Cadastre in Nepal: Need for 3D and Way Towards 4D

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ABSTRACT

Increase in population and its migration towards urban areas are leading to unmanaged urbanization generating pressure on the land. To meet the demand of migrating people, high rise buildings are being developed. Since land is a limited resource, this is a better solution. Rights on vertical strata in the same parcel need to be recorded technically and legally in cadastral data as well as land registers. In Nepali context, despite some limited legal provisions for recording 3D cadastral data, there is still a gap in recording spatial information technically. On the other hand, due to the lack of clear spatial information recording and limited provisions for recording in land registers, land disputes are also arising. However, an increase in land dispute cases is not the only issue; there are a huge number of reasons related to legal and technical provisions in land administration. Therefore, in order to minimize land dispute cases, 4D cadastre can provide a better solution. The paper discusses the legal provisions of 3D cadastre and its need in the context of Nepal, along with the need for 4D cadastre to support in reducing land dispute cases

1. BACKGROUND

Rapid population growth leading to intense pressure on land for urban development ultimately creates limited availability for a growing population, necessitating the development of high-rise apartments and complex building structures above and below the ground. This demand for efficient land administration services to record ownership details of these complex structures (Karki, 2013). Population increase around the world has put more emphasis on land use, and this trend has highlighted the importance of recording changes in the relationship between humans and land clearly and indisputably in a system (Stoter, 2004). Such a system is referred to in various ways, such as cadastral system, cadastral registration, land registry, land registration, land administration, property register, land book etc. In this paper, the system is simply termed cadastre. The paper follows the term cadastre as defined by the International Federation of Surveyors (FIG) in its statement on the cadastre (FIG, 1995): "A Cadastre is normally a parcel based, and up-to-date land information system containing a record of interests in land (e.g., rights, restrictions and responsibilities). It usually includes a geometric description of land

parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g., valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g., for planning and other administrative purposes), and enables sustainable development and environmental protection."

Cadastral registration in Nepal is a record of the land rights that are registered on land and the information of land registration which is linked to parcels are maintained in two different data structures. Hence cadastral registration in this paper refers to both spatial and attribute data. In Nepal, there are two different institutions working for land administration services. Cadastral survey and first registration are done by Survey Offices (SO) and after that, regular land administration services are provided from Land Revenue Office (LRO). In the land administration service, cadastral subdivision and other technical activities are conducted by the SO.

Cadastral registration was originally introduced in Nepal to assist with land taxation during the implementation of land reform program after the formulation of Land Related Act, 1965. It now also provides detailed information required for land transactions, increasing efficiency in land transactions and tenure security. It also provides relevant cadastral information for the government and private sector for various development activities (Stoter, 2004). However, to meet all of these requirements, the system must provide all relevant information such as legal status, Rights, Restrictions & Responsibilities (RRR), location, size, value, use and more. The basic entity for all of this information is the parcel, which is currently shown in 2-Dimensional (2D) cadastral maps. Even though the parcel is represented in a 2D cadastral map, the owner of the parcel is always entitled to the space above and below that parcel in 3D. If the ownership is restricted to the surface only then the use of property would be impossible (Stoter, 2004). The Bathurst Declaration of FIG concluded that "the most land administration systems today are not adequate to cope with the increasingly complex range of rights, restrictions and responsibilities in relation to land" (FIG, 1999) and there is a need for re-engineering in the present land administration system to handle the increasing complexity of the relationship between personal and parcel (Williamson & Grant, 2002).

2. RESEARCH IN 3D CADASTRE

Accurately measuring and visualizing 3D property units is crucial for implementing 3D cadastre. Precise measurement of all dimensions, including height, is necessary to define the 3D boundaries of a property unit (Stoter, 2004). Recent studies have investigated various techniques for 3D cadastral mapping and data collection, including aerial photogrammetry, terrestrial laser scanning, indoor mobile mapping systems, and utilizing existing 3D datasets like building information models (BIM) (Oldfield *et al.*, 2017).

Research is also focusing on 3D visualization and querying mechanisms through web-based 3D cadastral mapping portals, integration with building models, and virtual/augmented reality solutions (Atazadeh *et al.*, 2017). Conceptual data models such as LADM, IndoorGML, and CityGML have been proposed and studied for standardized 3D digital representation of cadastral objects and property units (Kara *et al.*, 2020). Different studies show that institutional and governance aspects, including legislative reforms, professional capacity building, stakeholder collaboration, and business models, are crucial for the successful implementation of 3D cadastral systems (Dimopoulou & Elia, 2012).

3. INTERNATIONAL PRACTICE IN 3D CADASTRE

Global efforts in 3D cadastre showcase the various strategies employed by different countries. Many countries have made progress towards developing 3D cadastral systems and standards in recent years. For example, the Dutch Cadastre, Land Registry, and Mapping Agency (Kadaster) have been at the forefront of implementing 3D cadastre whose system enables the registration of 3D property units such as apartments, utilities, and complex spatial constructions (Stoter *et. al*., 2017).

In 2004, Sweden implemented a 3D cadastral system that enables the registration of 3D property units called 3D property spaces which can represent buildings, apartments, or other structures with intricate spatial dimensions (Paulsson, 2007). Similarly, the Queensland Government has introduced a 3D cadastral system using "building format plans" to define the spatial boundaries of individual property units within a building. This system enables the registration of 3D property units like apartments and townhouses in multi-level developments (Karki *et. al*., 2010).

Singapore has adopted a 3D cadastral system for registering strata titles, used for owning apartments, office units, and multi-level properties. This system also facilitates the registration of subterranean properties like underground tunnels and utilities (Khoo, 2012).

International practices in 3D cadastre offer valuable insights and solutions. They utilize techniques such as 3D digital cadastral databases, spatial data models, and legal frameworks for 3D property rights (Stoter *et al*., 2017; Karki *et al*., 2010; Paulsson, 2007). The insights from global practices can guide Nepal in developing a successful 3D land administration system that suits its specific socio-economic conditions.

4. NEED OF 3D CADASTRE

Tremendous pressure on land especially in urban areas has led to the development of apartments where ownership of apartments overlaps on a single parcel or multiple parcels (Karki, 2013; Stoter, 2004). The significant pressure on the limited available land to develop infrastructure for a growing population is the main driving force behind the emerging 3D cadastre (Acharya, 2011). Different ownership on different floors or even on the same floor in an apartment is also being registered. In the context of Nepal some basic legal provisions have been made to register the flat system in apartments. However, these legal provisions are not efficiently practiced in reality due to unclear working procedures and database management for 3D registration. Despite the legal provisions, there has always been a challenge in describing and recording 3D information in cadastral registration (Stoter, 2004). In addition to high-rise apartments, there is also an increasing number of underground utilities that need to be mapped in cadastral registration. These above-ground and underground developments have increased the interest in 3D cadastral registration, with reasons including but not limited to the following:

- Addressing the challenges of overlapping ownership in multi-level apartments.
- Efficient management of complex ownership structures in urban areas.
- Facilitating accurate property valuation and taxation.
- Enhancing land administration and management practices.
- Improving spatial data infrastructure for urban planning and development off underground structures and utilities.

Overall, the growing complexities in land ownership and development patterns

necessitate the adoption of 3D cadastral registration to ensure efficient and effective land administration in urban areas.

5. EXISTING PROVISION OF 3D CADASTRE IN NEPAL

Besides the provision of surveying and registration of land in 2D context, land related laws and regulations spell out some provision of 3D registration of land.

5.1. Organizational aspect

Two different organizations are involved in land administration services: the Survey Office (SO) and the Land Revenue Office (LRO). The SO conducts cadastral survey and maintains all the spatial data related information such as cadastral maps and field books from the initial survey. Once the cadastral survey and first registration are completed, the SO provides a copy of a register to the LRO. The LRO then maintains all attribute information of land owners including Rights, Restrictions & Responsibilities (RRR) and other information related to person-parcel relationship. All land transactions are handled by the LRO, while the technical aspects of the transactions are handled by the SO.

The Land administration system in Nepal only includes 2D information, with attributes and spatial components limited to two dimensions. Parcels, buildings, roads, canals and other objects on the ground are measured in 2D and their attributes are recorded accordingly. Acharya (2011) identified several shortcomings in the cadastral maps of Nepal including:

- Vertical information is sparse in cadastral maps and does not exist in all subdivision plans, particularly building subdivisions.
- Determination and measurement of dimensions and areas from these maps and plans may not always be as accurate as the clients' aspirations.
- Rights, restrictions and responsibilities cannot be spatially represented in the plans.
- Restrictions and responsibilities are not mentioned in the title.
- Paper-based plans cannot depict the 3D structure and do not support 3D analysis.
- There is no provision for visualizing the third component on the cadastral maps.

5.2. Legal aspect

The 4th amendment of Land (Survey & Measurement) Act in 1978 incorporated the provisions for registering stratified properties, indicating an early recognition of the need for 3D cadastre. However, it was acknowledged that these provisions were insufficient to address all issues related to 3D cadastre. Article 6, sub-article 5(b) of the Land (Survey & Measurement) Act 1963 stipulates that if different floors of the building have different ownership or even if the same floor has different owners, then the ownership should be registered in the name of separate land owners according to the prescribed format provisioned by land (Survey & Measurement) Rules 4 (4). The existing format of the land register and certificate indicate that, in the case of high-rise buildings, such as apartments, the ownership of the land remains with the developer company.

According to the Land Administration Directive" (LAD), directive number 38 clarifies that if the ground floor belongs to one owner and the upper floor has other owners, details of land parcel should be written in the register of the ground floor owner and the description of all the owners of upper floor should be written in its remarks. In the register of the owner of the uppermost floor, the length and breadth of the house and the parcel number of the ground floor are written in its remarks. The LAD does not address the registration of apartments/flats on a floor. The owner of the ground floor can

sell a part of his/her property but the directive remains silent about the subdivision of the property in the upper floor.

The Ownership of Joint Residence Related Act 1997 controls and regulates the permission for construction, sale, ownership and transfer of the property. Some relevant legal provisions are listed as follows: -

- An Apartment can be constructed with the permission of concerned legal authority.
- The apartment can be sold, rented or given to use through other means by the legal founder person (having permission to build the apartment) according to the act.
- The apartment owner can transfer the right or sell the apartment with the permission of the founder.

Similarly, the land administration directives provide guidance on recording details of multi-floor properties in land registers, but they do not comprehensively address complex 3D property scenarios, such as shared ownership of a single floor. The legal framework should be enhanced to facilitate proper 3D cadastral registration and documentation of all types of 3D property interests.

5.3. Technical aspect

The technical aspect of 3D cadastre in Nepal encompasses limited regulatory provisions meanwhile insufficient technological infrastructure. According to the Land (Survey and Measurement) Regulation of 2058 B.S., there are provisions for recording the flat system and the related owners' names in the Field Book. Additionally, the Land Records Information Management System (LRIMS), a centralized system operated through intranet and used by LROs, plays a crucial role in ensuring record of apartment and its details. It ensures whether the particular property has an apartment or not, limiting to further transaction of that parcel.

Within LRIMS, there are provisions for recording detailed information about apartments, including apartment number, name, builder's name, block number, flat number, area, height, length, and type. Moreover, LRIMS captures data related to apartment societies, such as society name, district, municipality, ward number, and relevant details.

The integration of LRIMS involves linking the Apartment Table and Apartment Society Table with the main Property Table using Property ID. Additionally, the Apartment Society Table is linked to the Apartment Table using Apartment ID. Furthermore, LRIMS incorporates a Facilities Table, which records information about amenities such as parking, groceries, and shops, linked with the Apartment ID.

Despite these advancements, one notable limitation is the absence of provisions for recording the names of individual flat owners. Also, spatial representation of 3D property is also not included in cadastral data. This gap in data collection represents an area for potential improvement in the technical infrastructure of LRIMS to enhance the comprehensiveness of 3D cadastral information in Nepal.

6. ISSUES IN 3D CADASTRE

Although the provisions of rights, restrictions and responsibilities have been included, they do not address the way they should be registered. The existing technical and legal system does not incorporate the issues such as properties overridden by other owner(s), properties of different owners overlapping on different floors, underground parking, overhead bridges, underground marketplaces and underground cable and utilities. The legal provision for adjudication and documentation of real estate is lacking. Existing legislation for 3D registration or the third dimension on the paper-based plans of subdivision

cannot meet current demands. The technical aspects of 3D data capturing, representation, visualization, updating and modelling of cadastral objects have not been addressed by existing laws. Therefore, there will be some technical obstacles to the development and implementation of the 3D cadastre.

In the present context, various issues need to be addressed to develop a 3D cadastre system in Nepal. Inheritance of property in Nepal is a very sensitive issue. Different rooms of a house can be inherited by different individuals. In some cases, especially in Kathmandu Metropolitan areas, there are places where the ground floor of a building is used by a community, while the upper floors are owned by different owners. In some districts, particularly in remote hilly districts like Jumla, houses are built in such a way that the roof of a house owned by a family is used as a courtyard by the owner of the house built in the upper terrace of the ground (Bhatta, *et.al*, 2005). These are some issues that have not been well addressed by the existing registration system.

With the growing population and a dramatically increase in migration towards urban areas, high-rise residential buildings are becoming the only solution. In the last decade, urban centers have seen significant investment in the construction of such buildings. Middle income families are attracted towards purchasing apartments in these buildings. However, there is hesitation in investment due to lack of clarity about the security of ownership over such apartments. Existing legal provisions do not clearly mention about the rights of the owner of each unit in a multi-story building over common space areas. People are unsure about the future consequences if the building is damaged and whether they have any rights over the land on which the building. Therefore, there is a strong need for clear legal provisions in this regard.

In another scenario, urban centers in Nepal are becoming densely populated, leading to a lack of space for constructing adequate transportation and utility infrastructures. To address the needs of the growing population, these infrastructures must be expanded, requiring the utilization of space below or above the land surface. Acquiring space below and above the earth's surface will involve obtaining rights from the owners of the respective parcels. Without a proper system for registering such cases, efficiency will be compromised, highlighting the necessity of implementing a 3D cadastre system. The current legal framework does not adequately support the registration of overriding interests of different entities over a single piece of land, a task that can only be achieved through the implementation of a 3D cadastre system.

7. CONCEPT OF 4D CADASTRE

Use of land is related to the area over the ground (2D), the area above the ground (3D) and the span of time (4D) (Doner, et. al., 2010). For apartments and underground utilities, a 3D representation is relevant, while changes in legal status of a parcel can be recorded in the 4D. Parcel often undergo changes in ownership either in a whole or in part after parcel subdivision. The history of this information can only be maintained in the 4th dimension (time dimension). Time has always played an important role in maintaining the history in cadastral system but has been treated separately and independently from the spatial aspect (Oosterom, *et. al*., 2006). 4D registration in cadastral system is specifically needed for recording dynamic objects cases, time sharing cases and utilities registration cases (Oosterom et al., 2006). Parcel boundaries in the field can change over time due to river erosion and meandering. In some cases, cattle farmers lease land to graze cattle for many years and put up fences, which may need to be defined as temporary parcel boundaries for that farmer.

In other cases, a certain piece of land can be rented for a specific period of time, or a unit in a building can be shared on a weekly basis, which may need to be recorded. Similarly, the registration of utilities underground is also becoming a crucial issue. To record all of the aforementioned issues, 4th dimension is very necessary.

8. LEGAL ASPECT AND DISPUTE RESOLUTION THROUGH 4D CADASTRE

The time component (4th dimension) in cadastre is necessary to track the history of land transactions and to reflect the reality of rights over due course of time (Vučić, *et al*., 2014). When conducting the land transactions, they are based on the legal framework that existed at the time of the transaction. As the time passes, changes in laws are needed to meet the requirements of the present context, leading to amendments or reformulations of different land-related laws. Recently, questions have been raised about land transactions conducted in the past in relation to current rules and regulations. This situation has increased the number of land dispute cases and the fraudulent land transactions cases by oversight agencies.

In the context of Nepal, most of the fraudulent land transaction cases registered by oversight agencies, were conducted many years ago under laws that were legal at the time but are now deemed fraudulent under current land regulations. The challenge is that decisions made during those periods may be poorly documented or lost due to inadequate archiving practices. Additionally, successive generations of employees may be unaware of these historical transactions. These transactions were genuine at that time they were made. Thus, it's crucial to contextualize such transactions within the legal framework of the time they occurred. Therefore, when analyzing transactions, the time dimension needs to be considered and linked to the prevailing laws at that time. Recording the time dimension (4D) and linking it to the rules and regulations in place at that time will help reduce land disputes and cases of fraudulent land transaction by the oversight agencies.

9. CONCLUSION

Modern day property ownership and land use are rapidly being changed to the highest levels of complexity due to increasing urbanization and population growth. This underscores the need for a more advanced cadastral system capable of not only representing real-world objects in two or three dimensions (3D) but also recording the 4th dimension (time). Nepal's existing cadastral system, though it includes some basic legal provisions for 3D registration, predominantly relies on two-dimensional (2D) cadastral maps and lacks the essential technical and legal frameworks to fully accommodate 3D and 4D cadastre.

The proliferation of high-rise buildings with apartment ownership, underground structures, and extensive utility networks has created a demand for 3D cadastral registration, while the increasing cases of land disputes has highlighted the necessity of 4D cadastre. However, Nepal's current legal framework lacks clarity on issues such as ownership of common spaces in multi-story buildings, registration of overriding interests on a single parcel by different entities, and documentation and adjudication of complex real estate situations.

Nepal's cadastral system struggles with capturing, representing, updating, and modelling 3D cadastral objects. The existing paper-based and semi-analog systems are inadequate to meet the growing need for 3D and 4D cadastre. Precise measurement and documentation of all dimensions are crucial for accurate visualization and modelling of 3D property units.

To establish a robust 3D and 4D cadastre system in Nepal, a comprehensive approach is necessary. This includes updating the legal framework to incorporate clear provisions for 3D property rights, registration, and adjudication over time, developing technical standards and guidelines for 3D data capture, modeling, visualization, and management over time, providing training and capacity building, exploring the use of modern technologies such as 3D GIS, BIM, and VR tools to enhance the visualization and management of cadastral data. By addressing current challenges and adopting a holistic approach, Nepal can establish a more efficient, transparent, and equitable land administration system that meets the needs of a rapidly urbanizing population.

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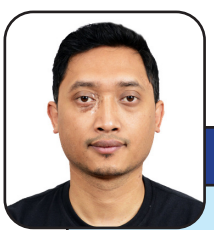

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