate market (Wang and Nixon, 2021). The proposed approach described in Mistrangelo et al. (2022) intends to set up a new business model that comprises environmental, economic and social aspects of sustainability, taking off from the illiquidity generated by the current real estate assets and market situation. The conceptual unfragmentable real estate property, its high ranking market price and its inherent stiffness make asset investing tricky, both for investment and disinvestment (Garcia-Teruel and Simón-Moreno, 2021).

These problems outline a static condition and assets persist blocked, a legacy passed down in families between generations, which excludes the economically less fortunate from the real estate market (Mendoza and Thelen, 2008), limiting inclusivity of the ownership particularly for the younger generations. In parallel, the older owners face difficulties when their assets need refurbishment and renovation intervention that are generally not affordable for retired landlords that can only rely on their retirement salary. New methods and business models are rising to overcome these issues affecting the asset market such as tax incentives for supporting renovation strategies aimed at increasing the energy efficiency of the built environment and activating the construction sector on virtuous practices. Moreover, new platforms removing third parties between request and offer in the housing market are catching on (e.g. Airb&b, Wimdu, Wunderflats, Traum-Ferienwohnung, Houzeo, Redfin, Opendoor, etc.).

Furthermore, the need of verification and trust in the asset market transactions turns the procedures into a long and complex process requiring detailed competences and qualified practitioners to navigate the procedure of building compliance to timely changing regulations.

Moreover, decentralized finance (De-Fi), based on the robustness of blockchain platforms is emerging alongside the traditional processes of notarization (Li et al., 2021). In line with this, platforms for property tokenization are entering the marketplace first in the virtual metaverse, and now in the actual real estate market (e.g. Blockchain app factory, Solidblock)

In this context, the process of tokenizing an asset offers multiple benefit by converting the asset value into digital tokens or securities where ownership of the tokens is recorded on blockchain (Latifi et al., 2019), granting the asset owners capital flexibility and options (i.e. tokens related to square meters or smaller dimensions, percentage of the asset) promoting high capital flexibility. This brings value to the asset market by intensifying liquidity, process speed through automation, cost reductions, reduced disputes, and a decentralization of data (Konashevych, 2020b).

To this end, this paper contributes to the tokenization discussions by outlining the applicability of the proposed framework and working mechanisms of a tokenization model integrating GIS and BIM, smart contracts and blockchain, simulating an economic feasibility analysis for the tokenization from an Italian perspective. This is deemed necessary to support the integration of blockchain-based tokenization with relevant technologies and the viability in the actual legal framework.

Literature review and background

The approach to the financial mechanism of property tokenization needs a digital and legally effective instrument to transfer a real estate asset while maintaining ownership and exclusive use for the owner, with the

crucial advantage of creating the resources that can be reinvested in the renovation of buildings towards an environmentally conscious strategy and addressing the third dimensions of sustainability, such as creating social support activities and space for financial communities. In fact, the property tokenization initiative is conceived to promote sustainable progress with social, economic and environment outcomes.

The use of blockchain to register the tokenized asset, associated with specific smart-contracts, ensures contractual conformity and streamlines the purchasing and trading procedure (Kalyuzhnova, 2018). It is crucial that the digital representation of the asset is consistent with the legal system. Currently properties are registered at national level on property registers, where the acts and records related to real estate trading are saved and stored, and the property registers do not comply with recording an asset by non-fungible tokens (NFT - ERC- 721 protocol), which is the way in which real estate tokenization on blockchain is to be realized (Wang and Nixon, 2021).

The tokenization could be constrained to an extensive interpretation of the legal institution of the bare ownership with additional security against possible frauds by means of digital technologies; however, the concept will involve the notary council, which currently provides the exclusive guarantee of the consistency of property rights for real estate assets. In the literature, Garcia-Teruel & Simón-Moreno (2021) analyze legal requirements for tokenization in real estate, highlighting their complexity. Konashevych (2020) gives an account of the government-backed global property tokenization pilots, how they cannot proceed further than initial stages, and introduces the theoretical basis for developing new type of property registries. Baum (2021) outlines the current property tokenization ecosystem with its benefits, challenges and start-ups in this area. Saari et al. (2022b) conclude after a systematic literature review on blockchain in real estate that most of the works in this domain are conceptual, the benefits of the concept need further justification and the proposed systems require reliable data through integration with other relevant and emerging technologies.

This conclusion is backed by Starr et al. (2022) and their analysis for the requirements for Real Estate 4.0 – a spin-off of Industry 4.0. In that regard, there are some initiatives such as BitRent (paused in 2019) integrating BIM, blockchain and smart contracts for real estate development, or proposals adding a BIM model to the blockchain-based real estate information database "the building/property passport", which could be transferred with the asset when the ownership changes (Saari et al., 2002a).

An initiative related to blockchain-based virtual real estate gaming in the United States demonstrates the potential for large-scale user participation with real benefits (Animoca, 2021). Nevertheless, it is observed from the literature that most of the publications in this domain are focused on designing high-level tokenization frameworks with their legal and administrative requirements and there is a need for demonstrating how these systems can generate benefits.

Property tokenization configuration frame

The deployment of property tokenization relies on the creation of smart contracts to run transactions in blockchain. This process is automatically accomplished using executable codes of pre-established instructions which can permit the transfer of assets. In order to do that, "tokens" are created; a token is a digital asset intended to represent a property right. This "digital tokenization" allows the creation of different virtual tokens as defined in the following: using the ERC-20 protocol, fungible tokens can be created; while with the ERC- 721 protocol it is possible to create non-fungible tokens, including specific data and characteristics in their metadata for the definition of unique identification; or with the ERC-1238 protocol non-transferable tokens can be created to represent titles or badges that can only belong to a certain person (Wang et al., 2021).

Therefore, the following types of tokens can be identified:
i) currency tokens, intended to function as a means of exchange and payment;

ii) security tokens, envisioned to represent bonds in companies or in certain projects;

iii) utility tokens, which enable the owner to profit from a utility offered by the issuer;

iv) asset-backed tokens, conceived to correspond to rights, whether of a proprietary or an obligatory nature, over actual assets (Garcia-Teruel, & Simón-Moreno, 2021).

In the property tokenization framework an owner decides to tokenize an asset and to transmit part of it to another subject (asset- backed tokens), consequently the shared ownership can be the entity of smart contracts and transmitted securely in the blockchain. The tokenization of assets issues a number of advantages, such as possibly cheaper and frictionless transactions, enhanced transparency concerning transactional data and information about the issuer, granting investors with direct access to primary and secondary markets or promoting asset flexibility.

Definitely, in the real estate field, this technology could empower to design forthcoming platforms that ease cross-border transactions involving real estate assets in EU or worldwide (the size of the professionally managed global real estate investment market accounted for $9.6 trillion in 2019) (MSCI, 2021). Furthermore, the proposed approach can engage the challenges sat by the digitalization of the collaborative economy and the new economic situations emerged after the pandemic crisis when a freezing effect on residential markets occurred and a decline in transactions by up to 80% was recorded due to the impossibility to perform on site visit to possible assets for purchase and new deals were tarped (Deloitte, 2020).

To overcome these problems and increase the opportunity to connect parties worldwide, the use of technologies for

digital validation of contract certificates via blockchain and virtual reality on-site visits can be proposed.

It is worthy to note, that European countries promoted legal measures to outline the use of smart contracts and specific tokens (Scheinert, 2016). EU countries have been required to publish by March 23 national rules making Regulation (EU) 2022/858 applicable in national laws. The target is a pilot scheme for market infrastructures based on distributed ledger technology. In fact, blockchain technology and traditional finance are similarly advancing in Italy, due to the implementation of the above mentioned European regulation that will allow the exchange of financial instruments such as shares and bonds in the form of tokens. Recently, the Council of Ministers has adapted the national legislation to the provisions of EU Regulation 2022/858: this is the issuance of a decree law that grants the basics for an adaptation to the European instructions on the "tokenization" of financial assets. Thus, there is a new experimental regime for market infrastructures based on distributed ledger technology (DLT pilot regime), which is acting as a forerunner for the digitized finance sector.

Concerning the use of blockchain for land registration, it is possible to underline as the Swedish mapping, cadastral and land registration authority (Lantmäteriet) has initiated an experiment using blockchain technology in a private and public partnership (Saari, Vimpari, Junnila, 2022). In fact, a blockchain trial project has been tested to verify the transmission of real property between parties by registration in the Swedish land registry, targeting time and costs saving for the public administration, by exploiting blockchain to achieve transparency and security. The project was initiated in 2015 and finalized in 2019 with the main benefit for the Swedish authorities related to security aspects of using blockchain technology. Moreover this experiment is particularly stimulating as it can have significant profits in developing countries where a central land registry of real property ownership is not applied, thus reducing the jeopardy of corruption and moreover easing administrative burdens.

Graglia and Mellon (2018) in the Blockchain Property Registry Adoption levels defined the stages used by the blockchain to record the progress of a transaction. In that document the Swedish experience is rated at the 2nd level, below Dubai which is at the 3rd level, as the Central database is replaced with a permissioned blockchain, and the so-called 'Pangea' which is at 6th level, namely a scheme where rights for a given parcel are fragmented and managed via blockchain. The highest levels, the 7th level where rights are transacted without intermediaries and 8th level where interoperability is guaranteed and different blockchain registries are merged are not implemented in any country already.

Some platforms are available for tokenization of assets with little financing (e.g. Atlant, Smartlands and Crowdli-token), nevertheless the business model of these initiatives entails that the ownership of the tokenized asset is typically held by a first corporation, while it is accomplished by a second company that chooses on its use and disposition. The owners of the token simply have the right to collect gains, without obtaining any proprietorship (Garcia-Teruel & Simón-Moreno, 2021).

Although blockchain technology can be used as an automated disintermediated registry that can provide some fundamental tasks of the land registries (reliable publication of the participants, the time, the event, etc.), the identification of this digital registration as equivalent to current national land registries is a public policy concern, consequently defined by policymakers that have to decide to grant a legal effect of the digital notarization. Actually, the broad matching between the current land registries and the tokenization saved on the blockchain can be seen as the most reasonable solution for coupling with legal systems. The parties could require to incorporate information about the blockchain notarization where real estate assets has been tokenized in the official Notarization Registry, in this way it is possible to keep track of the blockchained transactions and the data of the official token owner (Konashevych, 2020).

Italian law (art. 8-ter.3 Legge of 11 February 2019) instituted that the storing of an electronic document through the use of technologies based on distributed registers has the legal effects of the electronic time stamps (art. 41 Regulation 910/2014). The use of automatic systems should have the crucial advantage to reduce the quarrels nonetheless skipping the notarial intervention in the property tokenization means that any possible clash must to be resolved by an ex-post quarrel solution system. However, two main issues such as a coherent control on the content of the contract and the verification of parties' identities could be handled adopting the following steps:

i) adding metadata to the NFT or in a file attached to this metadata of the contract in natural language that can be also analyzed with NLP techniques (Natural Language Processing) to unveil unfair terms. This procedure could be applied not only in customer contracts related to property acquisition, but furthermore in real estate assets contracts;

ii) including the smart contract alternative conflict resolution procedures (e.g. mediation or arbitration) within the blockchain to enable the implementation non only of the lex chryptographica, but harmonizing it with the current law;

iii) determining the identity of the parties in a public blockchain by linking their identity with their digital user through a "sovereign identity", or using a reliable third party, (i.e. notary), or by checking the Civil Registry as an oracle. In this sense, the decentralized system could benefit from encompassing the electronic signature legalized in eIDAS (electronic IDentification Authentication and Signature) (Regulation 910/2014), granting valid authentication across EU countries;

iv) tackling the requirement to certify that the agreement of the parties is not exercised under any type of unwarranted influence or vice (e.g. violence or intimidation). Emotions recognition technologies can be connected with the smart contract to check for hints of any vice of consent to help on this issue as nowadays they are

employed to check emotions related to product advertisements (e.g. Emotient by Apple, or Emotion Research lab) detecting customer's reaction (i.e. happiness, surprise, anger, disgust, fear or sadness).

Methodology

As outlined in the previous section, blockchain-based property tokenization models need integration with other relevant technologies and a better justification of their applicability and benefits. The technological chain proposed in this paper includes the following technological chain: GIS | BIM | tokens | blockchain | smart contract for property tokenization development (Mistrangelo et al. 2022), for the creation of a transparent, digital and accessible sequence (Wang et al., 2019a,b), 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 regeneration projects (Ma and Ren, 2017) s as well as with regard to the execution of digital authorization processes (i.e. Digital Building Permit) (Noardo et al., 2020).

The property tokenization is based on smart-contracts, i.e. contracts that incorporate the if-then type control functions and digital agreements between parties (Wang et al., 2019b), enabled by blockchain. Their persistence, transparency and immutability are guaranteed by the nature of these connections, validated and verified on a blockchain. Blockchain platforms can be permissioned, if the possessor is a unique entity that performs as a guarantor of the process, or permissionless, if the operation is certified by a system 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, and therefore separable. On the other hand, if they represent a unique asset, such as a work of art or a specific piece of asset, they take the form of non-fungible tokens (NFT) and they can be auctioned or traded for their uniqueness (Chirtoaca et al., 2020), as in the proposed scheme (Mistrangelo et al., 2022).

The economic information of a territory and urban areas and typology of building assets can be extracted from GIS models. In a GIS model it is possible to associate alphanumeric information of several typologies based on location, in the proposed model case we checked the rates of sale of real estate assets according to different urban areas, in topological relation with spatial information. The definition of a coordination between GIS shape of the buildings in the city and the updated information on the renovation processes which are coherent between the GIS public maps and the legal tool of the cadaster.

Moreover, the possibility to download the assets to define a volume that can be translated in a BIM model for compliance checking and validation of the real estate property can support the correct and coherent definition of the assets and prevent by the sale of property with undeclared building abuse (as is often the case). Furthermore, information about the asset such as energy certification, building logbook, technical reports, ownership documents, state of the property, etc., can be connected to the digital model creating a consistent and complete repository that can support the building life cycle.

The calculation of the economic value and profitability of the proposed business model by simulation of scenarios created on the owner age, bare property value and investment revaluation is provided. The simulation considers the percentage of asset disposal and the age of the owners related to the annual income rate and revaluation.

The organization of the blockchain for the notarization of the tokens is related to the asset fractions and the value share that is consequence of the value of the territorial areas and asset typology. 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 state the validation and the legal contract between the involved parties. This is demonstrated through an economic analysis of tokens that can be made possible by the linked data from such a tokenization model.

Results

Asset representation and compliance

The organization of assets on a digital platform to enable the connection to tokens and blockchain will open the process to a digital cadaster that can improve the reliability and timely update of the information of assets in cities.

A first test in this direction to justify this claim was executed in the present research by connecting the base information on the city assets to the cadaster information (https://www.cert-o.com/fastmap/dbt_catasto.html) to check the updating of the data. For new developments (e.g. The new University Bocconi campus in Milan, Italy – Figure 1) the DBT (the regional topographic database) is not updated while the cadaster is updated and allows to download the vectorial cadaster geometry information.

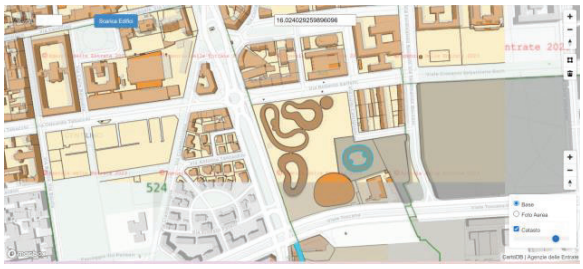

Figure 1: Urban building mapping with cadaster comparison.

The future step will be to define from the extruded polygon the information to generate a building IFC (i.e. height, roof typology, windows distribution, number floors, etc,) and therefore create a direct connection from the cadaster to a BIM model of the asset. This will enable the connection from the GIS and the cadaster to the BIM

definition of the asset that can be adopted to verify consistency and compliance of the building in the platform for the tokenization process (Mistrangelo et al, 2022).

Economic evaluation

An economic value analysis where the value of the properties connected to the public territory map with the costs of asset typologies has been performed (Figure 2). A new development area near Porta Nuova in Milan, Italy was analyzed (Figure 2). The granularity of the information allows to define the token values consistent with specific urban areas and status of the assets.

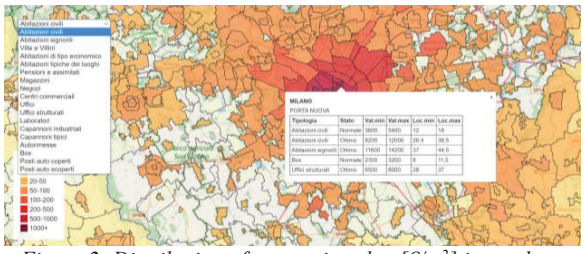

Figure 2: Distribution of economic value [€/m²] in northern Italy (focus on Milan new Porta Nuova area).

In Figure 2, the geographical information of the central area is augmented with information related to the asset market cost, used for the definition of property specific value and thus token values. The linked information is listed as follows: i) the typology of buildings, ii) the maintenance status (Centro Studi Confartigianato, 2015) iii) the minimum and maximum sale values [€/m²] for different building uses and vi) the minimum and maximum lease values [€/m²/month].

The effectiveness of the business model additionally 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%) (Agenzia delle Entrate, 2023)allowing the vendor to boost the perceived value of the property and the customer to invest with a high rate of return compared to other instruments in the trading marketplace. 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.

Table 1: Example of Property token: partial disposal

Input Parameters	Unit	Value
Asset value	€	450’000
Disposable percentage	%	20
Owner age	years	60
Annual revaluation	%	2
Years of ownership	Years	25

Output parameters	Unit	Value
Bare property value	€	36’000
Future property value	€	572’202
Revalued bare property	€	91’552
Estimated revenue	€	55’552
Annual income rate	%	9.12

The calculation shows that 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 year of ownership.

The diagram shows that the annual income rate is actually profitable in time and it is beneficial for the owner to start the share after some year of ownership and can be beneficial to start the share after few years of ownership and this can suggest that the share is suitable not only for long-standing investors but also for new-fangled owners. At the same time the bare property value has a strong revaluation, increasing the percentage of disposal (5-40%) (Figure 4).

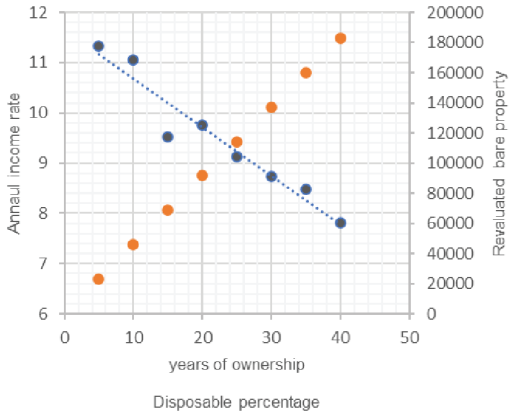

Figure 4: Variation of the annual income rate related to the years of ownership and the revaluated bare property.

An additional simulation is provided considering a buy-back process of the property of an owner who wants to return to being the sole owner of the asset to test the flexibility of the economic mechanism and the feasibility of the procedure (Table 2).

Table 2: Example of Property token: buy-back

Input Parameters	Unit	Value
Asset value	€	450’000
Disposable percentage	%	100
Owner age	years	45
Annual revaluation	%	5

Years of ownership	Years	20
Loan interest	%	2
Output parameters	Unit	Value
Bare property value	€	90’000
Asset cost	€	360’000
Future property value	€	712’752
Revalued Bare Property	€	356’376
Revalued Usufruct	€	356’376
Estimated revenue	€	266’376
Split share	€	133’188
Annual BP income	%	11.02
Annual U	%	3.24
Loan payment	€	1821.18

These assumptions, embedded in an exchange platform based on GIS-BIM- blockchain technology, increase the transparency of activities, allowing the possibility to monitor the direction of the real estate market, and ensuring a long-term investment security.

Conclusions

The paper summarizes a preliminary model concerning tokenization of assets supported by GIS, BIM and blockchain technologies from an Italian perspective by discussing its components, demonstrating how economic analysis for tokens can be executed on the model’s linked data. It is advocated that the tokenization of properties in a blockchain environment will facilitate the needed flexibility in asset ownership arrangements. This plasticity includes but is not limited to the following options:

i) fractional ownership of an asset with full rights;

ii) fractional ownership of an asset with limited ownership-rights;

iii) time-bound ownership and time-share ownership of an asset.

It is intended that the realization of these arrangements will enable new business models to support communities financially, to raise funds for the retrofitting of the building stock in Europe, to mitigate the existing housing challenges, and to improve the current inclusivity in the asset market for underprivileged clusters. This will ultimately lead to a more dynamic asset ownership and use modes catering to different needs and financial capabilities, and reliving municipalities and governments of pressures for low-carbon renovation processes or affordable housing policies, securing the property tokenization framework to sustainability as a key goal in the built environment.

GIS and BIM will be integrated and operate concurrently in the tokenization as the backbone of information needed at the urban and asset level. Their combined use will improve the build-up of the information to be blockchained and controlled in this agreement to a finer detail. This is also necessary to provide reliable data for tokenization applications and render them future proof from a technology perspective as advised in the literature. This high-level management will facilitate innovative ownership offerings. In time, with the rapid digitalization in the built environment, the tokenization idea can be expanded to components other than buildings (e.g. parks, roads, trees etc.), where funds raised through tokens can be employed for environmental, economic and social sustainability purposes. It is expected that the current level of technology backbone and asset value knowledge is adequate to operationalize and pilot the property tokenization system and the blockchain architecture depicted can effectively support the tokenization and registration processes.

With an expanded degree of control in market directions and data analytics enabled through BIM/GIS/Blockchain and 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 deliver assurances against illegal and illicit activities in asset proprietorship (e.g. double sale of the same asset to two buyers). In time, a dynamic asset token-exchange market can be formed enabling spin-off businesses in this area. 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.

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 the refurbishment/retrofitting of aged assets, to reach the goal of for low-carbon emission, which is one of the major concern in Europe related to built environment.

As demonstrated and discussed in the paper, the technological backbone is not the real challenge in implementing tokenization models and opportunities. The technology infrastructure is evolving and available with increasing provisions. What is needed is making the currently static asset ownership laws and regulations, and asset recording and registry administration compliant with tokenization. It can be achieved in two ways: leadership by policy makers and governments, or public pressure with increased awareness on tokenization and blockchain-based applications. In that regard, the next

immediate step for the proposed project is to define a cloud-based architecture and compiling its requirements analysis by the property laws, regulations, administrative processes, and legacy IT systems. The validation a of the model will be also sought with practitioners and academics through a focus group study.

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