Evaluation of the potential for the implementation of a 3D-Cadastre in urban areas in Indonesia

by

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LIST OF ABBREVIATIONS

BPN	National Land Agency (*Badan Pertanahan Nasional*)
BAL	The Basic Agrarian Law (Law Number 5 in the year 1960)
HM	The Right of Ownership (*Hak Milik*)
HGB	The Right of Building (*Hak Guna Bangunan)*
HP	The Right of Use (*Hak Pakai*)
HGU	The Right of Exploitation (*Hak Guna Usaha*)
HT	The Security Right (*Hak Tanggungan)*
LOC/KKP	Land Office Computerization / *Komputerisasi Kantor Pertanahan*
MRT	Mass Rapid Transit
PTSL	Systematic Land Registry Completion Program / (*Pendaftaran Tanah Sistematis Lengkap*)
UUPA	The Basic Agrarian Law /*Undang-undang Pokok Agraria*

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SUMMARY

Construction around urban growth is a phenomenon in the fast-growing and evolving landscapes of Indonesia's largest cities. A lot of the infrastructure is being built above and below ground level: this is in contrast to the low-rise cities with transportation networks that evolved in the colonial and post-colonial times.

The Indonesian Land Registration System still uses a two-dimensional cadastral model which is inadequate for the three-dimensional above-ground landscapes and the complex infrastructure. Land registration is becoming unmanageable, with an increasing number of conflicts around land rights, registration, and responsibilities.

This research endeavours to understand the opportunities and obstacles around the implementation of a 3D-land cadastre in Indonesia by conducting a critical and evaluation study in Jakarta and Bandung; and surveying a building of some complexity.

This thesis is composed of seven chapters. Chapter One is an introduction to the study context, including the background; the research aims and objectives of the study; and the thesis structure.

Chapter Two analyses the state of knowledge of 3D-cadastral systems. The chapter focuses on land registration and cadastre; then explores the 3D-cadastral registration systems by identifying the demand for registering unit spaces into a 3D-system and how these systems are developing across the world; and in a third section examines the development of 3D-cadastre system, and considers the laws related to land and buildings in Indonesia.

Chapter Three introduces the research design framework and the methods used. The application of 2D-, partial 3D, and full 3D-methods to survey and make linear measurements of a building of some complexity, the Flinders University Earth Sciences Building (FU-ESB), are described. The procedures for interviews with stakeholders are also outlined.

Chapter Four presents results from the development of a 3D-model of the FU-ESB and compares linear measurements from the 3D-model with those made from 2D- CAD plans, and those made with a distometer. The result showed that both the horizontal and vertical measurements made with the distometer and those from the 3D-were almost identical.

However, differences were apparent for some measurements where 2D- CAD plans compared with either distometer or 3D-model measurements, which is an indication of human error in surveying for or drawing the 2D- CAD plans.

Chapter Five presents the results of the interviews about problems and key issues of current 2D- cadastre systems in two cities, potential solutions were identified and the readiness of the legal system, human resources, and organizational structures to adopt a 3D-cadastral system were examined.

Chapter Six analyses the result from the previous chapter which provides the researcher's interpretations and evaluation of the interviews. It demonstrates the connections between the findings of the study related to the proposed implementation of a 3D-cadastral system using a SWOT analysis.

Conclusions in Chapter Seven summarizes introduction of a 3D-cadastral system in Indonesia with upgrading the legal and institutional frameworks, provide the laws related to 3D-cadastral object, which lead to economic growth; and promotion of the new technology, through Building Information Modelling (BIM) that would be beneficial asset management, decision making, and building performance analysis.

DECLARATION

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed

Date 3 September 2020

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CHAPTER 1: INTRODUCTION

1.1 CONTEXT

Amongst the list of the contemporary global phenomenon, rapid urbanisation ranks highly according to many authorities. Nowhere is this more so than in the rapidly evolving urban landscapes of southern and eastern Asia. For example, in China, Chen et al. (2008) argue that land saving related to rapid urbanization is essential to secure China's long-term sustainability, According to Datta (2006), in India the most important of the six issues related to urbanization is housing. In Pakistan many people are migrating to cities, which is placing increased pressure on basic services such as the provision of housing, electricity, clean water, and healthcare (Kugelman, 2013). Indonesia is no exception to these countries, and its burgeoning cities are prime examples of urban growth and the range of problems that the governance of urbanization heralds.

The focus of this research is on the important issues that the land surveying profession faces, and will continue to face, in contemporary urban landscapes in Indonesia. These issues arise from modern infrastructure development. Of concern is the growth in apartment blocks—ranging from cheap apartments to luxury condominiums; commercial spaces such as 'high-tech' malls and other retail outlets; and complex flyovers and bridges. Simultaneously, road tunnels, train systems, and car parks are carving out new underground spaces. Consequently, the development of new infrastructure in Indonesian cities is occurring below as well as above ground level. This is in stark contrast to traditional low-rise Indonesian cities and the older parts of these rapidly expanding cities with their now seemingly rudimentary surface transportation networks that evolved in the colonial and immediate post-colonial eras.

From my perspective as a land surveyor, the key issue is that the Indonesian Land Registration System still uses a 2-dimensional (2D-) model based on the idea of the traditional low-rise southeast Asian city with a simple surface transportation network. In this model, the land is considered to be a two-dimensional concept—a land parcel or plot–on which there is a single or, perhaps, a two-floor building owned by one person, or a road or railway track. This concept is inadequate for the emerging three-dimensional (3D) landscapes of towering high rises and the increasingly complex and cavernous underground infrastructure that increasingly characterises cities like Jakarta and Bandung, as well as parts of other smaller cities in Indonesia. As high-rise housing and commercial premises have multiple owners, land registration is becoming increasingly unmanageable in Indonesia, with conflicts around land registration, boundaries and responsibilities increasingly coming to the fore.

This research endeavours to understand the opportunities and obstacles around the possible implementation of a 3D-land cadastre in Indonesia by conducting a critical and evaluation of the readiness of key stakeholders in surveying and property management in two important Indonesian cities—Bandung and Jakarta. My employers, the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (BPN), do not yet employ 3D-surveying. Therefore, another important aspect of this research was to improve my understanding of the potential of 3D-surveying, by developing a 3D-model of a relatively complex building on the Bedford Park campus of Flinders University in Adelaide, and then comparing measurements made from the 3D-model with measurements made as part of a partial 3D-survey and from 2D- plans of the spaces within the building.

1.2 AIMS AND OBJECTIVES

The previous section has provided a context for the need to upgrade from 2D- to 3D-cadastral systems in Indonesia. This will be expanded on in the thesis, in particular in the next chapter. However, bearing the context in mind, this section outlines the aims and objectives that have been developed for this research.

The overall aims of the research are:

1. To conduct a critical analysis of the potential for the implementation of 3D-cadastral systems in Indonesia. Specific reference will be made to the obstacles that may hinder its implementation, and the opportunities that will aid the transformation from a 2D to a 3D-system; and
2. To investigate new knowledge that might be applied to surveying in Indonesia. Specifically, to understand the 3D-situation in the context of the 2D-cadastre

system exists; and understand advances in the field of 3D cadastre and the development of 3D models of complex buildings."

The specific objectives are:

1. To use, and critically review, the use of 3D-laser scanning to develop a 3D-model for a complex multi-floor building; and to compare this to other surveying systems.
2. To investigate the feasibility of implementing a 3D-cadastral system in Indonesia.
3. To find evidence of circumstances in which the existing 2D- surveying methods and the 2D-cadastre in Indonesia are inadequate in the face of increasingly complex infrastructure in two major Indonesian cities.

The research questions that emanate from these objectives are:

Research question 1

a. What does a review of research into 3D-cadastral systems and 3D-surveying globally indicate would be the issues facing urban land surveying and property management in Indonesia? This question is dealt with in Chapter 2.
b. What are the issues arising from the use of the current 2D- cadastre in complex infrastructure developments in Indonesia? This question is dealt with in Chapters 5 and 6.

Research question 2

a. How accurate are measurements extracted from a 3D-model of the building surveyed, relative to other forms of measurements at the same locations? This is dealt with in Chapter 4.

Research question 3

a. What are the levels of preparedness of legal frameworks, human resources, and organizational structures and operations to adopt a 3D-cadastre in Indonesia? This question is dealt with in Chapters 5 and 6.
b. How prepared are stakeholders to accept a 3D-cadastral system in Indonesia? This question is dealt with in Chapters 5 and 6.

c. What are the key issues that need to be addressed for full 3D-cadastre implementation in Indonesia? This question is dealt with in Chapter 6.

1.3 POTENTIAL SIGNIFICANCE OF THE RESEARCH

The research reported in this thesis will provide a significant contribution to my employer, the Ministry of Agrarian and Spatial Planning, particularly for their work in urban areas. The research will also offer useful information to licensed land surveyors, land deed officers, apartment/commercial building managers, and unit owners and renters in Indonesia. In addition, the results of this study will be useful for other densely populated countries, such as China, India, Pakistan, and Singapore, which the requirements for more multilevel residential places due to limited urban land areas are very high.

1.4 RESEARCHER POSITIONALITY STATEMENT

I am a geodetic engineer on secondment from the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (BPN) in Indonesia. Prior to taking a secondment to pursue my Ph.D. in Australia, I was Head of the Thematic Mapping Section at the Regional Land Office of Gorontalo Province. I graduated with an undergraduate degree in Engineering from Gadjah Mada University, Yogyakarta, Indonesia, where I also completed a Masters in Geomatics Engineering.

My research at Flinders University was funded by the Indonesian Ministry of National Development Planning (BAPPENAS) through the Scholarship Program for Strengthening and Reforming Institutions (SPIRIT), which is funded through World Bank loan 8010-ID to the Government of Indonesia. As I had to declare my affiliation to BPN as part of the interview process in this research as a requirement of Human Subjects Ethics Approval at Flinders University, this may have unavoidably introduced bias in some of the responses.

1.5 ORGANISATION OF THE THESIS

This thesis is organized into seven chapters. Chapter 1 introduces the overall study context and the research aims, objectives and questions. The second chapter reviews the land cadastral systems (land registration principles and the cadastre concept); 3D-cadastre registration systems; identifies the demand for registering unit spaces into a 3D-system and the development of 3D-cadastre system globally; and examines the development of the 3D-cadastre system in Indonesia. The next chapter specifies the conceptual framework for the study and the research methods used. It describes in detail the methods used to acquire technical survey data of the building on Flinders University campus, and the interviews in Bandung and Jakarta. The fourth chapter provides details on the development of a full 3D-cadastre prototype model for a moderately complex multi-floor building, the Earth Sciences Building on the main campus of Flinders University. This chapter also compares horizontal and vertical measurements made of the Earth Science Building from 2D-CAD plans, those made with a distometer and those generated from the 3D-model. Chapters five and six analyse the possible introduction and integration of a 3D-cadastral system into everyday land surveying and registration in Indonesia. Chapter five provides the results from interviews, and chapter six analyses the results and provides the results of a SWOT analysis conducted on them. Conclusions and recommendations for further research are provided in the final chapter.

CHAPTER 2: 3D-CADASTRAL SYSTEMS – STATE OF KNOWLEDGE

2.1 INTRODUCTION

This chapter reviews the 3D-cadastral system. The first section (Section 2.2) reviews land cadastral systems from the viewpoint of land registration and its principles and considers the cadastre main concept. Section 2.3 explores 3D-cadastre registration systems, identifies the demand for registering unit spaces into a 3D-system, and how 3D-systems are developing across the world. The last part of this chapter (Section 2.4) examines the level of development of a 3D-cadastral system in Indonesia.

2.2 LAND CADASTRAL SYSTEM

A land cadastral system is essential for a nation due to the increasing use of land for investments in buildings and other infrastructure. In densely populated areas a land cadastral system plays important roles for the people who live in the area. These roles are to provide security of landownership; to create business opportunities by maintaining cadastral asset information; to make people aware of data security and privacy; and to prevent land abuse. Therefore a cadastral system should become a tool that manages activities for, and reduces disputes, among people.

2.2.1 Land Registration

As acknowledged by FIG (1995), land registration is the authoritative recording of legally recognized interests in the land. Land registration is used to support several functions, the main functions of land registration are in providing land tenure security through registration of legal documents, ownership, and use rights. One of the secondary functions is property taxation. Land registration systems are often a source of government revenue through the collection of fees and transfer taxes. Land registration is not a static system, it should be improved in accordance with new demands for information, land transactions and expense reduction. In several cases, new land registration systems have been introduced to replace existing systems or informal arrangements.

Principles of Land Registration

A land registration system cannot be separated from its legal framework. According to (Henssen 1995), four basic legal principles can be perceived:

- The booking principle indicates that a change in real rights of a property, especially by transfer, is not legally accomplished until the change or the expected right is booked or registered in the land register.
- The consent principle specifies that the real entitled person who is booked as such in the register must give their consent for a change of the inscription in the land register.
- The principle of publicity demonstrates that the legal registers are open for public inspection and that the published facts can be upheld as being more or less correct by third parties in good faith so that they can be protected by law.
- The principle of specialty explains that in land registration, and consequently in the documents submitted for registration, the concerned subject and object (i.e. real property) must be precisely identified.

Concerning the effect of a land registration system, especially a title registration, three principles occasionally arise namely:

1. The mirror principle, which means that the register is supposed to reflect the correct legal condition;
2. The curtain principle, which means that no further (historical) investigation beyond the register is necessary, except for overriding interests; and the
3. The insurance or guarantee principle, which means that the state guarantees that what is registered is true for third parties in good faith and that a bona fide rightful claimant who is contradicted by the register is reimbursed from a state's insurance fund (Henssen 1995).

The 3D-cadastre concept is created from the specialty principle. The consideration of including a 3D-component in the land registration system, because the existing 2D-cadastral registration cannot stipulate 3D-information on how properties are in three dimensions, e.g., apartment units, thus provides accurate information. Starting from this point, this research will review whether the existing 2D-cadastral registration system is adequate considering the 3D-conditions that exist in urban areas in

Indonesia. This mainly concerns strata title registrations as the main object of 3D-cadastre.

Types of land registration

Land registration is divided into two types. The types of transaction evidence and the protection of rights. Types of transaction evidence consist of four categories: oral agreement, private conveyancing, the registration of deeds, and the registration of title (Larsson 1991)**.** Those can be explained as follows:

- An oral agreement is a transaction that is based on an agreement made verbally in a close-knit society and will be completed by a symbolic act such as handing over a small item as a symbol. It can be a leaf, twig or blade of grass. It is important not only for both parties to be aware of a transfer but also for the rest of the community using verbal affirmation or in witnessing the contract. This method works well for small communities with infrequent transfers; however, it poses problems when communities get larger and/or become less coherent. In Ghana this is called the '*cutting of guaha'*, whereby the seller gives or breaks a leaf, twig or blade of grass (Ollennu & Woodman 1985; Agbosu 2000), while in the Netherlands sellers used to 'throw' a twig or blade from the land being transferred to the purchaser (Dekker 1986).
- In private conveyancing, documents agreeing to the transfer of ownership are passed between the seller and purchaser, usually with the guidance of a land deeds officer. In this case, the State merely provides a legal framework within which this process takes place. Private conveyancing is generally regarded as inefficient and potentially dangerous since it can be subject to fraud as there is no guaranteed proof that the seller is the true owner of the property or land. Private conveyancing was commonplace in England in the mid-19th century (Zevenbergen 2002).
- A deed registration system means that the deed itself is registered. A deed is a document that describes an isolated transaction, and is evidence that a particular transaction took place, But it is in an principle document, and not in itself proof of the legal rights of the involved parties. Consequently, it is not evidence of a transfer's legality. Thus before any dealing can be safely

executed, the actual owner must trace his ownership back to a good root of the title (Henssen 1995). This system is used in some parts of the USA, South Africa, Netherlands, and France (Zevenbergen 2002).

- A title registration system means that it is not the deed, i.e., the transfer of rights, that is registered but the legal consequences of that transaction, i.e., the right itself. Therefore, the right itself together with the name of the rightful claimant and the object of that right (the property) with its restrictions and charges are registered. With this kind of registration, a title or right is created. Countries which operate a title registration system are often divided into three groups which are: an 'English group' (including England, Ireland, some provinces in Canada and Nigeria); a 'German/Swiss group' (including Germany, Austria, Alsace-Lorraine in France, Switzerland, Egypt, Turkey, Sweden and Denmark), and the 'Torrens group' (including Australia, New Zealand, other provinces in Canada, some states in the USA, Morocco, Tunisia and Syria) (Henssen 1995).

The protection of the right of land registration is divided into two types; positive and negative land registration. The positive effect of registration is commonly given by law, which is that it explicitly states that the issuing authority certifies or guarantees the title of the holder of the rights as stated in the registration. The legal entity (subject) mentioned in the registration is seen as the possessor of the title, regardless of the way in which the registration came about. The negative effect exists when the registration only gives an indication that the legal entity mentioned in the registration as the holder of the rights to land might be the legal possessor of the title (Zevenbergen 2002).

The primary difference between them is that in positive registration, the government guarantees that what has been registered gives absolute evidence of ownership of the land; and that if there is a mistake when land is registered the state is under an obligation to compensate the rightful claimant. In negative registration the possibility remains open for the other person to prosecute what has been registered by the government, i.e., registration itself is not the only evidence used to prove the ownership of land.

In some countries, numerous ways are used to give provide land registration. For example, a comparative study was conducted on the real estate registration system in mainland China and Hong Kong (Wang et al. 2018). They found that the advantage of the Hong Kong system is its simplicity, with the complexities being left to the legal profession; while the present system of deeds registration is transformed into a system of title registration. The leading achievement of the Hong Kong system has been in providing full information to the public by establishing a public search system (on condition that the expense of a search is compensated) so that anyone can obtain official land information of a property online. This was different from mainland China where the system was conservative and difficult to access. Another example is from Turkey, where cadastres have been extended to a new land administration system to assist in land taxation and real estate conveyancing (Yomralioglu & Cete 2017). A concise overview of cadastral development was advised, and a new land administration system proposed to eliminate existing legal, organizational and technical issues, to fill gaps in the current system; and to provide a suitable legal basis for a well-functioning land administration system.

2.2.2 Concept of Cadastre

Land registration cannot be separated from a cadastre; both are essential concepts. However, there is a distinction between them. A cadastre is a system to assist land registration through map-based registration. Land registration does not always use the map as a tool to register the ownership of land, but cadastre is an information system that is built by using the large-scale map to provide information related to land ownership. Experts defined a cadastre in a more extensive definition: “A cadastre is an organized public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. Such properties are systematically identified by means of some separate designation. The outlines of the property and the parcel identifier normally are shown on large-scale maps, which, together with registers, may show for each separate property the nature, size, value and legal rights associated with the parcel. It gives an answer to the question of where and how much?” (Henssen 1995).

In line with this definition of a cadastre, according to 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.

A cadastre is always related to spatial information. It is very dynamic and follows technological developments and policy interests in land information. In order to provide complete information, a cadastre is expected to have two basic principles (Van der Molen 2003). First, publicity principles: which means that all documents regarding the creation, transfer, and deletion of rights and interest to land are open for public inspection, thereby providing an opportunity for third parties to be informed about the legal status of the land. Secondly, specialty principles: which mean that all subjects, objects, and their mutual relationships are specified, providing an opportunity to third parties to know exactly which rightful claimants claim which rights and interests to a land parcel.

A land parcel is the basic spatial unit in a cadastre. Each parcel has boundaries that restrain the right of people to use their real property. Two types of parcel boundaries are regularly used in cadastres, general and fixed boundaries. According to the United Nations (1996), in the general boundary case, the precise line of the legal boundary between adjoining parcels is left undetermined as to whether it is one side of a hedge or fence or the other or down the middle. The ownership of the land is guaranteed by the bounding feature, the ownership of which is left uncertain. There is no need for a precise survey, although a reasonably accurate topographic plan is needed. Meanwhile, in the fixed boundary case, boundary corner points become fixed in space when the agreement is reached at the time of alienation of the land. The location of the legal boundary cannot then be changed without some document of transfer. Fixed boundaries are usually acquired by conducting precise survey measurements of the boundaries of the parcel to determine their exact position.

The concept of a 3D-parcel has been introduced in Australia. In these cases, parcels have a volumetric condition, which means that the determination of parcel position involves a height aspect (z) in addition to planimetric (x, y) aspects. Stoter and Oosterom (2006) explored examples of 3D-parcels that have been established in Queensland, Australia. They found four types of parcels with 3D-components, namely:

1. Building parcels that are generally defined by floors, walls, and ceilings.
2. Restricted parcels, which are parcels restricted in height or depth by a defined distance above or below the surface by a defined plane.
3. Volumetric parcels, which are parcels that are fully bounded by surfaces and are therefore independent of the 2D-boundaries of the surface parcels.
4. Remainder parcels, which are parcels that remain after a volumetric parcel or building parcel has been subdivided out of it.

A cadastre also has the principle of specialty, as indicated before. A primary assignment of the cadastre to make a profile of parcels based on an existing or anticipated legal situation, which is then represented on a large-scale map with a parcel identifier. These identifiers are used in the land register to indicate the legal object in a special, short and unambiguous manner (specialty). As mentioned previously, this identifier (usually a parcel number) connects the legal part with the cartographic and surveying part, i.e., maps (Henssen 1995). In a land information system that benefits from computerised database management, a parcel identifier is an essential link between each unit parcel and the attribute information related to it.

Cadastral maps contain spatial information in graphical format. They show the relative location of all parcels in a given region. They commonly range in scale from 1:5,000 to 1:10,000. Diagrams and large-scale maps showing more precise parcel dimensions and features (e.g., buildings, irrigation units, etc.) can be compiled for each parcel based on ground survey or remote sensing. Information in the attribute files of the cadastre, e.g., land values, ownership, or use, can be accessed by the unique parcel codes shown on the cadastral map; thus creating a complete cadastre (FIG 1995).

The use of parcel identifiers to give unique identification can also be used for 3D-properties. For example, in apartment unit registration, the common way to determine the identity of an apartment is based on the land parcels common to all apartments in a building. The identifier of an apartment unit, therefore, is linked to the identifier of the common parcel where the apartment building is erected. An example is that in a strata title, a common parcel is subdivided into a minimum of two-unit apartment (lots). Lot numbers in buildings may be numeric and may be made up in the form FL, TFL, or TL, where T is the tower number, F is a floor number, and L is the lot number (Stoter & Oosterom 2006)

There are several factors that can be used to evaluate the success of land administration systems. One critical aspect of a good land administration system is how far it can satisfy its stakeholders. The stakeholders of land administration system are, for example, government stakeholders (e.g., land and environmental affairs offices; local governments; taxation offices), and private-sector stakeholders (e.g., surveyors, lawyers, notaries, land deeds officers, real-estate agents, property managers, and land and property owners and tenants. This approach will be adopted in Chapters 4 and 5 in this thesis.

2.2.3 ISO Standard 19152:2012 – Land Administration Domain Model (LADM)

ISO 19152: 2012 Standard - Geographical information - The Land Administration Domain Model (LADM) was first introduced by Lemmen (2012). Since then it was raised to ISO 19152. This International Standard defines the Land Administration Domain Model (LADM). The LADM is a conceptual model, and not a data product specification. LADM states that:

- reference to the Land Administration Domain Model (LADM) consisting of fundamental components related to land administration (including above water and land, and elements above and below the earth's surface);
- this model can present an abstract, conceptual model with four packages related to parties (people and organizations); basic administrative units, rights, responsibilities and restrictions (ownership rights); spatial units (parcels, and building legal spaces and utility networks); spatial sources (surveys), and spatial representations (geometry and topology);
- supports terminology for land administration, based on a variety of national and international systems, which are as simple as possible to be useful in practice.

Terminology allows a joint description of different formal or informal practices and procedures in various jurisdictions;

- this model also offers a basis for national and regional profiles; and enables the integration of land administration knowledge from various sources in a coherent approach.

The purpose of the LADM is not to replace existing systems, but to provide a formal language to describe the concept of the system, so that the similarities and differences can be better understood. It is a descriptive standard, not a prescriptive standard.

The focus of this international standard is on land administration which is a broad field which focuses on rights, restrictions and responsibilities affecting land (or water), and the geometrical (geospatial) components thereof. LADM provides a reference model that has two objectives:

- to provide a foundation that can be used for the efficient and effective development and improvement of land administration systems based on Model Driven Architecture (MDA); and
- to enable the parties involved, both within a country and between different countries, to communicate used a based on a shared vocabulary (i.e., an ontology) that is implied by the model.

The second target is relevant for creating standardized information services in a national or international context, where the semantics of the land administration domain must be shared among regions, or countries, to enable the necessary translations. The four considerations in designing a model are that:

- it covers general aspects of land administration throughout the world;
- it will be based on the 'Cadastre 2014' conceptual framework of the International Federation of Surveyors (FIG) [14];
- it will be as simple as possible to be useful in practice; and
- all geospatial aspects follow the conceptual model of ISO / TC 211.

Until now, most countries, states, or provinces have developed their own land administration systems. For example, one country may operate a deed registration system, while another has rights registration system. Some systems are centralized while others are decentralized. Some systems are based on the general boundary approach, others on a fixed boundary approach; and some systems have a fiscal background compared to others with legal systems. The permutations may seem endless. However, when looking at it from a distance, it can be observed that different systems are, in principle, broadly similar in that they are all based on the connections of people to land by ownership or use rights, and in most countries are influenced by developments in Information Technology and Communication (ICT). Furthermore, the two main functions of each land administration (including cadastral and / or land registration) are to:

- keep the contents of this relationships up to date (based on related regulations and transactions); and
- provide information from the (national) register.

Land administration is described as the process of determining, recording and disseminating information about the relationships between humans and land. If ownership is understood as a mechanism through which land rights are held, we can also talk about land ownership. The main characteristic of land ownership is that it reflects social relations regarding land rights, which means that in certain jurisdictions the relationship between people and land is recognized as a legal relationship. In principle, these recognized rights fulfil registration requirements, with the aim of giving certain legal meanings to registered rights (e.g. title). Therefore, land administration systems not only 'handle geographic information', because represent a meaningful relationship between people, and between people and land.

2.2.4 Cadastre 2014

Cadastre 2014 was written by Jurg Kaufmann and Daniel Steudler (Steudler 2014); the Chair and Secretary of the working group 7.1 of the FIG 7 commission. It presents a cadastral vision for the future and is expected to be a benchmark for reforming and developing future cadastral systems. Indonesia is a FIG member and uses the 2014 cadastral benchmark in assessing the development its cadastral system. It is well known amongst the surveying community that Cadastre 2014 produced six key statements about the envisioned world cadastre.

The first statement is:

> "The 2014 Cadastre presents all the rights and legal aspects including public rights and restrictions on land use."

It is known that land resources are limited, and that because of population growth demand for land will continue to increase. For this reason, restrictions on land rights which are often absolute in the public interest will also increase. Therefore, to provide legal certainty over land, all legal facts related to land must be explicitly presented in a cadastral system.

From this statement it is clearly seen that the 2014 cadastral system will expand in scope. Rather than merely presenting land parcels and land rights data in private law as a traditional cadastral function, it will be his is necessary to include the protection of natural resources, including, land from overexploitation, damage or destruction by defining zones or protected areas established by the State. If the land parcel is called a plot of land, then a zone or area designated by limitation on land use it will be a legal land object in the 2014 cadastre. A legal land area or object is usually determined by a political decision in the form of laws and regulations and clearly impacts ownership and controls over land use.

The second statement is:

> "The separation between the map and the register will end".

Currently, land administration systems are generally characterised by the cadastre handling the map being separate from land registration system administering land certificates. This occurs because of the technological constraints of paper-based and pen-based technologies not allow for other solutions.

BPN began building an electronic land database in 1999 through the *Komputerisasi Kantor Pertanahan* / Land Office Computerization (KKP/LOC). All Regional Offices and Local Land Offices in Indonesia have now implemented online computerized systems. The intended that the online service will allow easy communication between each Land Office and the Central BPN Office, between Land Offices and the public community and *Pejabat Pembuat Akta Tanah* (*PPAT*)/Land Deeds Officers (LDOs)); and between Land Offices and other ministries.

In the context of implementing the 2007-2009 BPN agenda on the development of a National Land Management and Information System (*Sistem Informasi dan Manajemen Pertanahan Nasional* (SIMTANAS)) and the Land Document Security System (*Sistem Pengamanan Dokumen Pertanahan* (SPDP)) the activities carried out included scanning all land documents (*warkah*) and the development of textual and spatial databases. This was done in accordance with Presidential Decree No. 34 of 2003 concerning National Policy in the Field of Land, in particular Article 1 which states that the construction of SIMTANAS includes among other things the compilation of a database of land throughout Indonesia and the preparation of textual and spatial applications in land registration services. BPN activities in the context of supporting SIMTANAS and SPDP include the implementation of Land Office Computerization (LOC) and Stand-Alone System (SAS) in land services.

The third statement is:

> "Cadastral mapping will die. Modeling will last "

In the future the map will no longer be the place to store land information. In fact, maps will be vehicles to present land information to the database. They will be changed into models. However, these models cannot be used under current conditions and levels of knowledge.

In the past surveyors have carried out two main cadastral activities - measurements to determine the position, dimension and location of an land object and saving these observations to depict the object on a map. In modelling, after determining the location of an object, the coordinates of the object and the object model will be calculated according to the data model applied and stored in an information system.

The fourth statement is:

> "Cadastres that use paper and pencils will become extinct"

The use of computer technology (geomatics) will continue to increase in developing the cadastre. For textual records, this has been tested across the world; though spatial data handling still requires more sophisticated software. Geomatics technology will become the normal tool for cadastral work; but real-world, low-cost solutions willonly only become possible when this technology is used together with streamlined administrative procedures. Developed, developing and transition countries may need different existing situation models to solve population, environmental and land-use problems. Surveyors around the world will need to be able to think in terms of models and apply modern technology to deal with them.

The fifth statement is:

> "Cadastre 2014 will be more privatized. Cooperation between the private sector and the government will be even tighter. "

The current trend is that many government tasks have been transferred to the private sector, on the premise that they will be more flexible and meet customer demands better. It is envisaged that this will be likewise for cadastres. Meeting customer demand is a key focus of land service activities.

Measurements can be made by the private sector with highly accurate results. Most work in cadastral construction and maintenance is already done by private engineering and surveying companies. However, that does not mean government has lost its function. The government is still obliged to guarantee the legal security of the land administration system and is also still obliged to carry out monitoring and quality control of the ongoing system.

The final statement is:

> "2014 Cadastre will become self-financing"

So far, cadastres are limited in their use to the purposes of land registration, and land sale and purchase transactions. Thus, only a limited number of people benefit deirecty from the information in a cadastre. It is envisaged that in the future cadastral information will not only include land registration data but an increasingly diverse array of land information relating to the land. With demand for this information, it is predicted that the any fees and costs charged to deliver this information to clients, can offset (some of) the costs of building and maintaining a cadastre.

2.2.5 UNECE WPLA Studies

The UNECE (United Nations Economic Commission for Europe) Working Party for Land Administration (WPLA) study (UNECE 2017). It comprises of the parties working in land administration operating under the ECE committee on housing and land management. Its members are the national land administration authority and related authority of the member states of UNECE. It's aims are:

a. the promotion and improvement of land administration and land management in the ECE region;
b. to support security of ownership;
c. to introduce and improve land and cadastral registrations;
d. to develop real estate markets;
e. to implement land and geodata policies; and
f. to promote and implementation the relevant Sustainable Development Goals (from the 2030 Agenda for Sustainable Development and the New Urban Agenda) in the region.

The WPLA's activities are based on cooperation and exchange of experience in UNECE member countries. This is done through:

a. workshops and seminars;
b. reviews of land administration procedures;
c. developing housing sector country profiles, by WPLA the Housing and Land Management Committee;
d. publishing of studies and guidelines on land administration and specific land management topics;
e. benchmarking and preparation of an inventory of land administration systems in the UNECE region; and
f. the provision of policy advice and expert assistance.

Specifically, the parties working on this commission have several major tasks. The first of these is land administration. This general area focuses on increasing the acquisition, registration, storage, maintenance and dissemination of information about real property rights and the geometrical and physical characteristics of the land. There is a long list of sub-tasks with this which include: providing advice on documentation of ownership rights, rents and mortgages, land cover, land-use and land-use restrictions, geographical reference addresses, transfer of ownership rights, adjudication of land rights, settlement of land disputes, cadastral mapping, database activities, real property valuation and mass valuation, protection of personal data, reuse of public land administration data and related activities, cost recovery requirements, professional skills development, taxation of land and real property, real estate market monitoring, electronic service development and participation of land administration authorities in e-government programs.

The second area is land management: which has the general objective of contributing to the formulation, implementation and monitoring of land policies and geo-data policies (including related financial policy issues); and the promotion of sustainable land management programs and projects. This provides support for the implementation of geo-spatial data policies; and contributes to sustainable development in urban and rural areas, with a special focus on land consolidation, protection of natural resources and strengthening governance.

The WPLA is tasked with periodically reviewing its work program to ensure coherence of its activities with the work of the Housing and Land Management Committee and within the overall objectives of the ECE. It does this by coordinating its activities with international governments and other non-governmental organizations in related fields, such as the following UN organisations UN-HABITAT, FAO, UNDP, the UN Global Geospatial Information Management centre (UN-GGIM) and UN regional commissions. Such organisations also include EU institutions concerned with land management activities (e.g., INSPIRE Initiative), European Land Information Services (EULIS), the International Federation of Surveyors Federation (FIG), The Kadastre Permanent Committee in the European Union (PCC), the International Registration Law Center (CINDER), the European Umbrella Organization for Geographic Information (EUROGI), EuroGeographics, and the European Land Registry Association (ELRA) amongst others. It also works with international financial organizations and donors to fund programs and projects relating to land administration in countries in the UNECE region. Furthermore, it encourages public-private partnerships in managing land resource capacity building for sustainable development; which in turn encourages collaboration with educational institutions in capacity building.

2.3 3D-CADASTRE REGISTRATION SYSTEMS

This section will explain 3D-cadastral registration and the increased demand for registering the property in a 3D-Cadastre. It will consider the extent to which 3D-cadastral systems are developing around the world.

2.3.1 3D-Cadastral registration

As stated above, to give a better insight into the relationships between land, rights, and owners a cadastre should be able to answer questions about which rightful claimants' rights and interest in a land parcel or lot; and that these should reflect the principle of specialty. The principle of specialty is needed to develop a cadastral system to manage the intensive use of space above and under the land surface; and a 3D-cadastre is a concept created in order to fulfill the interests of the public that needs complete, accurate, land information to support the activities related to land.

The 3D-cadastre is also a concept that is needed to overcome the problems related to how to give better insights in registering the uses of space in three dimensions rather than two. Basically, the terms regarding 3D-cadastres in this thesis follow the definitions given by Stoter and Oosterom (2006). They explain that a 3D-cadastre is a cadastre that registers and gives insight into rights and restrictions not only for parcels but also for 3D-property units. A 3D-property unit also abbreviated as 'the 3D-property' is the bounded amount of space to which a person is entitled by means of real rights. 3D-property situations (or 3D-situations) refer to situations in which different property units are located on top of each other or constructed in even more complex structures, i.e., interlocking with one another.

According to Van der Molen (2003) a 3D-cadastre is needed if it there is multiple use and multiple ownership of land, In a situation where the separation of ownership is present, the legal object should be represented on the cadastral map. If the legal object coincidences with the real object, the representation of the legal object include the real object. If not, the orientation function of the cadastral map makes a representation of the real object recommendable.

Cadastral registration of the 3D-object

3D-cadastres cannot be separated from the legal point of view. According to Stoter and Oosterom (2006), the present right, which should be taken into account in registering 3D-property situation, can be explained as follows:

- Right of ownership.

  Basically, a legal boundary of land ownership is an infinitesimally thin surface extending from the center of the Earth to the sky and is essentially an abstract concept. In the case of strata titles, such as in high-rise buildings, the boundary surface may be horizontal. In the 3D-situation when multiple uses of land exist, the ownership of land always has 3D-components. Each restriction attached to the right always has a correlation with how much space can be used by the parcel owner. The restriction to limit how far or how much the use of the parcel is needed when multiple uses of a parcel exist. If there is no regulation in either public or private law to regulate the restriction regarding the ownership of land in space, land disputes can arise. For example, in the case of underground construction built through several parcels, if the construction will disturb or damage the existing construction on the surface this becomes a matter of dispute.
- Accession.

  Accession is a legal term used to determine the ownership of certain buildings or constructions that are built above or below the ground surface. There are two types of accession: vertical and horizontal. Vertical accession applies to buildings and other constructions that are permanently fixed to the land and are considered part of that land. Consequently, constructions below or above the surface that are permanently fixed to the surface are owned by the owner of the land unless other rights or restrictions have been established on the surface parcel. Horizontal accession can be implemented if there are constructions that are part of another property. The owner of the main construction is the owner of parts of the construction that encroach on another parcel. In contrast with the principle of accession, the right of superficies gives a chance to differentiate the owner of the parcel and the owner of the construction built-in, on, or above it. The right of superficies is a real right to own or to acquire buildings, works, or vegetation in, on, or above an immovable thing owned by another person.

- The right of easement.

  An easement is a charge imposed on a parcel in favor of another parcel. An example would be a driveway through a property to allow access by the owner of a property. A more common form of the easement is that given to utility companies to run cable and powers line through properties.

- Apartment rights and strata title.

  An apartment is one example of a common 3D-property. The concept of strata title is used to register the ownership of an apartment. In the strata title concept, there are basically two parts to areas of the apartment; a communal area which is held in co-ownership and full ownership of a part of the building which is held by a person or persons. The owners of the apartment units are joint owners of the entire building and the ground below.

Stoter and Salzmann (2003) explained that solutions to register 3D-properties can be achieved with three distinctive approaches. First, a full 3D-cadastre, in which persons are explicitly be entitled to volumes. In this solution, the registration object is fully bounded by 3D-volumes, so the parcel is not considered as a basis for land registration anymore. Secondly, a hybrid cadastre, which provides opportunities to associate prevailing 2D- registration for a traditional-type of parcel and 3D-registration for a 3D-property situation. Furthermore, there are two options for hybrid solutions; the first is the registration of 2D-parcels in all cases of real property registration, and then additional registration of 3D-legal space in the case of 3D-property units within one parcel. The second is the registration of 2D-parcels in all cases of real property registration and additional registration of the legal space of physical objects in 3D-space. The third solution is 3D-administrative tags or files linked to parcels that exist in the present cadastral registration.

2.3.2 The demand for registering the property in 3D-Cadastre

Some researchers have investigated the demand for registering properties in a 3D-cadastre. Stoter and Oosterom (2006) found that no cadastral registration existed that reflected the 3D-characteristics of 3D-property units as part of the cadastral geographical data set (i.e., a cadastral map). Consequently, cadastral registration is not able to provide 3D-insights into the real situation, even though real rights always have entitled a person to a volume and not to flat parcels. 3D-cadastres provide the opportunity for access to the legal status of a stratified property including 3D-spatial information as well as to public law restrictions. While Van der Molen (2003) explains that as a representation of 3D-legal objects to meet the requirement of specialty, the existing system of real rights tends to be appropriate. However, without such representation, real rights should verbally specify the 3D-legal object (i.e., a 3D-description should be made); though this appears to be impossible.

Another way to approach this issue is to look at the user requirements of a 3D-cadastre because any land registration system is meaningless if it does not provide solutions that society demands. As the government is an organization where society is the customer, one role of government is to provide a good service for society. Todorovski and Lemmen (2007) stated that meeting user requirements is a critical success factor; and a factor that is becoming a big challenge for all organisations, whether they are governments or businesses. Organisations which succeed in this are deemed more efficient in their performance. Their products and services are increasingly in demand, which in turn gives them opportunities for investment in improvements and further development. In terms of improving cadastral systems, every country has distinct needs, as well as elements that are common to other countries. The diversity of needs for each country was clearly explained by Williamson (1997). The Bogor Declaration for cadastral reform argues that different countries have different needs for a cadastre at different stages in their development. This is because, at different stages in their development, countries have different capacities for developing cadastral systems. Human, technological and financial resources will determine the most appropriate form of cadastral system that can meet the needs of a country at any one time. Therefore, in order to improve a cadastral system, identifying and focusing bottlenecks, inefficiencies and duplication in the cadastral processes are important. Once processes have been fully documented and understood, it is possible to re-engineer them to improve efficiency and effectiveness in the delivery of cadastral services to the user. Such re-engineering often requires changes to legislation, modified institutional and administrative arrangements, and the use of different technologies.

2.3.3 Development of 3D-cadastral system globally

To understand 3D-cadastral systems, a critical evaluation of research was conducted as part of this research. Therefore, this section explores the development of 3D-cadastral systems around the world. It should be noted that almost all cadastral systems encountered were two-dimensional. Yet, 3D-cadastres have been researched during the last decade. Some countries have been developing 3D-cadastral as a land administration tool and are preparing to implement 3D-cadastres in the future. The research reviewed is structured around the following geographical regions: Asia; Australia and Oceania; Europe; Africa; the Middle East; and the Americas. In addition, two articles on comparative 3D-cadastral research between the two countries were reviewed.

Asia

Guo, Li, et al. (2012) reported on the development of a new city—Shenzhen—being built in southern China. A full 3D-cadastre has been designed and will be embedded in the cadastral system in the future. The research was done to advise the land institution to make simple modifications so that the government could fully implement it for land administration purposes. Their research demonstrates the easy implementation and practicability of a 3D-cadastre system in new developments. Easy implementation and practicability mean that to embed it in the existing cadastral system, the 3D-data would need to be compatible with the 2D-system and that the focus on 3D-modeling and computation which will reduce the disruptive impact on the existing system and data. This research method will help prevent future conflicts in the land administration system because of the clear and explicit spatial land use visualization.

However, they note that the full implementation of 3D-cadastres will require some modifications. First, in changing the organizational administrative framework to support the advanced technology. Second is the problem of applying 3D-representation, which needs extra training of labor to adopt new technology. Moreover, the key issue for the development of a 3D-cadastre is the 3D-geometric computation it relies upon. This will require increased financial investment to add support tools and equipment to move to the 3D-environment and more staff training to run the advanced computation.

Guo, Luo, et al. (2012) also conducted research into solving land management problems that exist in the field of 3D-land utilization in administrative procedures in China. They identified and elaborated on the basic characteristics of land ownership and management and represented the main concepts and steps in the urban land management procedure. In doing so, they revealed the deficiencies in supporting 3D-utilization for urban areas. The result of the research was a proposed new administrative procedure of urban land management: a reconstructed form the existing system.

In China, land ownership has a different basic characteristic from many other countries as it has followed socialist public ownership which can be parsed into ownership by the whole people and ownership by land collectives. To be more specific as stated in the 'land management law', urban land belongs to the whole population (state-owned land) and rural land belongs to rural residents (collective-owned land). Land uses comprise farm use, construction use, and unused. There are strict controls on converting farm use to construction use in order to control the total amount of land for construction use and to protect cultivated land. Trading, transferring and circulating land are allowed only for state-owned (urban) land for construction use, although the ownership of the land still belongs to the entire population. Other forms of trade in land are prohibited. Thus, the focus of cadastral management in China is state-owned land for construction use. This is relevant in the context of developing cities, in which urban governments acquire land owned by peasant collectives and compensate them. Then, they turn the land owned by peasant collectives into land owned by the state.

In 2007, China implemented the 'Property Law' which explicitly stated that the right to use the land for construction applied separately to spaces above and below the land surface. This law, therefore, provides legal support for 3D-land uses, e.g., overpasses; and underground passages, shopping malls, and car parks. Guo, Luo, et al. (2012) discussed this and tried to find solutions that have emerged within 3D-land use, i.e., how to avoid potential conflicts and ensure the realization of 3D-land use rights. In other words, the resulting 3D-systems should have the ability to accurately measure the spatial range (surfaces, lines, and points) of land rights. However, they also noted that 3D-cadastres may lead to more problems involving administrative procedures such as technical specifications and operational procedures for measuring boundary points and surfaces, and the procedures of checking completed 3D-constructions.

(Lee & Koh 2007) explored the 2D- cadastral system in the Republic of Korea and how it is linked to the administrative record. They found that the system cannot handle spaces above and below the land surface and that a new system that can support the conditions of land ownership related to 3D-spaces is required. They found that an experimental implementation of 3D-cadastre could perform 3D-analysis based on 3D-network data model to identify spatial spaces. Further research in Seoul by Park et al. (2009), recognized that the 2D-cadastre was not appropriate to the conditions. Their paper proposed that a 3D-cadastre must be introduced in Korea. This, they argued, should consist of a 3D-cadastre feature model (3D-rights and features derived from case studies) and a 3D-cadastre geometry model (based on ISO19107 Spatial Schema modified for Korea), and the data produced by such a 3D-cadastre data structure which would comprise of point, line, polygon and solid primitives (Soyoung et al. 2010).

In Malaysia, Rahman et al. (2012) report on 3D-modeling for a multipurpose cadastre; for example, linking the physical and legal spaces of buildings and other objects within a multipurpose cadastre, building a relevant database and to enable queries on the objects. They defined the multipurpose cadastre as 3D-modeling of cadastral objects such as legal spaces in and around buildings, utility networks, and other spaces. Objects in the Malaysian multipurpose cadastre can be grouped into two types. The first group consists of components with spatial objects that have legal and administrative definitive (3D-cadastre parcels, 3D-marine cadastre, and 3D-building strata). The second group comprises components that refer to physical spatial objects (3D-topographies such as building footprints), 3D-underground utilities, and 3D-city models. 3D-models are needed to support the existing cadastre system by providing spatial and semantic information on the 3D-objects according to their exact situation in the real world. Their research used the Land Administration Domain Model (LADM) and a Unified Modelling Language (UML). The 3D-modeling for 3D-cadastre has been initiated and a concept for volume parcels introduced. The multipurpose cadastre must be integrated and include marine parcels and strata title conditions. They argued that the proposed approach for incorporating 3D-modeling could be implemented for multipurpose cadastre in the future.

The Singapore Land Authority (SLA) plans to improve its system performance to 3D-cadastre by moving toward a high-level strategic plan called “smart cadastre”. The old system still uses the 2D-system and is inadequate to maintain cadastral improvements. Khoo (2011) argues that intelligent data in 3D is the way to achieve SLA visions of developing a modern 3D-smart cadastre system. Soon (2012) describes the concepts of the Singapore 3D-cadastre system with the integration of land lots, air space lots, subterranean lots, and strata lots in a Web Ontology Language (OWL). This conceptual framework is seen as a logically important step to achieve the vision of a ‘Smart Cadastre’ and emphasizes the semantic aspect of 3D-cadastres.

To sum up, cadastral developments in these countries are pushing for a 3D-system due to the inadequacies of the traditional cadastral systems. In the case study in China, it is clear that the plan to embed a full 3D-cadastral system in an updated administrative framework required high levels of financial investment (Guo, Yu, et al. 2012). The advances in technology and infrastructure developments which characterise this world region, not only provide a need to upgrade the 3D-cadastral system but show that many of the technological advances and first adopters of 3D-cadastres are likely to be in east and southeast Asia.

Australia and Oceania

In Australia, 3D-cadastre is set to revolutionize Australian land registration, development, and planning. First introduced in Victoria, it has forced the representation of 3D-cross-sections in the paper-based plans. However, some obstacles have occurred, such as underground car parks on existing 2D- plans being inadequately represented to identify the object. Vertical information was also not available in subdivision plans, and could not support 3D-projects (Aien et al. 2011).

There are concerns over growing urban populations, urbanization, and industrialization in Australia (Aien et al. 2012). As a result, more complex infrastructure is being built above and below the land surface, therefore the need for 3D-cadastre to manage the development of infrastructure is an important consideration in Australian cities. They presented a 3D-cadastral model with the legal and physical extents of 3D-properties for Melbourne to evaluate the effectiveness of the data model.

The implementation of 3D-cadastre has been considered in Australia by Karki (2013). Due to the different federal and state jurisdictions in Australia, the implementation of a 3D-cadastre is expected to be challenging. He investigated the institutional and technical issues and characteristics of 3D-cadastre development around Australia. Surveys were carried out around Australia and five case studies were undertaken to identify specific issues and characteristics of the 3D-cadastral implementation. The results showed that Queensland registered 3D-rights in a similar way to 2D- rights; however, the data cannot be stored in the existing cadastral database as 3D-objects. He argued that the Queensland authorities needed to develop a specific 3D-cadastre database with corresponding validation rules in the future to implement a full 3D-cadastre in the state. In order to visualize land ownership, the need to provide interactive 3D-cadastral visualization arises. Shojaei et al. (2013) explore methods for this and classified them into three categories. First, features to visualize underground and cross-section views. Secondly, features that can be handled interactively and visually representation. Thirdly, features that show usability and interoperability.

The latest cooperative program between Australian land authorities and the surveying industry is the ePlan program. This aims to replace paper and PDF plans with digital files in a national coverage. This program was first introduced in 2011 in Victoria and is in operation. Olfat et al. (2017) explored the status of ePlan implementation to support 3D-building subdivision plans.

In the early 2000s, New Zealand integrated its survey and title system automatically in a system called Landonline. It supplies cadastral survey data, lodgement, and recording electronically successfully. A new component of this system is the capability to adapt to a 3D-cadastral system (Gulliver & Haanen 2014). This dimension was developed through the two-dimensional plan and elevation graphics supported by text-based information. This system will allow the capture, submission, validation, visualization and recording or rights, restriction and responsibilities in 3D. The updated system is called Advanced Survey and Title Services (ASaTS), and it provides a new way to handle cadastral survey data and integrate parcel data into polyhedron 3D-parcels (Gulliver et al. 2016). The authors also discussed how New Zealand's digital 3D-cadastre could be applied to other jurisdictions (Gulliver et al. 2017).

Only Australia and New Zealand have started to upgrade to a 3D-cadastre upgrade in this world region. Other countries such as Papua New Guinea, Fiji and Vanuatu still working under the prevailing 2D- cadastral system.

Europe

Croatia has a well-developed 2D--cadastral system, and there is a strong capital base to develop this towards 3D-cadastral system. The construction of multi-storey buildings, bridges, tunnels, and public utility infrastructure above and below the ground continues to increase the need for a 3D-cadastre. Vučić et al. (2017) argues that adopting this would lead to better ownership registration and legal security in the real property market, which in turn will provide better land and building management than at present. This argument is relevant to any country that will develop a 3D-cadastral system which has a strong foundation in the application of LADM, which in essence is the provision of 3D-situation registration from the real world that can be applied in the development of new 3D-cadastral systems. Moreover, it will aid the transition from 2D- and 2.5D- to a 3D-cadastral system.

For the formation of a complete 3D-cadastre, it is first necessary to harmonize and adapt existing regulations and to better regulate the registration of separate parts of the real property in the cadastre as a register of basic real property. Therefore, it must develop its own 3D-data registers based on well-established regulations that will guarantee the legal security of registered facts and meet the technical prerequisites for 3D-cadastre.

In the Czech Republic, Huml (2001) explored how 3D-determination of cadastral subjects, especially in real estate definition, related to legal frameworks. Janečka and Souček (2017) presented legal and spatial components to develop with a 3D-cadastre. The Czech government has launched an initiative to build a national set of spatial objects which will define, guarantee and reference 3D-geographic data to the highest level of detail for the entire Czech Republic.

Policy makers in the land sector in Finland have accommodated developments in this field. In this case, adjustments are needed in stakeholders' interests in the development of the cadastral system in Finland. Using the Delphi survey method among the country's cadastral experts, respondents identified digital culture, artificial intelligence and transparency trends, accessibility and data disclosure as the most important megatrends in the development of the Finnish cadastral system to 2035. It is anticipated that new forms of public service and collaboration between public and private sectors in generating cadastral information will appear. Hence the development of a cadastral system as a process that is driven by technological developments, including 3D-cadastres and even 4D-cadastres if a time dimension is added (Krigsholm et al. 2017).

In 2009, the demands for 3D-applications from environmental planning, energy supply, and disaster management were raised by the German authorities. Gruber et al. (2014) explored the process and identified the benefits of a 3D-cadastre for these applications in Germany. Consequently, the German surveying and mapping administration in has accepted the need for fiscal 3D-spatial information (3D-geodata) as a base for multiple applications.

In Greece, as elsewhere, cadastral maps and charts only represent the ground surface. The 3D-reality is presented in a 2D--manner by making the cadastral system bi-dimensional. This condition requires cadastral systems with 3D-enabled geometrical and topological models for property registration and description. An application of a 3D-cadastral registration process has been developed for the village of Castelli on Santorini Island (Papaefthymiou et al. 2004).

Loshi (2015) analysed cadastral system development in Kosovo, in terms of its potential solutions to issues already discussed and to develop A roadmap for the establishment of a 3D-cadastre was developed. The main conclusion was that it is important to build a suitable legal framework; the first step in which is to identify priority areas where 3D-cadastre is needed immediately to provide better security of ownership and to state these in terms of tax collection, property valuation, and mortgage facilities.

Research into 3D-property registration in FYROM (now North Macedonia) was conducted by Gjorgjiev and Gjorgjiev (2009). Due to its recent socialist history, land management was a state function, and individual land (but not building) ownership was not possible. This situation lasted until 2001 when a law adopting the concept of delimitation of the space was passed, so registration of the property could be applied. However, now that buildings can be owned privately, registration in the cadastre needs to be adjusted for 3D-registration since ownership of the land and the ownership above and below ground are different.

In the Netherlands, the first 3D-cadastral registration was carried out in March 2016 (Stoter et al. 2017). Cadastral, organizational, and technical frameworks were examined to gain a deeper knowledge about the optimal way in applying 3D-registration, a methodology representing legal volumes in interactive 3D-visualization that can be entered in the land register. Researchers used the 3D-building information model (BIM) and case studies were conducted at: (1) at the main railway station in Delft, resulting in an actual 3D-registration in 2016; and (2) a building complex in Amsterdam that complemented the case studies from Delft, and illustrated the general workflow from design data to a legal document. They concluded that under certain conditions, the 3D-approach has advantages over the 2D--approach to land registration. But further research was required to develop the land registration process in the future. The optimal 3D-cadastral solution is the exchange of juridical/legal, cadastral and technical aspects that need to be investigated further.

New regulations for a cadastral law have been introduced in Norway (Onsrud 2003). This covered separate rights related to the registration of spaces underground, as well as above the surface, e.g., apartment buildings. Oslo Municipality has established its own 3D-real estate registration system (Valstad 2003). Properties defined in three dimensions can be mortgaged and have similar rights and restrictions as ground parcels. The existing laws did not have arrangements for 3D-objects, so a new method of surveying, mapping and registration was introduced and a new law, The Sectioning Act, was introduced to cover ownership of apartment sections.

The development of a 3D-cadastre in Poland started when the perceived need for space increased and became more complicated through multiple ownership in complex buildings (Marcin 2012). He examined various 3D-objects in Warsaw and analyzed data concerning those objects registered in the cadastre and land registration systems. His general conclusion was that Poland needed to improve its cadastral system by introducing a 3D-cadastre. (Siejka et al. 2014) also proposed a transition from a 2D- to a 3D-cadastral system. They considered an essential part of the modernization of the Poland cadastral system; which is planned and will focus on the protection of property while increasing the efficiency of the database and improve data quality for effective land planning and management.

Initiatives led by United Nations (UN) and FIG for upgrading cadastral systems have been followed by Portugal's Government in trying to adopt an object-oriented model for their cadastral domain. The evaluation of the FIG core cadastral model was proposed for Portugal by Hespanha et al. (2006), and the model was adopted in order to suit the conditions of Portugal cadastre system and learn from other nations. According to Hespanha et al. (2009), the country planned to modify the legal framework for the cadastral domain in 2009.

Vandysheva et al. (2011) presented a 3D-cadastre modeling project for Russia (2010-2012), the main aim of which was to provide guidance in the making of a prototype and in creating the correct legal and institutional conditions 3D-cadastre modeling in Russia. There is a strong drive in the Russian Federation towards a 3D-cadastre to meet challenges of complex buildings, other types of construction, and subsurface networks (e.g., cables and pipelines). This 'investigation project' ended in July 2012, and recommendations for the future introduction of 3D-cadastre were formulated. These included improvements to the Russian legal framework and the organization of 3D-cadastre (Elizarova et al. 2012). The next stage is to evaluate the future workflow around 3D-parcels: accepting newly registered 3D-parcels, and correctly storing them in a database (Vandysheva et al. 2012).

In Serbia, a new Land Administration Domain Model (LADM) was adopted in 2017 (Aleksandra et al. 2017). This system can handle some of the problems that occurred in the old system, i.e., interoperability, the divergence of spatial and textual data, and lack of integration in a cadastral information system. LADM also provides support for 3D-representations and 3D-registration of rights.

In Slovenia, the cadastre is divided into a land cadastre and a building cadastre. The government proposed modernization that would upgrade existing conditions and simultaneously perform an upgrade to a 3D-system (Pogorelcnik & Korošec 2001). The transition from 2D- to 3D-was explored further by Drobež et al. (2017). The main problem is the same as elsewhere, i.e., that a 2D- system cannot define complex 3D-objects and cannot register them on 2D- cadastral maps.

Paulsson (2013) examined 3D-property rights in the Swedish legal system. Though 3D-rights have been implemented for years in Sweden to provide secure and lasting rights in order to maintain land use in complex urban situations. 3D-property rights have also enabled an expansion in the quantity of individual separate ownerships. It has also been found that a 3D-property is a useful way of solving problems related to the use of space by different parties with different needs. In the Swedish legislation, the introduction of 3D-property development has also increased the possibility of constructing and financing large and more complex buildings in particular; and it has created more secure and fairways of constructing infrastructure objects.

Western Asia

Benhamu and Doytsher (2003) investigated a cadastral geodetic solution for characterizing and defining above and below surface spaces for a future analytical, 3D-spatial cadastre which will replace the existing 2D- cadastre system in Israel. The research had a number of elements that are important in the context of this research, such as developing a spatial cadastre model; defining guidelines for the transition from a surface to a spatial cadastre; developing a model to register property rights in a 3D-cadastre; developing a model for managing spatial cadastral information; and creating a geodetic cadastral background for a legal solution. Several actions have been initiated in Israel in preparation for this 3D-cadastre, such as analysis of alternatives for solving problems in the development and implementation of 3D-cadastre. There is a possibility that establishing a 3D-cadastral land database may rely on coupling height information on the existing 2D-database. The alternative would be a new survey with 3D-data. They anticipate that their research will assist the authorities responsible for the cadastre and land registration to understand and characterize the future cadastral environment in order to define proper and accurate registration of land rights.

In neighbouring Jordan, Sadoun and Al-Hanbali (2007) investigated a need to have a better understanding of the spatial issues related to urban modeling in Khalda, Amman. The information has to be spatially linked to the buildings required to accommodate population increases by managing in three dimensions. They believe that such a model does not need to be accurate but should represent reality.

In Turkey, Cadastre Law Number 3402, was passed in 1985 to try and eradicate disputes by assembling all existing cadastral rules under one law and also to produce the basis for a 3D-cadastral that would include subsurface spaces and ascertain their legal position. Although the mandate for the 3D-cadastral survey is described and explained by the law, only a 2D- cadastre exists at the present time and the reality is that legal deficiencies still occur. Aydin (2008) evaluated the use of underground spaces in the cadastral system in Turkey by examining the concept of 3D-cadastral data and the need for registering underground spaces in the traditional 2D- register system. However, no solutions were proposed.

Other parts of the world

Griffith-Charles and Sutherland (2012) assessed the feasibility of introducing a 3D-cadastre in Trinidad and Tobago. They assessed the percentage of the country where 3D-rights exist, were acknowledged and supported; where 3D-restrictions and responsibilities existed and were actively enforced; and the benefits of using 3D-cadastre to manage those rights. They compared this information with the increased costs that would arise from the introduction and maintenance of a 3D-cadastre, discovering that optimum effectiveness would be gained from introducing a 3D-cadastre in high-population density urban and the nation’s oil-producing areas.

Van Oosterom et al. (2005) analysed 3D-property issues in the USA and showed how legal information on the geometry of 3D-properties can be obtained from existing registration data. However, they encountered a problem in that 3D-information was only available in separate documents that were not linked digitally to the administrative information. Therefore, it was impossible to interactively view and query 3D-representations of properties. They developed a prototype GIS for condominiums in Richland County (South Carolina), based on the true 3D-volumetric representation of the individual units and shared facilities and discovered that a full 3D-system required more knowledge and investment technology that the prevailing 2D- system.

The use of visual variables in 3D-cadastres was researched by Wang et al. (2012) in Canada. They found that visual variables can be appropriate for visualization of 3D-legal units in a 3D-cadastre. These include position, size, shape, value, color, orientation and texture (Bertin 1983) and can represent bounded and partially bounded 3D-units; the relationships between 3D-legal units and 2D-land parcels; the relationship of 3D-legal units to corresponding physical objects; as well as representing spatial relationships among 3D-legal units and labelling them with official measurements.

Wayumba (2004) highlighted the need for integrated GIS databases that provide a comprehensive definition of land tenure with 3D-elements of land and its spatial and non-spatial attributes so that land tenure in the arid and semi-arid lands (ASALS), the 10-mile wide coastal strip, and for communal group ranches in Kenya can be recorded and mapped. This is quite different from the studies introduced in this review so far, in that the need is related to rural, rather than urban areas. A need to upgrade land administration, particularly people's land rights, restrictions, and responsibilities, was identified in Nigeria. Though unlike Kenya, this is an issue in urban areas. The story is similar to many countries: the 2D- cadastral system is incapable of handling the complexities of infrastructure growth. It is perceived that a 3D-system will help land administration due to its storage, updating, analysis, manipulation and visualization capabilities (Oyetayoa et al. (2015).

Comparative studies

Pouliot et al. (2013) compared cadastral systems in relation to condominium units in Quebec (Canada) and Alsace Moselle (France), with specific attention on the third geometric dimension of the spatial representation used in each jurisdiction. Their research discusses the advantages and limitations of using LADM (land administration domain model) layouts in the two locations. The advantages of using LADM layouts are in making comparisons easier and matching various concepts and their relationships to obtain a better view of possible semantic conflicts between jurisdictions. This was done through graphical views of both systems. The limitations of the LADM layout are the fact that technical and official definitions must be provided for each property because some concepts remain unclear due to different precise meanings (e.g., spatial unit, the meaning of spatial unit which can be confused since it can refer to space, not the legal object. Some LADM classes were missing and this representing the contents of the cadastral and the co-ownerships plans difficult.

Comparative research on 3D-cadastres in four federal Latin American countries, Argentina, Brazil, Mexico, and Venezuela has been undertaken (Erba & Piumetto 2012). The concept of a parcel, their identification and description, the extension of properties, restrictions on property rights, and other aspects were compared and found to be different. Overall, the research illustrates the importance of how land objects are defined and treated in the legislation in each country. Though the visualization of buildings and their restrictions in a 3D-cadastre offers a considerable improvement for those responsible for urban decision making, there is much progress to be made before the 3D-information is integrated as part of urban legislation and property titles in these countries.

Stoter (2003) investigated infrastructure and building property registration in 3D-cadastres in The Netherlands and Denmark. The comparison showed broad overall similarities, but there are differences. In the Netherlands cadastral information is more accessible than in Denmark, with only one query being required. Whereas in Denmark queries about several registrations need to be done to find out the legal and factual status. Finally, the Dutch cadastral system gives more information about who owners and the people who have rights to a certain parcel. The Danish system does not have information on rights and the subject of rights on that parcel. In summary, she found the Dutch system is in a better state of preparation for a 3D-cadastre than the one in Denmark.

2.3.4 Legal perspectives of 3D-cadastres

Paulsson and Paasch (2013) discussed 3D-research to identify the areas of interest and discuss legal aspects and trends in 3D-property research between 2001 and 2011. Around 150 publications were analysed. 3D-property rights were sorted by four different categories: legal, technical, registration, and organization. More work had been carried out on technical aspects and registration than legal aspects at this time. In the legal category, most studies were discussions about national laws and their practical uses. Many of these researchers believed that fundamental legal research was a pressing need. Subsequent research by Aien et al. (2013) was conducted on the visualization of property rights as legal objects, and the conditions of the building property and utility lines above and below ground.

Any application that can identify detailed and integrate 3D-legal and physical objects for property management and 3D-space management is important. Yet efficient implementation and application requires many elements to support digital 3D-cadastre such as: 3D-property registration laws, appropriate 3D-data acquisition methods, a 3D-spatial database management system and a 3D-visualization platform. Additionally, an appropriate 3D-cadastral data model is needed because this is the key to successful 3D-cadastral development. Such models must be able to reflect the complexity and interrelationship between 3D-legal objects and their physical objects.

Many jurisdictions set their own cadastral data models for legal purposes but ignore the third dimension of sustainability with physical objects and semantic aspects. To overcome this, investigations need to be made about why existing cadastral data models do not facilitate the effective representation and analysis of 3D-data, and the integration of 3D-legal objects with their physical and semantic objects. The 3D-cadastral data model (3DCDM) is proposed as a solution. This has been developed to ISO standards and uses the UML modelling language. Results can be used to improve existing data models and new developments to support 3D-cadastral requirements.

People use and occupy space in various dimensions, but at present the spatial element is still managed in two dimensions. Legal uncertainty and limited land administration are increasingly apparent, especially in urban areas. Therefore, an area of research has emerged that is referred to as "3D-cadastre", i.e., to examine the relationships between the administration of land/space parcels and the reality of their physical building boundaries. Though this area has developed rapidly in the technical literature the field of law has not kept up with this. This fact explains the lack of operational realization of 3D-cadastres. Given that many countries manage property ownership in 3D, it is pertinent to ask why legal issues are not developing. Surely legal issues must be real problem in 3D-cadastral operations in different countries?

Ho et al. (2013) consider, clarify and re-conceptualize the meaning of law as an obstacle to the implementation of 3D-cadastre. They reviewed legal issues in the literature and looked at the extent of their impact using current practices and concluded that it is necessary to facilitate the registration of 3D-properties in the implementation of 3D-cadastresl. This contradicts the dominant assumption that legal issues are a significant barrier. They also proposed considering legal issues through an institutional lens to obtain other insights about legal issues in implementing 3D-cadastre. This framework was used to discuss institutional issues that have not been considered in the literature and they concluded that a significant obstacle to the application of 3D-cadastral lies not in technological or legal issues but in social and cultural issues that form the institutional framework that underpins any cadastral system.

Legal and cadastral frameworks are needed that can overcome these conditions arising from construction above and below ground in facilities in modern society. Kitsakis and Dimopoulou (2014) attempted to summarize the rules governing multi-surface property units in common law and civil law jurisdictions. Civil law is influenced by principles that allow vertical ownership of land parcels. Whereas common law jurisdiction does not explicitly regulate ownership of surface property with its vertical space.

Research has been carried out in many countries which has resulted in legal reforms and special cadastres for certain types of properties such as condominiums, housing companies and the introduction of 3D-property units. Common law has gradually been adopted by civil law jurisdictions. Both jurisdictions share the same concepts, although they differ in structure, terminology, cadastral infrastructure and aspects of implementation.

While the concept of 3D-property has evolved since the late 90s legal aspects have lagged behind technical aspects. Kitsakis et al. (2016) compared the concept of 3D-property in Austria, Brazil, Croatia, Greece, Poland and Sweden. The choice of these countries was based on different origins from civil law and the fact that they are at different stages in implementing the 3D-cadastral system. Their study investigated the concepts behind the main 3D-cadastral property, as well as the deficiencies and weaknesses of 3D-cadastral systems.

At present, a 2-dimensional analogue-based building division is used to limit private, public and communal ownership rights. There is a challenge in communicating the complexity of spatial space in multi-storey buildings. Therefore, 3D-data is being researched as a potential approach in managing complex and vertical storey ownership arrangements.

Atazadeh et al. (2017) argue that the Building Information Model (BIM) can be used for management of 3D-digital data associated with complex ownership spaces because BIM provides a common digital and 3D-data sharing space, which underpins a reliable basis for decision making. However, the ownership attributes and spatial structure have not yet been accommodated in BIM. A series of data elements to manage the complex ownership space have been presented to divide the ownership space in a multi-storey building in Melbourne, Australia. It was concluded that a data model in the BIM domain is required with a prototype multilevel building model to demonstrate 3D-digital data management and its visualization related to complex ownership arrangements

2.3.5 Recent developments in 3D-cadastral research

A review of research on 3D-real property cadastres (Tekavec et al. (2018) stated that a 3D-cadastre is an important interdisciplinary research topic. The main objective appears to be to develop concepts for 3D-cadastre that will encourage research and implementation activities. In the early 1990s the FIG Working Group on 3D-cadastre was formed to link research activities in the field. Under its auspices five international workshops have been held and significant research progress has been made. However, new complex problems have arisen. In particular, the realization of 3D-concepts in multipurpose cadastral systems and the integration of various spatial datasets in 3D-cadastres. In the last decade significant technical research relating to 3D-cadastre has been carried out by LADM (2012), CityGML (2012) and IndoorGML (2014). They also noted that research in legal issues is lagging behind technical aspect: the work of Paulsson and Paasch (2013) is a notable exception.

Research challenges in the area 3D-cadastres are also related to integration of data from other domains, for example BIM data in 3D-data models and vice versa. Modelling structures in building space is also important topic, because of the complexity introduced by data structures, the complexity of the data models, as well as the aspects of data acquisition and the integration of space models in buildings and outdoor models of cities and landscapes. One topic within this area that is relevant to this thesis is the types of 3D-shapes that may need to be included in a 3D-cadastre for urban areas in Indonesia.

In 3D-cadastre registration systems it is necessary to introduce standard 3D-shapesdrawn from 3D-geometry (figure 2.1).

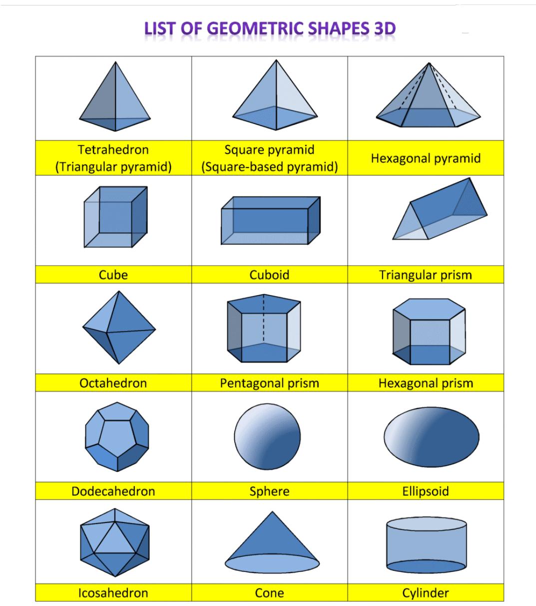


Figure 2.1 3D-geometric shapes.

(Reproduced with permission by (Math Salamanders 2010))

Clearly some of these shapes will be very rare in terms of urban infrastructure. Cubes and cuboids will form the vast majority of spaces, while underground tunnels and overhead passageways may well be cylinders, some modern buildings may include elements which are pyramidal. However, most apartments and retail spaces will be represented as cubes or cuboid shapes (Figure 2.2). A cuboid shape has 6 faces, 12 edges and 8 vertices. All the faces of a cuboid are rectangular. A cube is a special type of cuboid in which all sides are equal length and all faces are square.

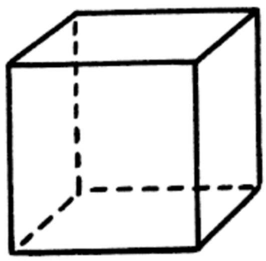
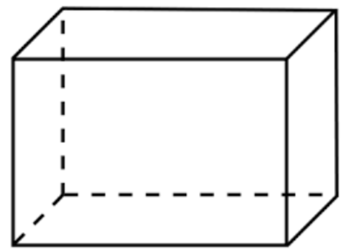
Cube	Cuboid
	

Figure 2.2 Faces, Edges and Vertices as the properties of 3D-geometric shapes (Reproduced with permission by (BYJU'S 2020))

Properties relevant to the development of 3D-cadastres (Figure 2.3) are associated with all of the 3D-shapes mentioned above, except cylinders, are:

- Faces

  A face is a flat or curved surface of a 3D-shape. For example, a cube has six faces.
- Edges

  An edge is where two faces meet. A cube has 12 edges.
- Vertices

  A vertex is a corner where edges meet. A cube has eight vertices.

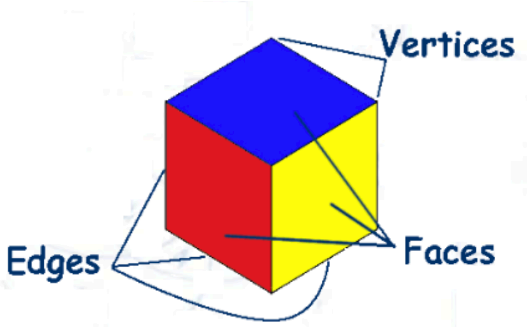


Figure 2.3 Faces, Edges and Vertices as the properties of a cube.
(Reproduced with permission by (BYJU'S 2020))

2.4 DEVELOPMENT OF 3D-CADASTRE SYSTEMS IN INDONESIA

The Indonesian land registration and cadastre system are introduced in this section.

2.4.1 Land registration in Indonesia

Every country has different needs for their land registration systems and, as the FIG statement on cadastres explains, there is no uniform cadastre that can be applied to all countries. Throughout history, many types of cadastral systems have evolved and the differences between them are influenced by, amongst other things, cultural heritage, physical geography, land use and technology (FIG 1995).

The development of land registration in post-independence Indonesia has partly been inherited from the system introduced during the Dutch colonial era between 1600 and 1945. A cadastral system was introduced to 'Indonesia' by the Dutch colonial administration in 1620 but was only applied to private property owned by Europeans. The colonial government conducted its cadastral functions, e.g., surveying and mapping services, from the cadastral office established in 1834. Even at that time, land registration was still for land ownership under a western-style legal and was usually applied to land possessed by non-Indonesians. Indonesians had no uniform regulation for registering their land, though there are some regulations based on *adat* or customary law that varied between tribal groups (Walijatun & Grant 1996).

This dualism of laws - the western system and the traditional system - existed until the Basic Agrarian Law (BAL1960) / *Undang-Undang Pokok Agraria* (Government of Indonesia 1960a) was first enacted as Law 5 of 1960.Until the BAL in 1960 laws were influenced by the colonial government and was in conflict with the interests of the state. BAL1960 tries to unify and simplify the diversity of land laws in Indonesia. It underpins modern land registration in Indonesia. In practice this means that all laws related to agrarian regulations should refer to BAL1960, this includes all regulations about land registration and the use of land, earth, water, and airspace. As BAL1960 is based, in part, upon customary law concerning land this national agrarian law recognizes traditional concepts and institutions while, at the same time, providing for the registration of individual rights to land (Heryani & Grant 2004).

According to BAL 1960, the state has the authorization to control land. Article 2 of BAL 1960 states:

> *"Bumi air dan ruang angkasa, termasuk kekayaan alam yang terkandung didalamnya itu pada tingkatan tertinggi dikuasai oleh Negara, sebagai organisasi kekuasaan seluruh rakyat."*
>
> "The earth, water, and airspace, including the natural resources, contained therein are in the highest instance controlled by the state which is the authoritative organization of the whole people."

The implementation of all matters related to land may be delegated to the autonomous regions in Indonesia and *adat* law communities. The rights controlled by the state provide the authority:

1. To regulate and implement the appropriation, the utilization, the reservation and the cultivation of that earth, water, and airspace.
2. To determine and regulate the legal relations between persons, concerning the earth, water, and airspace.
3. To determine and regulate the legal relations between persons and legal acts, concerning the earth, water, and airspace.

All rights to land in Indonesia have a social function, the state does not accept land titleholders who merely use their right for their own interest or where it can harm social and public interests. The uses of land must fit the nature of the rights that they have been granted and therefore the benefits to state and society are known to all parties. A balance between individual interests and social functions exist in order to achieve prosperity for citizens holding land rights. According to BAL 1960, there are five main types of land rights. First, the Right of Ownership (*Hak Milik / HM*) [*UUPA/1960* Article 20].

> *Hak milik adalah hak turun-temurun, terkuat dan terpenuh yang dapat dipunyai orang atas tanah, dengan mengingat ketentuan dalam pasal 6.*
>
> *Hak milik dapat beralih dan dialihkan kepada pihak lain.*
>
> The Right of Ownership is a hereditary right and is the strongest and fullest right one can have on land that may be possessed by a citizen, under the provision of Article 6.
>
> The right of ownership can be exchanged and transferred to another party.

This right can only be held by an Indonesian citizen. These land rights have social functions, meaning personal interest in land is not acceptable if it is to the general interest of many people. This right can be purchased, exchanged, transferred and mortgaged.

Secondly, the Right of Building (*Hak Guna Bangunan / HGB*) [*UUPA/1960* Article 35].

> *Hak guna bangunan adalah hak untuk mendirikan dan mempunyai bangunan-bangunan atas tanah yang bukan miliknya sendiri, dengan jangka waktu paling lama 30 tahun.*
>
> *Atas permintaan pemegang hak dan dengan mengingat keperluan serta keadaan bangunan-bangunannya, jangka waktu tersebut dalam ayat (1) dapat diperpanjang dengan waktu paling lama 20 tahun.*
>
> *Hak guna bangunan dapat beralih dan dialihkan kepada pihak lain.*
>
> The Right of Building is a right to construct and own buildings on land which is not his own, with a maximum period of 30 years.
>
> At the request of the rights holder and keeping in mind the necessity and circumstances of its buildings, the period referred to in section (1) may be extended for a maximum period of 20 years.
>
> The Right of Building may be exchanged and transferred to other parties.

This is the right to construct and own a building on a plot of land which is not one's property for a period of up to 30 years, which can be extended for a further 20 years. But upon the expiration of such an extension, a new *HGB* title may be granted for the same land with the same terms. These land titles are quasi-leasehold because they can be renewed in perpetuity. This right can also be sold, exchanged, transferred or mortgaged, and can be held by Indonesian citizens and corporate entities owned by local and approved foreign investors.

Thirdly, the Right to Lease Land for Building (Hak Sewa Bangunan) [UUPA/1960 Article 44].

> *Seseorang atau suatu badan hukum mempunyai hak sewa atas tanah, apabila ia berhak mempergunakan tanah milik orang lain untuk keperluan bangunan dengan membayar kepada pemiliknya sejumlah uang sebagai sewa.*
>
> *Pembayaran uang sewa dapat dilakukan:*
> - *satu kali atau pada tiap-tiap waktu tertentu;*
> - *sebelum atau sesudah tanahnya dipergunakan.*
>
> *Perjanjian sewa tanah yang dimaksudkan dalam pasal ini tidak boleh disertai syarat-syarat yang mengandung unsur-unsur pemerasan.*
>
> An individual or a legal entity has the right to lease the land if he is entitled to use another person's land for building purposes by paying to the owner an amount of money as rent.
>
> Payment of rent can be made:
> - *once or at any given time;*
> - *before or after the land is used.*
>
> The land lease agreement referred to in this article shall not be accompanied by conditions containing extortion elements.

This right allows a person or legal entity to use land owned by (or leased from) another private party to construct a building on. The right cannot be registered, but foreigners permanently domiciled in Indonesia and foreign corporations with offices in Indonesia can hold this right. This right cannot be mortgaged or pledged for a debt.

The fourth is the Right of Use (Hak Pakai) [UUPA/1960 Article 41], which states:

> *Hak pakai adalah hak untuk menggunakan dan/atau memungut hasil dari tanah yang dikuasai langsung oleh Negara atau tanah milik orang lain, yang memberi wewenang dan kewajiban yang ditentukan dalam keputusan pemberiannya oleh pejabat yang berwenang memberikannya atau dalam perjanjian dengan pemilik tanahnya, yang bukan perjanjian sewa-menyewa atau perjanjian pengolahan tanah, segala sesuatu asal tidak bertentangan dengan jiwa dan ketentuan-ketentuan Undang-undang ini.*
>
> *Hak pakai dapat diberikan:*
> - *selama jangka waktu yang tertentu atau selama tanahnya dipergunakan untuk keperluan yang tertentu;*

- *dengan cuma-cuma, dengan pembayaran atau pemberian jasa berupa apapun.*

Pemberian hak pakai tidak boleh disertai syarat-syarat yang mengandung unsur-unsur pemerasan.

The right of use is the right to use and / or collect proceeds from land directly controlled by the State or the property of another person, authorizing and liabilities specified in the decision of his award by the competent authority to give it or in agreement with the landowner, not the lease agreement rent or land-processing agreement, everything of origin does not conflict with the spirit and provisions of this Act.

The right of use may be granted:
- for a specified period of time or as long as the land is used for a particular purpose;
- free of charge, with any payment or service giving of any kind.

The granting of a right of use shall not be accompanied by conditions containing extortion elements.

The Right of Use allows a party to use and/or to collect products from land directly controlled by the state, or land owned by other persons. The actual use has to be for a specific purpose agreed by both parties such as for social activities, religious worship, embassies, and international organizations. The title can be held by Indonesian citizens, individual foreigners residing in Indonesia, foreign embassies or representative offices of foreign institutions. It cannot be sold, exchanged or transferred unless explicitly provided for in the initial agreement. The title can be granted for 25 years and is extendable for a further 20 years. In certain cases, such as land for foreign embassies, the title can be granted for as long as the embassy resides on the land.

Finally, the Right of Exploitation (*Hak Guna Usaha / HGU*) [*UUPA*/1960 Article 28]:

Hak Guna Usaha adalah hak untuk mengusahakan tanah yang dikuasai langsung oleh Negara, dalam jangka waktu sebagaimana tersebut dalam pasal 29, guna perusahaan pertanian, perikanan atau peternakan.

Hak Guna Usaha diberikan atas tanah yang luasnya paling sedikit 5 hektar, dengan ketentuan bahwa jika luasnya 25 hektar atau lebih harus memakai investasi modal yang layak dan tehnik perusahaan yang baik, sesuai dengan perkembangan zaman.

Hak Guna Usaha dapat beralih dan dialihkan kepada pihak lain.

> The right of exploitation is the right to cultivate land directly controlled by the State, within the period referred to in article 29, to an agricultural, fishing or livestock enterprise.
>
> The right of exploitation is granted to a land of at least 5 hectares, provided that if 25 hectares or more must use proper capital investment and good corporate techniques, in accordance with the times.
>
> The right of exploitation may be exchanged and transferred to another party.

The Right of Exploitation is the right to use land that is directly controlled by the state for a period of up to 35 years for agriculture, fisheries or cattle breeding. Twenty five-year extensions are commonplace. Indonesian citizens and corporations, as well as the government, can hold HGU. The right of the Exploitation certificate is registered on the cadastre and can be mortgaged.

Besides these five main rights, there are special rights that can also be granted under the Basic Agrarian Law:

- the right to opening-up land and collect forest products (*Hak Memungut Hasil Hutan*
- the right to use water (*Hak Guna Air*);
- the right to breed or catch fish (*Hak Pemeliharaan dan Penangkapan Ikan*);
- customary rights (*Hak Ulayat*), traditional rights based on communally held land;
- The right of management (*Hak Pengelolaan*), which is the right for state agencies to manage state-land on behalf of the central government. This titles them the right to operate state-owned land for a specific purpose as approved by the authorities. It is given exclusively to government institutions or state-owned companies for unspecified periods. The titleholder can transfer this right to another party by a title conversion process;
- Apartment unit rights (*Hak Milik atas Satuan Rumah Susun*) is the equivalent of strata title rights in common law systems. It was introduced in 1985 to encourage high-rise development in urban areas and can be issued to the owners of residential, commercial or retail units in multi-story buildings such as condominiums, strata-title offices, and trade centres. The title's

validity period depends on the expiry date of the land right of the plot on which the building is located; and

- The security right (*Hak Tanggungan*), a form of title acquired by mortgage holders.

All of these rights and their definitions have been extracted from Basic Agrarian Law (Government of Indonesia 1960a) and can be divided into three broad categories. First, primary titles, which are directly derived from the state, e.g., the rights of ownership, building, and management. Secondly, secondary titles that are granted by another titleholder based on a contractual agreement, e.g., rights of use, and to lease land for building. The final category of rights only includes the right to security of rights.

Land registration

The land registration process is a government responsibility, and land registration offices are found at provincial, municipal and district levels. Registration can be either fiscal or legal. The difference between them is based on purpose. Fiscal registration is administered by tax offices, which have responsibilities for the fiscal cadastre, and legal registration occurs at offices of *Badan Pertanahan Nasional* (*BPN*) or the National Land Agency, which has responsibility for the legal cadastre. *BPN* is a government ministry responsible undertaking both land and cadastral registration. Most land registration services are conducted at the municipal office level (local land offices).

The formal Indonesia Land Registration system adopts the registration of deeds. A copy of all agreements that affect the ownership and possession of the land must be registered at a Land Office. As a result, by searching the registry for the most recent document of transfer, any would-be purchaser can be confident that the vendor has the right to sell, as the register will show how the vendor obtained the property and the conditions under which it was acquired. Of course, there is no proof that the previous transaction was legitimate, and previous transactions need to be inspected to obtain a clear chain of title (Walijatun & Grant 1996). All land transactions must be made by deed, and the BAL requires that these are executed before a land deed official (LDO) at a *Pejabat Pembuat Akta Tanah (PPAT)* or land deeds office. Each LDO is authorized by the *BPN*. Once transferred, the land parcel must be registered in the regional office of *BPN*.

The boundaries and extents of land parcels are protected by the Indonesian Government (through the BPN) with a proof of land ownership certificate. This provides details on the geometric shape of the parcels, the location of the coordinates of the parcels, their area and legal certainty.

The principle of Indonesia's land registration is negative registration but tends toward positive registration (Section 2.2.1). This ambiguity is caused by the title certificate being strong but not absolute evidence, and the fact that the register cannot fully guarantee the title. A court decision is needed in terms of competing ownership claims. But the BAL also provides a regulation to protect the titleholder from plaints. This states that if a person lets another person manage their land for a certain period, it is possible to lose the right to land-based on the assumption that it has been neglected.

Two approaches are used for land registration in Indonesia. The systematic approach is conducted at a region or village level. This approach is usually financed by the government and it can help poor people to get land titles. This approach also leads to good quality spatial data because the areas are surveyed as an integral part of registration. The second is the sporadic approach. This takes place whenever the owner of land requests their land is registered. It happens only for the individual parcel and the costs are paid by the landowner. This approach has a risk of providing inaccurate spatial data if a new survey is not undertaken.

In summary, land registration in Indonesia has three aims:

1. to guarantee legal security for land and apartment unit title holders;
2. to provide cadastral information for the government (Parlindungan 1999), and
3. to run the regular land administration.

2.4.2 Land Cadastre in Indonesia

A cadastre is strongly associated with the collection and information of spatial data within a country or district based on a land survey of boundaries (Henssen 1995). The spatial data depicted in a cadastral map involves not only land parcel boundaries, but also geographic features. The base map for cadastral registration in Indonesia is the responsibility of the BPN Directorate of Surveying and Cadastral Mapping (*Direktorat Pengukuran dan Pemetaan Kadastral)*. BPN's surveying and mapping activities have a strong relationship with *Badan Informasi Geospasial (BIG)* (the Geospatial Information Agency), as BIG provides the geodetic reference system and topographic maps for cadastral survey and mapping. BPN is in the process of digitising its existing analogue cadastral maps.

Cadastral activities comprise of five strands:
1. developing the base map;
2. establishing parcel boundaries;
3. surveying and mapping of land parcels and producing land registration maps;
4. creating a list of the legal owner of the land; and
5. Generating letters of measurement.

The principle of contradicter delimitation is utilized for establishing parcel boundaries. This principle states that the boundaries of a parcel must be resolved in front of all connecting neighbors and that all the neighbors have to sign on the map as proof of their understanding.

BPN provides cadastral data for all government agencies, and also uses data provided to it from spatial data held by other government organizations: the Geospatial Information Agency; the Directorate of Taxation, Ministry of Finance; the Ministries of Public Works, Forestry, and Agriculture; as well as property agents, private companies and local governments.

Since 1960, BPN - the official Indonesian government land agency - has been conducting measurements and mapping to register all land parcels in Indonesia Measurement and mapping are only done if there is a request for land registration for the first time by an applicant (this is called sporadic land registration) or if there is a transfer of ownership rights of a parcel of land due to a sale, purchase, grant or inheritance. Systematic land registration is carried out on projects funded by the government.

When there is a transfer of ownership, there is no obligation to undertake field measurements. However, if there is a request from the buyer or seller to check the land area, e.g., because they want to ascertain whether the data in the land certificate is in accordance with the actual field situation or there is a boundary dispute problem, a field measurement can be undertaken.

However, starting in 2017 the Indonesian government, through BPN, has been implementing the PTSL program of complete systematic land registration, mapping all parcels of land in an administrative area. This has changed the approach to systematic registration and has accelerated the mapping of parcels throughout Indonesia (Ministry of Agrarian and Spatial Planning Affairs/National Land Agency 2018). It is expected that all land parcels in Indonesia will be registered before 2025.

2.4.3 3D-land registration system in Indonesia

Issues related to urban infrastructure in Indonesia have given rise to questions around how far the current land rights provided the BAL have the capacity to deal with property in Indonesia's cities, as has been the case in other counties (Section 2.3.3.). Though there are rights that give the title holder's authority use and to build on their land, there is a question in terms of how far the authority allows a titleholder to use land. According to BAL Article 4, the land is a surface, and therefore the land right is the right to the land surface, not spaces above or below it; though titleholders still use spaces above and below the surface, if their interests are directly related to land use.

Horizontal divisions occur in Indonesian land law, which gives the possibility of separation between land ownership and building ownership in the same parcel. Generally, the landowner is also the owner of the building, but by giving secondary land titles based on agreements between landowners and building owners, the horizontal divisions can be implemented. The Right of Building and The Right to Lease Land for Building are enacted in the case of horizontal division. For example, there are cases of underground utilization where underground space has no correlation with the surface land surface. The Mass Rapid Transit (MRT) train network in Jakarta is an example of this and the current land law cannot provide a proper title for MRT spaces. Therefore there are considerations such as these in developing the new right, named the Right of Underground Utilization, which is based on Article 33, Point 3 of the State

Constitution of the Republic of Indonesia (Government of Indonesia 1945), which states:

> *"Bumi, air dan kekayaan alam yang terkandung didalamnya dikuasai oleh Negara dan dipergunakan untuk sebesar-besarnya kemakmuran rakyat"*
>
> "The earth, water, and natural resources are brought under the power of the State and shall be used for the greatest benefit of the people."

The term earth, in this case, is not only merely land but land surface and the soil and therefore includes underground spaces. The reasons behind the development of this new right are to protect the legal security of titleholders and the other parties who benefits from the part of available space and to give the security for users of underground constructions and the users of the buildings above them.

The use of spaces above the land surface that still has a physical connection with the land surface, e.g., flyovers and bridges. For these kinds of properties, the existing Right of Building (*Hak Guna Bangunan/HGB*) and the Right of Use (*Hak Pakai/HP*) can be used to give the title. The reason for this is that though the construction is in an above-ground space is still physically connects with the land surface (Hutagalung 2008).

As a concept, physical property and rights of property always have had a 3D-meaning, when it comes to restrictions and the scope of the rights. But, in reality, the existing cadastre has neglected this third dimension by mapping the situation in 2D. This is the case in Indonesia, like other cadastral systems in the world.

Strata title registration

The registration of an apartment unit in strata is the only kind of 3D-property registration that exists in the Indonesian cadastral system. High-rise buildings with several spaces, where each space is used individually have been known for a long time in large cities in Indonesia. As building and land ownership are generally the same, the use of the individual spaces is contracted by the rental agreement. The Apartment Unit Act, number 16 of 1985 has provided a new ownership title concept related to 3D-property rights.

Are there problems with 3D-parcel registration in Indonesia? At the time of submitting this thesis 3D-registration has not been routinely carried out in Indonesia. Therefore, the nature of the problems that will arise when it is carried out can only be estimated. The major problem that 3D-registration will face is that no fully 3D-cadastre exist at the present time, i.e., a 3D-cadastre with 3D-marks or administrative tags. This 3D-situation is currently documented in 2D-, in the form of 2D- drawings for each floor in an apartment as 3D-objects (Figures 2.4-2.6). Figure 2.4 shows a floor plan that explains where the position of a room is in a 2-D situation, i.e., on the floor where the room is located. Figure 2.5 is a map of the apartment unit (*Gambar Situasi)* with detailed information about the unit in 2D-dimensional system at a larger scale (1:200). Finally, Figure 2.6 shows the building's site or land and provides the whole-building context for the apartment.

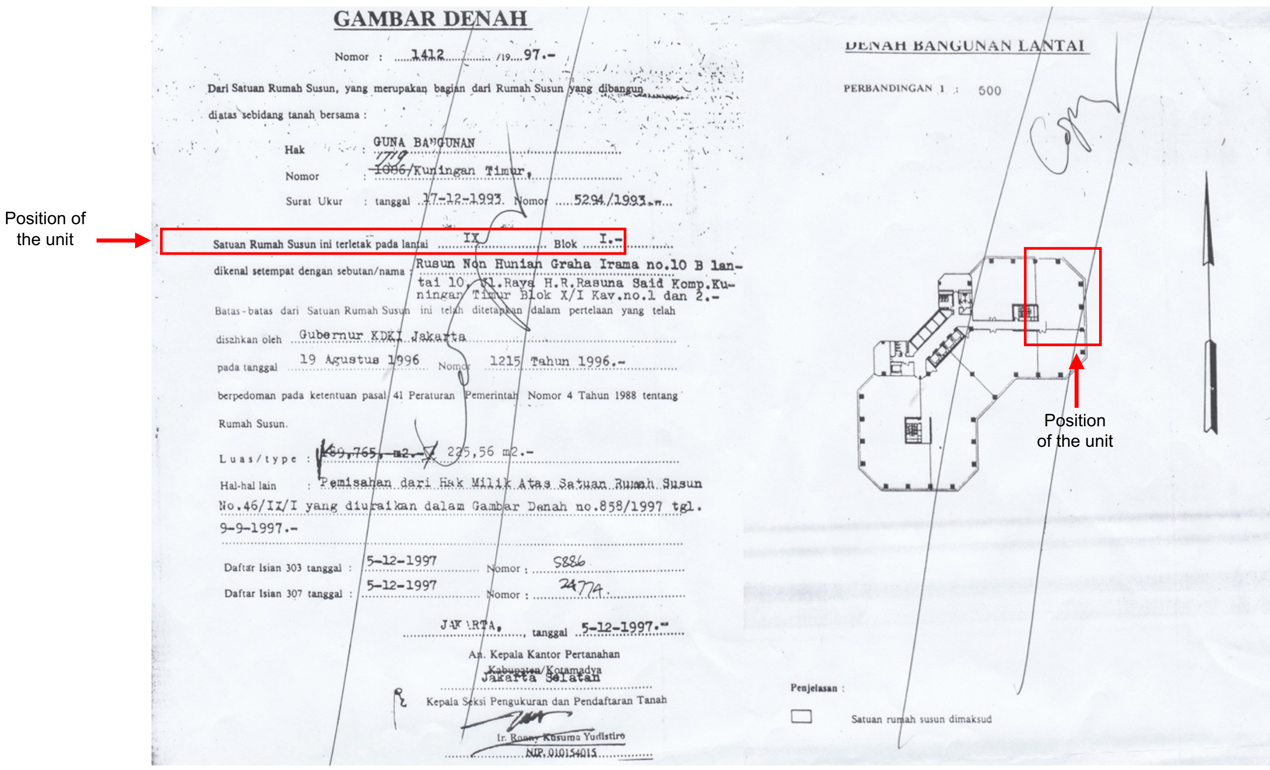


Figure 2.4 Map of the apartment floor (*Gambar Denah*): Scale 1:500

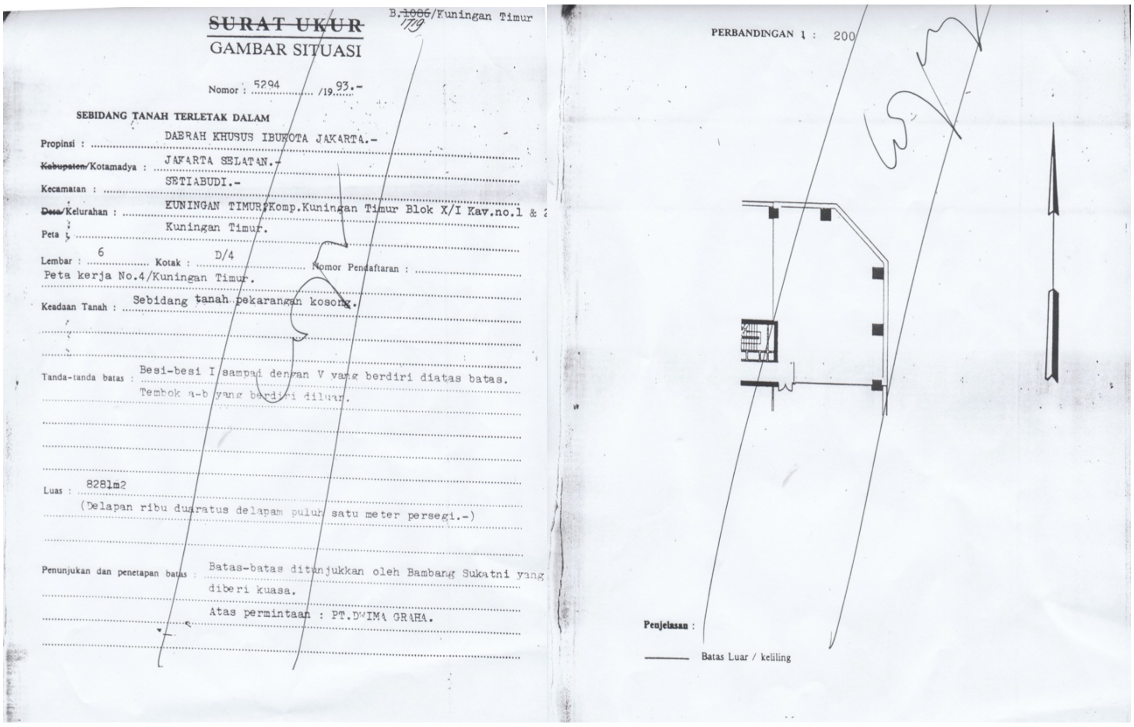


Figure 2.5 Map of the apartment unit (*Gambar Situasi*): Scale 1:200

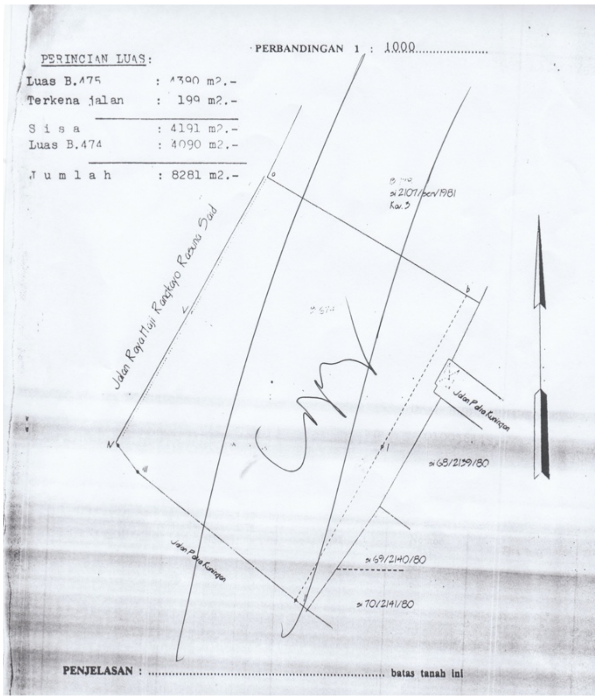


Figure 2.6 Map of the apartment land parcel: Scale 1:1.000

The situation of an apartment or strata title that needs to be in 3D-is not clearly described in the form of a 2D- map. Moreover, if an apartment is already occupied by the apartment owner, he or she can add to the apartment or install other supporting equipment as illustrated in the following figures:

- the installation of objects that protrudes beyond the parcel boundaries (Figure 2.7).

Figure 2.7 Garage fence that protrudes beyond a parcel boundary.

- construction of building extensions over rivers (Figure 2.8)

Figure 2.8 Building extensions over rivers

- installation of AC compressors on walls directly adjacent to a neighbours' land parcel boundary (Figure 2.9)

Figure 2.9 AC compressor installation crossing a parcel boundary

These conflicts in the unauthorized uses of 3D-space, i.e., those exceeding ownership rights, found by researcher indicate each case needs to be clarified physically (i.e., sizes and dimensions measured) and examined in relation to prevailing regulations and laws, because if they are illegal problems will arise in the future. Of course, they highlight some of the inadequacies of the 2D-cadastre system in Indonesia.

The definition of the apartment is that they are parts of high-rise buildings that are divided in both horizontal and vertical directions, i.e., divided into units, which have clear boundaries and sizes. They can be separately owned and occupied, and have both private and common elements (Government of Indonesia 1985). The common parcels in a high-rise building cannot be individually owned. The apartment unit is defined as a part of a building that has a primary function for domestic habitation. It should have access to a public road, usually through a common area.

The Right of Ownership of an Apartment is given for one of two purposes: as a dwelling place or as a place of business. The apartment unit for a dwelling has to be above the land surface, whereas for business purposes they can also be below the land surface. The Right of Ownership of an Apartment is based on Article 41 of Government

Regulation number 4 of 1988 (Government of Indonesia 1988). This will be returned to in the discussion in Section 6.4.1. This regulation shows that apartment units do not always have walls as boundaries. This condition exists in the case of units used for business locations in many malls and shopping centers. Each business space in such buildings entitles a person through the strata title mechanism, but every business space does not have a wall to separate it from another. This situation provides a further reason for 3D-registration because without complete registration this situation can lead to unclear boundaries.

Collective ownership

Strata titles always include the concept of co-ownership. The definition of co-ownership based on Law 20 of 2011 concerning the Apartment Act (Government of Indonesia 2011) can be summarized as:

> The common land [Act No.20/2011 Article 1 section 4]:
> *Tanah bersama adalah sebidang tanah hak atau tanah sewa untuk bangunan yang digunakan atas dasar hak bersama secara tidak terpisah yang di atasnya berdiri rumah susun dan ditetapkan batasnya dalam persyaratan izin mendirikan bangunan.*
>
> The common land is a land parcel right or leased land for buildings used on the basis of collective rights which are not separated on top of which stands apartment and set boundaries in terms of building permits.

Common land is a land parcel that is used on the basis of co-ownership right and during the construction of an apartment building. It can only be built on the land owned through the Right of Ownership, of building, of use of state land, and of management. For apartment buildings built on the land entitled by the Right of Use of State Land, the law guarantees the Right of Use will be granted for a lengthy period. The Right of Management only can be granted to legal bodies owned by the government, In the case of apartments built on the land entitled by the Right of Management, the developer has to make an agreement with the holder of the Right of Management to grant the Right of Building:

> Common parts [Act No.20/2011 Article 1 section 5]
>
> *Bagian bersama adalah bagian rumah susun yang dimiliki secara tidak terpisah untuk pemakaian bersama dalam kesatuan fungsi dengan satuan-satuan rumah susun.*

> The common parts are the indivisibly divided piece of apartments for shared use in a functional unit with apartment units.

The common parts are the parts of the apartment that are owned for collective uses cannot be separately entitled and used by the owner of an apartment unit. Moreover, they cannot be separated from apartment ownership. Examples of common parts are the building foundations, columns, beams, walls, floors, roofs, gutters, stairs, elevators, corridors, conduits, pipes, and electricity, gas and telecommunication networks. They also include plant, landscaping, meeting rooms and social facilities, places of worship, playgrounds, and parking spaces that are separate or incorporated into the structures of apartment buildings.

> Common areas [Act No.20/2011 Article 1 section 6]
>
> *Benda bersama adalah benda yang bukan merupakan bagian rumah susun melainkan bagian yang dimiliki bersama secara tidak terpisah untuk pemakaian bersama.*
>
> The common areas are the object/areas that not a part of the apartment but is a collective owned indivisibly for shared use.

According to Law 20 of 2011 (Government of Indonesia 2011) which is concerned with the Apartment Act, apartment units can be sold after the suitable occupancy permit has been issued by a municipality, and a certificate of ownership of apartment rights has been issued by BPN. Three requirements [Act No.20/2011 Article 24] need to be fulfilled by the developer building an apartment, namely:

1. The administrative requirement consists of the clear status of the land rights as documented by a building permit, ratification of municipal division plan, a certificate of land title, land use planning advice, a division plan, and architect's, builder's and utility plans [Act No.20/2011 Articles 28-34].
2. The technical requirement consists of a building layout that the geographical location, the building design and that includes health and safety, requirements. The technical requirement is usually provided in digital and paper formats associated with the floor and division plan besides paper format. [Act No.20/2011 Articles 35 and 36].
3. The ecology requirement which comprises environmental impact analysis documents (*Dokumen Analisis Mengenai Dampak Lingkungan, AMDAL).* [Act No.20/2011 Articles 37 and 38].

It is the responsibility of the developer to make division plans. These contain the description and some information about the right of the ownerships (area in m^2, boundaries and adjacent ownerships) (figure 2.10), in map and text form. It must show horizontal and vertical boundaries and common areas.

In Indonesian law, the vertical boundary has not yet been regulated. Therefore, the boundary included in the ownership of a right needs to be clarified, because in BAL (Government of Indonesia 1960b) ownership is limited to the surface of the land and the vertical extent is unclear. (e.g., how many meters above the top or below the bottom of a building plot/land parcel does a property extent?).

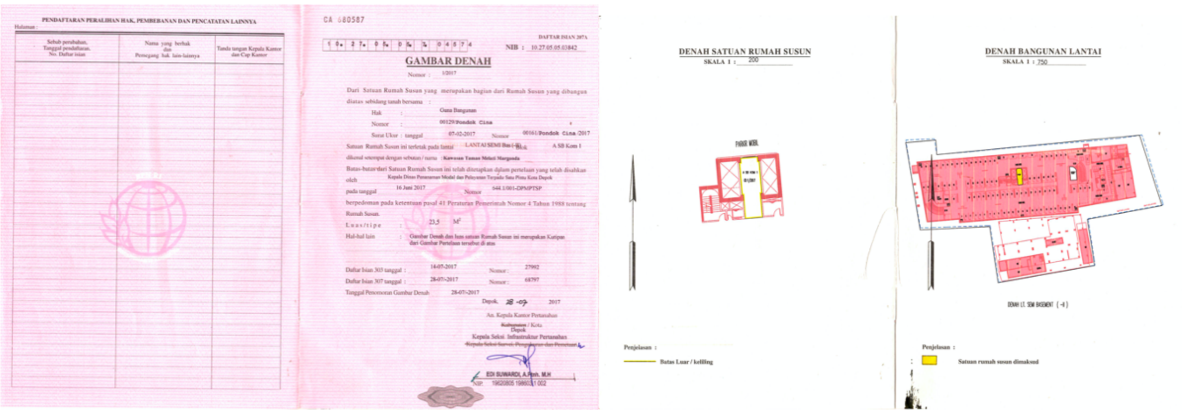


Figure 2.10 Example of of a Certificate of Space Ownerships Right (Hak Milik atas Satuan Rumah Susun / *HMSRS*)

Furthermore, the plan lists the value of each unit as a proportion of the entire building. Apartment rights certificates are initially issued on behalf of the developer, who then has the right to transfer their rights to the buyer of a unit. The property transaction must be proved by a land deed officer (LDO); a signed deed being proof that the ownership of apartment rights has been transferred from the developer to the occupant. This includes all rights of co-ownership of areas and things that cannot be separated from the apartment. A certificate of ownership of the apartment right comprises a copy of the ground book (*Buku Tanah*) and letter of measurement (*Surat Ukur*); the division plan; the division deed; and an occupancy permit.

It should be clear from the above that at the present time cadastral surveying is not involved in registering strata title properties, rather surveying and mapping just

concentrate on registering land parcels on which buildings are erected. The division plan, which is provided by the developer, is the only item of spatial data in that it shows the relative position of a unit. It is legal evidence and is kept in the BPN register.
The weaknesses of the existing system in registering 3D-properties are that:

1. cadastral registration cannot administer 3D-information on how properties are in a building because the cadastre map and the division plan are separate, and there is no integration of the two types of information;
2. the legal part does not provide adequate rules and regulation for all types of 3D-situations;
3. no height information is provided on the unit strata plan or drawing plan because cadastral surveying is not specifically executed for an apartment unit;
4. it is not possible to view 3D-property units interactively, which is helpful to get insights into complex buildings; and
5. There is limited accessibility of information because analog achieves is still in use.

Research on the 3D-cadastre in Indonesia

The current Indonesian cadastral system is a two-dimensional representation based on land parcels. The development of a 3D-cadastral system might be expected to clarify ownership definitions. Hendriatiningsih et al. (2007) proposed a prototype registration system for Indonesia that accommodates vertical dimensions with existing spatial information. They showed that a 3D-prototype could be implemented alongside the 2D- cadastral system to solve complex cadastral situations. This prototype was based on a hybrid cadastre method, which is a method of 3D-visualization by uniting 3D-property registration within a 2D-parcel-based cadastre system. Considering that 2D-information is routinely used by BPN and other government institutions for registering real estate objects, the hybrid cadastre method may be suitable for this purpose in Indonesia.

However, vertical registration is still very uncommon in Indonesia, even though a cadastral registration system for apartment ownership was introduced in 1985. Public infrastructure (e.g. bridges, underground rail networks) have not yet been registered as cadastral objects in the existing system (Aditya et al. 2009). Moreover, where they do exist in official land documents there is no single system that includes all elements of land registration. (Aditya et al. 2009) examined the challenges posed by this problem and developed a prototype model using PostgreSQL, a PostGIS database, and visualized in an X3D/Google Earth application. They later expanded the research to a 3D-cadastre web-based map (Aditya et al. 2011). Their research considered field data processing, data compatibility, and browser limitations. They used an OpenGIS standard (KML) for streamlining 3D-measurements into the existing cadastral geodatabase and X3D-to store and visualize 3D-objects above and below the ground surface. Two case studies were examined. First, the use of KML as an intermediate format to bridge between CAD and PostgreSQL/PostGIS, and the second was the use of cadastre in X3D-format to support rapid mapping. The 3D-web map was found to be suitable for the proposed hybrid 3D-cadastre.

2.5 BIM (BUILDING INFORMATION MODEL)

GIS has been used to model buildings in 2D-systems, but it is expected that new models with building information, called BIM, will replace GIS 2D-models. This advance is a result of the increased power of computing technology, increasingly sophisticated data acquisition methods, and automated workflows that can produce increasingly detailed 3D-data. The BIM methodology will also lead to a move away from traditional 2D-CAD drawing systems for buildings to a more complete system with supporting information.

Nonetheless GIS and BIM compete, and will continue to do so, when modelling a city because each has it’s a different foci and characteristics. BIM focuses on building design and construction, while GIS provides environmental information at different time points so that the data can be updated regularly and covers a wide area. The drawback of GIS compared to a BIM, is that the information is less detailed.

Because GIS and BIM have their respective strengths and weaknesses, their integration will useful for modelling 3D-cities in the future. More detailed BIM data will be able to complement more general GIS data, and vice versa; and it will enrich information infrastructure in developing smart cities that supports spatial analysis with highly detailed information.

Unfortunately, GIS and BIM cannot, as yet, be combined directly due to the different modelling paradigms: GIS uses city MLS while BIM uses IFC. This results in fundamentally different datasets and there is currently no optimal and uniform conversion between the two models. This is an active research area. Starting the GeoBIM project in early 2017 (Liu et al. 2017; Diakité et al. 2018; Ohori et al. 2018), have created interfaces of the complex IFC model and changed it into a CityGML based on IfcOpenShell and CGAL, the library that is used for BIM and GIS models.

2.6 CHAPTER SUMMARY

This chapter has reviewed the literature and related legal documentation on 3D-cadastral systems. The concepts of land registration and land cadastre which cannot be separated from each other were reviewed. Then 3D-cadastral registration systems and prototypes from around the world were analysed.

The history of the Indonesian cadastre was introduced, along with rights and regulations associated with the Basic Agrarian Law of 1960. The issues around the development of a 3D-cadastre system for Indonesia were introduced. It is clear that 3D-cadastral development in Indonesia requires further work. In particular, research is needed into the use of a full 3D-cadastral method which requires the use of more advanced technologies than those available in the country at present. This had created both knowledge and technology gaps that will be addressed in this thesis. In particular, it will fill the need to clarify 3D-spatial property rights as a way of avoiding land-use disputes especially in the two cities investigated - Jakarta and Bandung.

The next chapter introduces the research project’s design and the methods used to address the research questions.

CHAPTER 3: RESEARCH DESIGN AND METHODS

3.1. INTRODUCTION

This chapter covers the research design and methodological aspects of this thesis. The research design framework is outlined in Section 3.2. The methods used to survey and a map of a building of some complexity on the Flinders University campus are introduced in Section 3.3. Section 3.4 covers the selection of different groups of Indonesian stakeholders to interview about issues with the current 2D-cadastral system, and potential benefits and issues around the introduction of a 3D-cadastral systems in Indonesia; the interviews themselves and procedures around their administration; and the methods used to analyze the information obtained through interviews.

3.2 RESEARCH DESIGN

Figure 3.1 illustrates the research design framework for this research. This framework was developed at the start of the research in consultation with my supervisory team and colleagues in the 'Land Lab' in the School of the Environment at Flinders University.

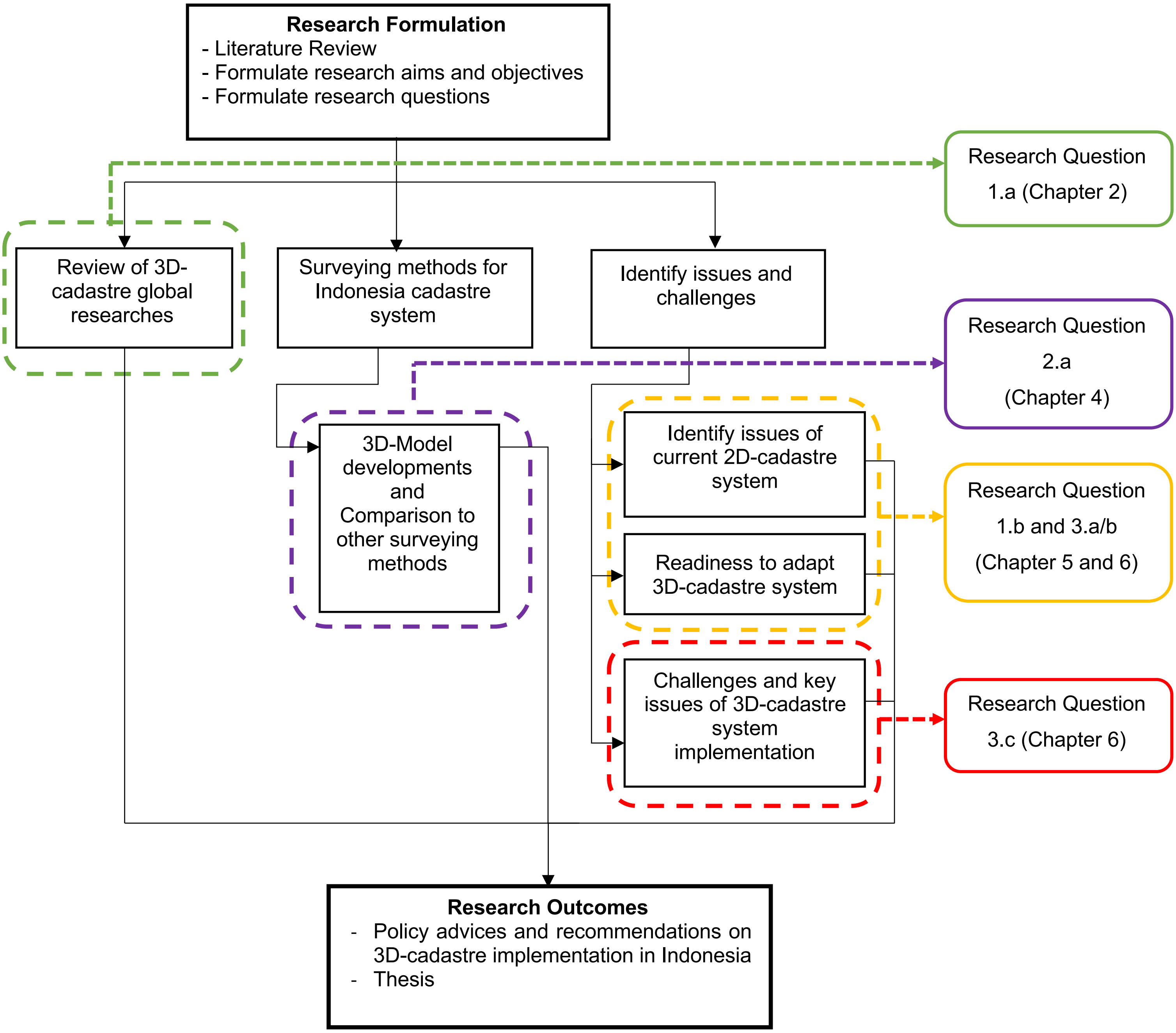


Figure 3.1 Research design framework

3.2.1 Quantitative and qualitative data

Two types of data were acquired in the pursuit of this research - quantitative and qualitative. The methods by which these two broad categories of data are acquired and analyzed are radically different but were deemed necessary in this project because they provided the information necessary to answer to different types of research questions introduced in Chapter 1.

Quantitative data are numerical and are generally analyzed using statistical methods to describe and endorse occurrences (McDougall 2006), numerical modeling to predict outcomes, and geospatial or cartographic methods to provide 2D and 3D-representations. Quantitative data were acquired using several building surveying techniques for a multi-floor building to compare the results from different approaches to surveying that may be relevant to shifting from a 2D to a 3D-cadastre. Quantitative methods were also applied when comparing measurements made using different surveying methods (Chapter 4) and in evaluating differences in responses between different groups of stakeholders (Chapter 5) in the form of statistical tests.

"Qualitative research methods examine the how what and why of various phenomena" (McDougall 2006, p. 95), and involve a researcher describing the characteristics of people and events without comparing events in terms of measurements or amounts (Thomas 2003). Denzin & Lincoln have described the qualitative approach as:

> "*The studied use and collection of a variety of empirical approaches including case study, personal experience, introspection, life story, interview, observational, historical, interactional, and visual texts – that describe routine and problematic moments and meanings*". (Denzin & Lincoln 1994, p. 2)

Qualitative research has strengths that derive primarily from its inductive approach, its focus on specific situations or people, and its emphasis on words rather than numbers (Maxwell 1996). He determined five research situations purposes that are especially suited to qualitative study:

1. understanding the meanings ascribed to participants in a study of events, situations, or actions;
2. understanding the contexts within which participants act, and the influence that these contexts have on their actions;
3. identifying unanticipated phenomena and influences;
4. understanding the processes by which events and actions take place; and
5. developing casual explanations.

In this research, qualitative approaches were employed to investigate the issues related to 2D and 3D-cadastre systems in Indonesia, especially the attitudes of five groups of Indonesian stakeholders. For example, the use of qualitative research provided opportunities to understand the contexts within which these cadastral systems operate, particularly any limitations posed by 2D-cadastral systems when considering complex infrastructure and the readiness of participants to adopt a 3D-cadastre.

Qualitative research methods have evolved over time and include ethnographies, participant observation, grounded theory, case studies, phenomenological research, narrative research, and action research (Creswell 2014). Semi-structured interviews were selected as the most appropriate method to obtain information on 2D and 3D-cadastral systems in Indonesia in this research.

3.3 METHODS USED TO SURVEY THE FLINDERS UNIVERSITY EARTH SCIENCES BUILDING

Building plans have traditionally been related to 2D-cadastral systems, each level of a building has been treated as separate and has a separate 2D-floorplan. This situation has translated into rooms and other spaces in buildings being surveyed using a range of 2D-surveying techniques from something as simple as the use of tape measures to total stations. In applying these methods there has generally not been a demand to measure the heights of rooms and spaces because the floor plans are in two dimensions. However, as noted earlier in this thesis the demand for three-dimensional representation of rooms and spaces has grown.

Starting in the early 2000s, terrestrial laser scanning (TLS) has progressed from a research and development topic to a geo-data technology used by a lot of land surveying companies around the world. The technology is primarily used for the impulsive acquisition of three dimensional information for a diverse range of topographic and industrial objects (Lemmens 2011). Three-dimensional (3D) modeling captures all the geometrical detail of objects, both exterior and interior, and represents these features with high-resolution triangular meshes for precise records and visualization (El-Hakim et al. 2007; El-Hakim et al. 2008).

While terrestrial laser scanning is now a proven and accepted surveying technology, it was not used by BPN when I started this research and therefore some of the details concerning its operational use in this chapter may be considered redundant in a PhD thesis. However, they are reported here because they were integral to the conditions of my scholarship.

A comparison is made between a 2D CAD plan of the building I surveyed, and a 3D plan I derived from terrestrial laser scanning for a building at Flinders University (see following paragraphs). This may seem strange in contemporary surveying, but the CAD plan was the only campus building plan that the Buildings and Property Section of Flinders University used at the time. It was updated every two years or so. It was, therefore, current and the comparison with a contemporary TLS survey was therefore valid. Any differences in time since the last CAD survey of FU-ESB were made obvious from discussions I had with technical staff in the School of the Environment and the Buildings and Property Section of the University. No parts of the building where any changes had been made since the CAD plan was last updated were used in the quantitative comparisons presented in Chapter 4.

Therefore, as part of this project the researcher surveyed a building of some complexity in the Bedford Park campus of Flinders University (FU) using a variety of surveying methods. The building was chosen as the Flinders University Earth Science Building (FU-ESB). The complexity of this building arises from the following:

- it is built on steeply sloping ground (average slope: 11,1%) (Figure 3.2);

Figure 3.2 Earth Sciences Building, Flinders University built on sloping ground.

- it comprises four levels, which themselves are discontinuous (Figure 3.3);

	
View from the north side	View from the west side

Figure 3.3 Earth Sciences Building, three levels of the building can be seen from these external photographs.

- there is a space, “the void”, that extends vertically through the centre of the building (Figure 3.4);

Figure 3.4 Central “void” in the Earth Sciences Building, which extends vertically through levels one and two.

- like many university buildings built during the 1960s and 1970s it is a ‘maze’ of corridors and staircases that lead to rooms of different sizes ranging from janitor’s cupboards, through the different-size office, to large laboratories (Figures 3.5 and 3.6).

	
The main entry of level two, seen corridors and stairs.	Example of the corridor (seen in level 3)
	
Bayview common room (level 3), shared room and kitchen.	Ph.D. student room (level 1), a shared study room for 12 students

Figure 3.5 Example of the different types of rooms in the Earth Sciences Building.

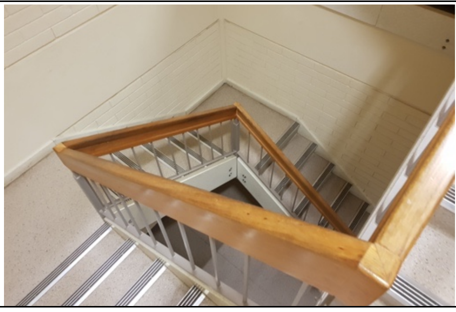
	
Bull’s Court, the only outdoor area ‘inside’ the building.	Bull’s court, view from level 2, this area has an outdoor balcony.
	
Connecting stairs between multi-level storeys.	Mid-size study room for six students

Figure 3.6 Other examples of the complexity of the Earth Sciences Building

Surveying this building using different techniques was done so that comparative analysis of the different surveying methods could be undertaken, specific emphasis was placed on horizontal and vertical dimensions of rooms and corridors, rather than other aspects of surveying.

The researcher considered that an important part of his postgraduate research training in Australia was to acquire experience in using 3D-surveying equipment that might be used to acquire 3D-data on buildings in Indonesia and also to gain experience in analyzing these data. This equipment had not been available to the researcher in BPN before he started this postgraduate research. Initially, the surveying carried out on the FU-ESB was planned for a bus terminal in Indonesia, explained in the following paragraph, but insurance issues meant that the survey had to be carried out in Australia. The FU-ESB building was chosen because:

- it had elements of complexity, as noted above;
- recently updated 2D--plans were available from the digital database of the FU Buildings and Property Services (FU-BPS);

- the researcher was able to obtain permission to obtain full access to all rooms and spaces in the building from the Dean of the School and all academic, administrative and technical staff; and
- it was logistically straightforward as the researcher's office was in the building.

Originally 3-dimensional measurement of the Bus Terminal - Blok M, Jakarta, was to have been carried out using a laser scanner in order to acquire field data within the context of the doctoral research. Figure 3.7 illustrates some the complexity of the 'Blok M' bus station with consists mainly of bus station above ground and an underground mall. Unfortunately, this element of the research had to be cancelled because BPN was unable to guarantee the security of the Flinders University laser scanner which I had planned to use sometime in the 2013 - 2015 time frame; and because of this Flinders University was unable to negotiate insurance cover through its providers. Hence, the decision to use a building in Australia.

Figure 3.7 Integrated underground mall and Bus Station 'Blok M' located in Jakarta, Indonesia.
(Blok M Mall by Lerdsuwa, CC BY-SA 3.0)

3.3.1 Laser scanning survey of the Earth Sciences Building

The display and register of overlapping objects in 2D-maps is challenging 3D-building models can overcome this. 3D-modeling can be defined as a process that starts with data acquisition and ends with a 3D-virtual model that is visually interactive on a computer (Remondino & El-Hakim 2006). In this section, 3D-model development was explored.

Laser scanning has been conceived as a method to directly and accurately capture object surfaces. In laser scanning, a surface is sampled (or scanned) using a laser and data on the object's shape is acquired. These data can be used to construct digital, 2D-drawings or 3D-models in a wide variety of applications. Laser scanning is also applied in archaeology, e.g., Abbott and Anderson-Whymark (2012) used laser scanning in a report on the archaeology of Stonehenge. Research on underground exploration using laser scanning has been performed by Guo et al. (2006) who propose a new technique of 3D-laser survey for underground mines.

A major advantage of laser scanning over other surveying methods is the fact that it can record huge numbers of points with very high accuracy in a relatively short period of time. It is akin to taking a photograph with depth information. There is no need to touch the measured object, which in some cases is not possible or prevented, e.g., in heritage buildings. A 3D-laser scan can represent space better than traditional 2D-representation. However, despite this advantage, the technology still has disadvantages, which are a high initial investment in surveying equipment, the need to purchase software to process the point clouds, and specific training for surveying technicians and in the data processing.

The basis for the scanning parameters used in this research are the default values for the TX5 scanner. As I had not used one of these advanced machines before, and as there was unable to find any technical literature supporting adjustments to scanning parameters, I had no basis on which to change them.

In this research, a Trimble TX5 a 3D-laser scanner was used. It has a maximum of 300° (vertical)/360° (horizontal) field of view, and accuracy of ±2 mm at 10 m and 25 m, and a range of 0.6 – 120 m. 3D-laser scanning was conducted in the FU-ESB building using the procedures indicated in the flowchart, which are described in detail below (Figure 3.8).

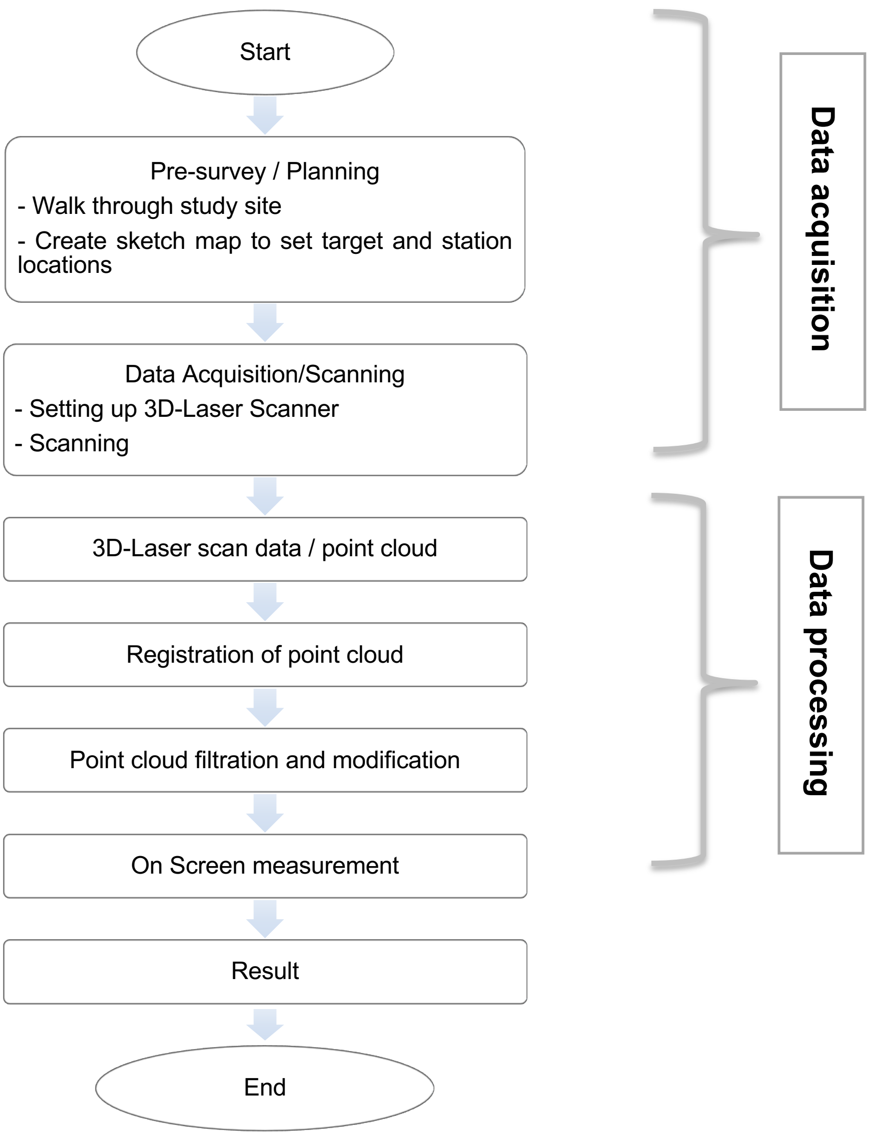


Figure. 3.8. Flowchart of the terrestrial laser scanning steps for this research

Data acquisition

The following data acquisition steps (Figure. 3.7) were carried out:

1. Pre-survey and planning

   The initial task in the pre-survey and planning step was to obtain permission from the Dean of the School of the Environment, the university school that occupied the FU-ESB at the time, for permission to survey the building. Once permission had been granted, the Dean informed all members of staff that the survey would take place and asked the staff to cooperate with the researcher.

The goals and objectives of every survey are different. They depend on user needs. For this study, the goal and objectives are for learning the use of laser scan equipment and create a 3D-model for a cadastral survey with particular emphasis on making accurate horizontal and vertical measurements of spaces. In other cases, the goal for the surveying operations might be for cadastral administration or constructing a 3D-model for conservation of a heritage object.

Next, the researcher analyzed the study area, to understand the constraints of the survey and to obtain as much contextual information about the object to be recorded as possible. Constraints include the resolution and accuracy of the survey and model, the time required to complete the survey and modeling, the resources available, data input requirements, and the format of the modeling software (Trimble 2013). In this study, the resolution and accuracy of the scan were programmed at setup before scanning started. The resolution was 1/10, the quality 6x, the horizontal and vertical scans were 0° to 360° and vertical -60° to 90° respectively, and the scan size was 4108 x 1707.

Contextual information includes hazards the building poses to the surveyor, periods when the building is busy, and access to the spaces in the building. Other things a survey team needs to be aware of are the complexity of the survey object, onsite restrictions and any paperwork that needs to be prepared, e.g., health and safety documentation, before acquiring data. In this study, scanning was conducted during the long vacation, access to the building was granted from the Dean and security, and workplace health and safety forms were completed.

The next task was to determine the optimal scanner station positions. Scan and target positions need to be planned on the basis of any site documentation available, such as building plans. The optimal locations for scanning stations must be planned to guarantee total coverage of all spaces the building being surveyed. To do this, the researcher walked through the building to familiarise himself with all rooms and spaces, and to decide the locations for scan stations and checkerboard targets so that the scanner would capture all the data required. The scan stations and checkerboard target locations were marked on a sketch map that was used to guide scanning later. The checkerboard targets were planned in such a way that each target would be visible from several scan locations (a minimum of the overlapping scan was three targets was used in this research, though in reality more were used because laser scan technology can use a fixed object like a wall corner to register between each scan). An example of a sketch map used to plan scan points can be seen in Figure 3.9.

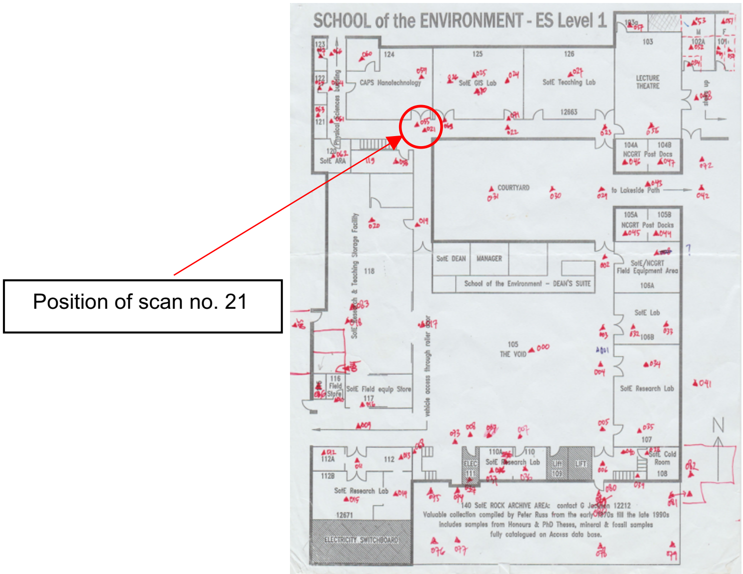


Figure 3.9 Scan points plan, FU-ESB level one.

The position of scan number 21 is highlighted and shown below (Figure 3.10).

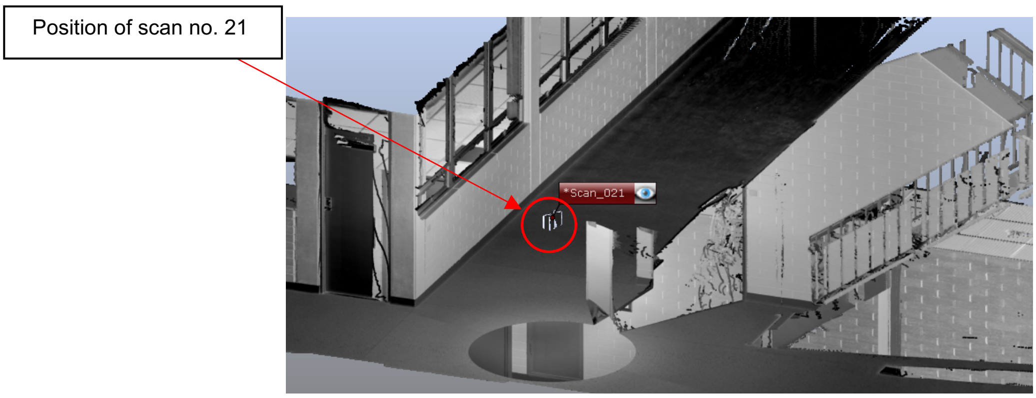


Figure 3.10 Laser scanner position number 21 on the rendered 3D-model.

After planning optimal scanner stand locations had been decided on, the next step was to position targets. Targets are used to register scans taken from different positions. In this study, paper targets/checkerboards (figure 3.11) were used due to their simplicity (i.e., they are cheap, easy to produce and easy to attach to objects) compared to prism, sphere and retro-reflective target. This type of target has been examined and approved by Fryskowska (2019). Target placement is very important. They need to spread widely in x, y, and z directions. In addition, they should not be placed in a straight line. They must be seen in more than one scan and the angle between the laser beam and checkerboard should not be <45°.

Figure 3.11 The scanner target type used in this research

Data management (storage) was also considered before scanning so that the correct size storage devices (SD Cards) were used. This storage management will be discussed in some detail in Section 4.5 of the next chapter.

2. Data acquisition and scanning

   This step consisted of survey preparation, scanner setup, and scanning. Survey preparation comprised checking batteries were charged before use, and that all the equipment (tripods and laser scanner) were functioning properly. The scanner setup was also adjusted before starting scanning. This comprised the targeting setup of the scanner (field of view setting) and resolution setting (the smallest detail of the object that needed to be scanned). These must be set before a survey commences because they affect the time frame for scanning and data storage requirements. The hardware filtering option was also set before the scan started, this includes filtering by the range and reflectance value.

Once all preparation had been completed and the scan locations had been established, the researcher approached members of staff to find times when it would convenient to survey their offices and laboratories, they were responsible for. Scanning was then initiated. The scanning process was fully automated and based on the settings noted above. Depending on the chosen resolution and the size of the area to be surveyed, the scanning process took from five to 40 minutes. The latest generation scanners scan at high speeds so that a 360° scan at very high resolution may only take five to ten minutes to complete.

During scanning, the researcher made notes that described the objects being scanned, target positions, and scan station positions. In addition, other conditions environmental conditions (rain, the brightness of the sun, and darkness of rooms) and other condition that might have influenced scanning (e.g. vibrations from machines or electrical plants) were noted.

As the artificial targets are often made from reflective material, their reflectance values can be higher than the surroundings. Automated detection tools can generate errors because of this. Therefore, results were checked to verify no targets were missing before moving to a new scan position. After the positions of the targets are recognized, the high-resolution (phase 2) option of the scanner was used to fit a specific target shape to the scanned target. The targets were then labelled using the field notes and sketches of the area surveyed.

Data processing

1. 3D-laser scan data/point cloud

   Scan data are collected as point clouds, which were stored in the SD cards in the scanner. A point cloud is a three-dimensional dataset of the scanner's environment (referred to as the ‘laser scan’ or ‘scan’). Depending on the selected resolution each point cloud consists of a very large number of scan points of the external surfaces of objects around them. These data were downloaded from the SD cards for data processing.

2. Registration of point clouds

   Combining several scans (i.e., point clouds) into a globally consistent model was performed using registration. Registration itself is the process in which ‘ScanWorlds’ are integrated into a single coordinate system. The term ‘ScanWorld’ is used in the SCENE software that is supplied by Trimble and refers to a scanned scene from one scan location (Step 1). A scanned scene is, therefore, a collection of 3D-points or a point cloud.

   The key idea in registration is to identify corresponding points between the scanned scenes and find a transformation that minimizes the distance between the corresponding points. In practice, this was accomplished by using a system of constraints, a constraint is a pair of overlapping objects, e.g., checkerboard targets, which occur in two ‘ScanWorlds’. Registration computes the optimal overall alignment transformations for each component, i.e., the eastings, northings, and heights so that the constraints are matched as closely as possible.

3. Point cloud filtration and modification

   In this step points that were inaccurate, due to the scanner environment or that were caused by dust, moisture, ambient light, vibration, distance, and surface quality were corrected or removed. Various filters were used to accomplish this (FARO product info 2015). The researcher used the default filter setup.

   - A stray filter with a grid size of 3 pixels. The grid size is the size of the surrounding area used for comparison. For each scan point of the scan or selection, the filter takes all valid scan points of this surrounding area and counts how many of them are at a distance to the scanner which is approximately the same as the distance of the scan point currently being viewed. A distance threshold of 0.02 m was used, meaning a scan point was counted if the difference in distance was smaller than the threshold. An allocation threshold of 50% was used, meaning at least 50% of the scan points in the surrounding area are also within this distance threshold.

- A distance-based filter with a minimum distance of 0 m and a maximum distance of 10 m. This removed all scan points that were outside the distance range.
- A dark scan points filter with a reflectance threshold of 300 was used. The reflectance threshold indicates the minimum reflection value a scan point must have to be included. This criterion is useful because with a dark scan point only a very small amount of light enters the scanner and therefore the inclusion of these measurements would decrease the signal-to-noise ratio.
- A smoothing filter with a grid size of three pixels and a distance threshold 0.02 m. The smoothing filter replaced the measured value of scan points with the mean value of scan points in the surrounding area defined by the grid size. If the distance between the center scan point and a scan point of the surrounding area was beyond the threshold, the scan point was not used to calculate the mean value.

4. On-Screen Measurements

Measurements of the distances between two points in an object, such as the distance between floor and ceiling, or between the facing walls were made once the point cloud had been filtered. An example is provided in Figure 3.12.

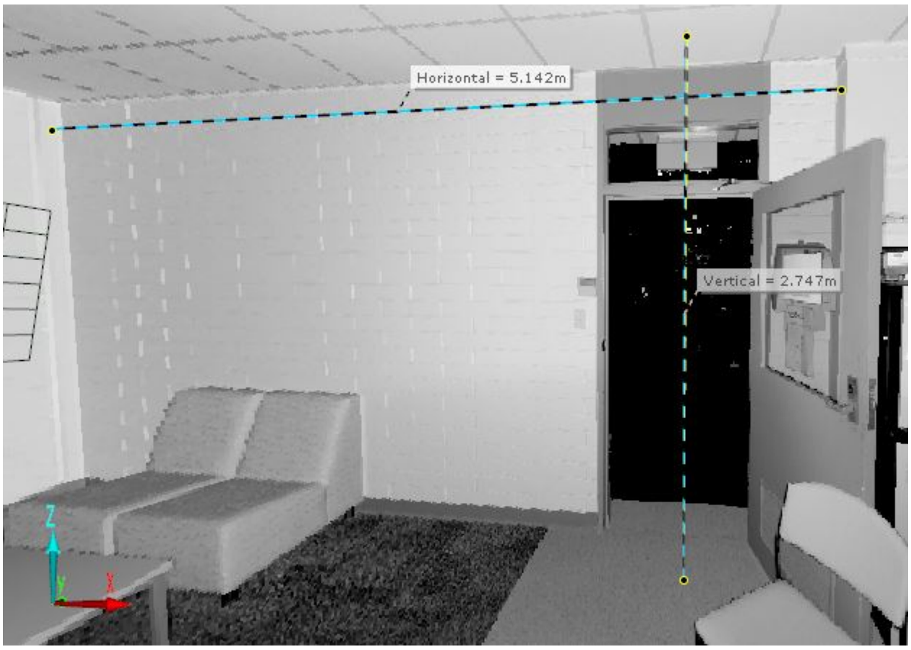


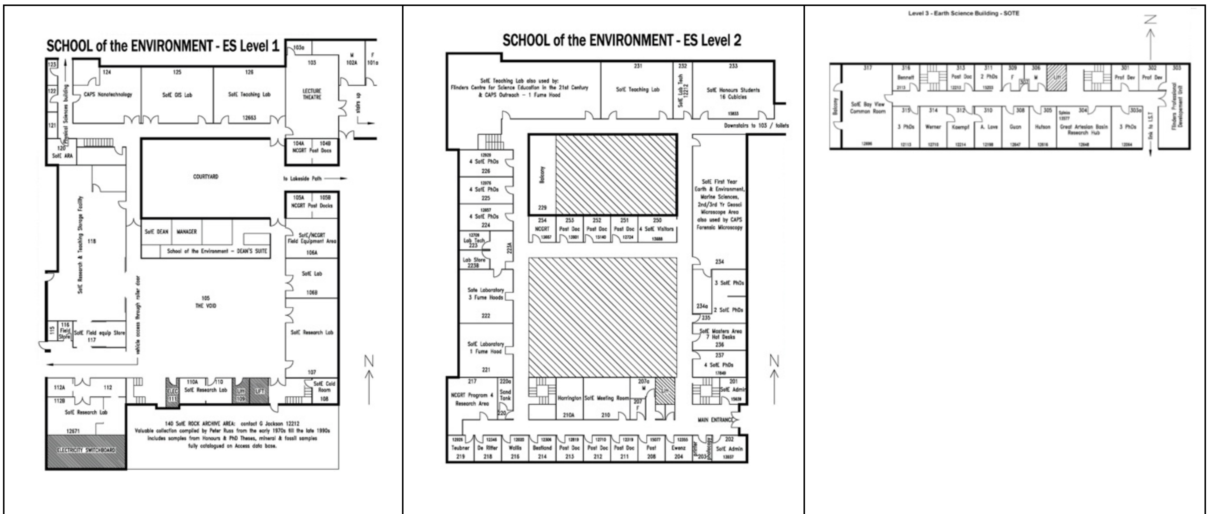
Figure 3.12 An example of the on-screen measurements from the 3D-model of the Bayview common room at level 3, FU-ESB.

A survey method using photogrammetry or lasergrammetry can produce a digital representation of a study location in the form of 3D-point cloud, with certain levels accuracy and completeness. Although this type of model can provide spectacular visualizations of structures almost instantly, this point cloud is often difficult to use because it emanates from an operational perspective. The point cloud contains an extremely large volume of information which has not been interpreted. This makes data extraction difficult (Héno et al. 2014).

3.3.2 Other surveying methods used in the Earth Sciences Building

Measurements were also made from 2D-plans and partial 3D-survey methods to compare with those from the 3D-model of the FU-ESB.

2D-floor plans for the FU-ESB were made by the Flinders University Buildings and Property Section (FU-BPS). This is a typical situation around the world, because of the dominance of 2D cadastral systems in surveying. This made the use of 2D- plans an important of the research project because this is exactly the situation faced by the government land agency, surveyors, the legal profession, property managers, and owners and tenants of properties in Indonesia. The plans that exist for all three floors of the FU-ESB had been made using CAD software and were stored, and made available to the researcher, as CAD files (Figure 3.13). The data used to create these floor plans were collected by theodolite survey when the building was constructed in the 1960s, they are updated whenever there is a new construction (i.e., when rooms are subdivided) with tape measures. This was last done in 2012, before I started surveying in 2014. The floor plans were created from these data using CAD software by FU-BPS staff. In this research, the x and y dimensions of the rooms and other spaces on each floor of the FU-ESB then were measured using the AutoCAD Software and imported into an Excel spreadsheet for comparison with other data. Complete data for each level can be found in Appendix 3.1.



(a) Level 1	(b) Level 2	(c) Level 3

Figure 3.13 The FU-ESB plans (a) Level 1, (b) Level 2 and (c) Level 3

In addition to obtaining the 2D-plans in CAD, the researcher applied a technique called partial 3D-measurement to survey the FU-ESB. This used a distometer which measures distances between two points with a laser beam. The researcher conducted a partial 3D-survey of the building using a survey-grade Leica Disto D810 distometer, which has an accuracy of ±1 mm and a range of 0.05 – 200 m. Measurements were made for all rooms and spaces. A partial 3D-survey comprises a set of survey measurements of a 3D-object using a device that measures x, y, z coordinates using measurements made by a surveyor.

The x, y and z dimensions of the objects in the building (rooms, corridors and other spaces like voids and stairwells) were measured by aiming the distometer from wall to wall to measure lengths and widths of spaces, or from floor to ceiling to measure the heights. The measurements were displayed on the screen of the distometer, which was connected to a mobile phone to capture pictures of the field situations and combine them into field records (Figure 3.11). Measurements data stored on the distometer were downloaded through its USB interface to the computer in pdf format (Appendix 3.2) for further use. The researcher noted the distometer measurement locations on the 2D- floor plans by annotation (Figure 3.14).

Photographs with measurement records (Figure 3.14) were called ‘photo sketches’. These were used to describe the condition of building at the time of measurement. They are, in effect, digital notes as to the record the actual measurements made in the field. The vertical or horizontal lines (see Figure 3.15) are not the actual lines of measurements, rather they are notes. The photos were taken with a tablet computer or a mobile phone. After the measurement was made it was sent wirelessly and a photo sketch created. Each photo sketch can have several measurements taken at the same location.

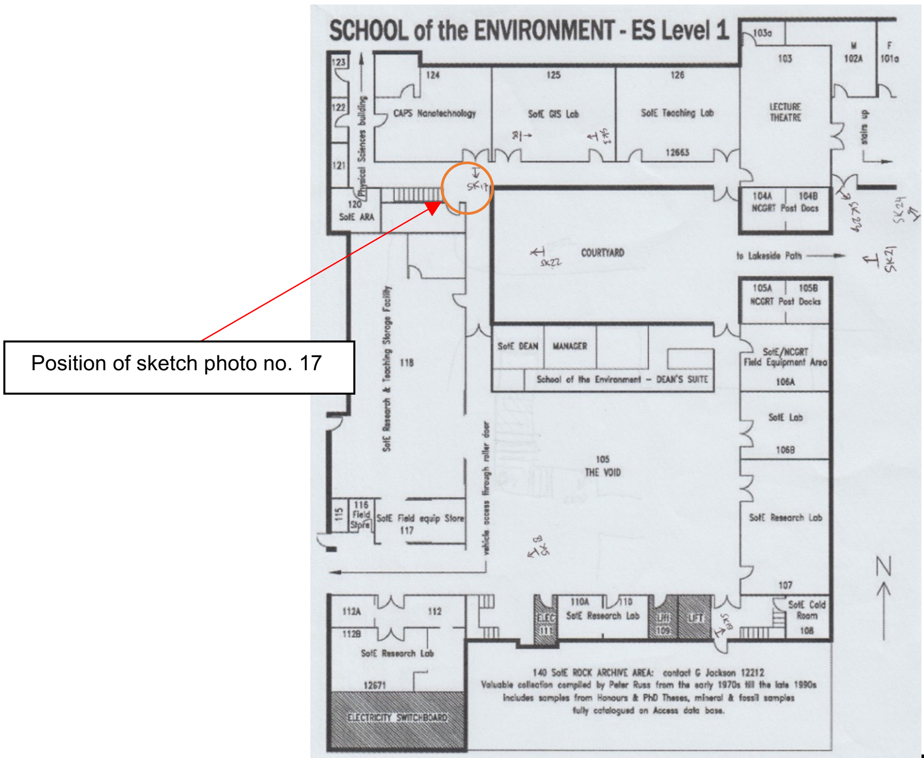


Figure 3.14 partially annotated floor plan of FU-ESB Level 1

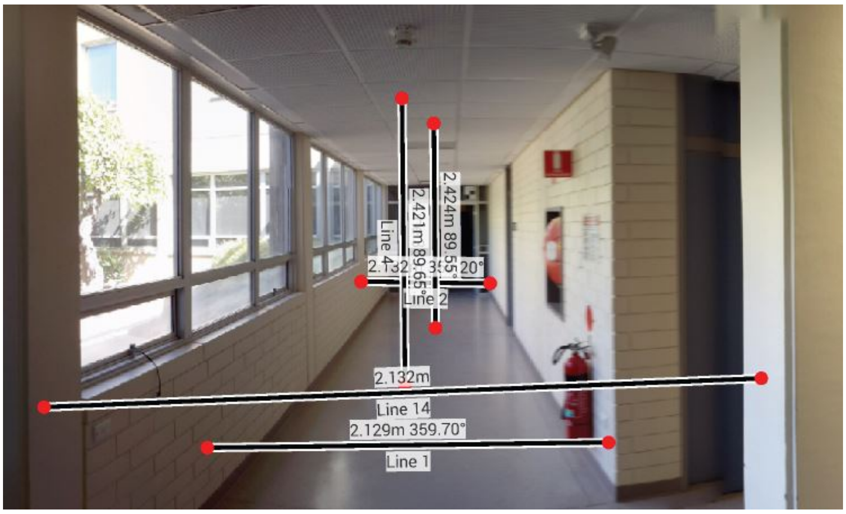


Figure 3.15 An example of a distometer photo sketch.

3.3.3 Analysis of measurements

The analysis of horizontal and vertical measurements used three formulae, namely RMSE (root mean square error), the Pearson product-moment correlation coefficient and the Student's t-test. RMSE was used to quantify the errors between measurements. The correlation coefficient was used to find the direction and strength of associations between sets of measurements and the t-test to whether sets of measurements were statistically significantly different

The Root Mean Square Error (RMSE), a measure of the magnitude of the error between two datasets (Equation. 3.1), was calculated using equation 3.1:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{n}} \qquad \text{.......................... (3.1)}$$

where *P* is the predicted value and *O* is the observed value. Low values of RMSE reveal better levels of agreement between measurements. RMSE is a good measure of how accurately a model calculates a response, and it is the most essential criterion for fit if the key purpose of the model is to predict (Martin 2012).

The Pearson correlation coefficient is used to measure the strength of a linear association between two variables, where the value r = 1 means a perfect positive correlation and the value r = -1 means a perfect negative correlation. So, for example, this test can be used to find out how well the measurements taken with one device correlate with those from another. Equation 3.2 was used:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad \text{......................} \quad (3.2)$$

where:

n is the sample size,

x_i, y_i is the single samples indexed with i,

$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$ (the sample mean) and analogously for $\bar{y}$.

The Student t-test (Equation 3,3) was used to compare the means of two sets of measurements made at the same points. It is used to test the null hypothesis that there is no significant difference between the two sets of measurements, i.e. Ho: U_D = U1 - U2 = 0, where U_D equals the mean of the population of difference scores across the two measurements:

$$t = \frac{(\sum D)/N}{\sqrt{\frac{\sum D^2 - \left(\frac{(\sum D)^2}{N}\right)}{(N-1)(N)}}} \quad \text{......................} \quad (3.3)$$

where

ΣD: Sum of the differences (Sum of X-Y)

ΣD^2: Sum of the squared differences

$(\Sigma D)^2$: Sum of the differences, squared.

3.4 3D-CADASTRE SYSTEM IMPLEMENTATION ANALYSIS

This section presents the methods that were used to investigate issues arising from the current 2D-cadastre in terms of surveying and managing properties with multiple owners in Bandung and Jakarta; to explore Indonesia’s readiness to adopt a 3D-cadastral system; and analyze the challenge with the advantages of a 3D-cadastral system could be implemented in Indonesia. A qualitative approach was used that focusses on the qualities of human behavior (Ferreira et al. 1988), with the aim of understanding and interpreting the meanings and intentions that underlie various human opinions and actions.

Interviews were conducted at Bandung and Jakarta. Jakarta (Figure 3.16) was chosen because it is the capital of Indonesia and, although it has a relatively long history of complex infrastructure development, contemporary construction of high-rise buildings such as apartment blocks and office towers; flyovers and underpasses, and above and below ground alterations and improvements to commercial and residential buildings is proceeding apace. Its population in 2011 was 9,607,787 according to Regulation 66 of 2011 of the Minister of Home Affairs/*Permendagri* No.66 *Tahun 2011*). With an area of 664 km^2, this gave a population density of 14,469 people per km^2 (Ministry of Home Affairs/*Direktorat Jenderal Pemerintahan Umum, Kementerian Dalam Negeri*, *2014*).

Figure 3.16 An example of complex above-ground architecture in central Jakarta. (ITC Cempaka Putih by Akhmad Fauzi, CC BY 3.0)

Bandung (Figure 3.17) was also chosen because of its very high population density. Its population in 2011 was 2,536,649 people according to Regulation 66 of 2011, of the Minister of Home Affairs/*Permendagri* No.66 *Tahun 2011*, its area was area 167 km^2 and its population density was15,189 people per km^2 (Ministry of Home Affairs/

Direktorat Jenderal Pemerintahan Umum, Kementerian Dalam Negeri, *2014*). This, along with that fact Bandung is being increasingly seen as a residential alternative by some workers in Jakarta (an opinion that will be strengthened by the fast rail link that is being developed between the two cities), is stimulating a shift toward the construction of high-rise buildings in Bandung.

Figure 3.17 A view of Bandung looking west showing a mixture of traditional low rise and modern high-rise architecture.
(Bandung City Centre - Dawn by musnahterinjak, CC BY-SA 3.0)

3.4.1 Participants

Five groups of stakeholders, present in both Bandung and Jakarta, were chosen as population pools from which to draw participants for this element of the research project. Government officers (Stakeholder category C1), legal deeds officers (C2) and licensed surveyors (C3) represented stakeholders involved in developing and managing the surveying and legal aspects of the cadastre in Indonesia. Property managers (C4) and the owners and renters of apartments (C5) represent the general public that uses the cadastre. The numbers of people in each stakeholder group in each city were identified and a sample drawn from each population pool (Table 3.1, Figure 3.18). Although this task was required for research clearance to undertake this research (Section 3.4.2), it is also a standard research procedure.

Table 3.1 Stakeholder groups and interview participants

Stakeholder group	**Population Pool**	**Numbers to be approached**	**Expected or required a number of participants in total**
Government officials (C1)	Indonesian Land Agency (BPN) offices in Bandung and Jakarta.	2 per city.	4
Legal deeds officers (LDOs) (C2)	Bandung: 238 Jakarta: 805	5% sample in each city = Bandung: 12, Jakarta: 20	32
Licensed surveyors (LS) (C3)	Bandung: 100 (estimate), Jakarta: 70 (estimate)	10% sample in each city = Bandung: 12, Jakarta: 7	19
Property management company managers (C4)	Bandung: 26 Jakarta: 106	10% sample in each city with a minimum of 3 = Bandung: 3, Jakarta: 10	13
Property owners and renters (C5)	Bandung: 10 Jakarta: 20	Two renters/owners per property sampled above (Stakeholder group C4) = Bandung: 5 x 2 = 10, Jakarta: 10 x 2 = 20	30
		Total number of participants interviewed	98

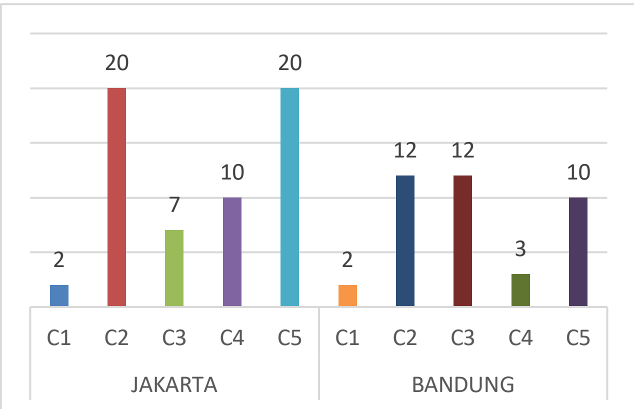


Figure 3.18 Participants by stakeholder category in each city.

3.4.2 Interviews

Data were collected on these aspects of the research through face-to-face interviews with individuals. Before the interviews could be administered the survey proposal and survey instruments (questionnaires) (Appendix 3.2) had to be approved by the Flinders University Social and Behavioural Ethics Committee. Approval, reference 7013, was granted on October 21, 2015 (Appendix 3.3). Permits to undertake the research were also obtained from the Ministry of Agrarian Affairs and Spatial Planning/BPN Central Office (letter 3464/3.1-100/VIII/2015 of August 19, 2015 (Appendix 3.4) and BPN West Java Regional Office/Kantor Wilayah BPN Provinsi Jawa Barat (letters 2/ND-100.2/I/2016 and 5/2-32/I/2016 of January 5, 2016) (Appendix 3.5)

Ferreira et al. (1988) argue that interviewing is the most important data collection instrument available to a researcher. The purpose of an interview is to obtain qualitative data such as opinions and personal interests that are required to develop deep knowledge about an issue. They can take the form of unstructured, semi-structured and structured interviews (Rowley 2012). These different structures define the degrees of freedom when interviewing. A structured interview is similar to a questionnaire except that the interviewer is present and this increases the response rate compared to mailing a questionnaire (Rowley 2012). A semi-structured interview is more adaptable than a structured interview and is more suited for a less experienced researcher. It consists of well-defined, open-ended questions that can be asked in any order (Rowley 2012). Unstructured interviews are based on pre-defined topics of relevance and the idea is that the interviewee can talk freely about these topics (Rowley 2012). These interviews are generally more difficult to conduct and experience in interviewing is required in order to stay track of the relevant topics.

Semi-structured interviews were used in this research project to gather information on and to capture a wide range of views on the issues related to the 2D-cadastre, and the potential for a 3D-cadastral system in Indonesia. The interviews comprised a list of questions and issues to be discussed that were designed to give time to discuss important and issues in detail, to probe the interviewee for clarification if needed, and deal with unanticipated aspects of the research that interviewees introduced. Questions were elaborated to suit stakeholder groups. Face-to-face interviews also enabled the researcher to read non-verbal communication and reactions, which, in some cases, proved helpful when analyzing data. These types of interview have some potency as they were clearly structured, flexible, adaptable, are based on personal interaction, and the survey atmosphere can, to a certain extent, be controlled. However, there are also disadvantages to this way of gathering information such as interviewer bias (which might be an issue in this project as I had to reveal that I worked by BPN as part of my research ethics approval), a relatively high cost per interview, and logistical constraints (in my case I was only able to budget financially for interviews in Bandung and Jakarta) and time compression on respondents (Alreck & Settle 1994; Szolnoki & Hoffmann 2013).

The interview process and subsequent analysis comprised six steps (Figure 3.19). Potential participants were selected from the population pool (Table 3.1) and contacted by e-mail or phone to see if they were willing to take part in the research. If they responded positively, a date, time and location were arranged for the interview.
At the start of the interview, each participant was given an information sheet about the research project and interviews. After reading this, the participant was asked again if they are willing to participate in the interview and if they were, they were asked to sign a consent form. If participants declined the interview at this point, the interview was canceled and the researcher returned to step 1 to select another potential interviewee. Each participant was interviewed using the list of questions and issues that were considered relevant for that group of stakeholders. Interviews were conducted in Bahasa Indonesia and recorded using a mobile phone. Notes were made simultaneously.

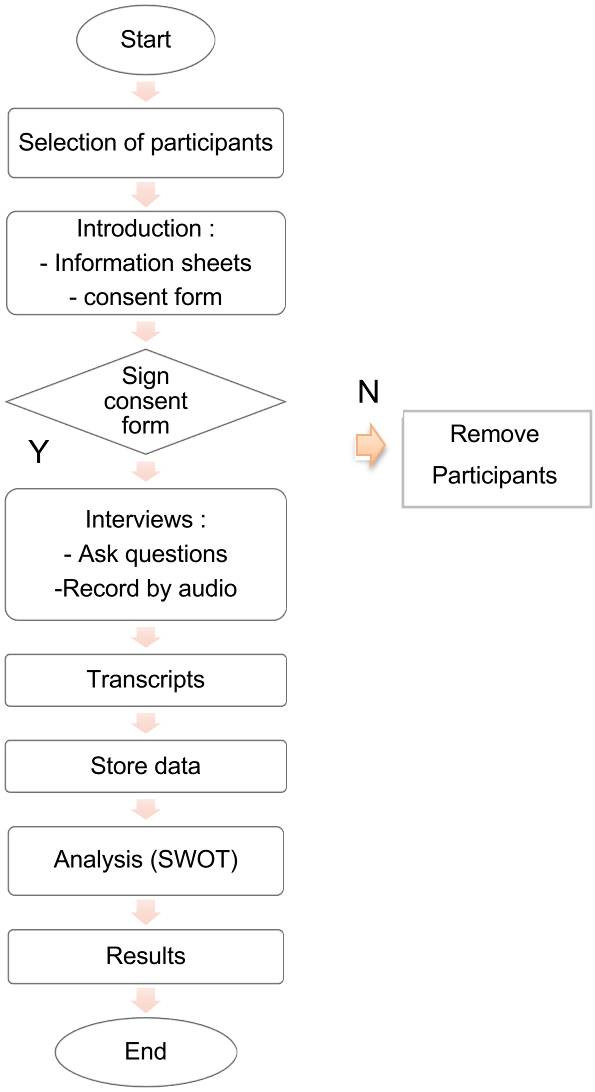


Figure 3.19 Flowchart of the interview process

The voice recording of each interview was converted into a transcript in Bahasa Indonesia and stored anonymously on my computer and the Flinders University server as advised by Australian Research Guidelines. The notes made by the researcher during the interviews were used alongside the voice recordings. Data were then stored in spreadsheets by data categories.

A thematic analysis approach was applied to some questions in the form graphs constructed from the responses stored in the spreadsheet. The lines of questioning variety slightly from one group of stakeholders to another. For example, the issues discussed with a government official (Stakeholder group C1) focussed heavily on technical, legal and organizational aspects around possible 3D-cadastre implementation. While other stakeholders, particularly managers and owners/renters, had fewer questions about the law and more on their opinions of how they might benefit if a new system was introduced. The questions for each group of stakeholders are presented in Appendix 3.6.

As part of the approval process to conduct this research all participants were informed of the confidential nature of their responses. Confidentiality implies that the dignity of a subject, in this case, both the individual and the organization they represent is respected. Therefore it was important that participants had no doubt that any identifying information they provided would be treated confidentially (Ferreira et al. 1988). Participants were informed that any information they provided could only be accessed by the researcher and the research supervisor.

Analysis of the information collected during interviews started when transcriptions were made of the interviews (Step 6, Figure 3.16). The transcripts were analyzed using a thematic analysis approach (Grbich 2013). This involves segmentation, categorization, and relinking of aspects of the data prior to final interpretation. The thematic analysis involved the following steps:

1. Reading and re-reading the transcripts in the database.
2. Recalling the research questions.
3. Underlining key segments.
4. Grouping like segments.
5. Attaching overarching labels and identifying subgroups.
6. Conceptualizing the groups and links with research literature and theory.

Matthews and Ross (2010) suggest data are organized using the following steps:

1. an index is created as a way to find data when needed;
2. initial categories related to themes or issues that have been identified are created and given codes; and
3. summary charts are created to visualize the data contained within each case (categories and cities).

The steps indicated by Grbich, and Matthews and Ross above were integrated into this study as follows:

1. all interview recordings and interview notes were transcribed;
2. an index of data was created in which each interview transcript was assigned a code;
3. initial categories related to some of the research themes drawn from the research questions the guiding the study were created; and
4. summary charts and tables were created from the data using Microsoft Excel 2015 and Microsoft Word 2015 software. These enabled the data to be analyzed by each respondent; and by categories/themes.

Wilcoxon Signed-Rank and Mann-Whitney U tests were used to test for significant similarities and differences, and associations in the responses between stakeholder groups and between cities.

Finally, the data were analyzed using SWOT analysis (Humphrey 2005) in which strengths (S) represent the characteristics of a system that give it advantages over other systems. Weaknesses (W) are the disadvantages of a system relative to others and are generally internal constraints within a system. Opportunities (O) are the elements in the system that can strengthen the advantages it has over other systems, and threats (T) are the elements that can weaken a system. Opportunities and threats are generally elements that are external to a system, whereas strengths and weaknesses are essential internal structural considerations.

The components were organized into a SWOT matrix in which S-O approaches indicate opportunities that a system can engage with that will strengthen it; W-O approaches address weaknesses that can be overcome by opportunities; S-T approaches identify system strengths that can be used to moderate vulnerability to threats; and W-T approaches can be used to form defensive plan to alleviate weaknesses to the external threats.

3.5 CHAPTER SUMMARY

This chapter has presented an overview of the project's research design and introduced the quantitative and qualitative methods employed to conduct the study. Quantitative methods were used to survey and model the FU-ESB building in 3D and compare the results of horizontal and vertical dimensions using different surveying methods. Qualitative data were collected through interviews with key stakeholders in Bandung and Jakarta to achieve a deep understanding of the current status of the 2D-cadastral system in Indonesia, the readiness of various stakeholders to adopt a 3D-cadastral system, and to evaluate key challenges the implementation of a 3D-cadastre.

CHAPTER 4: DEVELOPMENT AND ANALYSIS OF A 3D-MODEL FLINDERS UNIVERSITY EARTH SCIENCES BUILDING

4.1 INTRODUCTION

This chapter will report on the development of a 3D-model of a building, and a comparison of selected aspects of the 3D-model with results from other surveying methods for the same building. The chapter focusses on the third objective of this thesis, and research questions 3a and 3b (Section 1.2). Therefore, the key objectives of this chapter are to: (i) compare the real situation with the 3D-model; (ii) compare the results from the surveys of the FU-ESB using the three surveying methods; and (iii) compare the advantages and disadvantages of using these methods and then extrapolate these from the survey of the moderately complex FU-ESB, and environment over which I had much control, to what might occur in a complex, multi-occupancy building in a bustling Indonesian city.

This thesis is at its core concerned with infrastructure surveying, and the extraction of building infrastructures is considered to be an object recognition challenge (Volk et al. 2014). The automatic and efficient extraction of information about building infrastructure from laser scanning and imagery is a current research topic; e.g. research on the use of 3D-laser scanning to support layout planning and geometry analysis of production systems (Lindskog et al. 2016); visualization of a 3D-cadastre (Gann 2016), and in airborne and terrestrial survey (Vosselman 2014). The current motivations of the scientific and technical communities in this area are due to the perceived benefits that can be gained from automating previously manual procedures to capture data, and new forms of computer modelling that can be applied to these data. These techniques have been used by a wide range of disciplines, e.g., surveying, archaeology, and history.

In archaeology, a 3D-laser scanning is used mostly for historical monuments or buildings. For instance, the use of terrestrial laser scanning (TLS) has been used effectively to produce accurate and high-resolution 3D-models of a cave with engravings dating back to the Upper Palaeolithic era in Southeast Spain (Lerma et al.

2010). In another example from geology, 3D-laser scanning has been used to characterize discontinuities in rock cuts (Sturzenegger & Stead 2009). In the preserve of historical buildings, Armesto-González et al. (2010) combined the technology of the terrestrial laser scanning with digital image processing in order to study damages on stone masonry on historic buildings.

4.2 3D-MODEL

Laser scanning was used to acquire data to create a 3D-model of the Earth Science Building (Figure 4.1) on the campus of Bedford Park, Flinders University.

Building elevation from east

Building elevation from the northeast

Building elevation from the southwest

Building elevation from south

Figure 4.1 Photos of Earth Science Building, Bedford Park Campus, Flinders University (multiple views)

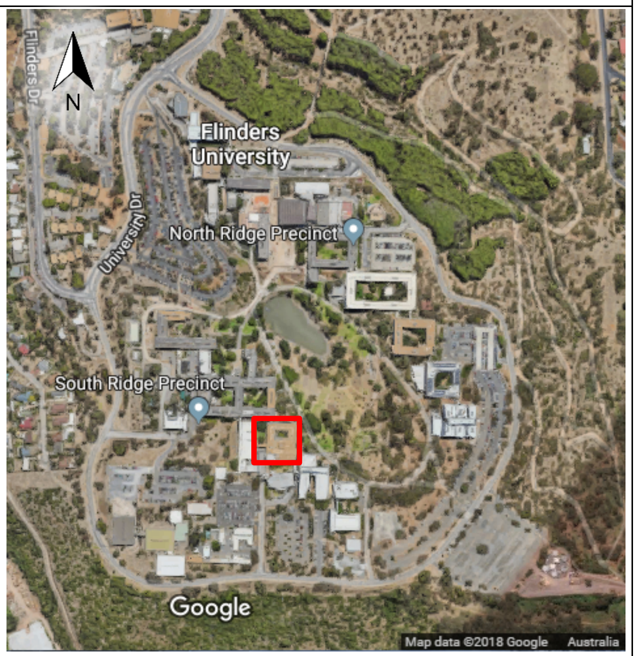
This building is located in the southern part of the Bedford Park Campus of Flinders University in Adelaide, South Australia (Figure 4.2). Its geographical centre is 35° 1'42.50"S, 138°34'19.20"E, and it consists of four levels and 104 internal divisions (rooms/spaces).

4.2.1 Data acquisition

The data acquisition stage of this part of the research project (Figure 3.5) was initiated with (i) the preparation of the 3D-laser scanner (equipment settings, battery and SD cards checks), and (ii) placing checkerboard targets in the building. Scan locations that stated before (Section 3.3.1). After this, a sketch map of scan locations was made (Figure 3.4). Scanning started in November 2014 and continued until February 2015 when all of the interior spaces and the exterior of the building had been scanned. External scans were acquired from 20 scan positions and there were 217 internal scan positions.

Map of the study area
Earth Science Building, Bedford Park Campus
Flinders University, South Australia

Map view



Satellite View

Legend:

□ : location of Earth Science Building (FU-ESB)

Source:

Map data ©2018 Google Australia

Figure 4.2 Earth Science Building Location, Bedford Park, Flinders University.

4.2.2 Data and point cloud

After the survey had been completed the original raw data scan was backed up in fls format (raw data scan with Trimble TX5 scanner). The survey data were analyzed and compared to field sketches and notes after the survey. Specifically, the scanned files were listed and compared to the field notes to see what environmental conditions may have affected the scans. Scan with no notes indicating potentially adverse environmental conditions were prioritized for modelling.

4.2.3 Construction of the 3D-model

The construction of the 3D-model was started by transforming raw, registered datasets or point clouds, into a 3D-model. The first step in processing the point clouds was data registration. Every scan position was defined in the scanner coordinate system. All the scanner positions were combined into a 3D-model in this system. After all of the scans were registered, they were geo-referenced into the Geocentric Datum of Australia (GDA) 1994 MGA Zone 54 coordinate system. The registration of point clouds into the same coordinate system is one of the most important steps in processing terrestrial laser scanner measurements. This can be clearly seen by visually examining the differences between the unregistered scans and registered scans for part of the FU-ESB (Figure 4.3). In this figure, the unregistered scans come directly from the original scanned data. It is clear that they are not properly aligned. The better alignments in the registered scan views are clear.

The next step aimed at improving the quality of the data by applying noise filtering. Noise in this context can be caused by objects that were not required to be scanned for this project (e.g., tree and bushes, people), the effects of wind, and poor reflection from walls, floors, and ceilings. The errors are recognized as noise and were filtered manually by the researcher; see for example the tree that was filtered out in Figure 4.4. Removing noisy points is based on two principles. The first principle is that points that have only a few or no other points in surrounding them are outliers. They arise due to objects moving in front of the scanner, e.g. people, while scanning was in progress. The second principle is to move points slightly to achieve optimal smoothness of surfaces.

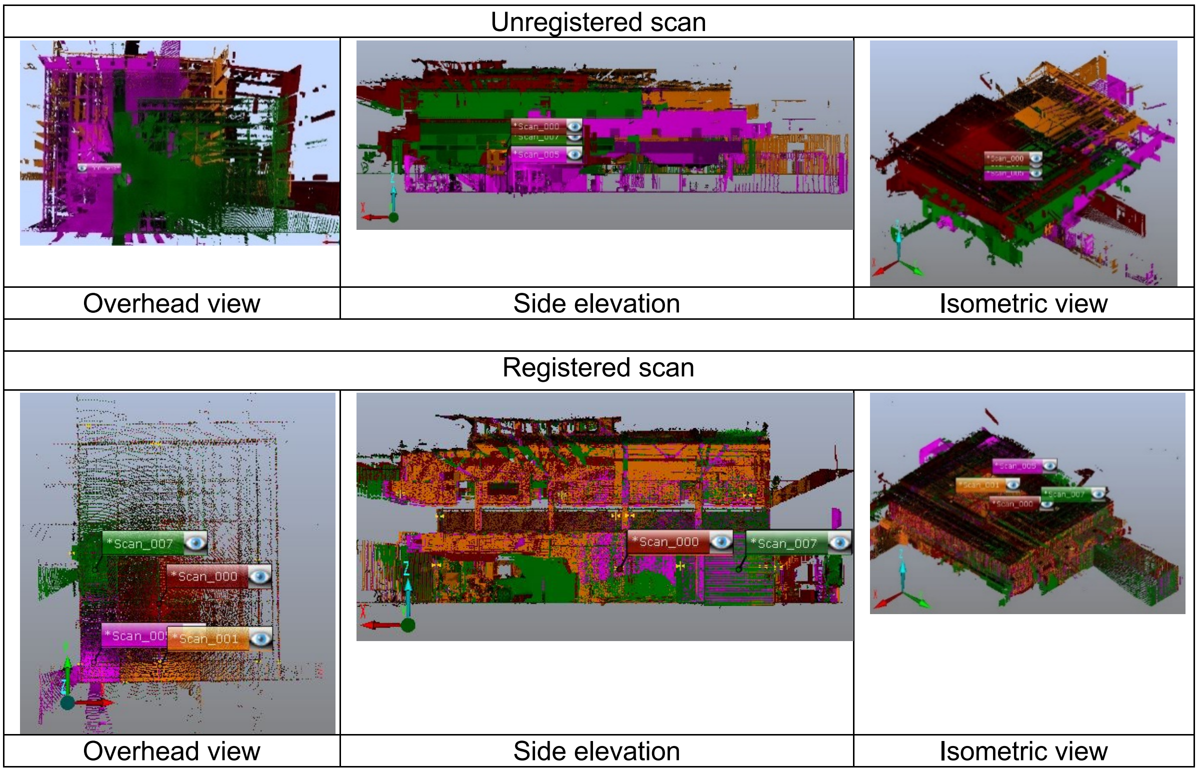


Figure 4.3 Unregistered and registered scan for various elevations of the FU-ESB

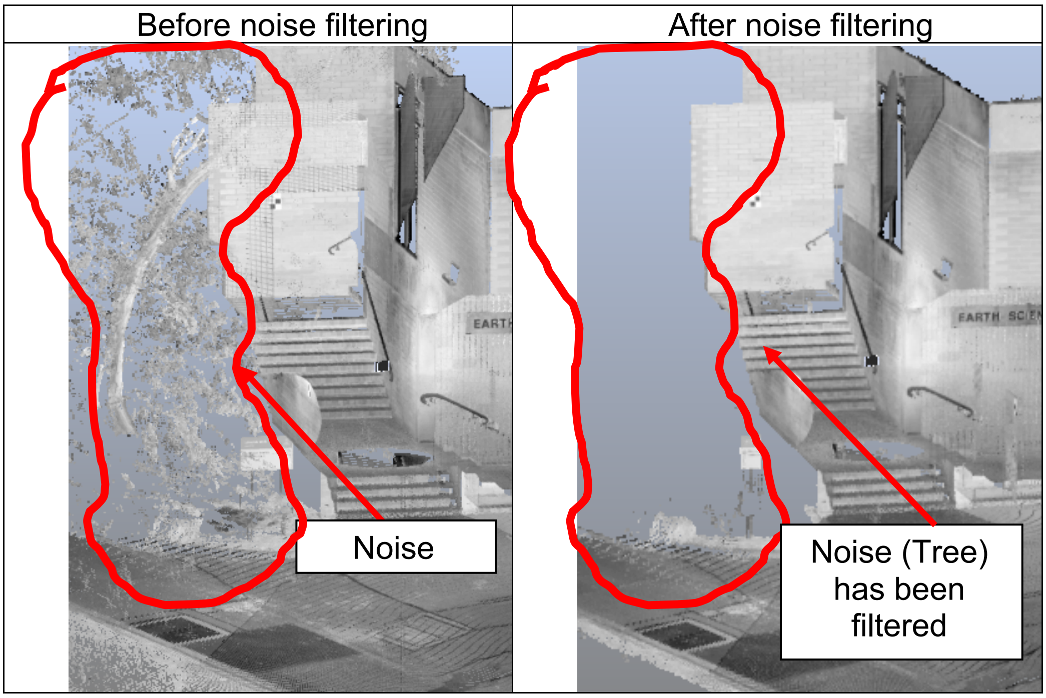


Figure 4.4 An example of noise filtering

The precise type of noise filter available depends on the type of scanner; however, a manual filter supervised by an operator always needs to be considered to avoid removing features that are part of the object being scanned, or to avoid removing too many points.

After registration and noise filtering, a registered, clean point scan is available for further processing. The point cloud for the FU-ESB is illustrated in Figure 4.5.

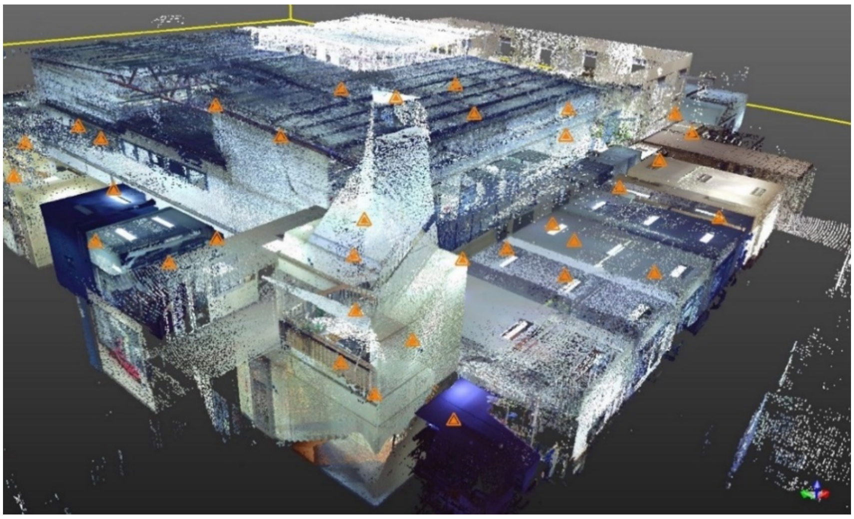


Figure 4.5 3D-point cloud of the FU-ESB

The next step was to make measurements from the 3D-model using SCENE software version 5.2 (Figure 4.6). Measurements like those illustrated in Figure 4.6 were made 237 scan locations in the FU-ESB (Table 4.7).

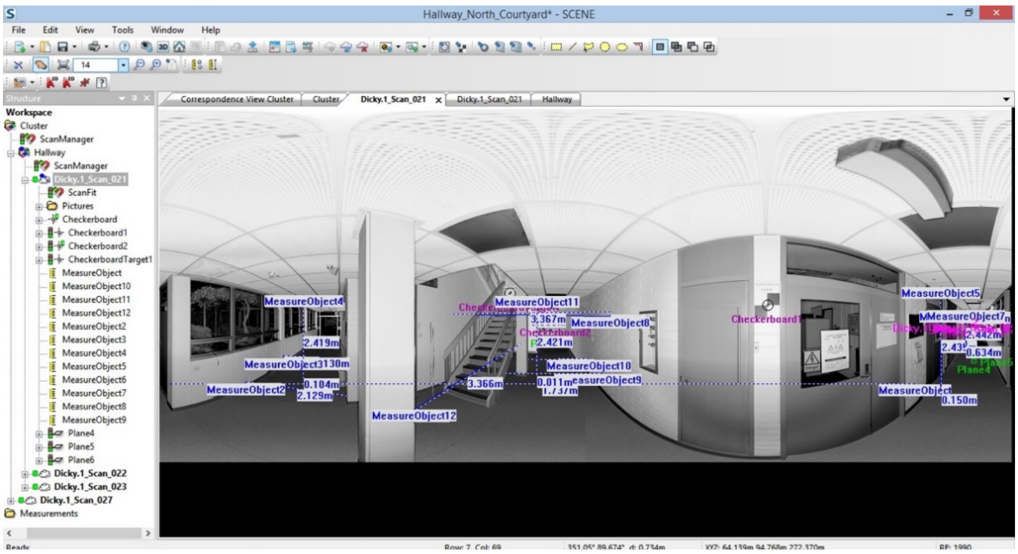
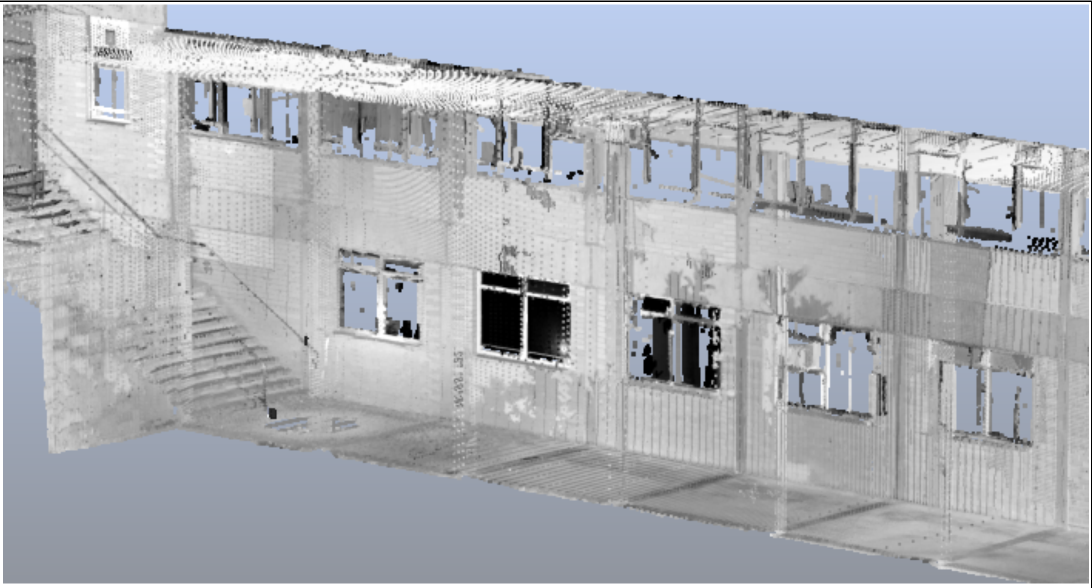
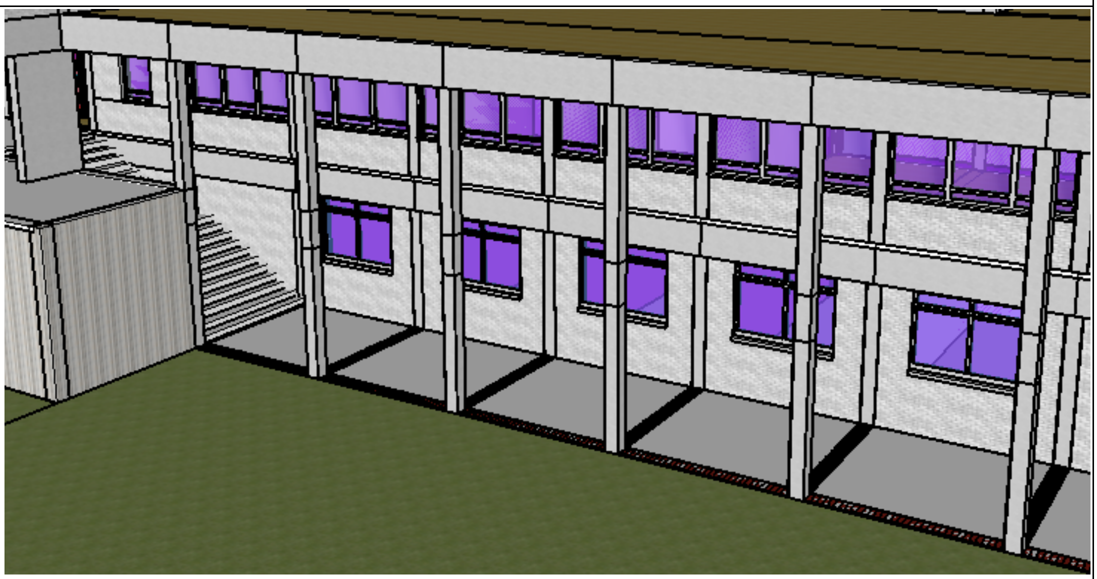


Figure 4.6 Measurements made on scanner photographs at location number 21 in the FU-ESB

The next step in processing was converting the point cloud into a 3D-model (Figure 4.7). The researcher measured linear distances from the point cloud in the SCENE software. For example, x, y and z dimensions of a room were made and then drawn onto the 3D-model in SketchUp Software. Knowledge of modeling is required for success in this step, i.e., a researcher must understand how to draw a 3D-model using the measurements acquired from 3D-point clouds.



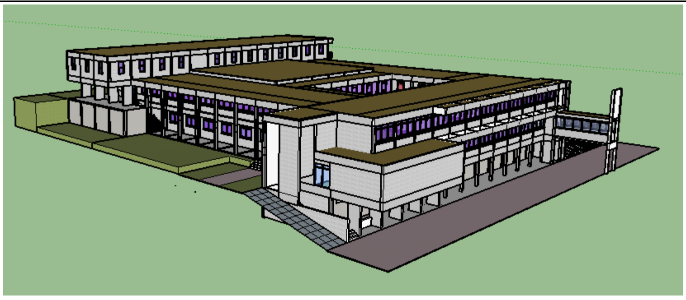
3D-point cloud of part of the east elevation of the FU-ESB



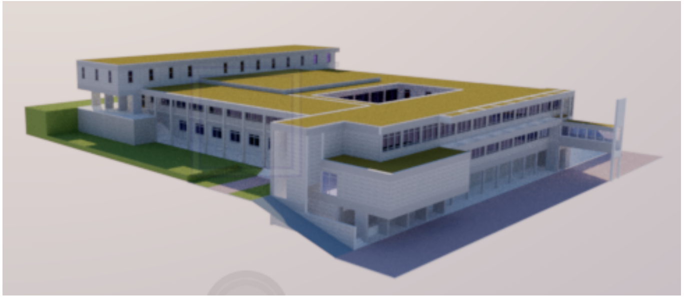
3D-model of part of the east elevation of the FU-ESB

Figure 4.7 3D-model for part of the east elevation of the FU-ESB created with SketchUp Software.

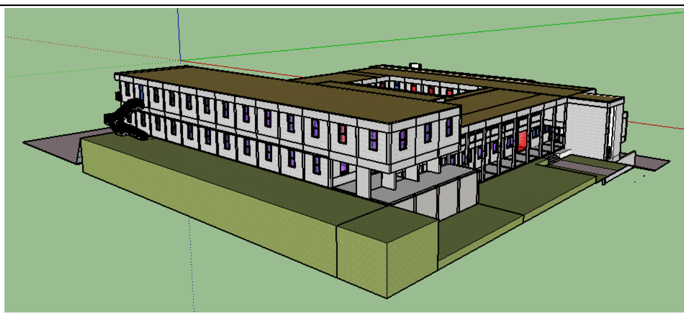
When the 3D-model had been created, it was rendered (Figure 4.8). Rendering was carried out with the Visualiser program, which is an extension of the Sketch-Up program.



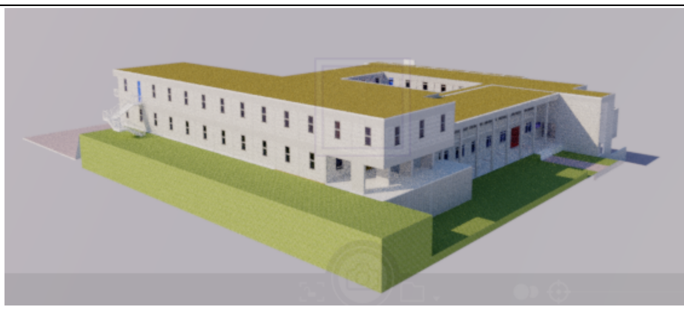
3D-model of FU-ESB north-east elevation



Rendered 3D-model of FU-ESB north-east elevation



3D-model of FU-ESB south-east elevation



Rendered 3D-model of FU-ESB north-east elevation

Figure 4.8 Rendered 3D-models of FU-ESB

4.2.4 Analysis of 3D-laser scanning

This project comprised 237 scan locations. Registering all of these scans required 45 projects (Table 4.1). A project is SCENE software in a folder in which a number of scans are registered.

The maximum error in registration accuracy occurred at scan project NEW_L_0-cluster B/45 on the External level, i.e., the exterior of the FU-ESB (Table 4.1, the maximum error was 0.0160, the mean error was 0.0088, and the standard deviation was 0.0057. The accuracy is probably low at this point because of the relative distance being measured. This argument probably applies to other large errors (>1 standard deviation) that occurred at the following scan projects: Dean's Suite, Main Void, CAPS-L1, Phd_Room-L1 and CourtYard-L1 on Level 1, Main_Void-L2. The minimum error occurred at scan project BayView_L3-cluster2 on Level 3. The maximum error here was 0.0007, the mean 0.0003, and the standard deviation 0.0003.

Figure 4.9 illustrates the point cloud registration for part of the eastern side of the building (Project scan name: NEW_L_1_EAST_EXT). The largest error occurred between scans of target P8 from scanning stations 41 and 42. The error was 0.0138 m (13.8 mm) (Figure 4.10). However, the result was acceptable because the deviation (0.0033 m) was below the maximum error of the laser scanner used, which was 0.0050 m.

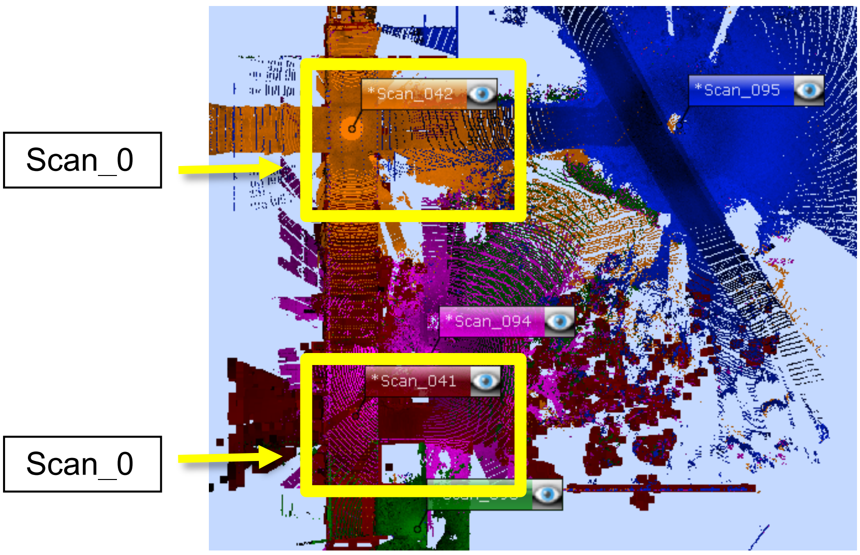


Figure 4.9 Point cloud registration of the eastern side of the study location.

Table 4.1 Scan project of the study area.

Level	No	scan project name	cluster name	min	max	mean	dev	
EXT	1	NEW_L_0	A/23	0.0000	0.0034	0.0020	0.0013	
	2		B/45	0.0000	**0.0160**	**0.0088**	**0.0057**	Max-error
	3		C/68	0.0000	0.0070	0.0024	0.0025	
	4	NEW_L_1_SOUTH_EXT	Scans	0.0000	0.0032	0.0021	0.0015	
	5	NEW_L_1_WEST_EXT	Scans	0.0000	0.0022	0.0006	0.0008	
	6	NEW_L_1_EAST_EXT	Scans	0.0000	0.0077	0.0028	0.0023	Example
L1	1	Cold_room	Cold_Room	0.0000	0.0022	0.0010	0.0007	
	2	Rooms_East_Void	Scans	0.0000	0.0050	0.0009	0.0012	
	3	Dean_suite	Scans	0.0000	0.0132	0.0028	0.0035	
	4	Main_Void	Scans	0.0000	0.0146	0.0044	0.0035	
	5	Entry_Gate	Scans	0.0000	0.0116	0.0029	0.0031	
	6	RAA_West-L1	Cluster	0.0000	0.0070	0.0034	0.0030	
	7		Cluster2	0.0000	0.0039	0.0017	0.0014	
	8	RAA_East-L1	Scans	0.0000	0.0115	0.0030	0.0032	
	9	Rooms_South_Void-L1	Scans	0.0000	0.0095	0.0022	0.0025	
	10	Room_West_Void-L1	Scans	0.0000	0.0123	0.0033	0.0034	
	11	Warehouse_Rooms-L1	Scans	0.0000	0.0061	0.0025	0.0023	
	12	CAPS_OUTER-L1	Scans	0.0000	0.0093	0.0023	0.0025	
	13	CAPS-L1	Scans	0.0000	0.0127	0.0035	0.0053	
	14	Phd_Room-L1	PhD	0.0000	0.0133	0.0027	0.0032	
	15	Hallway_North_Courtyard-L1	Scans	0.0000	0.0059	0.0015	0.0020	
	16	Theatre-L1	Scans	0.0000	0.0044	0.0018	0.0015	
	17	Toilet_Theatre-L1	Scans	0.0000	0.0026	0.0011	0.0009	
	18	F_Toilet_Theatre-L1	Scans	0.0000	0.0108	0.0024	0.0032	
	19	CourtYard-L1	Scans	0.0000	0.0128	0.0036	0.0037	
	20	New_gate_Courtyard-L1	Scans	0.0000	0.0071	0.0013	0.0019	
L2	1	NEW_MAIN_ENTRANCE_L2	Scans	0.0000	0.0048	0.0013	0.0018	
	2	NEW_TOILET_ENTRANCE_L2	Scans	0.0000	0.0068	0.0018	0.0022	
	3	South_Hallway_L2	Scans	0.0000	0.0088	0.0018	0.0022	
	4	Sandtank_L2	Scans	0.0000	0.0068	0.0020	0.0021	
	5	Around_NCGRT_L2	Scans	0.0000	0.0066	0.0015	0.0015	
	6	Main_Void_L2	Scans	0.0000	0.0142	0.0027	0.0028	
	7	West1_L2	Cluster	0.0000	0.0094	0.0022	0.0028	
	8		Cluster2	0.0000	0.0079	0.0020	0.0022	
	9	West2_L2	Scans	0.0000	0.0100	0.0017	0.0022	
	10	CAPS_L2	Scans	0.0000	0.0038	0.0013	0.0016	
	11	North_L2	Scans	0.0000	0.0095	0.0022	0.0024	
	12	R231_L2	Scans	0.0000	0.0040	0.0028	0.0015	
	13	East_L2	Scans	0.0000	0.0144	0.0025	0.0030	
L3	1	Around_BayView_L3	4567	0.0000	0.0049	0.0014	0.0015	
	2		cluster2	0.0000	**0.0007**	**0.0003**	**0.0003**	Min-error
	3		cluster3	0.0000	0.0103	0.0041	0.0038	
	4		cluster4	0.0000	0.0011	0.0007	0.0005	
	5		cluster5	0.0000	0.0050	0.0017	0.0016	
	6	East_L3	Scans	0.0000	0.0131	0.0014	0.0024	
		mean			0.0080	0.0023	0.0023	
		Standard deviation			0.0041	0.0013	0.0011	
		max			**0.0160**	**0.0088**	**0.0057**	
		min			**0.0007**	**0.0003**	**0.0003**	

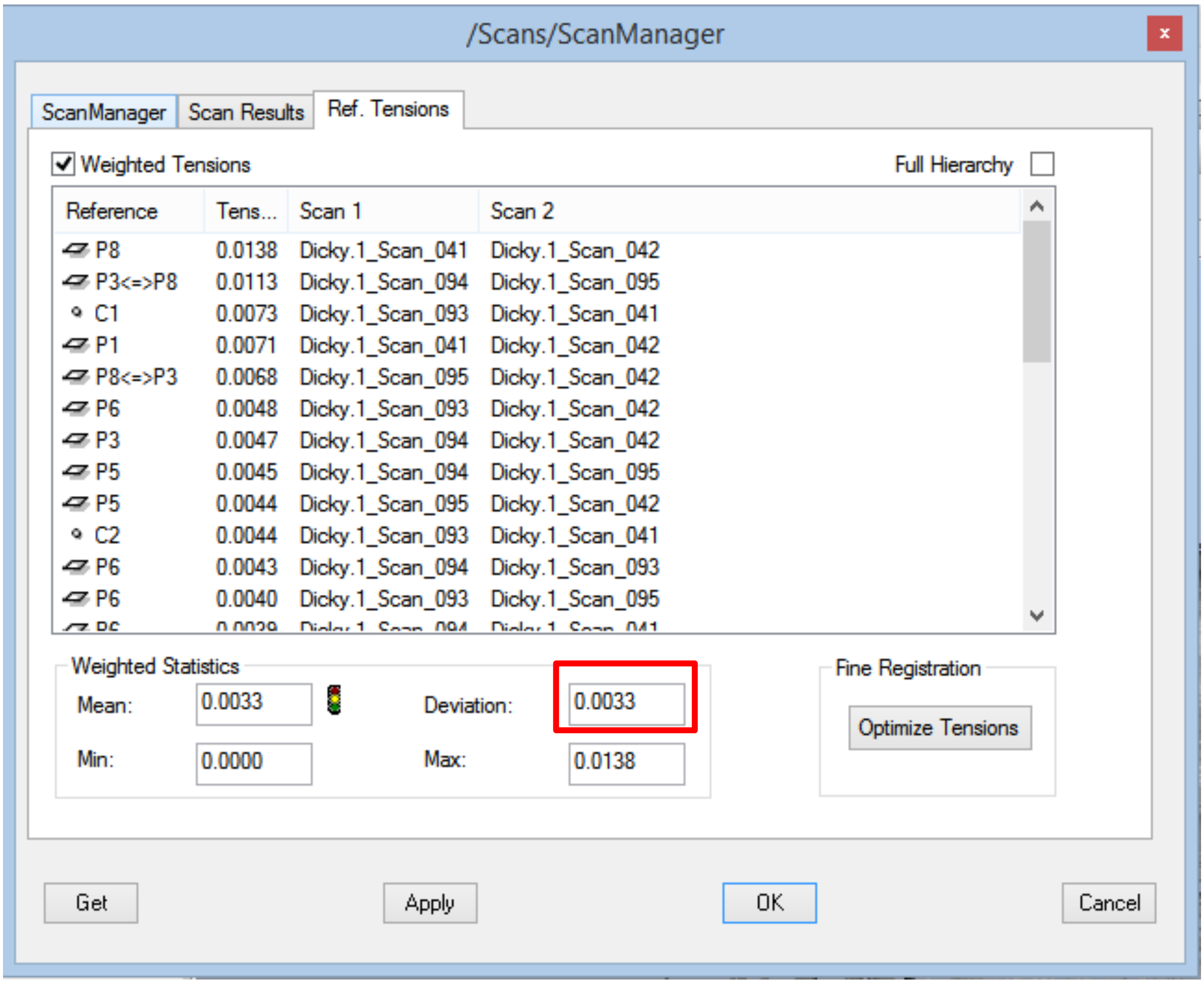


Figure 4.10 Example of the registration result.

It is possible that these large differences occurred when different objects were interpreted as the same object during registration. This is caused by the divergence of laser light, resulting in an error ranging from millimetres to centimetres. The magnitude of the registration error results in different orientations and forms when compared to real-world situations. Such large registration errors can be resolved by re-selecting binding points, e.g., targets or points like corners of windows, on the objects until the registration error is reduced to <5 mm, the accuracy of the scanner. In the example given in Figure 4.10, the result was improved by improving registration by applying anti correspondence to P8, and the deviation was reduced to 0.0023 m (Figure 4.11).

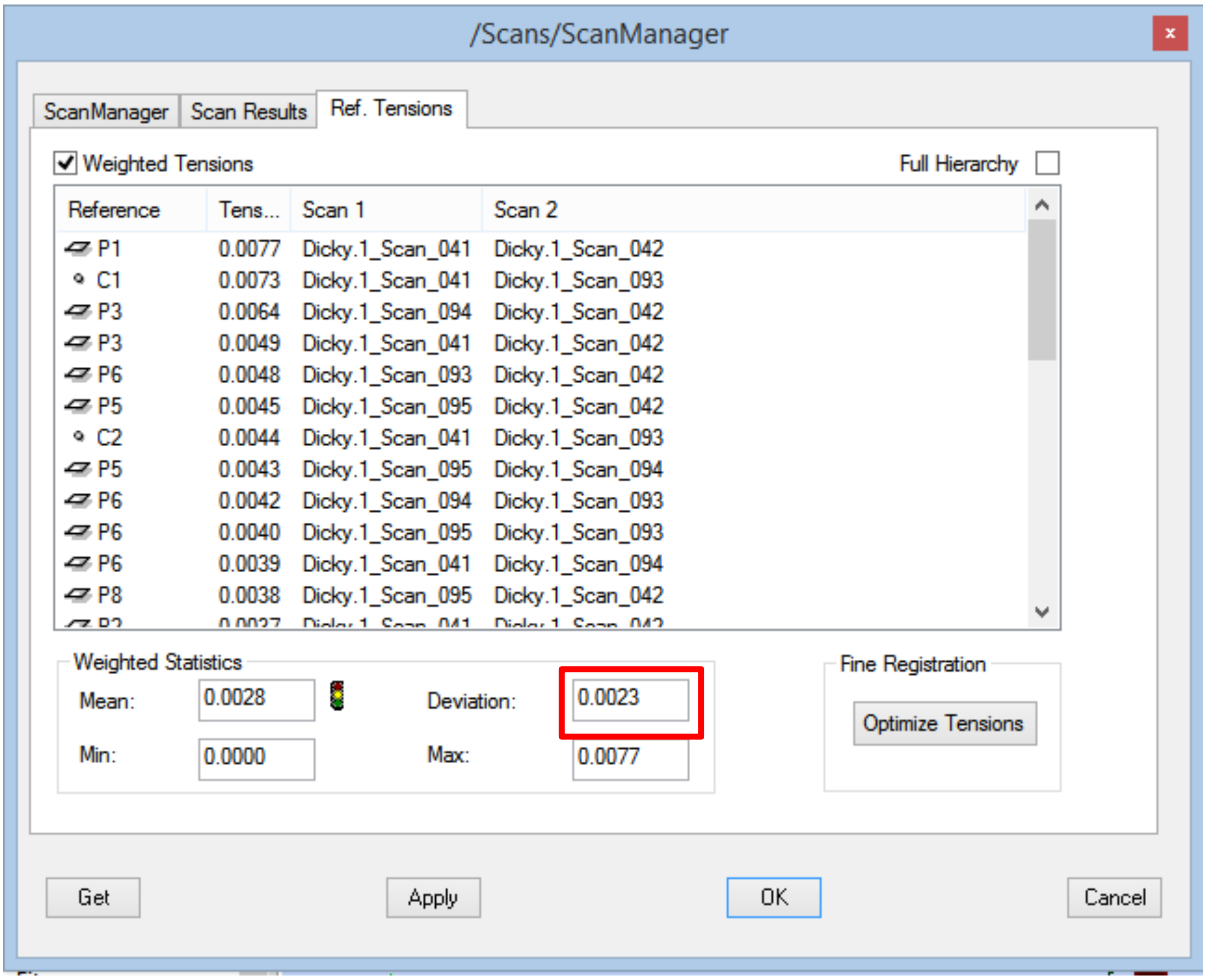


Figure 4.11 an example of reduced standard deviation in relation to Figure 4.10.

The maximum error of 0.0138 m for scan position P8 was reduced to 0.0077 m in P1 and the deviation decreased from 0.0033 m to 0.0023 m. As this process must be conducted carefully and precisely, it takes a long time. In this research, error registration was reduced by gradually dividing all data into parts, so that the registration error(s) does not exceed the maximum error of 0.0050 m.

4.3 AN EVALUATION OF 3D-MODEL

4.3.1 Real situation compare to 3D-Model

Figures 4.12 – 4.19 enable visual comparisons of the actual building and the rendered 3D-model to make. In each case, the photographs were taken with a Nikon D5300 DSLR with a 35-80mm AF zoom lens and are compared to sections of the rendered 3D-model. The situations were chosen to illustrate how different the laser scanner and the model development dealt with different types of structures and spaces. In each case, the rendered 3D-model represented the real situation well. In Figures 4.12 and 4.13 the vegetation alongside the building was removed during the noise removal phase of model development.

Figures 4.12 and 4.13 cover two external elevations. Figure 4.13 shows a photograph of the covered walkway and stairs along the exterior of the eastern side of the building at Level 1. The photograph captured the structure of the walkway and stairs to Level 2, but some details which do not affect measurements of linear dimensions such as window air conditioning units (the fourth window from left in Figure 4.13 left, and central handrails on the stairs, were omitted. Figure 4.14 shows Bull's Court, an external courtyard, i.e. open to the sky, which is surrounded on all sides by internal spaces. On all four sides, the courtyard is enclosed by parts of Levels 1 and 2 of the FU-ESB. The rendered 3D-model represents the hard surfaces (courtyard walls and floors), while the photograph shows the large pergola with its grapevine, and beds with shrubs and perennial plants, and benches for seating which were edited out the model.

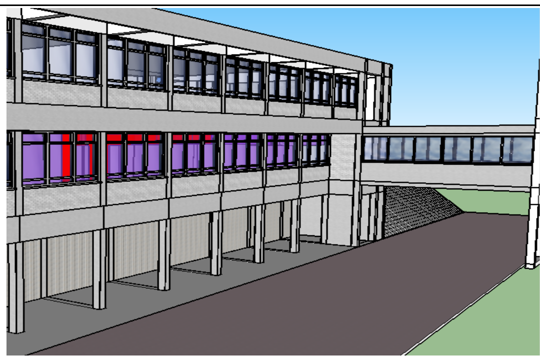
	
North elevation, photograph.	North elevation, rendered 3D-model

Figure 4.12 Comparison of north elevation of FU-ESB: photograph (left), rendered 3D-model (right)

	
External walkway and stairs along the east of building Level, photograph.	External walkway and stairs along the east of building Level, rendered model

Figure 4.13 Comparison of the eastern side of the FU-ESB at Level 1: photograph (left), rendered 3D-model (right)

	
Bull's Court, view looking west, photograph.	Bull's Court, view looking west, rendered model.

Figure 4.14 Comparison of Bull's Court, Level 1: photograph (left), rendered 3D-model (right)

The next two figures show the Main Void, a space that extends through the first and second floors. Figure 4.15 shows a view looking southwest from the first floor to the second floor, while the next figure shows a view looking down from the second to the first floor in a northwest direction. In Figures 4.15 and 4.16 it can be seen that the open ironwork structure in the roof space was not created in the 3D-model (Figure 4.16) because the purpose of the research was to make accurate dimensions of spaces in the building, and not to provide a detailed rendition of the entire building. The level of detail is also moderate, as small details are not specified (e.g., wall surfaces) and furniture and fittings on the floor of the void were not modelled for the same reason given above.

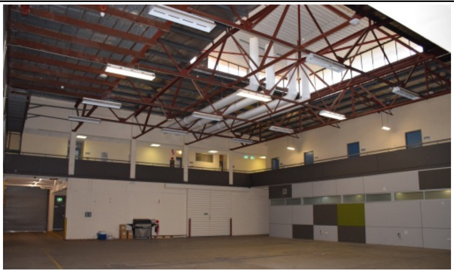
	
Real photo from Main Void view (Level 1)	3D-model from Main Void (Level 1)

Figure 4.15 Comparison of the Main Void from Level 1 looking up Level 2, southwest view: photograph (left), rendered 3D-model (right)

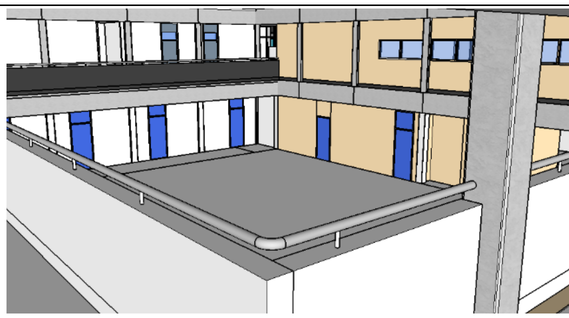
	
Real photo of Main Void (Level 2)	3D-model of Main Void (Level 2)

Figure 4.16 Comparison of the Main Void from Level 2 looking down to Level 1, northwest view: photograph (left), rendered 3D-model (right)

Figure 4.17 captures the main entrance to the building at the top of the stairs (see Figure 4.13) on level 2 (Figure 4.16). The model is a good representation of the actual situation without small details like the centre rail of the stairs and the fire alarm fittings.

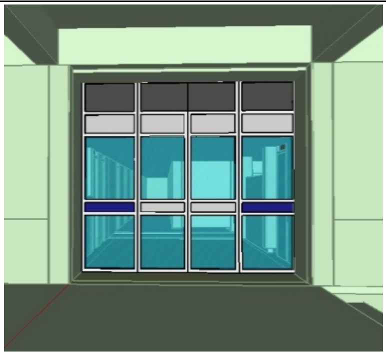
	
Real photo of Main Entry (Level 2)	3D-model of Main Entry (Level 2)

Figure 4.17 Comparison of Main Entrance of FU-ESB: photograph (left), rendered 3D-model (right)

Figure 4.18 shows the situation on Level 3 between the door of the elevator on the left and the stairs to the right. The model simplifies the shape of the cupboard housing fire hoses (the white cupboard in the centre of the photograph with the red rectangular label) and omits the mobile photocopying machine. Figure 4.19 shows the condition of the Bayview common room at level 3. The model again simplifies the shape of the fire hose cupboard and omits movable objects like tables, chairs, fridge, and coffee machine.

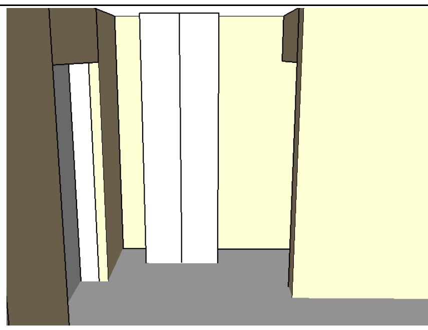
	
Real photo of near lift (Level 3)	3D-model of near lift (Level 3)

Figure 4.18 Comparison of the entrance to the elevator on Level 3 to the left of the images, and the doorway leading to the stairs down to Levels 1 and 2 to the right of the images.

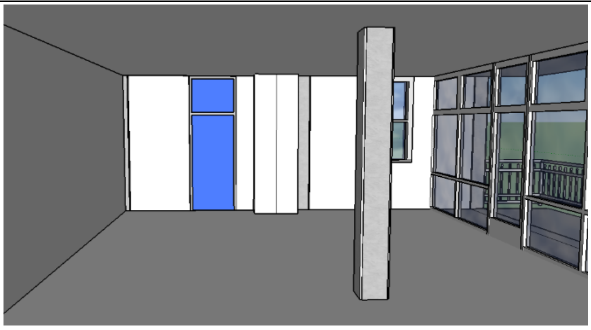
<table>
<tr><td></td><td></td></tr>
<tr><td>Real photo of Bayview common room (Level 3)</td><td>3D-model of Bayview common room (Level 3)</td></tr>
</table>

Figure 4.19 Comparison of the Bayview Common Room on Level 3, looking south. Photograph (left), rendered 3D-model (right)

4.3.2 2D-CAD compare to Partial 3D-(distometer) (horizontal)

Measurements taken from the CAD plans and 3D-model, and made with the distometer, were compared to see if they were statistically different. This was done for horizontal (wall-to-wall) dimensions for all three types of measures, and vertical (floor-to-ceiling) measurements for the last two. The null hypothesis used in comparing each pair of measurements was that there was no significant difference between pairs of measurements. The distribution of each of the sets of measurements evaluated, and they were found to be normal. Therefore, the Student's t-test was used to test the for statistical differences, root mean square errors were calculated for the differences in pairs of measurements, and Pearson's product-moment correlation coefficients were calculated to test the strength and direction of associations between pairs of measurements were calculated, and outliers were identified from bivariate linear regression.

Wall-to-wall, horizontal measurements

Sixty-three horizontal measurements were made across spaces bounded by solid partitions, e.g. brick walls. These spaces were selected randomly using random integer tables.

The first step in each comparison was to visually assess the paired measurements by plotting the distance measurements for each measurement location on the same axes (Figure 4.20)

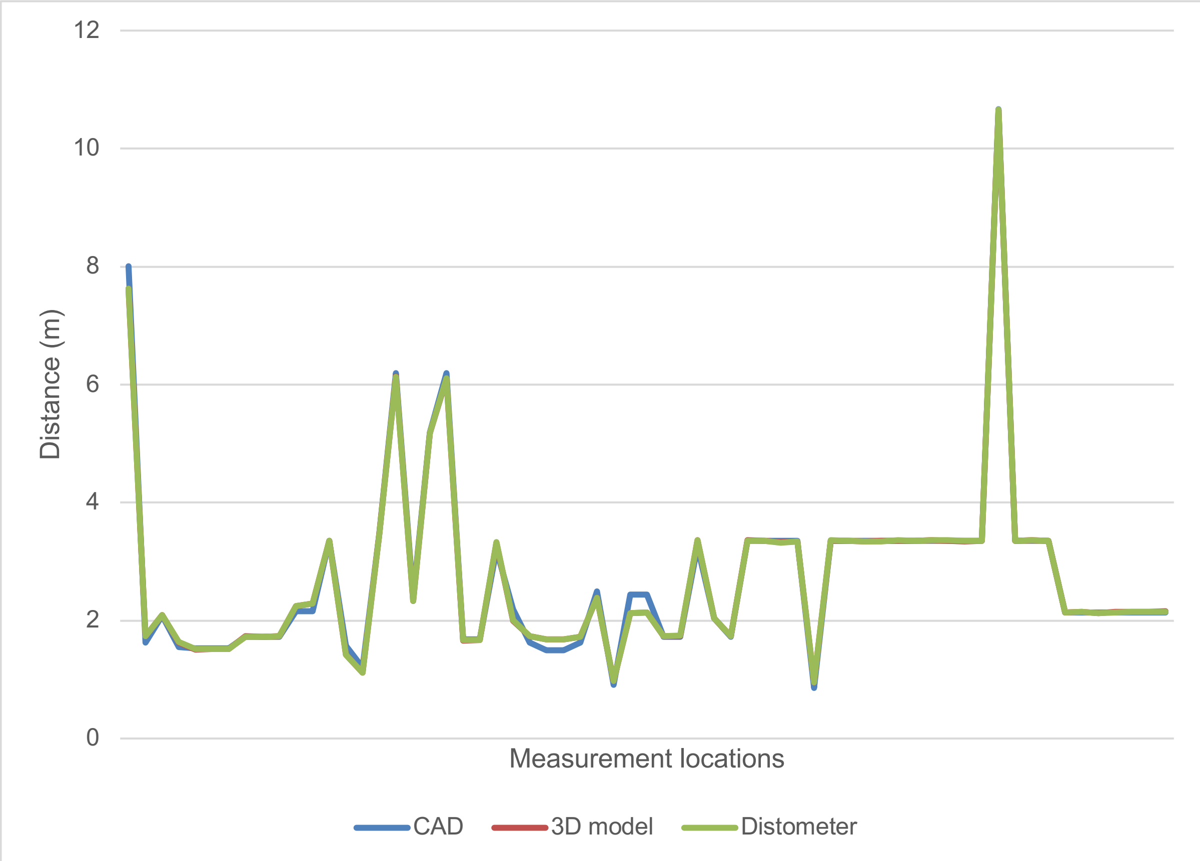


Figure 4.20 Visual comparisons of wall-to-wall measurements acquired from the 2D-CAD plan and the 3D-model, and those measured with the distometer.

A very close association between the measurements made using all three methods can be clearly seen in Figure 4.20. Most differences between measurements at the same location are only millimeters. Such small differences are not clear in Figure 4.20 because of the scale of the y-axis. The actual measurements for the 63 locations are provided in Table 4.2, and the differences between the measurements in Table 4.3. The differences are visualised for each pair of measurements in Figures 4.21-4.23.

Table 4.4 showed that the maximum difference of any pair of 2D- CAD and distometer measurements was 0.185 m (18.5 cm), and the minimum difference was 0.380 m (38 cm). The mean difference for all pairs of measurements was 0.006 m (6 mm), and the RMSE was 0.098 m (98 mm).

The maximum difference of any pair of the 2D- CAD and 3D-laser scan measurements was very similar to the differences between 2D- CAD and distometer measurements, at 0.184 m (184 mm). The minimum difference, -0.377 m or 377 mm was only 3 mm different. The mean difference between all pairs of measurements was -6 mm, and the RMSE was 98 m.

The maximum and minimum differences between any pair of distometer and 3D-laser scan measurements were much less than the differences between either of these or the CAD plan. The maximum difference was 0.010 m (10 mm), and the minimum was 0.014 m (14 mm). The mean difference between all pairs of measurements was 0.000 m, and the RMSE was 0.003 m.

The differences between the wall-to-wall measurements were tested to see if they were significantly different using a two-tailed paired Student's t-test (Table 4.5). In each case, the null hypothesis of no significant difference between the sets of measurements was accepted at $p = <0.05$.

Table 4.2 CAD, 3D-model, and distometer measurements

No.	Disto	CAD	3D
1	7.622	8.002	7.625
2	1.730	1.626	1.733
3	2.092	2.086	2.091
4	1.633	1.554	1.630
5	1.513	1.524	1.511
6	1.517	1.524	1.517
7	1.520	1.524	1.519
8	1.726	1.728	1.730
9	1.728	1.728	1.728
10	1.737	1.728	1.736
11	2.242	2.161	2.242
12	2.287	2.161	2.285
13	3.351	3.353	3.350
14	1.419	1.576	1.417
15	1.120	1.200	1.118
16	3.454	3.460	3.457
17	6.131	6.196	6.135
18	2.335	2.385	2.335
19	5.177	5.180	5.178
20	6.104	6.196	6.100
21	1.667	1.676	1.664
22	1.670	1.676	1.671
23	3.325	3.200	3.321
24	2.001	2.188	1.999
25	1.734	1.626	1.732
26	1.680	1.500	1.681
27	1.685	1.500	1.684
28	1.729	1.626	1.729
29	2.382	2.496	2.381
30	0.974	0.908	0.972
31	2.129	2.438	2.129
32	2.132	2.438	2.132
33	1.730	1.728	1.737
34	1.741	1.728	1.740
35	3.360	3.252	3.367
36	2.042	2.033	2.043
37	1.735	1.728	1.736
38	3.352	3.353	3.366
39	3.350	3.353	3.353
40	3.323	3.353	3.325
41	3.344	3.353	3.341
42	0.951	0.857	0.950
43	3.358	3.353	3.355
44	3.352	3.353	3.355
45	3.345	3.353	3.340
46	3.345	3.353	3.348
47	3.360	3.353	3.350
48	3.353	3.353	3.354
49	3.360	3.353	3.358
50	3.360	3.353	3.356
51	3.348	3.353	3.345
52	3.351	3.353	3.350
53	10.662	10.668	10.658
54	3.350	3.353	3.351
55	3.360	3.353	3.361
56	3.348	3.353	3.348
57	2.139	2.134	2.137
58	2.143	2.137	2.143
59	2.128	2.134	2.125
60	2.141	2.134	2.145
61	2.144	2.134	2.145
62	2.148	2.134	2.148
63	2.151	2.134	2.155

Table 4.3 Differences between CAD, 3D-model and distometer measurements of wall-to-wall dimensions

No.	CAD Disto	CAD 3D	3D Disto	No.	CAD Disto	CAD 3D	3D Disto
1	-0.3800	-0.377	-0.0030	33	0.0020	0.009	-0.0070
2	0.1040	0.107	-0.0030	34	0.0130	0.012	0.0010
3	0.0060	0.005	0.0009	35	0.1080	0.115	-0.0070
4	0.0790	0.076	0.0030	36	0.0086	0.010	-0.0014
5	-0.0110	-0.013	0.0020	37	0.0069	0.008	-0.0011
6	-0.0071	-0.007	0.0000	38	-0.0010	0.013	-0.0140
7	-0.0041	-0.005	0.0009	39	-0.0030	0.000	-0.0030
8	-0.0020	0.002	-0.0040	40	-0.0300	-0.028	-0.0020
9	0.0000	0.000	0.0000	41	-0.0090	-0.012	0.0030
10	0.0090	0.008	0.0010	42	0.0940	0.093	0.0010
11	0.0810	0.081	0.0000	43	0.0050	0.002	0.0030
12	0.1260	0.124	0.0020	44	-0.0010	0.002	-0.0030
13	-0.0020	-0.003	0.0010	45	-0.0080	-0.013	0.0050
14	-0.1570	-0.159	0.0020	46	-0.0080	-0.005	-0.0030
15	-0.0802	-0.082	0.0018	47	0.0070	-0.003	0.0100
16	-0.0060	-0.003	-0.0030	48	0.0000	0.001	-0.0010
17	-0.0650	-0.061	-0.0040	49	0.0070	0.005	0.0020
18	-0.0500	-0.050	0.0000	50	0.0070	0.003	0.0040
19	-0.0028	-0.002	-0.0008	51	-0.0050	-0.008	0.0030
20	-0.0920	-0.096	0.0040	52	-0.0020	-0.003	0.0010
21	-0.0090	-0.012	0.0030	53	-0.0060	-0.010	0.0040
22	-0.0060	-0.005	-0.0010	54	-0.0030	-0.002	-0.0010
23	0.1250	0.121	0.0040	55	0.0070	0.008	-0.0010
24	-0.1870	-0.189	0.0020	56	-0.0050	-0.005	0.0000
25	0.1080	0.106	0.0020	57	0.0050	0.003	0.0020
26	0.1800	0.181	-0.0010	58	0.0060	0.006	0.0000
27	0.1846	0.184	0.0006	59	-0.0060	-0.009	0.0030
28	0.1030	0.103	0.0000	60	0.0070	0.011	-0.0040
29	-0.1140	-0.115	0.0010	61	0.0100	0.011	-0.0010
30	0.0658	0.064	0.0018	62	0.0140	0.014	0.0000
31	-0.3090	-0.309	0.0000	63	0.0170	0.021	-0.0040
32	-0.3062	-0.306	-0.0002				

Table 4.4 Summary of the differences in wall-to-wall measurements between the three types of measurement

Variable	CAD_distometer	CAD_3D-model	Distometer_3D-model
Minimum difference	-0.380	-0.378	-0.014
Maximum difference	0.185	0.184	0.010
Mean difference	-0.006	-0.006	0.000
RMSE	0.098	0.098	0.003

Table 4.5 Summary of the Student's t-tests for pairs of wall-to-wall measurements

Pair of measurements	t statistic	Significance at p =<0.05
CAD_Distometer, 4.25	0.557	Not significant
CAD_laser scanner, 4.26	0.574	Not significant
Laser Scanner_Distometer, 4.27	0.911	Not significant

The Pearson product-moment correlation coefficient and linear regression equations were used to evaluate pairs of measurements are given in Table 4.6. Scatterplots of the relationships are illustrated in Figures 4.24-4.26.

Table 4.6 Summary of correlations and linear regressions for pairs of wall-to-wall measurements

Pair of measurements and associated figure	r^2	Regression equation
CAD_Distometer, 4.25	0.997	$M_{CAD} = 1.0021M_{Disto} - 0.0039$
CAD_laser scanner, 4.26	0.999	$M_{3D-}= 1.0022M_{CAD} - 0.0038$
Laser Scanner_Distometer, 4.27	1.000	$M_{3D-}= 1.0000M_{Disto} - 0.0000007$

where M_{CAD} = measurement from CAD plan, M_{Disto} = distometer measurement, M_{3D-}= laser scan measurement

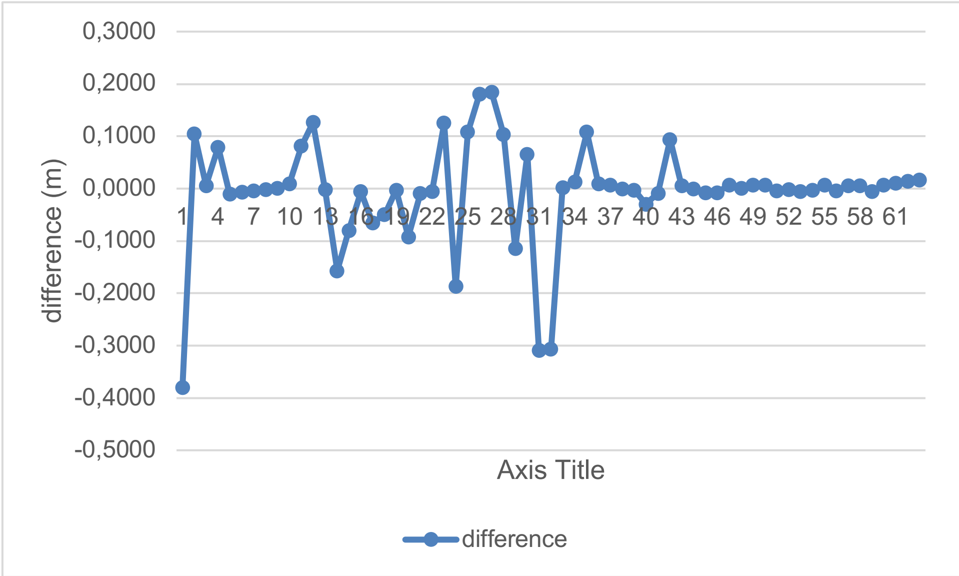


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Figure 4.21 Differences between 2D- CAD and distometer wall-to-wall measurements by location

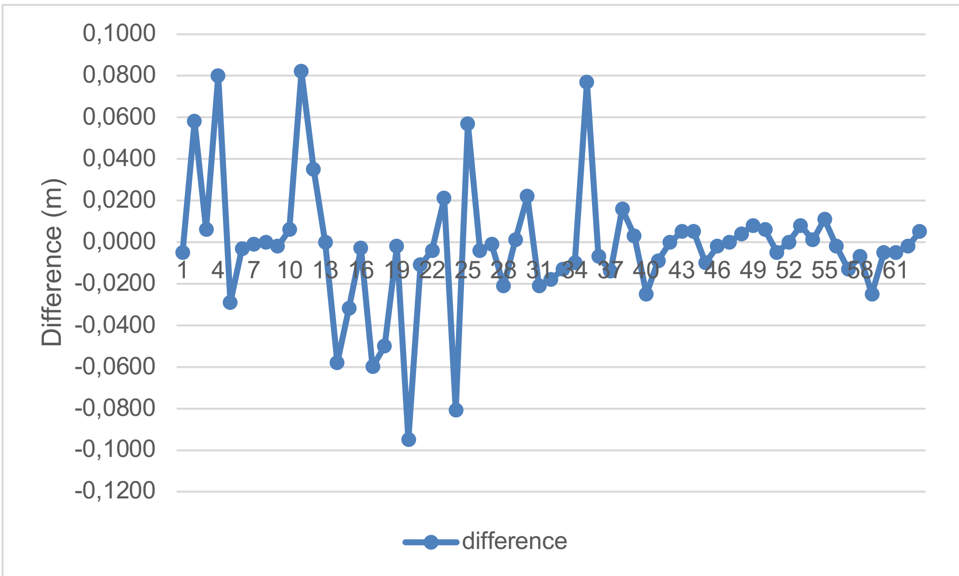


Figure 4.22 Differences between 2D- CAD and 3D-TLS wall-to-wall measurements by location

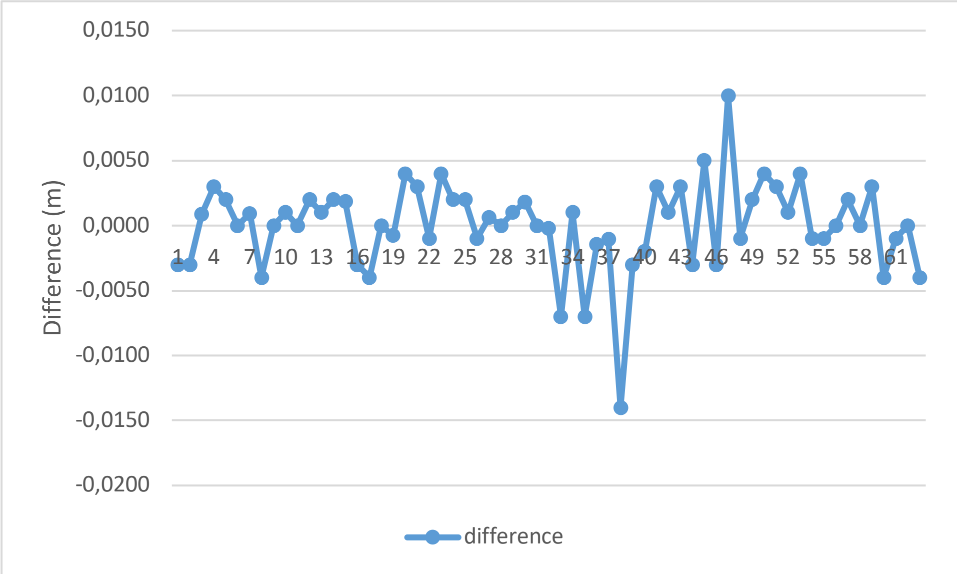


Figure 4.23 Differences between distometer and 3D-TLS wall-to-wall measurements by location

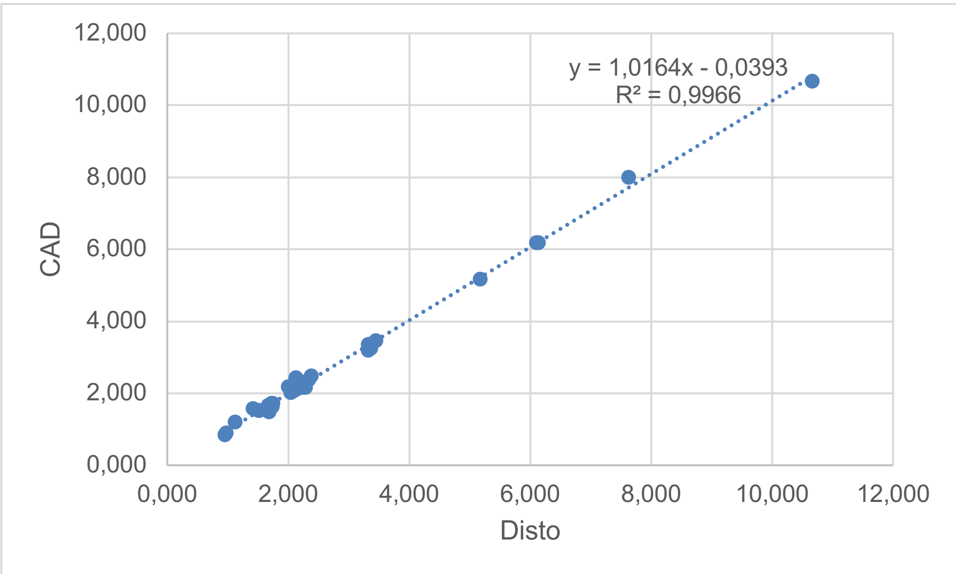


Figure 4.24 Scatterplot of CAD and distometer measurements, with trendline and regression equation

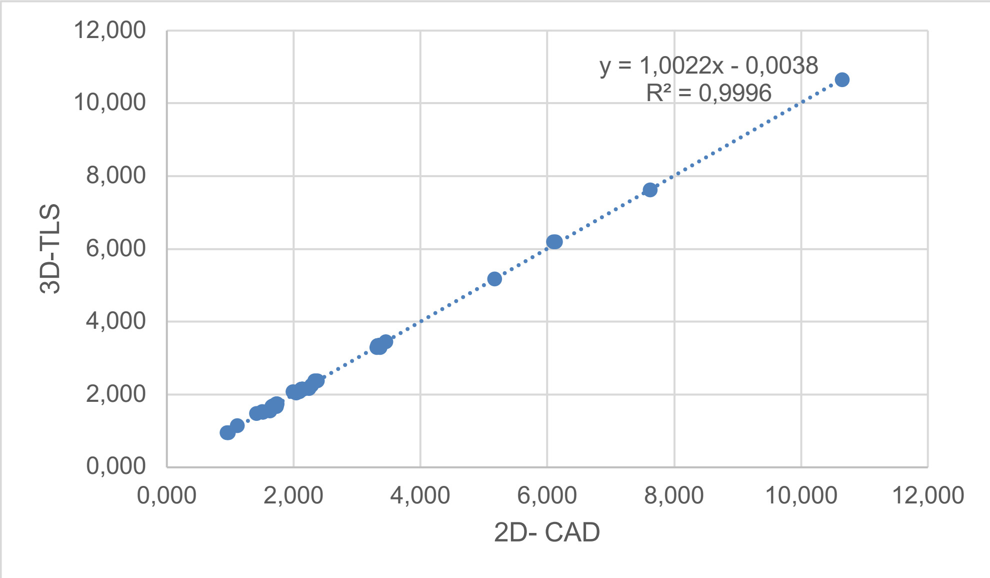


Figure 4.25 Scatterplot of CAD and laser scan measurements, with trendline and regression equation

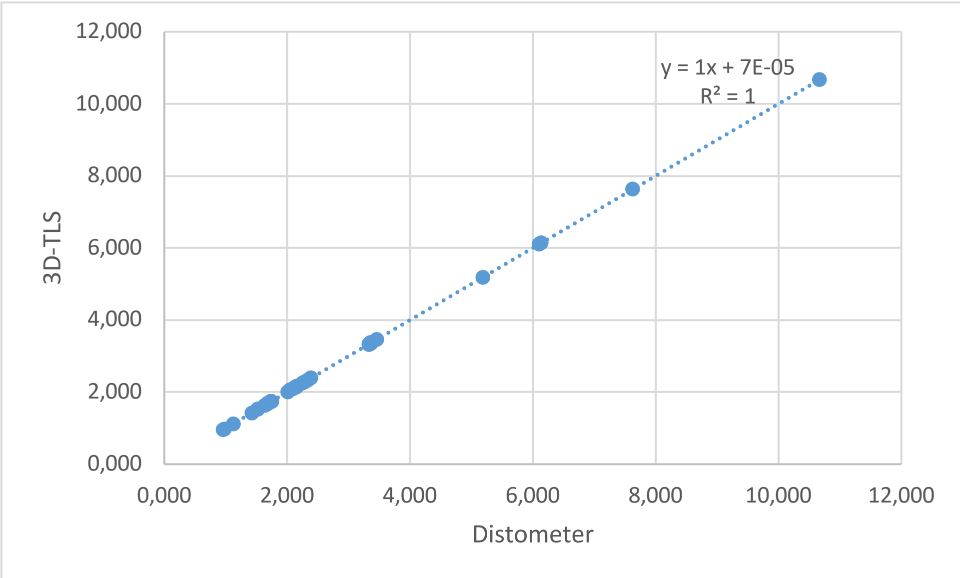


Figure 4.26 Scatterplot of laser scan and distometer measurements, with trendline and regression equation

Floor-to-ceiling, vertical measurements

Forty-five vertical measurements taken with the distometer were compared with those from the 3D-Model (Table 4.7). These differences are visualised in Figure 4.27. Both the table and the accompanying figure show that there is a very close correlation between the two sets of vertical measurements. The maximum difference of any pair of measurements was 0.005 m (5 mm), the minimum difference was -0.005 m (-5 mm). The mean difference between all pairs of measurements was 0.000 m, and the RMSE was 0.002186 m or 2.19 mm. A two-tailed paired Student's-test produced a value of 1.7698, which is greater than the p-value at 0.05 of 0.0837. The null hypothesis was accepted indicating no significant differences between the two sets of vertical measurements. The r^2 value of 0.999 indicates an exceptionally strong positive correlation between distometer and 3D-model vertical measurements (Figure 4.28).

The results of the analysis of measurements are summarised in Table 4.8. Comparative analysis was done for 63 horizontal measurements acquired through three survey methods: 2D- CAD plans, partial 3D-(distometer) and 3D-laser scanning; and 45 vertical measurements made with both a distometer and a 3D-laser scanner. The horizontal measurements are visually very close (Figure 4.20). The maximum, minimum, mean and RMSE differences (Table 4.4) were not significantly different (Table 4.5). The differences between the distometer and the 3D-model were very small compared to the differences between the CAD plans and the distometer, and the 3D-model, i.e., the results from 3D-model measurements were better than the 2D- CAD measurements.

Table 4.7 Summary of distometer (Disto) and 3D-model (3D) floor-to-ceiling measurements and the differences between them |Δ|(m).

No.	Length (m)		|Δ| (m)	No.	Length (m)		|Δ| (m)
	Disto	3D			Disto	3D	
1	3.512	3.508	0.004	26	2.425	2.421	0.004
2	3.510	3.508	0.002	27	3.524	3.527	-0.003
3	2.432	2.431	0.001	28	3.445	3.445	0.000
4	2.438	2.437	0.001	29	2.840	2.845	-0.005
5	2.434	2.433	0.001	30	2.559	2.558	0.001
6	2.432	2.432	0.000	31	4.806	4.805	0.001
7	2.440	2.439	0.001	32	5.478	5.478	0.000
8	2.440	2.438	0.002	33	6.638	6.637	0.001
9	2.427	2.426	0.001	34	6.630	6.625	0.005
10	2.837	2.840	-0.003	35	2.980	2.979	0.001
11	4.078	4.076	0.002	36	2.972	2.971	0.001
12	2.434	2.435	-0.001	37	3.111	3.109	0.002
13	2.840	2.844	-0.004	38	6.639	6.639	0.000
14	2.743	2.743	0.000	39	2.967	2.966	0.001
15	2.432	2.431	0.001	40	2.969	2.965	0.004
16	2.434	2.432	0.002	41	4.644	4.643	0.001
17	2.851	2.853	-0.002	42	2.737	2.736	0.001
18	2.781	2.781	0.000	43	2.296	2.295	0.001
19	2.768	2.767	0.001	44	3.015	3.015	0.000
20	2.781	2.780	0.001	45	3.015	3.011	0.004
21	4.664	4.664	0.000			Min	-0.005
22	2.424	2.423	0.001			Max	0.005
24	2.432	2.435	-0.003			Mean	0.000
25	2.439	2.442	-0.003			RMS	0.002186

The minimum CAD-distometer (-0.38 m) and CAD-3D-(-0.37 m) are for measurement 1, a measurement of wall-to-wall measurement in Room 125. The distometer_3D-measurement difference was only -0.003 m at this point. It appears the 2D-measurement is incorrect, this could be due to an error by the researcher (human error), or a measurement error by the original surveyor or once introduced when drafting the 2D- floor plan (again human error). The maximum CAD-distometer and CAD-3D-differences are for measurement 27. Again, this was a wall-to-wall measurement along a corridor on level 3. Here the distometer_3D-was only 0.0006 m. So once again, the 2D CAD measurement is in error.

The RMSE value was also significantly better for the distometer_3D-model comparison (0.003), compared to the CAD-distometer (0.098) and CAD-3D-model (0.098). Low RMSE values reveal higher levels of accuracy between measurements. This is confirmed by an r^2 value of almost one (Table 4.6).

Turning to the vertical measurements, the mean difference between the distometer and 3D-measurement was 0.000 m and the RMSE was 0.002186 m or 2.19 mm. There was no significant difference between two sets of vertical measurements, which also has a strong positive correlation with an r^2 value of 0.999. Both horizontal and vertical measurements are strongly associated and are not significantly different.

4.4 DISCUSSION OF THE 3D-MODEL OF THE FU-ESB IN THE CONTEXT OF 3D-SURVEY IN INDONESIA

In this section issues and observations that arose from the development of the 3D-model of the FU-ESB will be discussed in the context of the implementation of 3D-surveying of complex buildings in Indonesia. In particular, the focus will be on the ways in which a 3D-data model could improve administration systems to better manage land management for complex 3D-land objects (Aien et al., 2011); and the capability to visualise 3D-modeled objects to the management of the following situations.

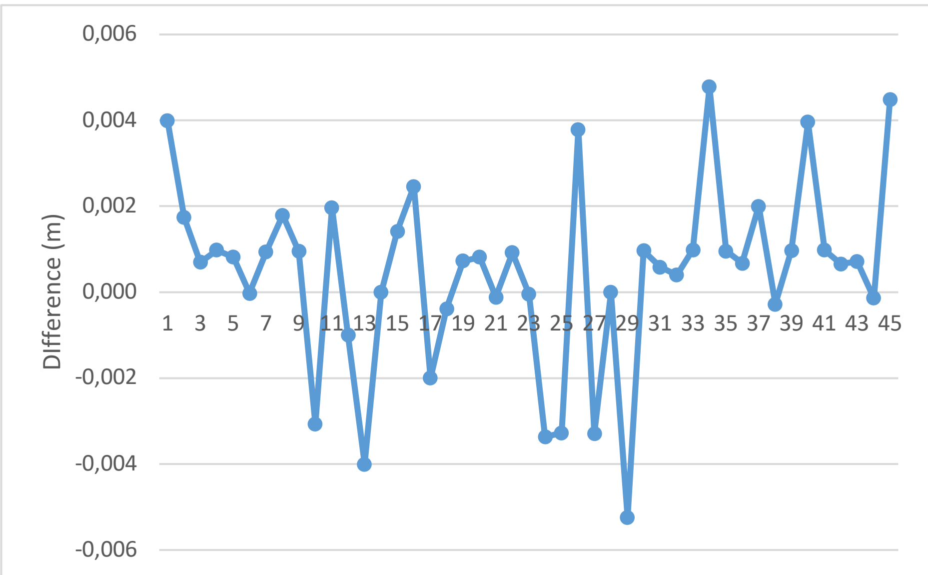


Figure 4.27 Differences between distometer and 3D-TLS wall-to-wall measurements by location

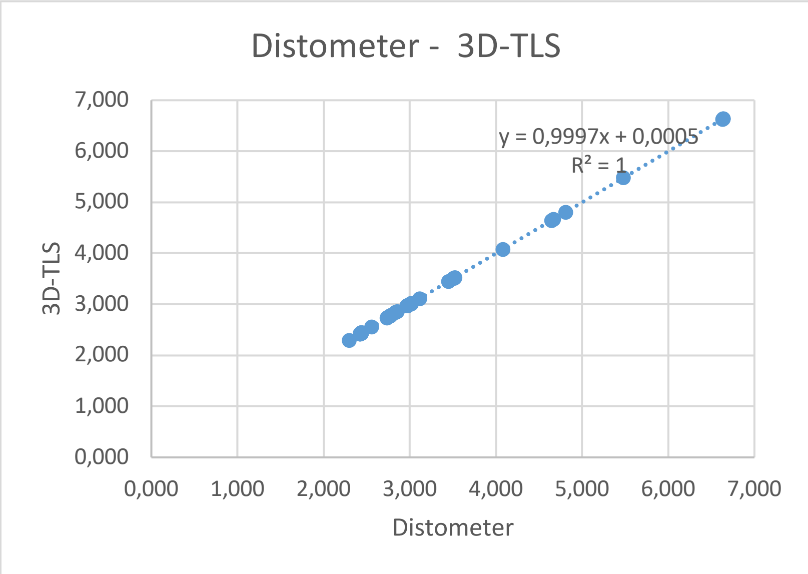


Figure 4.28 Scatterplot of distometer – 3D-TLS correlation.

Table 4.8 Summary of surveying method comparison

Comparison	RMSE	Correlation	T-test
CAD and distometer (horizontal)	97.60 mm	very strong positive correlation, r(61)=0.999, at p<0.05	no significant difference, t=0.565, p-value=0.574 at p<0.05
CAD and 3D-measurement (horizontal)	97.50 mm	very strong positive correlation, r(61)=0.999, at p<0.05	no significant difference, t=0.565, p-value=0.574 at p<0.05
Distometer and 3D-measurement (horizontal)	3.36 mm	very strong positive correlation, r(61)=0.999, at p<0.05	no significant difference, t=-0.111, p-value=0.911 at p<0.05
Distometer and 3D-measurement (vertical)	2.19 mm	very strong positive correlation, r(45)=0.999, at p<0.05	no significant difference, t= 1.77, p-value=0.084 at p<0.05

4.4.1 Visualization of information in a 3D-model

Ownership rights

A 3D-model can provide a lot of information about ownership rights for each space in a building which, at the present time, is not presented clearly in any textual description (e.g. "the interior of the wall"). Using the red space (an office) in the FU-ESB (Figure 4.29) the value of visualization of space in a 3D-model in aiding owners or administrators to understand the location of a space, its relation to other spaces, and information associated it. For example, the open tab in Figure 4.29 gives the volume of the red space. This figure is a static representation of the red space, on-screen and interactive view would enhance this information.

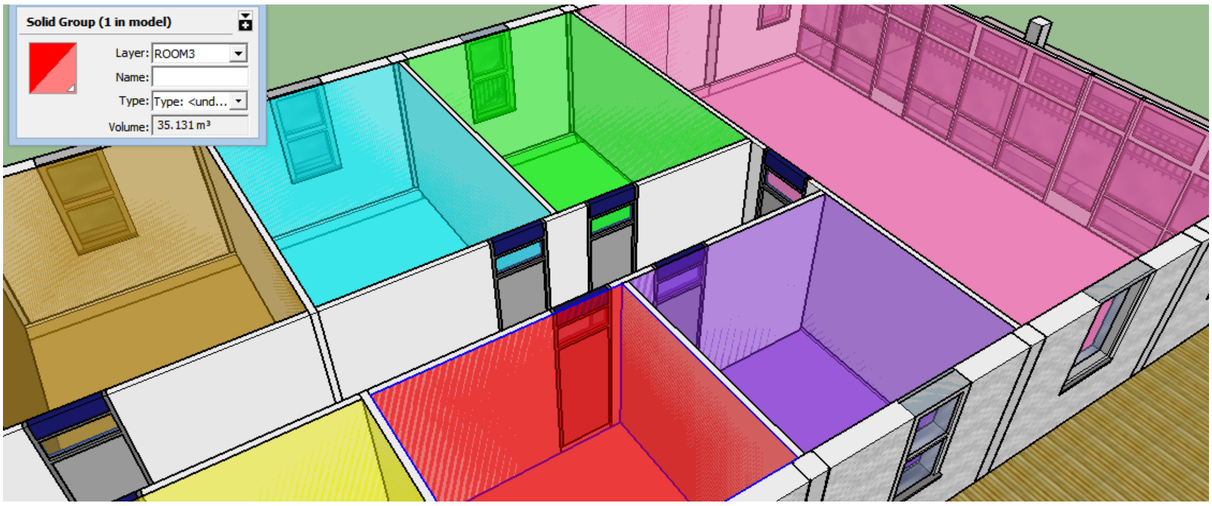
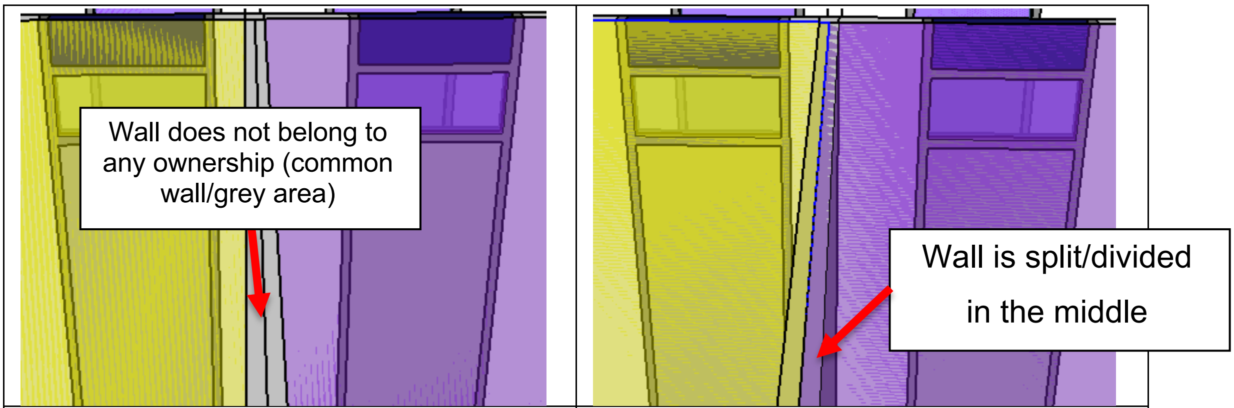


Figure 4.29 an example of the visualisation of spaces and information associated with them (using the red space as an example).

Boundary rights

A 3D-model can very clearly represent the boundary right of each space in the building in detail. This is something that cannot be done with a 2D- CAD plan. The left part of Figure 4.30 shows that the owners of the yellow and purple spaces share a common wall, i.e., the wall does not belong to either of them ownership, which is coloured in grey. The right part of the figure shows the situation where ownership of the wall is shared between the yellow and the purple space owners. The wall has been divided down the middle and shows the proportions of the wall that each person owns. This is a matter that is an issue in Indonesia and will be discussed in relation to laws and regulations about the boundaries of units in Chapters 5, 6, and 7.



Left: a wall does not belong to any ownership (common wall)	Right: the wall is divided in the middle

Figure 4.30 Visualisation of different types of wall ownership in a 3D-model

Common areas and individual spaces

The example of the 3D-model of the FU-ESB shown in Figure 4.31 shows individual objects (purple, mainly office spaces) and common spaces (red, corridors) in a 3D-cadastre object.

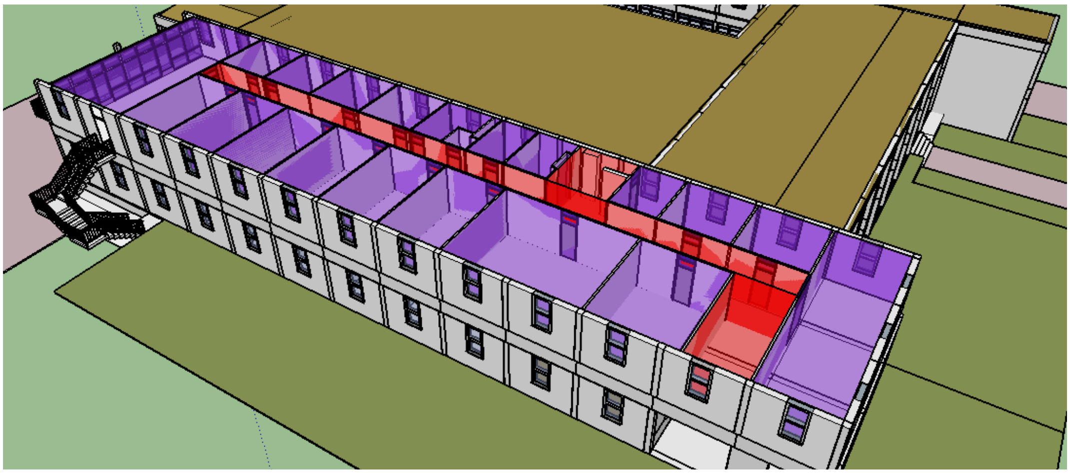


Figure 4.31 Visualisation of individual and common spaces in a 3D-model.

4.4.2 Lessons from FU-ESB 3D-model that can be applied in an Indonesian situation

From this study, the researcher learned that 3D-laser scanning is an advanced form of surveying that enables the capture and recording of highly accurate spatial information, such as the dimensions and shapes of interior spaces and exterior forms. In the context of this research, laser scan data is mostly used to construct digital models that can be obtained from the original (measured) point cloud by interpolation algorithms. These are not much different from photogrammetric modules that have been in use since the second half of the last century. However, by implementing laser technology in a 3D-cadastre, the exterior form of a building, as well as the location of objects within a building can be mapped relatively quickly in digital format. Point cloud data can be exported, and 3D-models constructed. The real advantages over 2D-plans potentially lie in the ways that information that is highly relevant to property management can be visualized by these models. Some of these data are available in contemporary 2D- plans, but other data, e.g. space volumes, can only be determined and visualized in 3D-models.

The accuracy of geometric information derived for 3D-physical objects from point cloud analysis was discussed. For each feature in the FU-ESB building, spatial information was measured using linear measurements between walls or from floors to ceiling. Wall-to-wall measurements between the features in objects extracted from the 3D-model had an overall accuracy of 2.3 mm, which was less than the maximum 5 mm error of the laser scanner used. However, the surveying environment and the situation of the research objects should be taken into consideration. The outdoor objects assessed in this research influenced by environmental conditions when scanning conducted so it will reduce the quality of the data.

The model of the FU-ESB illustrated the use of a terrestrial laser scanner (TLS) data in developing a 3D-object that could be used in a 3D-cadastral system. The 3D-model was used to exemplify how information related to ownership, boundaries, and common and individual areas, all of which are issues that arose in questionnaires administered in Jakarta and Bandung, can be perceived in such a model.

Vertical dimensions, e.g., the building height, as well as the heights between floors and ceilings, can be acquired with high accuracy in a 3D-model. However, due to the ground-based data acquisition approach employed in this research, the top structure of the buildings cannot be represented in the 3D-model, thus it affects the result of the total height detection for the buildings to some extent.
In this method, the researcher became primarily responsible for subsequent data processing, this is a time consuming, labour-intensive process. The entry cost is

considerable – the equipment is more expensive compared to a standard GPS – and there is a set of operational skills to be developed before rapid and reliable data collection can begin.

4.5 LIMITATIONS

This section explores the limitations with, and errors that arose from, the development of the 3D-model. The first limitation of the 3D-model was that it did not create objects such as vegetation (trees, indoor plants), furniture, and other small details (paints and surfaces, AC compressors) and the environment around study object, e.g. road and parks around the building, etc.). In this context, furniture refers to movable objects such as chairs, sofas and stools; tables and desks; and cupboards and shelves.

Data storage management needs to be considered. In this study, one scan using Trimble TX5 generated approximately 338 MB of data per scan station. In this study, a 32 GB SD card was used to save the data. All the scans produce almost 29.7 GB of data (Table 4.9). Adequate storage needs to be prepared for storing all scans data if the data too big then there must be a limitation on the setup process to handle all data.

Table 4.9 List of scans in this research

Building Level	Scan	Size in total (Mbytes)
Level 0	9 scans	574,824
Level 1	105 scans	6,231,140
Level 2	86 scans	21,517,636
Level 3	35 scans	1,402,872
	237 scans	29,724,472

4.6 CHAPTER SUMMARY

This chapter presents models of the type of object (the FU-ESB) that would appear in a 3D-cadastre, a terrestrial laser scanner was used to scan the FU-ESB building. The 3D-point cloud acquired was used to create a 3D-model of this multi-floor building. The graphical model represents real data, the maximum and minimum deviation errors from the laser scans errors were 0.0057m and 0.0003m.

This chapter also presents the results of a comparative analysis of different methods of surveying the FU-ESB. Both the vertical and horizontal measurements made with the distometer and those extracted from the 3D-were almost identical, However, larger differences were apparent for some horizontal measurement locations when measurements from the 2D- CAD plans were compared with either distometer or 3D-model measurements. This is most likely an indication of human error in surveying for or drawing the 2D- plans.

The 3D-model had limitations which were the details provided in the model and data storage limitations. Nonetheless, this chapter has shown that a 3D-cadastre can be more informative than a 2D-cadastre for a multi-space building if spaces are well visualized in 3D-and pertinent information accompanies these visualizations and is in line with research findings from the Netherlands (Stoter & Ploeger 2003).

Nonetheless the comparison between TLS and CAD performed shows that the data obtained by measuring using TLS (the data collection tool for a full 3D-cadastre) is the appropriate tool for this method, particularly because it can to automatically detect height dimensions that are not provided by CAD.

The next chapter will explore the information acquired from semi-structured interviews with stakeholders in surveying and property management Indonesia and identify common issues.

CHAPTER 5: INTRODUCTION OF 3D-CADASTRAL SYSTEM IN INDONESIA: RESULTS OF INTERVIEWS

5.1 INTRODUCTION

This chapter presents the results of the interviews that were introduced in Chapter Three. The aim of this and the next chapter is to address the first and second research objectives of this thesis (Section 1.2). It begins with an overview of the interviews conducted and the participants involved (Section 5.2). This is followed by sections that address the research questions that aim to identify the key issues that need to be addressed if a full 3-D cadastre is to be implemented in Indonesia. Stakeholders' views of the purpose of survey and issues that arise from the current 2D- cadastral system in complex infrastructure developments in Indonesia and associated public awareness issues are dealt with in Section 5.3. The readiness of the legal framework, human resource capacity and organizational capacity to implement a 3D-cadastre in Indonesia are discussed in Section 5.4.

5.2 STAKEHOLDERS AND PARTICIPANTS

The stakeholders interviewed came from Jakarta, and Bandung (Section 3.4), and were divided into five categories: Government officials (C1), Land deeds officials [LDOs] (C2), licensed surveyors [LSs] (C3), Property Managers (C4) and Owners and tenants (C5).

These participants were selected because of their roles as users of 2D- cadastral information, and potential users of 3D-cadastral information in Indonesia. The government officials (Category C1) were selected because of their position as the main institution which manages land and properties in Indonesia. The land deed officials (LDOs) (Category C2) were selected because of their role as the main officials responsible for creating land title deeds. The licensed surveyors (LSs) (Category C3) were selected because these companies assist in the process of land registration. The user of the 2D- cadastral system is the people who have roles in managing or living in complex buildings for instance apartments. To cover these stakeholders, the property managers (Category C4) and owners/tenants of the apartments (Category C5) were selected. The numbers of stakeholders interviewed in each category are outlined in Table 3.1.

The interviews were conducted after determining how to select participants. The method used was random selection or random sampling. In terms of government officials (C1), this was done by randomly selecting prospective participants who held manager positions in land offices that have been selected as data collection locations, namely the Jakarta and Bandung land offices. The four elected officials who served in the West Jakarta City Land Office (this office was randomly selected from the five land offices in Jakarta) and Bandung City (also, randomly selected from five land offices in the Bandung area). Next step, in terms of LDOs I obtained lists of all LDOs registered with the West Jakarta City and Bandung City land offices from those offices. I then numbered each LDO and randomly selected 20 for Jakarta and 12 for Bandung using a random number generator. The selection of 12 and 20 was based on the same sampling rate for both offices. The third step is almost the same as LDOs, the LSs (C3) registered at the two land offices so that 19 prospective LSs (12 from Bandung and 7 from Jakarta) are randomly obtained, and the fourth step is to find apartment data in the locations of the two offices. Apartment data in the working area of the land office is obtained data using randomly number generated of prospective apartment managers (C4) and also apartment owner data (C5) and randomly selected from the data obtained, for C4 selected 13 people (10 people from Jakarta and 3 people from Bandung), while 30 people were randomly selected for C5 (10 from Bandung and 20 from Jakarta), so that the entire sample of 98 participants was randomly selected (Table 3.1).

5.3 ISSUES WITH CURRENT INDONESIAN CADASTRAL SYSTEM

This section explores issues around the current Indonesian cadastral system; specifically, any inadequacies with the system in the context of this research (Section 5.3.1) and the public awareness about issues in the national cadastral system (Section 5.3.2).

5.3.1 Inadequacies with the 2D- system

To elicit knowledge about how the different stakeholder groups, understand the current 2D- cadastral system, the researcher asked three questions (Questions 2D-1, 2D-2, 2D-3 – Appendix 5.1). These questions cover the participants' understanding of the current 2D- system, their views about its advantages and disadvantages, and how infrastructure development above and below the land surface is dealt with. Each question dealt with sequentially below.

Government officials, land deed officials, and licensed surveyors were asked about their knowledge of the existing 2-dimensional survey and cadastral system (Question 2D-1 – Appendix 5.1). All of the government land management officials and the licensed surveyors interviewed in Jakarta and Bandung knew about Indonesia's 2D- cadastral system in detail. Their depth of knowledge was shared with most legal deeds officials (LDOs) in the two cities. However, three of the 20 LDOs interviewed in Jakarta and two in Bandung had no or little knowledge of the 2D- system (Figure 5.1). One response was quoted from participants in Jakarta who had no knowledge of the 2D- system:

> *"Saya kurang mengetahui tentang sistem dua dimensi, mungkin saja karena saya tidak mengenal istilah teknis pertanahan secara detail"*
>
> "I am less knowledgeable about two-dimensional systems, probably because I am not familiar with the technical terms of land cadastre in detail". (Interview with an of legal deed official in Jakarta (C2/J211/En), December 2015).
>
> *"Apakah yang dimaksud dua dimensi itu? Saya hanya mengenal istilah pertanahan secara umum sehingga maaf tidak mengetahuinya"*
>
> "What are the two dimensions? I only know the term land in general so sorry not to know about that term". (Interview with a legal deed official in Bandung (C2/B208/Wa), January 2016).

Figure 5.1 illustrates that generally speaking there a good working knowledge of 2D-- cadastral systems among professionals closely associated with it in both cities, despite the handful of small misunderstanding I encountered.

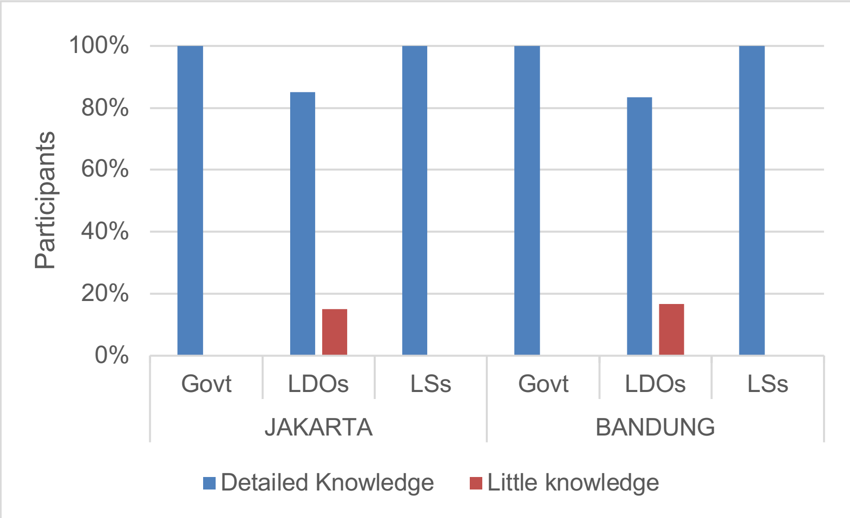


Figure 5.1 Knowledge of the 2D-cadastral system.

Government officials, land deeds officials, and licensed surveyors were asked also about the advantages and limitations in the use of the current 2D- cadastral system in surveying and managing complex infrastructure developments in Indonesia (Question 2D-2 – Appendix 5.1). Nineteen of the 55 government officials, LDOs, and LSs interviewed felt that the current 2D- system was still adequate for managing urban land in the two cities. A number of respondents said they preferred a 2D- system over a 3D-system that may be introduced in the future because it would be simpler and cheaper to use (13 respondents), and because the processing of land information would be faster (11). Six people felt that there would be no need for new staff training if the 2D- system was retained, and another six explained that surveying is easier with the current 2D- system than it would be if a 3D-system was introduced. Eight stakeholders did not mention advantages, two of whom did not understand the question (Table 5.1). The Wilcoxon Signed-Rank Test was applied to see if the advantages of the 2D- cadastre articulated by the government officials, LDOs and LSs in Jakarta were statistically different from those in Bandung. The W-value (13.5) was greater than the critical value (2, $p \leq 0.05$, $n = 7$), indicating that the null hypothesis of no significant difference between the responses of these three groups of stakeholders in the two cities could be accepted.

Slightly under a fifth of responses to the question about disadvantages of the current 2D- system (19.7%) centered on the fact that it cannot help in the management of complex objects, i.e., spaces in 3D-buildings. A further 15% of responses indicated the information contained in the current 2D- system did not provide enough detail for contemporary land management. A handful of respondents listed other disadvantages, the most important of which was that property disputes occurred because of the nature of the information in the 2D- cadastre (4.0%) and that 2D-cadastral surveys were less accurate than 3D-surveys. Five responses (4.0%) did acknowledge any disadvantages, three of these were because the respondent did not understand the question (Table 5.2). The W-value of 21 from the Wilcoxon Signed Rank Test, was again greater than the critical value (10, $p \leq 0.05$, $n = 11$). The null hypothesis of no significant difference between the responses of the stakeholders in each Jakarta and Bandung was accepted.

The same three groups of stakeholders were then asked about managing improvements to buildings, and infrastructure developments above and below the land surface in a 2D- system (Question 2D-3 – Appendix 5.1). If all the responses are considered across the two cities, the dominant response (32.4%, Table 5.3) was that the current cadastral system cannot handle these complex objects; particularly objects below the land surface such as underground car parks. A further 32.4% of responses were split equally between the fact that land deed officials still have to make deeds in accordance with the prevailing 2D- system, and that infrastructure development is managed by BPN as it is the government ministry with responsibility for land regulation.

None of these three responses actually answered the question. The first two states that the current situation in the two cities is inadequate (in contrast to the previous question on the current situation) and the third response from LDOs and licensed surveyors shifts the resolution of the problem to BPN, i.e. the government. A fourth response (10.8% of answers) is that Indonesia needs special legislation governing the management of land in a three-dimensional context, which was common amongst LDOs and licensed surveyors. Four respondents did not understand the question. There was no significant difference between the three groups of stakeholders interviewed in Jakarta and Bandung regarding these answers ($W = 22$, critical value 10, $p \leq 0.05$, $n = 11$).

Because the answers to the final question in this section of the questionnaire generated more nuanced answers about the issues professionals are facing in using the 2D- cadastral system in two large cities in Indonesia than the other questions, differences between the responses of LDOs and licensed surveyors were investigated using the Wilcoxon Signed-Rank Test. No statistical differences were found between LDOs on the two cities, or between LDOs and LSs combined (Table 5.1). The basic argument here is that deeds officers and surveyors in both cities are arguing in a similar way, i.e., for a new system that can manage the complexity of land management in urban Indonesia.

Table 5.1 Comparison of responses between stakeholders' groups about the management of infrastructure developments.

Groups compared	**W**	**W_{crit} $p \leq 0.05$**	**Significantly different**
LDOs Bandung, LDOs Jakarta	23	11	No
LSs Bandung, LSs Jakarta	*		
LDOs both cities, LSs both cities	17	11	No

n = 11 for the tests reported in rows 1 and 3
* = W could not be calculated because of the small sample size.

It is clear from the overall responses in Table 5.2 is that a conservative opinion in which a possibly inadequate 2D- system is deemed to perform well enough to meet the requirements of urban land management in the two cities, and that as a consequence there is a reluctance to implement new systems. This probably because of a combination of factors such as reluctance to embrace change and that the existing 2D- system is cheap and affordable, whereas there may be fears about various costs associated with a new system. This is explored further in other questions.

What is more difficult to interpret is the fact that many stakeholders consider the disadvantages of the current 2D- system (Table 5.3) large enough to make it inadequate in handling complex objects; and that this led to an increased number of property conflicts in the future. What is pertinent about all of the responses to the second question, regardless of stakeholder type or city, is that they form an extended set of opinions about the inadequacy of the 2D- cadastre for land management in modernizing Indonesian cities, as well as suggesting some ways that the situation could be improved. It appears that none of the interviewees were managing to cope with contemporary urban land management in a 3D-context.

The preliminary conclusion to the answers to this set of questions is that there is a dichotomy between professionals in the two cities. On the one hand, there is a group hold conservative opinions about moving to the new system, opinions that might arise from a range of concerns. While on the other hand there are professionals who argue that change is needed so that the system provides more accurate and complete information and avoids future land conflicts that can be implemented.

One of those individuals and gatherings in the local community group with an enthusiasm for the land administration and ownership right, whatever their individual perspectives, supportive or something else. Questions are about the need for 3D-cadastre, extra cost in the application of 3D-cadastre systems, and public satisfaction about land cadastre information.

Table 5.2 Participants' views of the advantages of the 2D- cadastral system over a 3D-cadastral system.

Advantages	Jakarta								Bandung								Both cities							
	Govt		LDOs		LSs		All		Govt		LDOs		LSs		All		Govt		LDOs		LSs		Total	
Still adequate	1	33.3%	7	30.4%	2	28.6%	10	30.3%	1	16.7%	3	23.1%	5	41.7%	9	29.0%	2	22.2%	10	27.8%	7	36.8%	19	29.7%
Cheaper tools used	0	0.0%	3	13.0%	3	42.9%	6	18.2%	2	33.3%	2	15.4%	3	25.0%	7	22.6%	2	22.2%	5	13.9%	6	31.6%	13	20.3%
Faster processing	0	0.0%	5	21.7%	1	14.3%	6	18.2%	0	0.0%	3	23.1%	2	16.7%	5	16.1%	0	0.0%	8	22.2%	3	15.8%	11	17.2%
No need staff training	0	0.0%	1	4.4%	1	14.3%	2	6.1%	0	0.0%	2	15.4%	2	16.7%	4	12.9%	0	0.0%	3	8.3%	3	15.8%	6	9.4%
Easier to survey	1	33.3%	2	8.7%	0	0.0%	3	9.1%	3	50.0%	0	0.0%	0	0.0%	3	9.7%	4	44.4%	2	5.6%	0	0.0%	6	9.4%
Acceptable by people	1	33.3%	0	0.0%	0	0.0%	1	3.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	11.1%	0	0.0%	0	0.0%	1	1.6%
No comments	0	0.0%	3	13.0%	0	0.0%	3	9.1%	0	0.0%	3	23.1%	0	0.0%	3	9.7%	0	0.0%	6	16.7%	0	0.0%	6	9.4%
Do not understand	0	0.0%	2	8.7%	0	0.0%	2	6.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	5.6%	0	0.0%	2	3.1%
	3	100.0%	23	100.0%	7	100.0%	6	100.0%	13	100.0%	12	100.0%	31	100.0%	31	100.0%	9	100.0%	36	100.0%	19	100.0%	64	100.0%

Table 5.3 Participants' views on the disadvantages of 2D- cadastral systems.

Disadvantages	Jakarta								Bandung								Both cities						Total	
	Govt		LDOs		LSs		All		Govt		LDOs		LSs		All		C1		C2		C3			
Cannot managed complex objects	2	1.6%	6	4.7%	2	1.6%	10	7.9%	2	100.0%	8	57.2%	5	41.7%	15	53.6%	4	100.0%	14	35.0%	7	36.8%	25	19.7%
Do not provide detail information	0	0.0%	5	3.9%	4	3.2%	9	7.1%	0	0.0%	3	21.3%	7	58.3%	10	35.7%	0	0.0%	8	20.0%	11	57.9%	19	15.0%
Many conflicts occurred	0	0.0%	4	3.2%	0	0.0%	4	3.2%	0	0.0%	1	7.1%	0	0.0%	1	3.6%	0	0.0%	5	12.5%	0	0.0%	5	4.0%
Less accurate	0	0.0%	2	1.6%	0	0.0%	2	1.6%	0	0.0%	1	7.1%	0	0.0%	1	3.6%	0	0.0%	3	7.5%	0	0.0%	3	2.4%
Different information provided with the fact	0	0.0%	1	0.8%	0	0.0%	1	0.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.5%	0	0.0%	1	0.8%
Less visualisation	0	0.0%	1	0.8%	0	0.0%	1	0.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.5%	0	0.0%	1	0.8%
Long processing time	0	0.0%	1	0.8%	0	0.0%	1	0.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.5%	0	0.0%	1	0.8%
Need cadastre system upgrade	0	0.0%	1	0.8%	0	0.0%	1	0.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.5%	0	0.0%	1	0.8%
Complicated process on correction of data revision	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	7.1%	0	0.0%	1	3.6%	0	0.0%	1	2.5%	0	0.0%	1	0.8%
Need digital archive for save storage and backup plan	0	0.0%	0	0.0%	1	0.8%	1	0.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	5.2%	1	0.8%
Do not understand	0	0.0%	3	2.4%	0	0.0%	3	2.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	7.5%	0	0.0%	3	2.4%
No comments	0	0.0%	2	1.6%	0	0.0%	2	1.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	5.0%	0	0.0%	2	1.6%
	2	100.0%	26	100.0%	7	100.0%	35	100.0%	2	100.0%	14	100.0%	12	100.0%	28	100.0%	4	100.0%	40	100.0%	19	100.0%	63	49.6%

Table 5.4 Participants' responses to the management of infrastructure development.

Responses	Jakarta								Bandung								Both cities						**Total**	
	Govt		LDOs		LSs		All		Govt		LDOs		LSs		All		Govt		LDOs		LSs			
Current land cadastre system cannot handle complex land objects especially underground objects	2	50.0%	9	32.1%	3	37.5%	14	35.0%	2	50.0%	3	21.4%	5	31.3%	10	29.4%	4	50.0%	12	28.6%	8	33.3%	24	32.4%
Land deed is made in accordance with the cadastre system that is still using two-dimensional	0	0.0%	9	32.1%	0	0.0%	9	22.5%	0	0.0%	3	21.4%	0	0.0%	3	8.8%	0	0.0%	12	28.6%	0	0.0%	12	16.2%
management of infrastructure development in Indonesia is managed by BPN as an official ministry that regulates land affairs	0	0.0%	0	0.0%	1	12.5%	1	2.5%	0	0.0%	2	14.3%	9	56.3%	11	32.4%	0	0.0%	2	4.8%	10	41.7%	12	16.2%
Indonesia requires special legislation governing the management of the underground space and also the management of all space in three dimensions.	0	0.0%	1	3.6%	2	25.0%	3	7.5%	0	0.0%	5	35.7%	0	0.0%	5	14.7%	0	0.0%	6	14.3%	2	8.3%	8	10.8%
Indonesia requires cadastral system upgrade	0	0.0%	2	7.1%	0	0.0%	2	5.0%	2	50.0%	0	0.0%	0	0.0%	2	5.9%	2	25.0%	2	4.8%	0	0.0%	4	5.4%
The management has been set in land law/regulations	0	0.0%	0	0.0%	2	25.0%	2	5.0%	0	0.0%	0	0.0%	2	12.5%	2	5.9%	0	0.0%	0	0.0%	4	16.7%	4	5.4%
Land management of this complex infrastructure just plotted in the 2-dimensional map	1	25.0%	0	0.0%	0	0.0%	1	2.5%	0	0.0%	1	7.1%	0	0.0%	1	2.9%	1	12.5%	1	2.4%	0	0.0%	2	2.7%
The cadastral system can only handle objects land at a ground surface level only	1	25.0%	0	0.0%	0	0.0%	1	2.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	12.5%	0	0.0%	0	0.0%	1	1.4%
Land management difficulties occur because the land data information is incomplete	0	0.0%	1	3.6%	0	0.0%	1	2.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	1.4%
frequent conflicts occurred about land information (different area sizes, different dimension size, no elevation data)	0	0.0%	1	3.6%	0	0.0%	1	2.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	1.4%
BPN / Ministry of Agrarian and Spatial Planning should be involved from the beginning in the construction of the building complex	0	0.0%	1	3.6%	0	0.0%	1	2.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	1.4%
Do not understand	0	0.0%	4	14.3%	0	0.0%	4	10.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	4	9.5%	0	0.0%	4	5.4%
	4	100.0%	28	100.0%	8	100.0%	40	100.0%	4	100.0%	14	100.0%	16	100.0%	34	100.0%	8	100.0%	42	100.0%	24	100.0%	**74**	100.0%

5.3.2 Public awareness

This section explores public views and opinions about the future of a 3D-cadastral system in Indonesia. Questions were asked about are about the need for a 3D-cadastre, any additional costs associated with a future 3D-cadastral system, and levels of satisfaction with land cadastre information.

In using the term 'public' at this point, the researcher is referring to the general population inside a nation or territory or the group of people in a predetermined locale. As such it will comprise individuals with various interests and states of mind, and gatherings of individuals recognized on the premise of shared interests. Individuals in various areas or social orders may have different social, ethnic or religious foundations, distinctive family and social esteems, and diverse levels of education. Gatherings containing general society incorporate residents or occupants, representatives of organisation and government, and businesses. They do not have similar concerns about land administration and ownership rights; in fact, many individuals may have clashing perspectives. Therefore, the general public voices the full range of opinions and views of every one of those individuals and gatherings. However, it has to be acknowledged that in this research only a representative sample of specific groups within the general public was sampled.

The need for a 3D-cadastral system

All participants were asked about the need for a 3D-cadastral system to replace the current 2D- system (Question PA1 – Appendix 5.5). The participants were given a brief explanation about new 3D-cadastral systems, after which most participants agreed that there was a need to implement a 3D-cadastre for the future of land administration in Indonesia. All government officials and LSs in Jakarta and Bandung agreed that this type of system is needed to handle the complex buildings being erected in Indonesian cities. However, between 20% and 40% of LDOs, property managers, and owners believed that the current 2D- cadastral system is adequate (Figure 5.2). Noteworthy is the fact that in Bandung more owners than managers wanted to move to the new system in the future, while n Jakarta this opinion was reversed.

The cost of providing a new cadastral system

Participants were asked about the defrayment of the costs of developing a 3D-cadastral system in the future (Question PA2 – Appendix 5.5). Opinions about the increase in prices in the new system are, of course, contingent on the economic capacity of each interviewee.

But it can be seen from Figure 5.3 above, that overall more than 50% of people would consider a price increase justified if it is offset by the increased provision of information on the certificate and increased security of tenure. A majority of respondents (55%) recognized that there would be additional costs.

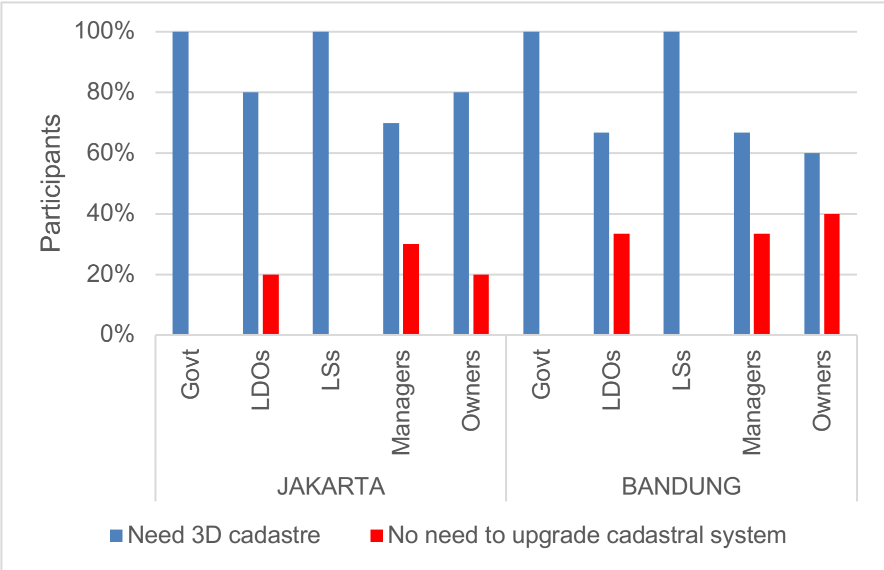


Figure 5.2 The need for the 3D-cadastral system.

However, there were divided opinions about who should pay for these. Some LDOs and property managers argued that additional costs should not be added to the cost of land certification with a 3D-cadastral process (Figure 5.3).

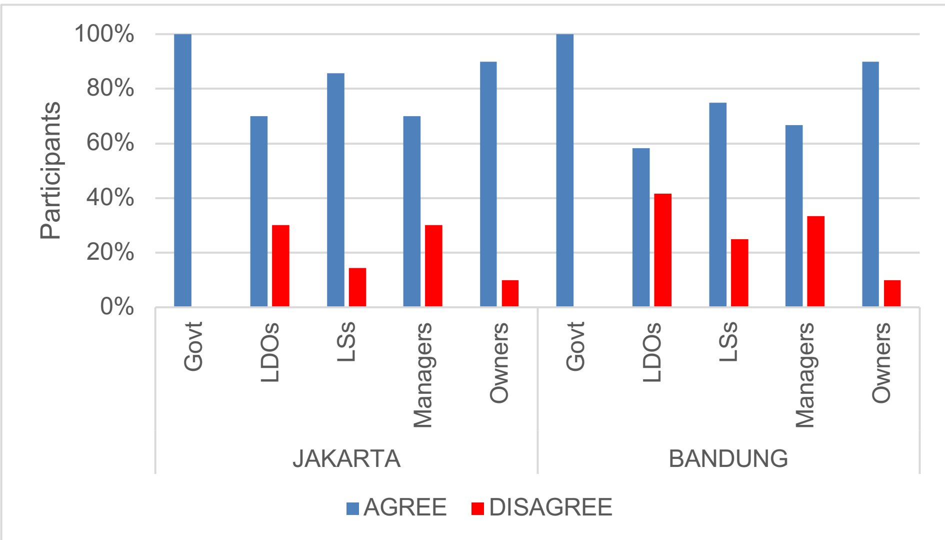


Figure 5.3 Stakeholder opinions about paying for the additional costs of developing a 3D-cadastral system.

However, those that have the roles of intermediaries between the general public and the government generally disagreed with additional costs being incurred. These were primarily LDOs. They argued that costs incurred should be accommodated by the government or BPN and not added to land certificates. The LDOs thought that many owners would not agree to pay more for 3D-land certificates Property managers felt that if some of the costs were recouped in this way it would increase the price of apartment sales and rents.

> *"ya pasti masyarakat akan keberatan dan akan complain gitu lho pak"*
>
> "Yes, surely people will object and will complain about the increasing price Interview with an LDO in Jakarta (C2/J202/La), December 2015).

A large minority of stakeholders believed it is a government responsibility to provide land certification at a low cost.

> *"kalau saya sih sebagai ppat dan yang selalu berhubungan dengan masyarakat yang banyak berhubungan dengan kepemilikan itu jujur saja kalau saya jangan ada kenaikan biaya sehingga merupakan tanggungan pemerintah atau bpn itu sehingga masyarakat tidak dibebani lagi kan sepanjang pengalaman saya kalau ada kenaikan biaya itu masyarakat itu teriak kenapa ada kenaikan biaya ini kenaikan biaya itu nah itu mereka sudah merasa menjadi tanggung jawabnyalah untuk tidak menambah biaya mereka."*
>
> "As an LDO, I always deal with people over ownership issues as honestly if I can. I do not want to see an increase in costs. It is the responsibility of government or BPN, to make sure that people are not overburdened by it all. Though my experience is that if there is an increase in costs, people will start screaming about why there is an increase in costs. They feel it is the government's responsibility to hold down any increase in the costs of (land) certificates. Interview with an LDO in Jakarta (C2/J203/Me), December 2015).

Land certificate information satisfaction

Property managers, owners, and tenants were asked about how satisfied they were with the information provided on land certificates and how it might be improved (Question PA4 – Appendix 5.5). Figure 5.4 shows that the property managers interviewed were generally not satisfied with the information on existing land certificates. Managers that were not satisfied accounted for 70% of managers in Jakarta and 66.67% in Bandung. Conversely, apartment owners and tenants believed that the information was adequate to guarantee the security of ownership.

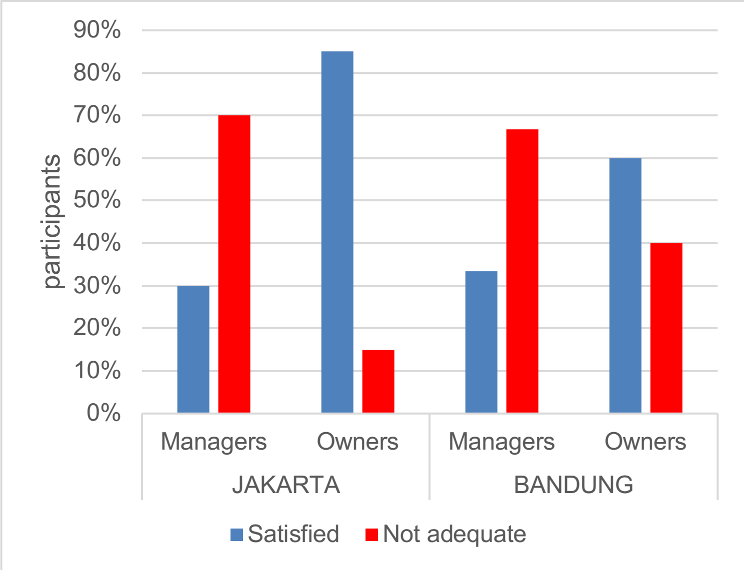


Figure 5.4 Satisfaction levels about the current amount of cadastral information on land certificates

In concluding this section, the need for a better land system in big cities so that better information can be accessed. However, this will generate increased costs and there are divided opinions about whether the government should absorb these or pass them onto customers.

5.4 ISSUES AROUND THE IMPLEMENTATION OF A 3D-CADASTRE IN INDONESIA

This following section identifies the key issues related to the introduction of 3D-cadastre in Indonesia, understanding of the 3D-system, and the advantages and disadvantages of a new 3D-system.

5.4.1 The introduction of a 3D-cadastre to Indonesia in the future

Government and land deeds officials and licensed surveyors were all asked about the introduction of a 3D-cadastral system in Indonesia (Question 3D1 – Appendix 5.6).

Twenty-two of the 55 stakeholders in these categories said that a 3D-cadastral system would provide complete, detailed and accurate land data information. Nine respondents went further and explained that a 3D-cadastral system would ensure legal certainty around ownership. While another nine stakeholders said that such a system would provide complete data for asset management in apartment buildings, and six argued that Indonesia, in fact, needs such a system to handle land data management given the complexity of building developments (Table 5.6). No significant difference was found between the responses of these stakeholders in Bandung and Jakarta according to a Mann-Whitney Test (Z = 0.10445, *p*-value = .92034 ($p < 0.05$)).

5.4.2 Understanding of 3D-surveying

All groups of stakeholders were questioned about their depth of understanding of 3D-surveying (Question 3D2 – Appendix 5.6). Only one group of stakeholders, the government officials, had any detailed knowledge. In the other groups of stakeholders, familiarity varied greatly. Surprisingly more LDOs had knowledge of this type of surveying than licensed surveyors (Table 5.5). The property manager and owners and renters were generally not knowledgeable in this area.

Table 5.5 Stakeholder's understanding of 3D-surveying.

	Understand		No knowledge	
JAKARTA	11	18.6%	48	81.4%
Govt	2	100.0%	0	0.0%
LDOs	5	25.0%	15	75.0%
LSs	1	14.3%	6	85.7%
Managers	2	20.0%	8	80.0%
Owners	1	5.0%	19	95.0%
BANDUNG	8	20.5%	31	79.5%
Govt	2	100.0%	0	0.0%
LDOs	3	25.0%	9	75.0%
LSs	1	8.3%	11	91.7%
Managers	1	33.3%	2	66.7%
Owners	1	10.0%	9	90.0%
Grand Total	19	19.4%	79	80.6%

Table 5.6. Responses about 3D-implementation in Indonesia

Responses	Jakarta								Bandung								Both cities						Total	
	Govt		LDOs		LSs		All		Govt		LDOs		LSs		All		Govt		LDOs		LSs		A	%
The 3D-cadastre system can provide complete, detailed and accurate land data information.	0	0.0%	8	57.1%	3	75.0%	11	55.0%	0	0.0%	4	50.0%	7	63.6%	11	52.4%	0	0.0%	12	54.5%	10	66.7%	22	40.0%
Ensure legal certainty	0	0.0%	5	35.7%	1	25.0%	6	30.0%	0	0.0%	1	12.5%	2	18.2%	3	14.3%	0	0.0%	6	27.3%	3	20.0%	9	16.4%
Complete data asset management for apartment managers and government	0	0.0%	5	35.7%	1	25.0%	6	30.0%	0	0.0%	1	12.5%	2	18.2%	3	14.3%	0	0.0%	6	27.3%	3	20.0%	9	16.4%
Indonesia needs system upgrades that can handle land data management according to the improvement and complexity of land and building development.	0	0.0%	1	7.1%	0	0.0%	1	5.0%	2	100.0%	1	12.5%	2	18.2%	5	23.8%	2	50.0%	2	9.1%	2	13.3%	6	10.9%
The corrected weakness of 2D- cadastre system	2	100.0%	0	0.0%	0	0.0%	2	10.0%	0	0.0%	2	25.0%	0	0.0%	2	9.5%	2	50.0%	2	9.1%	0	0.0%	4	7.3%
	2	100.0%	14	100.0%	4	100.0%	20	100.0%	2	100.0%	8	100.0%	11	100.0%	21	100.0%	4	100.0%	22	100.0%	15	100.0%	55	100.0%

Table 5.7. Advantages of 3D-cadastral systems

Responses	Jakarta												Bandung												Both cities										Total	
	Govt		LDOs		LSs		Managers		Owners		All		Govt		LDOs		LSs		Managers		Owners		All		Govt		LDOs		LSs		Managers		Owners		T	%

More detailed and complete information	1	50%	11	52%	5	71%	0	0%	10	50%	27	45%	0	0%	5	31%	10	43%	0	0%	1	14%	16	31%	1	20%	16	43%	15	50%	0	0%	12	40%	44	38%
Guarantee law certainty	0	0%	5	24%	2	29%	4	40%	5	25%	16	27%	1	33%	5	31%	12	52%	1	33%	4	57%	23	44%	1	20%	10	27%	14	47%	5	38%	11	37%	41	36%
Corrected current 2-dimensional land cadastre system	1	50%	0	0%	0	0%	2	20%	2	10%	5	8%	2	67%	1	6%	1	4%	2	67%	0	0%	6	12%	3	60%	1	3%	1	3%	4	31%	2	7%	11	10%
Give more valuable price on property	0	0%	2	10%	0	0%	2	20%	0	0%	4	7%	0	0%	5	31%	0	0%	0	0%	0	0%	5	10%	0	0%	7	19%	0	0%	2	15%	0	0%	9	8%
Reduce potential conflicts	0	0%	2	10%	0	0%	2	20%	3	15%	7	12%	0	0%	0	0%	0	0%	0	0%	2	29%	2	4%	0	0%	2	5%	0	0%	2	15%	5	17%	9	8%
no comment	0	0%	1	5%	0	0%	0	0%	0	0%	1	2%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	1	3%	0	0%	0	0%	0	0%	1	1%
	2	100%	21	100%	7	100%	10	100%	20	100%	60	100%	3	100%	16	100%	23	100%	3	100%	7	100%	52	100%	5	100%	37	100%	30	100%	13	100%	30	100%	115	100%

Table 5.8. Disadvantages of 3D-cadastral systems

Responses	Jakarta												Bandung												Both cities										Total	
	Govt		LDOs		LSs		Managers		Owners		All		Govt		LDOs		LSs		Managers		Owners		All		Govt		LDOs		LSs		Managers		Owners		T	%
High cost	2	67%	15	68%	4	57%	10	100%	17	85%	48	77%	1	25%	8	67%	8	67%	3	100%	7	100%	27	71%	3	43%	23	68%	12	63%	13	100%	27	90%	79	76%
Need staff training	0	0%	6	27%	1	14%	0	0%	0	0%	7	11%	2	50%	0	0%	4	33%	0	0%	0	0%	6	16%	2	29%	6	18%	5	26%	0	0%	0	0%	13	13%
Need new systems	1	33%	1	5%	2	29%	0	0%	0	0%	4	6%	1	25%	4	33%	0	0%	0	0%	0	0%	5	13%	2	29%	5	15%	2	11%	0	0%	0	0%	9	9%
no comment	0	0%	0	0%	0	0%	0	0%	2	10%	2	5%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	3	10%	3	3%
no understanding	0	0%	0	0%	0	0%	0	0%	1	10%	1	1%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
	3	100%	22	100%	7	100%	10	100%	20	100%	62	100%	4	100%	12	100%	12	100%	3	100%	7	100%	38	100%	7	100%	34	100%	19	100%	13	100%	30	100%	104	100%

5.4.3 Advantages and disadvantages of the 3D-cadastral system

The advantages and disadvantages of a 3D-cadastral system that might be implemented in Indonesian cities in the future were explored through two questions asked of all stakeholders. First, they were asked about what they thought would be the advantages of a 3D-cadastral system (Question 3D4 – Appendix 5.6) and then they were asked about disadvantages (Question 3D4 – Appendix 5.6).

Forty-four of the 98 participants interviewed in both two cities said that the main advantages would be in obtaining more detailed and complete information. Forty-one respondents explained that another major advantage would be to guarantee ownership legally, while a further eleven stakeholders said that it would correct weaknesses, which they did not specify, in the current cadastral system. Nine respondents anticipated that the implementation of the 3D-system would add value to properties, while an equal number said that it would potentially reduce conflicts over the property (Table 5.7). The null hypothesis of no significant difference between the responses from the two cities was accepted: a Wilcoxon Signed-Rank Test generated a W of 10, which is greater than the critical value (0, $p \leq 0.05$, n = 6)

Seventy-nine of the 98 participants interviewed said that the main disadvantages would be of the high cost of providing a complete 3D-cadastral system. An additional thirteen respondents thought another disadvantage would the need for good quality staff training, and another nine stakeholders said that a new system would require investments in tools and computer hardware and software (Table 5.8). The Wilcoxon Signed-Rank Test was applied to these answers about the disadvantages of the 3D-cadastral system generated a critical value of W for N = 5 at $p \leq 0.05$ is 0. The null hypothesis was rejected because the result is significant at $p \leq 0.05$. The response of stakeholders in Jakarta and were statistically different from those in Bandung.

Foremost in the answers about the potential advantages of a 3D-cadastral system focus on the provision of information, which is more detailed, accurate and complete. It is felt that such information will provide better guarantees about secure and legal ownership, and therefore reduce future land conflicts. Stakeholders also identify potential disadvantages, the most important of which will be the high cost of initial investment followed by the need for training, and software and hardware provision. The issues are less the actual cost and more who will ultimately pay for it.

5.5 READINESS OF THE LEGAL FRAMEWORK, HUMAN RESOURCES AND ORGANIZATIONS TO ADOPT A 3D-CADASTRE SYSTEM IN INDONESIA

In this section, the readiness of the legal framework, human resources, and organizations to adopt a 3D-cadastral system are explored.

5.5.1 Legal Framework

This section examines the responses to a series of questions regarding the readiness of Indonesia's legal framework to adopt a 3D-cadastral system:

Opinions about 3D-cadastre systems such as why Indonesia needs a better 3D-land cadastral system? (Question L1 – Appendix 5.2), and what legal benefits would arise from a new 3D-system? (Question L2 – Appendix 5.2);

The state of existing laws and regulations around 3D-parcels (Question L3 – Appendix 5.2), the construction industry (Question L4 – Appendix 5.2), and official technical guidance on 3D-surveying (Question L7 – Appendix 5.2);

The status of certificates of ownership (Question L8 – Appendix 5.2) and land certificate details (Question L9 and L10 – Appendix 5.2;

Knowledge of stakeholders about apartment ownership: such as apartment boundaries (Question L5 – Appendix 5.2), limitations of ownership (Question L6 – Appendix 5.2), knowledge about ownership of other parts of an apartment complex (common areas (Question L11 – Appendix 5.2), common land (Question L12 – Appendix 5.2), the space above and below apartments (Question L13 – Appendix 5.2), and unit identification (Question L14 – Appendix 5.2); and

Conflict management (Question L15 – Appendix 5.2), and its resolution (Question L16 – Appendix 5.2).

Opinions about 3D-Cadastral systems

Land deeds officials were asked how 3-D plans better legal certainty of land rights would compare to 2D- systems (Question L1 – Appendix 5.2). The majority (90%) of the majority of LDOs in both cities contended that a 3D-cadastral system would lead to better legal certainty of land rights than the current 2D- system. Ninety percent of LDOs in Jakarta believed that a 3D-cadastre would secure better and ownership right than the 2D- cadastre. A similar opinion was held by most (75%) LDOs in Bandung. Very few said that a 3D-cadastral system would not improve the security of ownership in both cities (Table 5.9).

Table 5.9 Opinions of LDOs about ensuring property rights under a 3D-cadastral system

Opinions	Jakarta		Bandung		Total	
3D-system better than 2D-	18	90.00%	9	75.00%	27	84.38%
2D- system still adequate	2	10.00%	3	25.00%	5	15.63%
	20	**100.00%**	**12**	**100.00%**	**32**	**100.00%**

LDOs were asked about other legal benefits that might accrue from a 3D-system (Question L2 – Appendix 5.2). Just under a half (42.5%) agreed that a 3D-cadastre would provide legal benefits. Greater certainty and legal protection of land ownership (17.5%) were also perceived as benefits by LDOs. Others thought that it reduces construction costs and those incurred during certification (10.0%), or believed that unspecified weaknesses in the 2D- system would be rectified (7.5%) (Table 5.10).

State of existing laws and regulations in the context of 3D-land parcels

Government officials, LDOs and licensed surveyors were questioned about existing national or regional laws and regulations that might concern the 3D-cadastral system (Question L3 – Appendix 5.2).

Table 5.10 Other legal benefits derived from a 3D-cadastre according to LDOs interviewed

Response	Jakarta		Bandung		Both cities	
Cadastre 3D-is expected provide complete data (position, dimension, and height)	9	37.50%	8	50.00%	17	42.50%
Certainty and legal protection	4	16.70%	3	18.80%	7	17.50%
Saves costs in construction and certification	3	12.50%	1	6.30%	4	10.00%
Cadastre 3D-can reduce weakness of 2D-systems	3	12.50%	0	0.00%	3	7.50%
Design and construction errors can be known immediately	2	8.30%	0	0.00%	2	5.00%
The difference of land /property data can be clearly known	2	8.30%	0	0.00%	2	5.00%
Generated maps can be used in existing systems	1	4.20%	1	6.30%	2	5.00%
Reduce the potential for land/unit conflict	0	0.00%	1	6.30%	1	2.50%
Speed up the certification process	0	0.00%	1	6.30%	1	2.50%
Ensure customer satisfaction	0	0.00%	1	6.30%	1	2.50%
Total	**24**	**100.00%**	**16**	**100.00%**	**40**	**100.00%**

All government officials and licensed surveyors in both cities explained that relevant land laws and regulations are stated Indonesia's Basic Agrarian Law (BAL 1960) (table 5.5). But only about half of the LDOs in Jakarta (55%) and Bandung (58%) said that there no laws and regulations are currently available that are suitable for a 3D-cadastral system. The dichotomy between government officials and licensed surveyors, and LDOs, probably arises from the difference in understanding and interpretation of the laws themselves, and the fact that no official technical guidance of 3D-systems is available in Indonesia at present time (Figure 5.5).

The same stakeholders were also asked about laws and regulations pertaining to the construction of building units (Question L4 – Appendix 5.2). There was considerable diversity in responses. Nineteen of the 55 government officials, LDOs and land surveyors interviewed said that Law No. 28/2002 on Buildings (Government of Indonesia 2002) is the foundation of all building laws in Indonesia. A further six respondents said that Law No. 5/1960 of the Basic Agrarian Law (Government of

Indonesia 1960a) is the primary land law in Indonesia and contains provisions about building. Six explained that Government Regulation No. 36/2005 on the Regulation of the Implementation of Law No. 28/2002 on Buildings (Government of Indonesia 2005) is the most appropriate law in this context. A handful of respondents cited Law No. 20/2011 on Apartments and another five said that Government Regulation No. 24/1997 on Land Registration (Government of Indonesia 1997) is the most important regulation related to the buildings. Twenty LDOs did not recognize any law or regulation related to the building in Indonesia (Table 5.11). These considerable differences in opinion between stakeholders will be discussed in-depth in the next chapter. The Wilcoxon Signed-Rank Test was applied to see if the answers about laws and regulations for construction were statistically different between Jakarta and Bandung. The W-value (12.5) was greater than the critical value (2, $p \leq 0.05$, n = 7), indicating no significant differences between the responses these stakeholders between cities, i.e. the high diversity on answers is common to both Bandung and Jakarta.

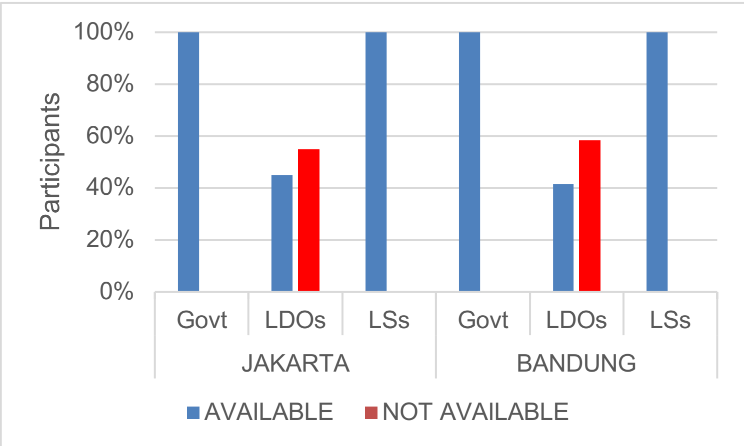


Figure 5.5 Availability of laws and regulations suitable for a 3D-cadastral system.

Government officials and licensed surveyors were asked about any technical circulars or directives that might assist surveyors in 3D-data collection (Question L7 – Appendix 5.2). However, the only guidance available at present is for 2D- systems exist.

Certificates of ownership

The participant's opinions about their land certificates were elucidated several questions. Firstly, property managers were asked about the availability of certificates for entire properties and for the individual units within a building (Question L8 – Appendix 5.2). All said that all the land certificates they have for their properties were granted under the prevailing 2D- cadastral system.

Property managers (participant category 4) and the owners or tenants (participant category 5) were also asked whether they felt that land certificates would guarantee property rights for either the property management companies or the individual owners (Question L9 – Appendix 5.2). All believed that land certificates granted in a 3D-cadastral system would guarantee their property rights and provide all the necessary details about their properties. However, they again pointed out that at the present time, the only certificates they have been granted under a 2D-, and not a 3D, system.

They were asked about rental agreements (Question L10 – Appendix 5.2). Approximately, two-thirds of property managers in Jakarta (66.7%) and Bandung (60%) argued that the information on the land certificates was inadequate in terms of detailed measurement of units in the apartment complexes they managed.

Table 5.11. Availability of the laws and regulations for construction or building unit

Response	Jakarta								Bandung								Both cities						Total	
	Govt		LDOs		LSs		All		Govt		LDOs		LSs		All		All Govt		All LDOs		All LSs		T	%
Yes, Law No. 28/2002 on Buildings	2	40.0%	3	13.0%	4	57.1%	9	25.7%	2	66.7%	4	33.3%	4	33.3%	10	37.0%	4	50.0%	7	20.0%	8	42.1%	19	30.6%
Yes, Law No. 5/1960 on Basic Agrarian Law	0	0.0%	3	13.0%	2	28.6%	5	14.3%	0	0.0%	0	0.0%	1	8.3%	1	3.7%	0	0.0%	3	8.6%	3	15.8%	6	9.7%
Yes, Government Regulation No. 36/2005 on Regulation Implementation of Law No. 28/2002 on Buildings	1	20.0%	1	4.3%	0	0.0%	2	5.7%	0	0.0%	0	0.0%	4	33.3%	4	14.8%	1	12.5%	1	2.9%	4	21.1%	6	9.7%
Yes, Law No. 20/2011 on Apartment	1	20.0%	3	13.0%	0	0.0%	4	11.4%	1	33.3%	0	0.0%	0	0.0%	1	3.7%	2	25.0%	3	8.6%	0	0.0%	5	8.1%
Yes, Government Regulation No. 24/1997 on Land Registration	0	0.0%	0	0.0%	1	14.3%	1	2.9%	0	0.0%	1	8.3%	3	25.0%	4	14.8%	0	0.0%	1	2.9%	4	21.1%	5	8.1%
Yes, Law No. 16/1985 on Apartment/Flat (previous Law)	1	20.0%	0	0.0%	0	0.0%	1	2.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	12.5%	0	0.0%	0	0.0%	1	1.6%
No laws available	0	0.0%	13	56.5%	0	0.0%	13	37.1%	0	0.0%	7	58.3%	0	0.0%	7	25.9%	0	0.0%	20	57.1%	0	0.0%	20	32.3%
	5	100.0%	23	100.0%	7	100.0%	35	100.0%	3	100.0%	12	100.0%	12	100.0%	27	100.0%	8	100.0%	35	100.0%	19	100.0%	62	100.0%

Knowledge about apartments

Owners or tenants of apartments were asked about the ownership boundaries of their apartments; limitations of ownership; ownership of the common area, land, spaces above and below ground, and the lot numbering convention through a series of questions.

First, all participants were asked about the 3D-boundaries of their apartments (Question L5 – Appendix 5.2). The four government officials interviewed said that walls, ceilings, and floors are neutral. In this context neutral means, this area is not owned by any individual in terms of 3D-boundaries. More than half of the LDOs in Jakarta (55%) and Bandung (58%) agreed (Figure 5.6). In contrast, licensed surveyors, property managers, owners, and tenants said that walls, ceilings, and floors are divided in the middle. In this context divided means that the ceiling, wall or floor is divided equally between the owners on either side of the partition. These answers clearly distinguish between the people in this group of stakeholders who recognize the critical article no. 25 of or Law 20 of 2011 (The Apartments Law) and those that do not. Article no. 25 states that:

> *"The shared parts consist of foundations, columns, walls, beams, floors, roofs, gutters, stairs, elevators, corridors, conduits, pipes, power grids, gas, and telecommunications"*

Those people that either know their legal position (or guessed correctly) were those that said the divisions are neutral. It can be seen from Figure 5.6 that correct understanding of this is not widespread, only slightly of 50% of LDOs in both cities knew this, and the proportions of surveyors, property managers, and owners and tenants were less, ranging from around 40% (property managers in Jakarta, and surveyors and owners/tenants in Bandung) to approximately a quarter of surveyors in Jakarta).

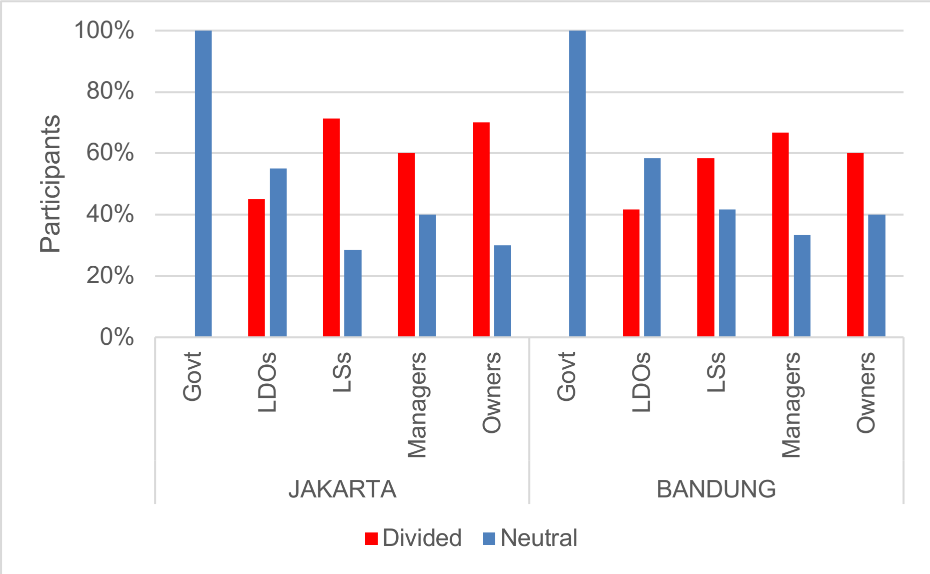


Figure 5.6 Knowledge about the 3D-boundaries of apartments.

Government and land deed officials were asked about any limitation's rights of land ownership in Indonesia that were relevant to this research (Question L6 – Appendix 5.2). Twelve of the 36 stakeholders in these two groups interviewed argued that Indonesia needs more detailed laws and regulations to manage spaces above and below the ground land surface. Twelve respondents thought that private land ownership should not collide with the public interest in this area, and eleven argued that this limitation potentially leads to property disputes. Six respondents assumed that spaces above and below ground are currently controlled by the government (Table 5.12). Despite the range of opinions across all stakeholders in these two groups, there is no significant difference between Jakarta and Bandung ($W=6$, greater than the critical value $=0$, $p \leq 0.05$, $n = 5$) (Wilcoxon Signed-Rank Test).

Table 5.12 Limitations associated with apartment ownership

Response	Jakarta						Bandung						Both cities				Total	
	Govt		LDOs		All		Govt		LDOs		All		Govt		LDOs		T	%
More detailed government laws/ regulations are required to manage spaces above and below ground land surface	2	100.0%	5	22.7%	7	29.2%	0	0.0%	5	29.4%	5	25.0%	2	40.0%	10	25.6%	12	27.3%
Public interest	0	0.0%	5	22.7%	5	20.8%	2	66.7%	5	29.4%	7	35.0%	2	40.0%	10	25.6%	12	27.3%
Prone to potential land conflicts	0	0.0%	6	27.3%	6	25.0%	1	33.3%	4	23.5%	5	25.0%	1	20.0%	10	25.6%	11	25.0%
Space above and below ground controlled by the government	0	0.0%	4	18.2%	4	16.7%	0	0.0%	2	11.8%	2	10.0%	0	0.0%	6	15.4%	6	13.6%
Owned by landowners	0	0.0%	1	4.5%	1	4.2%	0	0.0%	1	5.9%	1	5.0%	0	0.0%	2	5.1%	2	4.5%
In accordance with the land ownership rights	0	0.0%	1	4.5%	1	4.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.6%	1	2.3%
	2	**100.0%**	**22**	**100.0%**	**24**	**100.0%**	**3**	**100.0%**	**17**	**100.0%**	**20**	**100.0%**	**5**	**100.0%**	**39**	**100.0%**	**44**	**100.0%**

A third question was posed to property managers, and owners and tenants in which they were asked about the ownership of common areas (e.g., lobbies, mezzanines, storerooms, car parks, lifts, etc.) (Question L11 – Appendix 5.2). There were three distinct answers. Nineteen of the 43 participants interviewed said that these common areas are owned by the property developers. Eleven respondents said that in their building's owners' associations owned the common areas and another eleven believed that the common areas were owned by the management company (Table 5.13). The Wilcoxon Signed-Rank Test was used again to see if there were differences in these responses between stakeholders in Jakarta and Bandung. The null hypothesis, i.e., no significant between stakeholders in the two cities, was accepted as the W-value of 5 was greater than the critical value 0, $p \leq 0.05$, n = 5.

Property managers and owners and tenants were also asked about the land on which their apartment buildings are built on (Question L12 – Appendix 5.2). Twenty-four of the 43 respondents interviewed said the land was owned by the developer of the apartment. Fourteen argued that owners' associations had the right to own the land and further three said that the land was owned by the management company (Table 5.14). This range of answers is similar to those related to common areas. As with the previous question, there was no significant difference between responses from stakeholders in these two groups in Jakarta and Bandung (W=7, greater than the critical value =0, $p \leq 0.05$, n = 5, despite the range of opinions expressed.

A fifth question focused on spaces above and below the apartment buildings (Question L13 – Appendix 5.2). Seventeen people (39.5%) said that such spaced were owned by the developers of the buildings; ten said owner's association had the right to own them, and seven said they were owned by the management companies. Nine respondents do not know about the ownership of these spaces (Table 5.15). The Wilcoxon Signed-Rank Test was used again to test for differences between responses in Jakarta and Bandung. The W value of 5 is greater than the critical value 0, $p \leq 0.05$, n = 5, allowing the null hypothesis of no significant difference to be accepted.

Table 5.13 Common area ownership

Responses	Jakarta						Bandung						Both cities				Total	
	Manager		Owner		All		Manager		Owner		All		All Manager		All Owner		T	%
Developer	0	0.00%	11	55.00%	11	36.70%	0	0.00%	8	80.00%	8	61.50%	0	0.00%	19	63.30%	19	44.20%
Owner's Association	6	60.00%	3	15.00%	9	30.00%	1	33.30%	1	10.00%	2	15.40%	7	53.80%	4	13.30%	11	25.60%
Management	4	40.00%	4	20.00%	8	26.70%	2	66.70%	1	10.00%	3	23.10%	6	46.20%	5	16.70%	11	25.60%
Do Not answer	0	0.00%	1	5.00%	1	3.30%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	3.30%	1	2.30%
Do not know	0	0.00%	1	5.00%	1	3.30%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	3.30%	1	2.30%
	10	100.00%	20	100.00%	30	100.00%	3	100.00%	10	100.00%	13	100.00%	13	100.00%	30	100.00%	43	100.00%

Table 5.14 Land ownership related to the apartment

Response	Jakarta						Bandung						Both cities				All	
	Manager		Owner		All		Manager		Owner		All		All Manager		All Owner		A	%
Developer	4	40.00%	10	50.00%	14	46.70%	2	66.70%	8	80.00%	10	76.90%	6	46.20%	18	60.00%	24	55.80%
Owner's association	6	60.00%	6	30.00%	12	40.00%	1	33.30%	1	10.00%	2	15.40%	7	53.80%	7	23.30%	14	32.60%
Management	0	0.00%	2	10.00%	2	6.70%	0	0.00%	1	10.00%	1	7.70%	0	0.00%	3	10.00%	3	7.00%
Do not know	0	0.00%	1	5.00%	1	3.35%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	3.35%	1	2.30%
Do not answer	0	0.00%	1	5.00%	1	3.35%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	3.35%	1	2.30%
	10	100.00%	20	100.00%	30	100.00%	3	100.00%	10	100.00%	13	100.00%	13	100.00%	30	100.00%	43	100.00%

In the last question property managers, and owners and tenants were asked about the lot numbering convention for the units in their apartment building (Question L14 – Appendix 5.2). Two-thirds of people interviewed said a format based on the tower, floor and unit number of the apartment was in place; five said numbering was based on the floor and unit number; and eleven knew that each apartment had its own unique number but did not know the format (Table 5.16). There were no significant differences in the responses between cities, W=7, greater than the critical value (0, $p \leq 0.05$, n = 5).

In reviewing the answers to these six questions, there are is a lack of understanding about ownership of the apartment and apartment boundaries among many property managers and the people who live in the apartments that they manage. Land and space rights attached to apartment units (*Sertipikat Hak Milik atas Satuan Rumah Susun/SHMSRS*) are still not widely known. This means there could be different interpretations by managers, owners, and tenants. These do lead to property disputes and the introduction of a 3D-cadastre in the future could improve the situation. But because there is a lack of understanding of the current situation, many stakeholders in these two groups will not immediately see the benefits of a 3D-system. Ownership of common spaces, the land on which the apartment is built, and spaces above and below ground is understood differently between these stakeholders, and the points made above in relation to apartment boundaries apply to these aspects of apartment buildings as well. The unique identity of an apartment unit (lot numbering) varies between the apartment buildings. While this is not an issue for owners, tenants and managers it may be a problem in surveying and legal areas and if a 3D-cadastre is introduced, the opportunity should be taken to introduce standards for lot numbering.

Table 5.15 Space ownership above and below the apartment building

Response	Jakarta						Bandung						Both cities				All	
	Managers		Owners		All		Managers		Owners		All		All Managers		All Owners		All	%
Developer	5	50.00%	7	35.00%	12	40.00%	2	66.70%	3	30.00%	5	38.50%	7	53.80%	10	33.30%	17	39.50%
Owner's association	5	50.00%	3	15.00%	8	26.70%	1	33.30%	1	10.00%	2	15.40%	6	46.20%	4	13.30%	10	23.30%
Management	0	0.00%	6	30.00%	6	20.00%	0	0.00%	1	10.00%	1	7.70%	0	0.00%	7	23.30%	7	16.30%
Do not know	0	0.00%	4	20.00%	4	13.30%	0	0.00%	4	40.00%	4	30.70%	0	0.00%	8	26.70%	8	18.60%
Do not answer	0	0.00%	4	20.00%	4	13.30%	0	0.00%	1	10.00%	1	7.70%	0	0.00%	1	3.30%	1	2.30%
	10	100.00%	20	100.00%	30	100.00%	3	100.00%	10	100.00%	13	100.00%	13	100.00%	30	100.00%	43	100.00%

Table 5.16 Lot numbering convention in the apartment building

Responses	Jakarta						Bandung						Both cities				All	
	Managers		Owners		All		Managers		Owners		All		All Managers		All Owners		All	%
Numbering by tower, floor, unit number	6	46.20%	16	64.00%	22	57.90%	3	100.00%	7	70.00%	10	76.90%	9	56.30%	23	65.70%	32	62.70%
Unique number	4	30.80%	6	24.00%	10	26.30%	0	0.00%	1	10.00%	1	7.70%	4	25.00%	7	20.00%	11	21.60%
Numbering by floor and unit number	0	0.00%	3	12.00%	3	7.90%	0	0.00%	2	20.00%	2	15.40%	0	0.00%	5	14.30%	5	9.80%
No standard rules	2	15.40%	0	0.00%	2	5.30%	0	0.00%	0	0.00%	0	0.00%	2	12.50%	0	0.00%	2	3.90%
Omit disliked number	1	7.70%	0	0.00%	1	2.60%	0	0.00%	0	0.00%	0	0.00%	1	6.30%	0	0.00%	1	2.00%
	13	**100.00%**	**25**	**100.00%**	**38**	**100.00%**	**3**	**100.00%**	**10**	**100.00%**	**13**	**100.00%**	**16**	**100.00%**	**35**	**100.00%**	**51**	**100.00%**

Conflict management

The question in this section was designed to explore how interviewees managed conflicts that have occurred within the existing cadastral system. The question was asked of government officials, property managers, and owners and tenants (Question L15 – Appendix 5.2). Most interviewees had experienced conflicts personally or in a professional capacity (Figure 5.7).

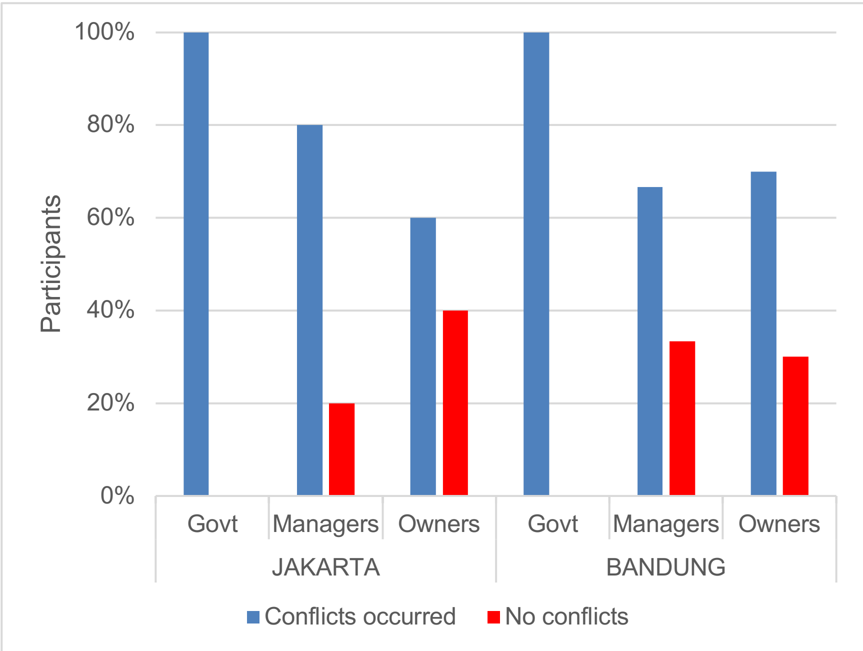


Figure 5.7 The occurrence of conflicts.

All the conflicts involving people interviewed had been resolved (Question L16 – Appendix 5.2), Solutions had varied from the mediation of the parties using customary practices of consensus decision making ("*musyawarah-mufakat*") to court proceedings. Issues like conflicts about noise and spreading odors were often solved by simple mediation. However, cases concerning apartment management, ownership, and changes in the structure of units were more likely to go to court.

The concluding this section most participants argue that a 3D-cadastral system will provide better legal certainty of land rights than the current 2D- system. But in order to do so, it is necessary to provide legal and regulatory instruments that are adapted to the increasingly complex conditions of Indonesia's urban infrastructure and the need to educate people through socialization about legislation so that the public will recognize their rights and obligations. Understanding of the rules and laws in the context of infrastructure development in Indonesia is varied. Some participants prefer to Basic Agrarian Law; others suggest technical rules concerning its implementation for the building are required; some argue regulation of through the Law of Apartments; while a further group refers to the land registration regulations. It is imperative that specific laws or legal regulations regarding 3D-buildings are provided. Property managers said that all the land certificates they have are still in 2D- systems, and they think 3D-system-generated certificates would be more complete and detail ownership.

5.5.2 Human Resources

This section explores human resource capacity in the context of the possible implementation of a 3D-cadastre using the following 23 technical questions which cover:

- 3D-data acquisition (data collection (HR1) and accuracy (HR2));
- software (HR3, HR13), software capabilities (HR7, HR14), editing (HR15), and web software (HR16, HR17));
- the spatial system reference (coordinate reference systems used (HR4), spatial reference systems used (HR5), and coordinate sources (HR6));
- use of databases (HR9, HR10, HR12);
- data visualization (HR11);
- validity checking (HR18);
- data presentation (HR19, HR20, HR22), and sampling (HR21); and
- operational aspects (HR23)

3D-data acquisition

Government officials and licensed surveyors were asked about 3D-data collection for the different surveying methods they currently use, i.e., CAD, surveying, sketching, photogrammetry, or laser scanning (Question HR1 – Appendix 5.3). None had conducted any 3D-surveying and therefore they did not know how to collect the data for 3D-surveys. At the time of the interviews, they only employed methods to collect 2D- land cadastral data. In response to the question about the accuracy of data collection during surveying (Question HR2 – Appendix 5.3), they were all of the opinions that accuracy depends on the equipment used and that more advanced tools have better accuracy. However, they did note that some methods have limitations, e.g., the use of GPS surveys in urban areas with many high-rise buildings:

> *"Kalau misalnya bidangnya ga terlalu besar ya bisa pakai pita ukur. Tapi kalo misalnya agak besar gitu bisa pakai theodolite atau total station (TS) gitu ya. Terus kalau misalnya memang kan ga semua bidang tuh kan mudah ya. Jadi kalau memang bidangnya sulit itu pake GPS CORS tapi syaratnya harus langitnya tuh kebuka ga ditutupin pohon karena akan mempengaruhi sinyal yang diterima."*
>
> "If the size of the area is not too large, I can use a tape measure. But if it is a large area, I can use a theodolite or a total station (TS). Then not all areas have the same condition. So, if it is difficult to measure, then we can use GPS CORS, but it must be an open area, the sky is not covered by the tree (or buildings, i.e. no obstructions) because it will affect the received signal". (Interview with a licensed surveyor in Jakarta (C3/J302/Ma), December 2015).

Software

AutoCAD and ArcGIS software were being used at the time of interviews to create and to process land data at the government (BPN) land offices (Question HR3, HR13 – Appendix 5.3). Through this software has the ability to process 3D-field data, it has not used in that way because the cadastral system is still based on 2D- (Question HR7, HR14 – Appendix 5.3). Editing cadastral data requires authorized access from the administrator in every BPN office (Question HR15 – Appendix 5.3). Web software to remote access cadastral data (Question HR16, HR17 – Appendix 5.3) had not been used by BPN at the time of the interviews.

Datum and spatial reference system

All government officials were asked about relative and absolute coordinate reference systems used (Question HR4 – Appendix 5.3). Indonesia, through the government land offices (BPN), uses the World Geodetic System/WGS 84 as its absolute coordinate system. This has been modified to DGN (*Datum Geodesi Nasional*, National Geodetic Datum) since 1995 (DGN-95) because WGS-84 is best for the overall ellipsoid geoid. The biggest deviation between the geoid and ellipsoid WGS-84 is 60 m above and 100 m below. So, this ellipsoid type is suitable for surveying and mapping in Indonesia. WGS-84 gained the smallest deviation obtained for all-region of Indonesia. Smallest deviation from the ellipsoid geoid WGS-84 in Indonesia is known as Padang datum, and this is used as a reference point for national mapping and surveying (Mugnier 2009). During the Dutch colonial era the Genuk datum, which is located around Semarang, Central Java was used. In this absolute datum system, central ellipsoid reference coinciding with central earth mass. Z coordinate has not used yet due to the cadastral system still use 2-dimensional (x, y) coordinates (Question HR8 – Appendix 5.3).

The spatial reference system used is TM3 (Question HR5 – Appendix 5.3). This is a modification of the UTM (Universal Transverse Mercator) coordinate system in which the earth is divided into 60 zones. Each zone consists of 6-degree longitude and has its own central meridian (Maling 2013). The modified TM3 coordinate system used by BPN has three-degree longitude width zones, rather than 6-degree zones. This is everyday use, e.g., all maps produced and used by BPN were sourced from Indonesian land base maps which have TM3 coordinates (Question HR6 – Appendix 5.3).

Database

At the time of the interviews, government officials and licensed surveyors explained that the Indonesian land cadastre has been migrating to a new computerized system called KKP (*Komputerisasi Kantor Pertanahan*) or Land Office Computerization (Question HR9 – Appendix 5.3). At that time all land parcels had been coded into a geodatabase called GeoKKP. Text data, which is stored manually in Land Books (*Buku Tanah*), includes field notes (*Surat Ukur*) and archives (*Warkah*) have been entered into the database. Spatial data from the field notes (*Surat Ukur*) and land registration maps (*Peta pendaftaran tanah*) had been scanned and stored in a spatial geodatabase. The spatial geodatabase is based on an Oracle spatial database system, integrated into one system (GeoKKP) at the Central Office of BPN in Jakarta. Administrators in regional BPN offices can input data into the GeoKKP online system, which is backed up at the central office of BPN in Jakarta (Question HR10 – Appendix 5.3). The geodatabase at the BPN central office is maintained by a central administrator (Question HR12 – Appendix 5.3).

Government officials and licensed surveyors were asked about visualization of data held in the GeoKKP database. (Question HR11 – Appendix 5.3). Data can be visualized as maps and textual information. The data being visualized are secure, in that no unauthorized person can apply a modification. This is because the system is maintained by authorized officials, called administrators, which have authorized legal access to manage land information in Indonesia. When visualization is required for information verification, e.g. when there is a change of ownership, owners of the certificate can make a request to see and obtain cadastral data of current ownership, through a defined procedure. When a licensed surveyor requires a map to conduct a land survey, they order it through a related procedure.

Validity checking

Government officials and licensed surveyors were asked about spatial validity checking (Question HR18 – Appendix 5.3). This is a procedure that is conducted after a BPN employee or a licensed surveyor finishes a land survey, for instance, producing a land map or a parcel measurement report. They responded that standard data quality checking procedures were conducted after a land surveying work is done, and only valid data can be saved into the land archives.

Operational aspects and data presentation related to 3D-cadastral systems

Government officials and licensed surveyors were also asked about 3D-land data information that could be presented in the official documents (Question HR18 – Appendix 5.3). However, as 3D-information is not yet available, they responded that no standard format had yet been decided on (Question HR20, HR22 – Appendix 5.3). Consequently, no operational or prototype 3D-parcels samples had been made at the time of the interviews according to government officials and licensed surveyors (Question HR21 – Appendix 5.3). The same group of stakeholders was unable to answer the question about 3D-survey operations (Question HR23 – Appendix 5.3), as they have never carried out a 3D-survey.

In this section, the readiness of human resources has been explored. Stakeholders are, in general, inexperienced in the concept of 3D-cadastre. The current land database is centralized and held on the main server in central BPN headquarters in Jakarta. Visualization, validation, and presentation of data can be done from this database, though access to the database is strictly controlled. In conclusion, there are significant needs for human resources training before the cadastre and land registration systems can be migrated from 2D- to 3D.

5.5.3 Readiness of Organisation

This section provides insights into the readiness of organizational structures to take a 3D-system on board. Government officials and licensed surveyors were asked about operational 3D-surveying departments in their offices and companies (Question O1 – Appendix 5.4). All of them said that as a 3D-cadastral system has not yet implemented in the Indonesian land cadastral systems, the question was premature. However, that said, there is a different organizational structure in BPN Main Office in Jakarta and BPN regional office in Bandung which points toward the future development of a 3D-cadastre (Question O2 – Appendix 5.4). In the main office, there is a specific section that managed all aspects of a 3D-cadastre at the time of interviews. The work of this department is mainly focused on the preparation of laws and regulations related to the future Indonesian 3D-land cadastre. An equivalent department did not exist in Bandung currently, or in any other regional office.

A further question focused on organizational structures (Question O3 – Appendix 5.4). Six of the 23 government officials and licensed surveyors interviewed in the two cities said that customer complaints about conflicts of 3D-cadastre are often not resolved properly. Five respondents explained that the current cadastral system cannot manage 3D-objects, e.g., multi-storey building with multiple ownership; and another four stakeholders argued that the organizational structure of regional land offices had not evolved to manage 3D-objects. Three respondents explain that there is a lack of staff knowledge about 3D-cadastre. Two participants said that there is no problem occurred about the 3D-system. Another three of them said they do not understand the 3D-cadastral system (Table 5.17). The Wilcoxon Signed-Rank Test was applied to see if the answers about the 3D-system problem existed in the organizational structure noted by the government officials and licensed surveyors in Jakarta and was statistically different from those in Bandung. The W-value (10) was greater than the critical value (0, $p \leq 0.05$, n = 6), revealing no significant differences between the responses in the two cities.

At the time of interviews, BPN had developed a centre for land management in Indonesia in which a special section that deals with the development of 3D-cadastral had been formed. Unfortunately, as this organizational structure only exists in the main

Table 5.17 Organizational structures and the implementation of 3D-cadastral systems

Responses	Jakarta						Bandung						Both cities				All	
	Govt		LSs		All		Govt		LSs		All		All Govt		All LSs		A	%
Customer complaints about conflicts of 3D-cadastre have not been resolved properly	0	0.0%	2	28.6%	2	22.2%	0	0.0%	4	33.3%	4	28.6%	0	0.0%	6	31.6%	6	26.1%
Cannot manage 3D-objects	0	0.0%	1	14.3%	1	11.1%	2	100.0%	2	16.7%	4	28.6%	2	50.0%	3	15.8%	5	21.7%
No relevant organizational structure in regional offices of BPN	2	100.0%	1	14.3%	3	33.3%	0	0.0%	1	8.3%	1	7.1%	2	50.0%	2	10.5%	4	17.4%
Lack of BPN staff knowledge about 3D-cadastre	0	0.0%	2	28.6%	2	22.2%	0	0.0%	1	8.3%	1	7.1%	0	0.0%	3	15.8%	3	13.0%
No problem	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	25.0%	3	21.4%	0	0.0%	3	15.8%	2	8.7%
Do not understand/No comments	0	0.0%	1	14.3%	1	11.1%	0	0.0%	1	8.3%	1	7.1%	0	0.0%	2	10.5%	3	13.0%
	2	100.0%	7	100.0%	9	100.0%	2	100.0%	12	100.0%	14	100.0%	4	100.0%	19	100.0%	23	100.0%

office of BPN in Jakarta, the familiarity with 3D-cadastral systems and their potential is not diffusing to regional offices. When interviews were conducted at the West Java regional BPN office in Bandung, it was clear that no directions or encouragement to engage with 3D-surveying and cadastral affairs had been issued from the head office to the regional office. The depth of knowledge of BPN staff about 3D-cadastre is directly proportional to the existence of the different organizational structures in Jakarta and Bandung. The West Java BPN staff did not have a very deep understanding of 3D-cadastre, how it could be implemented in the field, or its potential advantages and disadvantages. Many complex buildings are being constructed in Bandung at the present time, as they are in other Indonesian cities. It is clear from the opinions of land surveying professionals in Jakarta that BPN requires a special section to begin preparing to handle 3D-cadastral issues in Bandung. In the future, organizational structures that acknowledge this need to be developed in both central and regional offices, thus reinforcing BPN as the spearhead of land management in Indonesia.

5.6 CHAPTER SUMMARY

This chapter has presented the results from the interviews of the participants in Bandung and Jakarta regarding the implementation of a 3D-cadastral system. Issues related to the current Indonesian cadastral system in the context of this research were elucidated, the key issues and potential solutions were identified, and the readiness of stakeholders to adopt a 3D-cadastre from the legal viewpoint, human resources, and organizational structures were examined. The next chapter will analyse and discuss these results obtained in this chapter to propose the potential implementation of a 3D-cadastral in Indonesia.

CHAPTER 6: INTRODUCTION OF A 3D-CADASTRAL SYSTEM IN INDONESIA: ANALYSIS AND DISCUSSION

6.1 INTRODUCTION

In this chapter, the inadequacies of the current Indonesian 2D- cadastral system in urban areas are balanced against the potential to convert to a 3D-system. The bulk of the chapter analyses the results presented in Chapter Five and discusses them in the overall context of the thesis.

The chapter is organized in five main sections: issues with the current cadastral system; key issues and solutions; readiness to implement the solutions; a SWOT analysis; and the development plan for the introduction of a three-dimensional cadastral system in Indonesia.

6.2. THE CURRENT ISSUES CADASTRAL SYSTEM IN INDONESIA

The first tranche of questions in the interviews probed the participants' opinions about issues with the current land cadastral system in Indonesia. In this section, the findings, in the face of the increasing complexity of land and infrastructure development in Indonesia, are discussed. The first subsection explores issues with the 2D- system and the second examines public awareness of the current cadastral system.

6.2.1 2D- issues

Current cadastral systems around the world are two-dimensional (2D-) and land parcel-based, i.e., geometric and descriptive information based on 2D- land parcels, even though properties have three dimensions (Aien et al. 2017). Of course, this is the case in Indonesia, where the 2D- land cadastral system is stated in Government Regulation number 24 of 1997 (Farzin et al. 1998), which emphasizes its two-dimensional nature.

Angus-Leppan and Williamson (1985) explored the need to upgrade the cadastral system in Thailand and found that the current system was inadequate due to the fact that cadastral plans in urban areas were in an unsatisfactory state and not able to fulfill many key aspects such as effective registration systems for land administration and land valuation. Van Oosterom (2013) argued that the current complexity of infrastructure development has led to a need for land cadastre systems to be upgraded to handle proper registration of legal status (private and public), which the existing 2D-cadastral registrations cannot properly manage. The introduction of 3D-cadastral systems has also been argued as necessary for various Australian states (Donnelly 2008). The contemporary problem of land valuation that is faced by many governments across the globe has, in part, also led to demands to upgrade the cadastral system toward 3D-as they are perceived as more accurate detail and complete regarding legal guarantees and valuation.

Unsurprisingly, exploration of the current cadastral system in Indonesia in this research found that the all government officials and licensed land surveyors, and most lands deeds officials had a good working knowledge of the 2D- cadastral system (Figure 5.1). Two answers dominated the responses. First, one major advantage of the current 2D- system over a potential 3D-system is that it is still adequate for the two cities in which the research was conducted. Second, 2D- systems are cheaper in terms of operating costs (Table 5.2). Of course, because these respondents have not worked with a 3D-it is difficult to really understand these responses as 'advantages', but rather they should be considered strongly held opinions about the familiar current 2D-system. This argument also holds for their opinions about the disadvantages of the 2D- system. In fact, few disadvantages were identified but those that were important relate to its weaknesses in managing complex cadastral objects and lack of details land information provided by 2D- systems (Table 5.3). Similar disadvantages were found encountered as imitations of the 2D- system in The Netherlands, in particular with the registration of multiple users of space (Stoter & Ploeger 2003). Other questions were asked about the management of buildings and infrastructure development above and below land surfaces. Many respondents were clear that the current cadastral system cannot handle such objects, particularly below land surface spaces such as underground car parks (Table 5.4). Stoter and Van Oosterom (2003) also researched the 2D- cadastral system in The Netherlands and found it cannot handle complex real estate situations which have separate ownerships of spaces under and above land surface.

Thirty percent of responses were split equally between the fact that land deeds still needed to be made in accordance with the prevailing 2D- system and the task of infrastructure development and land management is managed by BPN as its main duty of the ministry with land regulation and management responsibility. These are interesting responses in light of the Indonesian Government's policy to complete the 2D- land registration system. During the interviews, some participants casually referred to the public's awareness of corruption cases occurring within the process of land registration in Indonesia. Despite these cases, the government has decided to maintain the policy of completing 2D- land registration by 2025 (Kompas CyberMedia 2017). This policy has undoubtedly increased pressure on government officers, licensed surveyors and lands deeds officials to finish all 2D- registration and certification all land parcels in Indonesia and they are not turning their attention to 3D- issues.

Interestingly, none of the following weaknesses of 2D- cadastral systems found in Australian states; mixed management responsibilities within government agencies, no single authority for surveying, spatial data management, slowness to update to new technology, and outdated legislation (Donnelly 2008) were specifically mentioned in responses to the open-ended questions about disadvantages in Indonesia. However, they did mention these issues in responding to specific questions on, for example, legal aspects and upgrading technology. This suggests that such issues do not rank very high compared to the overall current levels of satisfaction in terms of fitness-for-purpose with the 2D- cadastre in the face of lack of knowledge about 3D-systems.

6.2.2 Public awareness.

In order to understand how the stakeholders interviewed could provide better land services to civil society, participants were asked questions about the need for a 3D-cadastre, the costs involved in providing such a system, and the satisfaction of land certificate information.

Almost two thirds (60%) believed that there is a need to improve the cadastral system. More property managers (70%) noted this need for improvement, though a majority of owners and tenants (60%) did as well (Figure 5.2). The need to upgrade a cadastral system has been explored in Shenzhen, China (Guo et al., 2013). The conventional land administration based on 2D- cadastre was altered with the addition of vertical spatial elements, requiring an upgrade of the cadastral system.

Changing to a new system will require significant costs, mainly in the upgrading of hardware and software, and in training. When the interviewees were asked about these costs (which were unspecified at the time the interviews were conducted) more than half of them agreed to support it (Figure 5.3). Other stakeholders believed that these costs should be borne by the government without any additional cost burden on the public. Positive acceptance is important because people need to develop strong positive feelings or some kind of empathy before accepting and adopting newly introduced systems (Amoako-Gyampah 1999). However, it is clear from the comments made that a sustainable 3D-land cadastre system will endure only if a good balance exists between the costs and the benefits.

Another question asked to the managers and owners, was how satisfied they were about the information provided on land certificates. Generally, property managers are unsatisfied with the information provided. On the contrary, owners believed the information was adequate to guarantee their legal ownership (Figure 5.4). This dichotomy is caused by managers dealt with many stakeholders and therefore experience more problems in a change of ownership transactions, than owners who experience fewer transactions in their lifetimes. They experienced a successful transaction; they do not worry about the legal ownership of the land certificate. But if a transaction caused problems, they think that the information on the land certificate is inadequate. The need for an upgrade to of the current 2D- system to the new 3D-cadastral system requires the addition of vertical spatial elements and handing complex cadastral objects. It is understood this will incur additional costs by more than half the participants interviewed, but the advantage will be that they will have more complete information and a better guarantee of legal ownership of their assets. This is also articulated by property managers in the context of a lack of information on the land certificate.

In summary, the issues of the cadastral system in Indonesia are consist of issues with 2D- cadastres that are found in all countries, and levels of public awareness. Specifically, 2D- systems cannot handle complex objects, e.g. apartment units and real estate with separate ownership above and below land surface. Most stakeholders in Indonesia are unfamiliar with 3D-cadastral concepts and are familiar with the 2D-system. Moreover, because of a national push to complete 2D- land registration during the next decade, their attention is currently focussed on 2D- activities. Nonetheless, property managers and some owners are aware of the need to upgrade to a 3D-system because they will obtain detailed information and better legal certainty over their land rights. This will reduce property conflicts but will incur extra costs.

6.3 KEY ISSUES AND POTENTIAL SOLUTIONS

Key issues and potential solutions are divided into the following topics: the introduction of a 3D-cadastre, understanding the 3D-cadastre, and the advantages and disadvantages of a 3D-cadastre system.

6.3.1 Introduction of 3D-cadastre

Government officials, land deed officials, and licensed surveyors were asked about introducing a 3D-cadastre (Section 5.4.1). The majority of the participants agreed that a 3D-cadastral system would provide complete, detailed and accurate land data information (Table 5.6). An important set of responses were those that explained that a 3D-system would correct weaknesses of the 2D- system, especially in complex infrastructure which is not supported by the 2D- system. Examples cited, were high-rise apartment buildings, road and rail infrastructure above and below the land surface, and underground car parks. These examples were also mentioned in the research on 3D-cadastres in The Netherlands (Stoter & Salzmann 2003). Therefore, this research project revealed that these stakeholders accept the concept that a 3D-cadastral system benefits Indonesia more than the current 2D- system.

6.3.2 Understanding of 3D-cadastre

The responses to participants' knowledge about 3D-cadastre were below the researcher's initial expectations (Table 5.7). It is probable that the levels of understanding are low because a 3D-cadastre has not yet been implemented in Indonesia; and the fact that 3D-cadastres are still in a development phase around the world with most countries still using a traditional 2D- system. Therefore, levels of appreciation and understanding must be increased in various ways, for example, public workshops, and public discussions and seminars. Publications produced by

BPN alongside advertising in public spaces, on television and radio, and on social media are all avenues that need to be explored.

6.3.3 Advantages and disadvantages of the 3D-cadastre

The main advantage perceived by participants was that they would have more detailed and complete information about land and properties if a 3D-cadastral system were in place (Table 5.8). This reveals that some participants still think land certificates do not provide adequate guarantees of ownership. Essentially what these people want is a registration system that can ensure their assets without problems, e.g. related to boundaries between units in apartment blocks, and they believe certificates provided by a 3D-system will provide this legal certainty.

The biggest disadvantage was perceived to be the high cost of providing a complete 3D-cadastral system (Table 5.9). These costs arise because of initial investments in hardware and software and related training. One solution to this could be combined purchasing of the equipment and training, with the discounted costs being reflected less increase in the cost of certificates than anticipated. However, there are other elements to this, such as the costs associated with updating existing regulations and laws related to a 3D-cadastre. Not only do the legal costs need to be considered, but the government also has to be willing to prepare the laws and regulations and publish them. This will take a long time to achieve, but if the legal process was started now the laws and regulations might be in place when the 3D-cadastre is implemented.

This section has analysed the key issues and presented some solutions. The introduction of a 3D-cadastral system would provide complete, detailed and accurate land data information which some participants feel would resolve existing weaknesses with the 2D- system. Understanding of 3D-cadastres was below expectations, and the government needs to develop a program of awareness-raising actions. The disadvantages of the current 2D- systems are the same as those experienced in other countries, but it is also clear that a disadvantage of 3D-cadastre system provision would be the initial high costs and some ideas about reducing these costs, such as combining the training required and discounted bulk purchasing of equipment, should be explored.

6.4 CURRENT READINESS TO ADOPT A 3D-CADASTRE

The readiness of stakeholders in Indonesia to accept solutions such as those introduced above comprises an analysis of legal issues and the conversion of legal frameworks; human resources needs, and changes to organizational structures.

6.4.1 Legal issues and the conversion of legal frameworks

The readiness of legal frameworks in Indonesia to adopt, or adapt to, a 3D-cadastre system is of great importance. Onsrud (2003) explained that Norway was one of the first countries in the world to provide regulations for property under and above the surface. New laws were drafted to cover the registration of parking garages underground, and buildings and other types of construction on pillars above the land surface, as separate properties. These regulations consider 3D-properties as subdivided spaces, and that subdivided spaces need to be registered in the same way as are property parcels on the land surface in 2D- systems.

In this context, the majority of users (84%) of the current cadastral system in Indonesia interviewed strongly favoured upgrading the cadastre (Figure 5.10) because they believe the 3D-system will perform better than the 2D- system in this area. Moreover, an upgraded legal system tied to a 3D-cadastre would provide the majority of participants the complete information about their land and premises they require (42.5%); and the certainty and legal protection (17.5%) (Figure 5.11).

There were different opinions amongst stakeholders, mostly between land deeds officials, concerning existing laws and regulations about 3D-parcels (Figure 5.5). All government officials and licensed land surveyors explained that the state has the authority to control the land, as stated in the Constitution 1945 article 33 section 3:

> *Bumi, air dan kekayaan alam yang terkandung di dalamnya dikuasai oleh Negara dan dipergunakan untuk sebesar-besarnya kemakmuran rakyat*.
>
> Provides that land (earth), water and the natural richness inside are controlled by the government and must be utilized for people's welfare.

The implementation of this sub-article is primarily through the Basic Agrarian Law (BAL) (Winoto 2009).

However, more than half the legal deed officials in Bandung and Jakarta pointed out those regulations or laws relating specifically to a 3D-cadastral system were not yet available. As a consequence, these officials represent a body of concern within the profession about the lack of availability of laws related-3D-cadastral systems which are hindering legal ownership of spaces in complex buildings (Figure 5.5). While the interviews revealed that there is no single reason for this difference of opinion, it is more than the fact that specific laws about 3D-cadastre are not available. It appears that the main reasons for these differences are due to different interpretations of existing laws or a more general lack of understanding about existing land laws and regulations in Indonesia.

Another legal issue arises in the context of construction or building law which related complex objects in a 3D-cadastral system, such as multi-floor buildings and below-ground spaces. There were different interpretations about how laws and regulations could be used for managing these in a 3D-cadastre. Some government officials, land deed officials, and land surveyors (30%) said existing Law 28 of 2002 on buildings is appropriate for managing building and construction in a future 3D-cadastre (Table 5.11). This was stated in Law 28 of 2002 on buildings article 1 section 2:

> *Penyelenggaraan bangunan gedung adalah kegiatan pembangunan yang meliputi proses perencanaan teknis dan pelaksanaan konstruksi, serta kegiatan pemanfaatan, pelestarian, dan pembongkaran*.
>
> Implementation of buildings constructions is a development activity that includes the process of technical planning and construction, as well as activities of utilization, preservation, and dismantling.

Other government officials, land deed officials, and land surveyors (30% in total) thought that the relevant regulations could be found in the following laws:

1. Law 5 of 1960 (the Basic Agrarian Law);
2. Law 16 of 1985 on Apartments, which has been succeeded by Law 20 of 2011 on Apartments;
3. Law 28 of 2002 on Buildings;
4. Government Regulation 36 of 2005 concerning the implementation of Law No. 28/2002 on Buildings; and
5. Government Regulation 24 of 1997 about land registration.

This question about the context of construction laws, which have multiple interpretations and laws, drew a response from stakeholders than more than one law can apply depending on their understanding. Therefore, some participants combine their answers:

> *Aturan konstruksi mengacu pada UU No 28 tahun 2002 mengatur tentang Bangunan Gedung di Indonesia, kalau tentang rumah susun/apartemen dapat dilihat dalam UU No 16/1985 dan diperbarui dalam UU No 20 Tahun 2011.*
>
> "Construction laws followed to Law no 28 the year 2002 on Buildings in Indonesia if about Apartment can be seen in Laws no 16 the year 1985 and has been updated into Laws no 20 the year 2011. (Interview with a government official (C1/J102/Ar), December 2015).

The researcher thinks that the difference between answers is highly dependent on participants' knowledge about land laws in Indonesia.

Thirty percent of participants did not recognize any laws or regulations that could be used in managing 3D-cadastre in Indonesia at the present time. These were all land deeds officials, and it can be argued that if they do not recognize any laws it means that there are no specific 3D-cadastre laws in Indonesia and that existing land laws have to interpret to cover something that is not designed for.

All apartment building managers had land certificates for their properties. This is good evidence of public compliance with land laws and regulations, in these two cities at least. It also implies that nobody can build an apartment without clear legal land status and the necessary permits relating to the apartment building itself. But all property managers and owners of apartments said that the land certificates are only provided in the 2D- system. Figure 6.1 provides an example of land certificates in 2D-. While this is to be expected, as certificates are issued within a 2D- system, the person who possessed this certificate noted that not enough detail was provided and that in particular there was no height information.

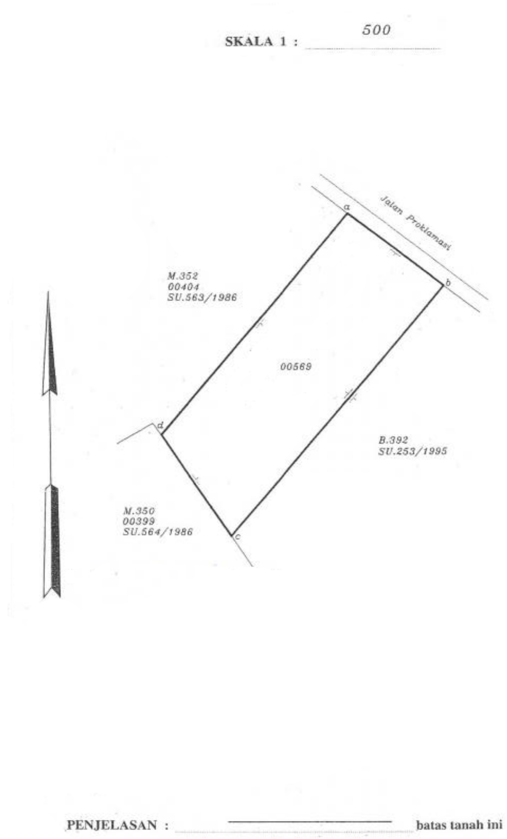


Figure 6.1 An example of the current land certificate for an apartment issued under the current 2-D cadastral system.

Tenants of apartments explained that they are not provided with complete land registration details in rental agreements (Question L10 – Appendix 5.2). They are provided with 2D- information relating to the position (or location) of the rental unit, a photograph, the floor dimensions of the rental unit and a tenancy agreement; but no information about the heights. While it is not normal to provide land registration documents to tenants anywhere in the world as far as the researcher understands, more complete information from current (2D-) certificates and future (3D) certificates could be beneficial to tenants. Specifically, the location of the rented unit within the cadastre and height information extracted from land registration documents. For instance, some tenants need height information particularly if they are planning to use units for commercial purposes or for storage; while some residential users may have specific interior design criteria.

Questions that have to bear on legal issues related to boundaries of the apartments revealed that the definition of apartment boundaries is in doubt in the minds of all stakeholders, except the government officials (Figure 5.6). This uncertainty arises despite the fact that Article 41 of Government Regulation 4 of 1988 (Government of Indonesia 1988) on the Apartment Act, that states:

1. *Hak milik atas satuan rumah susun meliputi hak pemilikan perseorangan yang digunakan secara terpisah, hak bersama atas bagian-bagian bangunan, hak bersama atas benda, dan hak bersama atas tanah, semuanya merupakan satu kesatuan hak yang secara fungsional tidak terpisahkan.*
2. *Hak pemilikan perseorangan sebagaimana dimaksud dalam ayat (1) merupakan ruangan dalam bentuk geometrik tiga dimensi yang tidak selalu dibatasi oleh dinding.*
3. *Dalam hal ruangan sebagaimana dimaksud dalam ayat (2) dibatasi dinding, permukaan bagian dalam dari dinding pemisah, permukaan bagian bawah dari langit-langit struktur, permukaan bagian atas dari lantai struktur, merupakan batas pemilikannya.*
4. *Dalam hal ruangan sebagaimana dimaksud dalam ayat (2) sebagian tidak dibatasdinding, batas permukaan dinding bagian luar yang berhubungan langsung dengan udara luar yang ditarik secara vertikal merupakan pemilikannya.*
5. *Dalam hal ruangan sebagaimana dimaksud dalam ayat (2) keseluruhannya tidak dibatasi dinding, garis batas yang ditentukan dan ditarik secara vertikal yang penggunaannya sesuai dengan peruntukannya, merupakan batas pemilikannya.*

1. The ownership of apartment rights consists of individual rights, collective ownership of the parts of the building, collective ownership of things, and collective ownership of land. All form a bundle of rights that functionally cannot be separated.
2. The individual right entitles the owner to a 3D-geometric space that is not always bounded by the walls.
3. Where the space described in Article 2 is bounded by the walls, the boundaries are the inner surface of the wall, the lower surface of the ceiling of the space, and the upper surface of the floor of the space.
4. Where the space described in Article 2 is partly bounded by the wall, the boundary of ownership is measured vertically from the boundary of the outer wall surface which is directly contacted with the air.
5. Where the space described in Article 2 is not bounded by the wall, the boundaries are established by measurement of the scope of space that the person is entitled too.

Interviewee's doubts about 3D-boundary can be found in answers to a series of questions (Figure 5.5). The discrepancy in responses is primarily related to the fact that the elements of this regulation are not well understood by participants. This indicates clearly that publicity and education need to be made widely available within the current system. Clarity is required because, at least, item 5 above has a large element of ambiguity and furthermore, it is unclear from the regulations which of items

3, 4 or 5 applies to a particular apartment or unit. This is an example of the logical interpretation of a law by participants who feel space should be divided equally without knowing the laws to do that. Stakeholders need to be enlightened so that no erroneous interpretations are made in addressing the inevitable dilemmas that occur in managing complex buildings.

The participants generally know about their buildings, and this extends to the plan of apartments and spaces within a building. However, Tables 5.14-5.16 revealed different opinions about who owned common spaces in a building, half though that the developer owned them, while 25% believe they belongs to an owner's association. Actually, the common ownership is stated in Article 25 of Law 20 of 2011 (Government of Indonesia 2011), the Apartment Unit Act:

> *Dalam membangun rumah susun, pelaku pembangunan wajib memisahkan rumah susun atas sarusun, bagian bersama, benda bersama, dan tanah bersama.*
> *Benda bersama sebagaimana dimaksud pada ayat (1) menjadi bagian bersama jika dibangun sebagai bagian bangunan rumah susun.*
> *Pemisahan sebagaimana dimaksud pada ayat (1) memberikan kejelasan atas:*
> - *batas sarusun yang dapat digunakan secara terpisah untuk setiap pemilik;*
> - *batas dan uraian atas bagian bersama dan benda bersama yang menjadi hak setiap sarusun; dan*
> - *batas dan uraian tanah bersama dan besarnya bagian yang menjadi hak setiap sarusun.*
>
> *Penjelasan:*
>
> *Pasal 25*
> *Ayat (1)*
>
> *Yang dimaksud dengan "bagian bersama", antara lain, adalah fondasi, kolom, balok, dinding, lantai, atap, talang air, tangga, lift, selasar, saluran, pipa, jaringan listrik, gas, dan telekomunikasi.*
>
> *Yang dimaksud dengan "benda bersama", antara lain, adalah ruang pertemuan, tanaman, bangunan pertamanan, bangunan sarana sosial, tempat ibadah, tempat bermain, dan tempat parkir yang terpisah atau menyatu dengan struktur bangunan rumah susun.*
>
> In apartment buildings, the perpetrators of construction are obliged to separate the apartment units on the apartment, common parts, common areas, and common land.
> The common areas as meant in section (1) shall be shared if they are constructed as part of the apartment building.
> The separation as referred to in section (1) provides clarity on:

- an apartment unit boundary that can be used separately for each owner;
- boundaries and descriptions of the common parts and common areas entitled to each owner as shared use; and
- boundaries and description of the common land and the magnitude of the portion entitled to each owner of the apartment.

Explanation:
Article 25
Section (1)

What is meant by "common parts", are the building foundations, columns, beams, walls, floors, roofs, gutters, stairs, elevators, corridors, conduits, pipes, electricity, gas, and telecommunications networks?

What is meant by "common areas", are meeting rooms, plants, landscaping, buildings of social facilities, places of worship, playgrounds, and parking spaces that are separate or incorporated into the structures of apartment buildings.

The interviews reveal a difference of opinions between property managers and owners regarding ownership of common areas, common land, and space above and below grounds. Answers ranged from the developer, the owner's association with the management company. Again, it is a lack of knowledge of the law that causes this confusing situation because in Article 13 of Law 20 of 2011 clearly states:

Nilai perbandingan proportional yang selanjutnya disebut NPP adalah angka yang menunjukkan perbandingan antara sarusun terhadap hak atas bagian bersama, benda bersama, dan tanah bersama yang dihitung berdasarkan nilai sarusun yang bersangkutan terhadap jumlah nilai rumah susun secara keseluruhan pada waktu pelaku pembangunan pertama kali memperhitungkan biaya pembangunannya secara keseluruhan untuk menentukan harga jualnya.

The proportional comparison value hereinafter referred to as NPP is a number showing the ratio between apartment units to the right of common parts, common areas, and common land calculated on the corresponding value of the apartment unit to the total value of the apartments as a whole when the developer first takes into account the development costs overall to determine the selling price.

Hence, the shared parts of an apartment belonging to the owner of the apartments within a portion to the proportional comparison value as stated above.

Conflicts inevitably arise in buildings with many spaces that have different ownership or tenancies. The majority of property managers (80%) and owners or tenants (60%) said that they knew of conflicts that had occurred in their buildings. On the one hand, big issues such as unauthorized structural changes and conflicts over ownership are usually finalized in court. While the other hand minor issues are not conflicts related to the 3D-cadastre system, e.g., loud noise and smells. Those problems are often resolved by the property managers through mediation (Table 5.7).

In summary, participants strongly favored upgrading the cadastre in the hope of gaining more detailed and accurate information on land certificates as well as ensuring legal certainty over their ownership rights. However, this need will have to be supported by laws and legislation to manage a 3D-cadastre, only parts of which now only found six articles in existing laws. It may be necessary to have more detailed laws and regulations that are specific to 3D-cadastral situations. In addition, knowledge about the law in relation to various aspects of multi-space properties is lacking amongst managers and property owners and tenants. This has led to many different interpretations of the legal constraints of a 3D-unit. Education and provision of information on laws relevant to a 3D-cadastre would need to be provided as part of its introduction to avoid the situation that currently exists with the 2D- cadastre.

6.4.2 Human resource needs

In adopting a new cadastre, the training needs across Indonesia will be enormous. In fact, if just surveyors and land deeds officials are considered, there are currently 3,756 licensed surveyors registered and 11,415 registered land deeds officials who will need training in different aspects of a 3D-cadastre and land registration system. In addition to this, BPN staff (which number in the thousands) will require training and property manager across Indonesia will at least need some awareness training with a new system.

In the questions about human resource capacity, a general lack of knowledge was evident. Thus, the author has developed a draft training needs plan for each category based on their responses and from the researcher's knowledge of the situation in Indonesia from his substantive position at BPN (Table 6.1). Training needs have been divided into four categories. Different stakeholder groups need different types and levels (basic or complete) of training, so an analysis of Table 6.1 shows that training needs can be tailored to the needs of each stakeholder group. Basic training for property managers and owners could do by BPN throughout the country in formats like public discussions, workshops or seminars. These would be forms of socialization about the laws and regulations related 3D-cadastre system. Promotion could be done in house by the BPN Media Information Center. While more advanced or complete training for professionals could be done through universities, colleges, and professional training agencies.

Table 6.1 Training needs for stakeholders

Type of training needed	Stakeholders to be trained
Laws and regulations of a 3D-cadastre system Right and obligations related to a 3D-system	Government officials, Land deed officials, Licensed surveyors (complete training) Property managers and owners (basic training)
Concepts and fundamentals of 3D-cadastre system Differences between 2D- and 3D-systems Advantages of 3D-systems	Government officials, Land deed officials, (complete training) Licensed surveyors, property managers and owners (basic training)
3D-Survey methods, hardware, and software.	Government officials, Licensed surveyors (complete training) Land deed officials (basic training)
Legal documents and deeds in 3D-cadastre system	Government officials, Land deed officials (complete training) Licensed surveyors (basic training)

6.4.3 Organizational structures

In Jakarta, the BPN central office has a special section related to 3D-cadastre management for the development and introduction of the 3D-cadastre in Indonesia (Figure 6.2). But this is not replicated in regional land offices throughout the country at the present time. The structure of the Bandung office (Figure 6.3) is typical of regional offices.

The 3D-section in Jakarta was introduced in 2006 in the Regulation 3 of 2006 of the Head of National Land Agency on Organizational Structure and Working Procedures of the National Land Agency (National Land Agency of Republic Indonesia 2006b). It was updated by Regulation 8 of 2015 of the State Minister of Agrarian and Spatial Planning Affairs/Head of the National Land Agency on Organizational Structure and Working Procedures in the Ministry of Agrarian and Spatial Planning Affairs/Land National Agency (Ministry of Agrarian and Spatial Planning Affairs/National Land Agency 2015). The updated regulation was introduced in 2015 due to changes in the organizational structure of the system and changes of regulations under new leadership, including the accommodation of three-dimensional space in Indonesian land cadastre.

The objectives of the 3D-section in Jakarta according to Article 252, Sub-article 2 of Regulation 8 of 2015 of the State Minister of Agrarian and Spatial Planning Affairs/Head of the National Land Agency,

> *Seksi Pengukuran Ruang dan Perairan mempunyai tugas melakukan penyiapan bahan perumusan kebijakan, pelaksanaan kebijakan, penyusunan norma, standar, prosedur, dan kriteria, pemberian bimbingan teknis dan supervisi, serta pelaksanaan pemantauan, evaluasi dan pelaporan di bidang pengukuran batas ruang dan perairan.*
>
> The spatial space and water surveying section have the task of preparing materials for policy formulation, policy implementation, a compilation of norms, standards, procedures, and criteria, providing technical guidance and supervision, as well as monitoring, evaluating and reporting in the field of spatial space and water boundary surveying.

The special 3D-section is currently preparing material for policy formulation and implementation; compiling norms, standards, procedures, and criteria; providing guidance and supervision, as well as monitoring, evaluating and reporting. They are the coordinating and managing section, not an operational section who will conduct the 3D-surveying in the future. The operational section should be established in the local and regional offices of BPN.

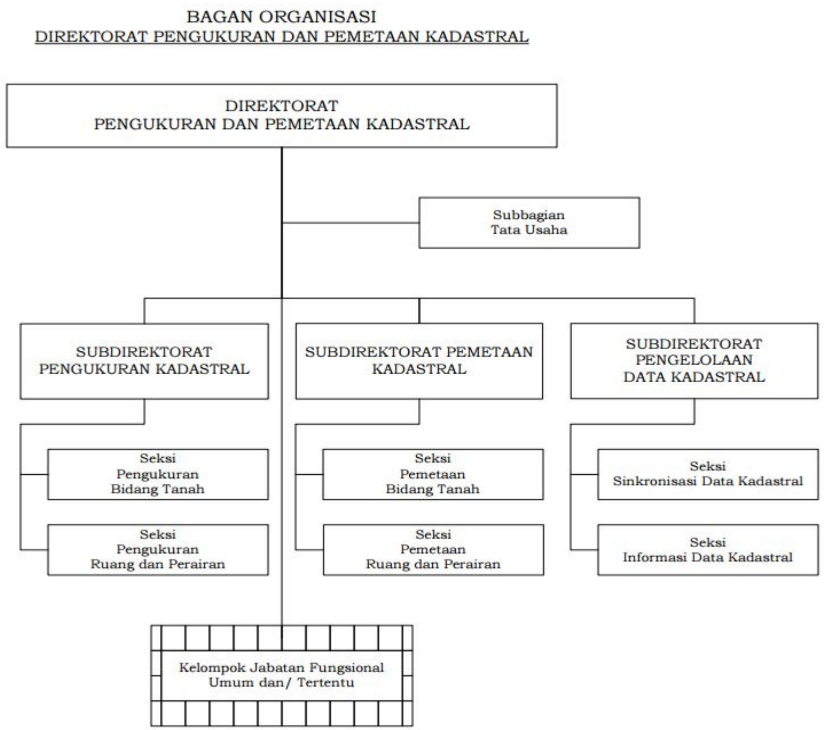
In the regional land offices (Figure 6.3) there are currently no special 3D-sections as stated in Regulation 4 of 2006 of the Head of the National Land Agency on Organizational Structure and Working Procedures of Regional Land Offices and

District Land Offices (National Land Agency of Republic Indonesia 2006a). This was also updated by Regulation 38 of 2016 of the State Minister of Agrarian and Spatial Planning Affairs/Head of the National Land Agency on Organizational Structure and Working Procedures of Regional Land Offices and District Land Offices (Ministry of Agrarian and Spatial Planning Affairs/National Land Agency 2016). As stated above, 3D-surveying sections should be established in this regional and district office to conduct operational works. It is pertinent to ask why they do not exist at the present time. Based on the semi-structured interviews and the researcher’s prior knowledge, this is most likely only because of Indonesia at the very beginning of introducing a 3D-to the land cadastral system. It is likely that these operational sections will be established once the laws and regulations of 3D-cadastre have been finalised. The researcher has not been able to acquire a firm timeline for implementation from discussions at BPN. In the researcher’s opinion, this should be considered as reasonably imminent because demands for the development of a cadastre in Indonesia that can deal with complex objects appear to be escalating and disputes with buildings with multiple occupancy and ownership also appear to be on the increase.

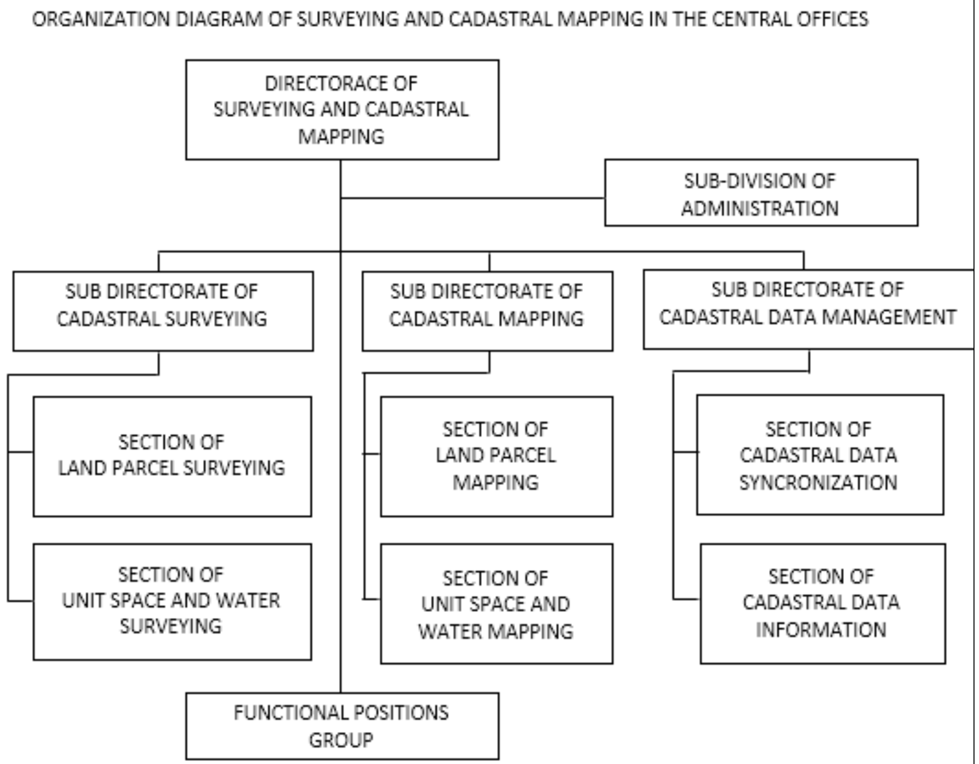
Some problems relating to organizational structures were unearthed during the interviews. These included customer complaints about conflicts in the apartment, for instance about 3D-boundaries not being handled properly. These relate to encroaching over boundaries, e.g. installation of outdoor air conditioner compressor units which cross boundaries of the ownership (Table 5.17). In the absence of special sections in local BPN offices to deal with specific three-dimensional cadastral problems, these complaints from the land deed officials as the representatives of the property manager and owners are evidence that the service BPN is currently providing the Indonesian government and civil society is not adequate. These concerns probably arise because the existing cadastral system is still in two dimensions, and expectations from participants that it can deal with three- dimensional problems are unrealistic.

In sum, there is a need to restructure the organisation of regional and district land offices to deal with 3D-objects, particularly in rapidly growing cities. In the researcher's opinion, the government must be aware of the increasing number of conflicts and disputes in apartment buildings; however, unless these have been articulated as an example of 3D-objects, the need for a 3D-cadastre to provide better land services society will be lost on government and policymakers. This also lends support for the location of operational 3D-surveying sections in local land offices because it is at this level that BPN staff dealing with people on a day-to-day basis and are asked to solve these ‘3D-problems’ at a practical level.

In summary, the met the needs of a new 3D-cadastre new laws need to be provided and socialization around these laws, as well as the 3D-cadastre in general, needs to be undertaken through seminars, workshops, and the use of social media. In the field of human resources training is required in accordance with the needs of stakeholders, and in terms of organizational structures, it was found that restructuring of local land offices will be needed in order to give better service to the community around 3D-cadastral issues.

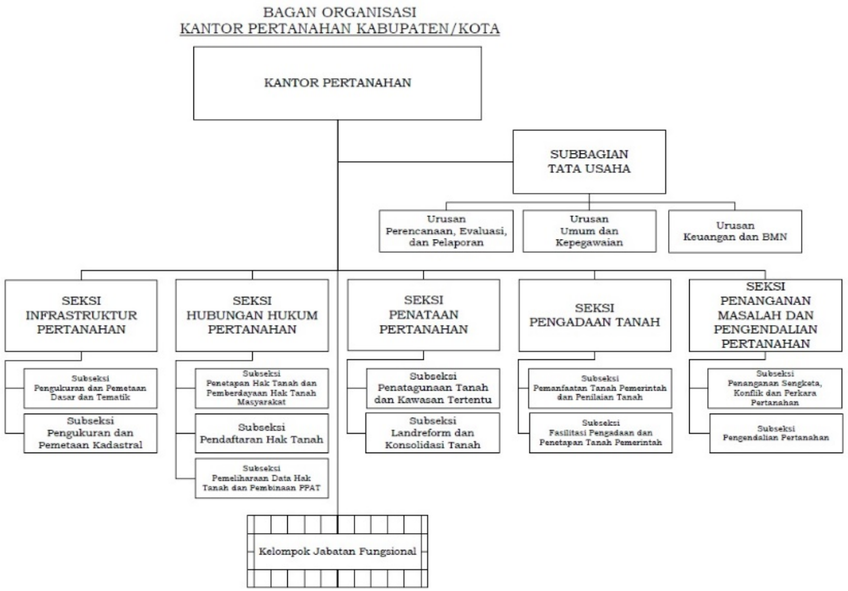


In Bahasa Indonesia (original)



Translated in English

Figure 6.2 The organizational structure of the BPN Main Office in Jakarta



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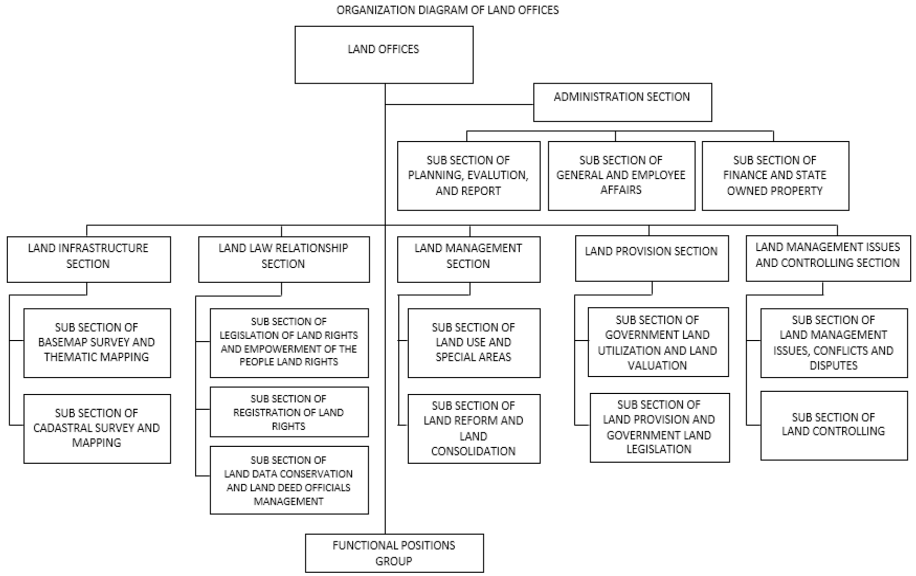


Translated in English

Figure 6.3 The organizational structure of the BPN Office in Bandung

6.5 SWOT analysis

SWOT is a strategic planning tool used to evaluate the strengths, weaknesses, opportunities, and threats to projects or a business venture that introduced by Albert S. Humphrey. Section 6.5.2 the strengths, weaknesses, opportunities, and threats associated with the introduction of a 3D-cadastre will be identified. In the following section (Section 6.5.2) a SWOT matrix analysis will be undertaken.

6.5.1 Identification of strengths, weaknesses, opportunities, and threats

The next step is the research was to evaluate the interview responses to the launch of 3D-cadastre and an associated land registration system in Indonesia (Sections 1.1 and 1.2) using a SWOT analysis.

In the context of a project to introduce a 3D-cadastre in Indonesia, the strengths, weaknesses, opportunities, and threats can be broadly defined as follows. Strengths are the characteristics of the project that will lead to advantages over the existing 2D- cadastre. Weaknesses that characterise the project would place it at a disadvantage relative to the existing 2D- cadastre and the operational processes that have built up around it. Opportunities would be the characteristics of the overall environment in Indonesia that project to introduce a 3D-cadastre could exploit to its advantage, and those of stakeholders and civil society more generally. Threats would be the characteristics of the overall environment that could cause problems for the introduction, and then routine use, of a 3D-cadastre in Indonesia.

In conducting the SWOT analysis, I reviewed all the answers and categorized them into strengths, weaknesses, opportunities, and threats. After this I looked at how many times an argument was made, bearing in mind, and the argument is not necessarily a response to the same question in an interview and often that a number of questions focus on one line of argument. The sorting and weighting of arguments undertaken by the researcher enabled the main strengths, weaknesses, opportunities, and threats to be identified and eliminated from the following analysis.

Four main strengths and an equal number of main weaknesses were identified. The strengths are:

- All stakeholders believe that a land certificate derived from a 3D-cadastral system will be a better guarantee that their ownership and title to land and units or spaces in complex buildings.
- A 3D-cadastral system would overcome the fact that the current land cadastral system cannot manage complex objects above and below the land surface.
- A 3D-cadastral system will provide more detailed information than the current 2D-systems.
- Property disputes, such as boundary disputes, would possibly be reduced.

The weaknesses are:

- The surveying tools used in 2D- surveying are less accurate than those in 3D-surveying.
- The absence of specific laws and land regulations governing 3-dimensional land objects, such as apartment buildings. And the lack of updating of laws on 3D-cadastral objects to cope with the development of complex buildings in urban cities.
- The absence of 3D-complex object management sections in local land offices.
- A lack of staff in most stakeholder groups with the necessary technical and managerial abilities to conduct 3D-property registration.

Many more opportunities, ten in total, were identified:

- The user requirement to have more detailed spatial information to assist them and to guarantee legal protection of ownership.
- The conversion to a 3D-cadastre can expand private sector involvement by creating employment and business opportunities; especially in areas such as assistance in the cadastral process, surveying, and legal assistance through legal deeds offices.
- Upgrading enabling and supporting technologies will create attractive, modern IT-focused jobs and business opportunities for hardware and software suppliers.
- The new 3D-system will provide more complete asset management systems that can be used by government, and property companies and managers.
- Some participants may support increased costs if they receive better cadastral information.
- Advanced technology (software, hardware, and surveying tools) will be increasingly used in 3D-property registration.

- Law and regulations need to be upgraded, revised or even new law introduced to support the products from a new 3D-cadastral system.
- The need for the addition of organizational structures in the land offices to improve services, especially to cope with the problem of 3D-objects.
- The increasing need for staff and professionals in the 3D-field to assist implementation in local land offices.
- Improvements in service to the community by upgrading 2D- to 3D-systems.

These opportunities outweigh the number of threats. The threats are:

- As apartment buildings and commercial premises are becoming more complicated in Indonesian cities, the threat is that if a 3D-cadastre is not introduced the number of disputes and court cases will rise, increasing the burdens on the surveying and legal professions.
- The high (initial) costs of delivering the new cadastral system.
- Complaints from the public about the quality and service of land registration in Indonesia will remain as this is essentially an issue with bureaucracy.
- The issue of corruption in the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (BPN).

These elements are presented in a matrix format (Table 6.2), which was an essential prerequisite for the SWOT matrix analysis.

6.5.2 SWOT Matrix

A SWOT matrix analysis was conducted using strengths, weaknesses, opportunities, and threats outlined in the previous section by examining four strategies namely strengths-opportunities (S-O) strategies; weaknesses-opportunities (W-O) strategies; strengths-threats (S-T) strategies; and weaknesses-threats (W-T) strategies. The main elements of each of these strategies are listed below.

Strengths-opportunities (S-O) strategies use the strengths of BPN strength to take advantage of opportunities that will become available if a 3D-cadastre is introduced. They are:

- improve the institutional and legal background of 3D-property management;
- increase participation of the private sector in providing surveying, mapping and legal services;
- upgrade contemporary systems used for land and building asset management;

- use information systems that can be easily accessed by customers, e.g., using mobile technologies; and
- Supported increased costs by participants in providing a better new 3D-system.

Weakness-opportunities (W-O) strategies overcome weaknesses by taking advantage of opportunities. They are:

- upgrading to a new 3D-system is the opportunity to upgrade surveying tools and equipment to gain more detail and more accurate survey results;
- creating and updating laws and regulation of 3D-land objects to improve the legal certainty of 3D-land certificates;
- establishing special sections in BPN that will deal with 3D-land management to provide better service for the public; and
- upgrading human resources by training in 3D-cadastral technology.

Strengths-threats (S-T) strategies highlight ways that the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (BPN) can use its strengths to reduce its vulnerability to external threats that may arise because of the cadastral conversion project. They are:

- an increase in user participation and awareness-raising so that the benefits of better land cadastral systems are understood and appreciated. Thereby reducing resistance any increase in costs to titleholders;
- an increase in the use of advanced technologies that will deliver more accurate data and efficient data management;
- an increasing burden on the surveying and legal professions due to disputes over boundaries in complex buildings; and
- Increase the use of advanced technologies that will deliver more accurate data and efficient data management.

Weaknesses-threats (W-T) strategies would be used by the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (BPN) to minimize its vulnerability to external threats because of its weaknesses. They are

- by placing emphasis on improved boundary certainty of 3D-objects because surveys will be conducted in a 3D-cadastre;
- simplification in the procedure of land registration will reduce the length of the bureaucratic process, which could have the additional benefit of reducing costs; and
- a decrease response times because of the use of IT technologies and online data support.

Table 6.2 SWOT Matrix

		OPPORTUNITIES	THREATS
		The user requirement to have more detailed spatial information to assist them and to guarantee legal protection of land/unit ownership. The conversion to a 3D-cadastre can expand private sector involvement by creating employment and business opportunities, especially in areas such as assistance in the cadastral process, surveying to provide cadastral data, and legal assistance through legal deeds offices. Upgrading enabling and supporting technologies will create attractive, modern IT-focused jobs and business opportunities for hardware and software suppliers. The new 3D-system will provide more complete asset management systems that can be used for government and property companies/managers. Support from participants of increasing costs when implementing system upgrades. Advanced technology (software, hardware and surveying tools) are available and are increasingly being developed to deal with 3D-property registration. Law and regulations need to be upgraded, revised or even new law introduced to support the products from a new 3D-cadastral system. The need for the addition of organizational structures in the land offices to improve services specially to cope with the problem of 3D-objects. The increasing need for staff and professionals in the 3D-field to assist implementation in local land offices. The need to improve service to the community by upgrading 2D- to 3D-systems.	Increased space requirements for both residential and commercial purposes in Indonesia. With the increasing use of space in urban systems pushing upgraded because the old system is inadequate to support the needs of space (many problems and disputes occur in 2D- systems). These reasons are urgency for upgrading to a 3D-cadastral system. The high cost of providing a new system (tools, hardware and software, more staff training, and upgrade legal system). Complaints from the public on the quality and service of land registration in Indonesia. There is still a bureaucratic problem. The issue of corruption in the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (BPN).
STRENGTH	All stakeholders believe that a land certificate derived from a 3D-cadastral system will better guarantee their ownership and title to land and units/spaces in complex buildings A 3D-cadastral system would overcome the fact that the current land cadastral system cannot manage complex objects above and below the land surface. A 3D-cadastral system will provide more detailed information than the current 2D- systems. Property disputes, such as boundary disputes involving complex land objects would possibly be reduced.	Improve institutional and legal background of 3D-property management. Increase participation of the private sector in providing surveying, mapping and legal services. Upgrade contemporary systems used for land and building assets management. Use information systems that can be easily accessed by customers, e.g., using mobile technologies. Supported increased costs by participants in providing a better new 3D-system.	Increase user participation and awareness-raising so that the benefits of better land cadastral systems are understood and appreciated, and therefore there will be less resistance to any increase in costs to titleholders; Increase the use of advanced technologies that will deliver more accurate data and efficient data management. Increase the 2D- system into the 3D-system due to the need for space for residential and commercial interests in Indonesia so that there are many buildings with complex construction above and below the ground there are multiple ownership in it Improve internal verification procedures to reduce corruption; Increase the use of advanced technologies that will deliver more accurate data and efficient data management.
WEAKNESS	The surveying tools used in the current are less accurate and details. The absence of specific laws and land regulations governing 3-dimensional land objects, such as apartment buildings and updating laws on 3D-cadastral objects to cope with the development of complex buildings in urban cities. Absence of 3D-complex object management section in local land offices. There is a lack of staff in most stakeholder groups with the necessary technical and managerial abilities to conduct 3D-property registration.	Upgrading a new 3D-system is the opportunity to upgrade the surveying tools and equipment to gain more detail and more accurate surveying result; Creating and updating laws and regulation of 3D-land objects to improve the legal certainty of 3D-land certificates; Making a special section that deals with 3D-land management to provide better service for the public; Need to upgrade human resources by training about 3D-cadastral technology.	Emphasise boundary certainty of 3D-objects in conducting a survey within the 3D-cadastre. Simplify the procedure of land registration to reduce the length of the bureaucratic process, this can be added benefits of reducing costs Decrease response times by using IT technology and on-line data support

6.6 CHAPTER SUMMARY

This chapter provides the researcher's interpretations and evaluation of the interviews, the results of which were presented in Chapter Five. It demonstrates the connections between the findings of the study related to the proposed implementation of a 3D-cadastral system using a SWOT analysis.

Specifically, the chapter evaluated the issues with the current cadastral system in Indonesia. After this, solutions were proposed for some of the key issues. The third section analyzed the readiness of the legal framework around the property in Indonesia, human resources and organizational structures to adjust to a 3D-cadastre.

A SWOT Matrix Analysis was undertaken which to identify four groups of strategies that will arise because of the introduction of a 3D-cadastre in Indonesia. There are (i) strengths-opportunities strategies which to will use the existing strengths of BPN to take advantage of new opportunities that become available; (ii) weaknesses-opportunities strategies which could be overcome existing weakness by taking advantage of opportunities afforded by a 3D-cadastre; (iii) strengths-threats strategies that will be BPN's strengths to reduce its vulnerability to external threats that may emerge during a cadastral conversion project; and (iv) weaknesses-threats strategies which will need to be tackled to minimise its vulnerability to external threats related existing weaknesses.

The following chapter considers the research outcomes in terms of the project objectives and proposes a plan for the introduction of a 3D-cadastral system in Indonesia.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter presents the key research findings in the context of the aims and objectives stated in Section 1.2. The following section puts the entire project into context by outlining a plan for the introduction of a three-dimensional cadastral system in Indonesia. The final section concludes by touching on the contributions this research makes.

7.2 KEY RESEARCH FINDINGS

The overall aim of the research was to conduct a critical analysis of the potential for the implementation of 3D-cadastral systems in Indonesia by identifying issues with cadastres and land management, proposing solutions, and investigating the state of readiness of Indonesian stakeholders to work with a 3D-cadastre. Specific objectives were to:

1. To find evidence of circumstances in which the existing 2D-surveying methods and the 2D-cadastre in Indonesia are inadequate in the face of increasingly complex infrastructure in two major Indonesian cities.
2. To investigate the feasibility of implementing a 3D-cadastral system in Indonesia.

The key findings related to the first objective were as follows.

1. In Jakarta and Bandung evidence from interviews supported the researcher's initial argument that high population growth is leading to the construction of complex infrastructure (high rise buildings and apartments were the particular focus of the research), which in turn is leading to pressure on space and conflicts within buildings over boundaries and uncertainties about the security of legal titles. This mirrors research findings from elsewhere in the world.
2. 2D-cadastral and land management systems are still prevalent around the world, even though research conducted by the researcher (Chapters 5 and 6) and the critical review of research literature (Chapter 2) show that they do not handle apartments and retail units well, nor do they deal adequately with separate ownership or tenancy in multi-owner buildings. This is a natural weakness of a 2D-system, and as a consequence, many apartment unit owners feel exposed to risk. In Indonesia, these risks were articulated as disputes around ownership of units, boundary issues or space conflicts (Chapters 5 and 6).

3. In Indonesia, the perceived need to upgrade land cadastral systems to 3D-is supported by public awareness that an entire system change is needed. Stakeholders felt that, in general, a 3D-system would provide more accurate and complete information in handling complex infrastructure objects and reduce property conflicts (Chapters 5 and 6).

The key findings related to the second objective were as follows.

1. To overcome the issues with the 2D-system, the overall proposal is to introduce a 3D-cadastre system, at least for urban areas. However, the interviews conducted in Bandung and Jakarta revealed a lack of understanding of 3D-surveying and cadastres. This creates a requirement to educate stakeholders either formally or through socialization. Nonetheless, stakeholders are aware of the advantages of a 3D-cadastre, which they articulated as being able to handle better the growth of complex buildings through the provision of more detailed, accurate and complete information on the land certificates. All stakeholders were aware that the biggest challenge may be the high initial investment required on behalf of many stakeholders to upgrade to the 3D-land cadastre system. Some stakeholders expressed concern that these costs would make land certificates more expensive and questioned the capacity of owners to absorb the extra costs. Some even considered the government should shoulder the entire financial burden. The illustration of 3D properties (both in paper and in digital form) was originally based on the standard that it was only used as the purpose of providing information and as additional records in a deed-based system. Any attempt to make these additional records is agreed upon by negotiation between the buyer and the seller if they want additional 3D information to be added to the deed files. It is possible to define the spatial features of a property. The costs required can be compensated for by reducing future conflicts over the property due to the lack of clarity on the spatial boundaries of ownership of the property. Preventing these upcoming conflicts and also social or individual expenses, both legally and economically, are key factors for implementing the 3D cadastre.
2. The readiness of Indonesian stakeholders to work with a 3D-cadastre in the future was examined. In terms of legal issues, upgrading the legal framework was identified as extremely important; modifications to six laws and regulations presently on the statute books to deal with 3D-rather than 2D-objects. It was clear that stakeholders felt that laws and regulations specific to the 3D-cadastre were necessary. Nevertheless, deep public knowledge about the law is lacking in this area (even

amongst stakeholders that are close to it). This was evinced by the many different interpretations of the legal constraints on 3D-objects identified by stakeholders. Therefore, training, socialization and the provision of information on laws that are adapted to meet the requirements of a 3D-cadastre will be a further requirement that will have to be addressed.

3. Human resource capacity and organisational structures were also examined. A lack of training appears to be the major obstacle faced in terms of human resources. The necessary training requirements according to the category of stakeholders were developed from the interviews undertaken (Table 6.1). In terms of organisational structures, the focus was on BPN. The main recommendation is the need to restructure regional and district land offices to include operational 3D-surveying and cadastral sections. It is believed that this will provide a better service to the community, which stakeholders noted is a cause of public complaint at the present time even with the 2D- cadastre.

The third research objective was to use, and critically review, the use of 3D-laser scanning to develop a 3D-model for a complex multi-floor building; and to compare this to other surveying systems.

1. A Terrestrial Laser Scanner was used to scan the Flinders University Earth Science Building (FU-ESB) and acquire 3D-point cloud data to create a 3-D model of this building. The model produced had a maximum deviation error of 0.0057m and the minimum deviation error is 0.0003m.
2. Horizontal and vertical measurements of locations in the FU-ESB were made from 2D- CAD plans, with a distometer, and from the 3D-method. The distometer and 3D-model measurements are highly correlated and did not exhibit the errors that were revealed in the 2D- CAD plans. In terms of simple measurements, the use of a distometer would be more efficient in surveying horizontal and vertical spaces within a building than undertaking a full 3D-survey. However, the research also showed that there a full 3D-survey has other advantages, e,g, visualizing boundaries, that indicate that it may be preferred over a distometer (partial 3D) survey.
3. Importantly, and perhaps somewhat tangentially, conducting this survey and modeling the FU-ESB in three dimensions provided the researcher with valuable technical expertise and insights that he will be able to use when he returns to BPN.

7.3 THE INTRODUCTION OF A THREE-DIMENSIONAL CADASTRAL SYSTEM IN INDONESIA

After the readiness of stakeholders in Indonesia had been analysed, the researcher has been able to start to develop ideas around a plan for the introduction and implementation of a 3D-cadastral system in Indonesia. This is provided a series of recommendations with commentaries in this section.

7.3.1 Consideration of legal frameworks

The following are the main actions that need to be taken in the context of the legal frameworks necessary for the regulations to make a 3D-cadastre workable in practice. Amendments need to be made to the existing laws and regulations so that they can be made applicable to 3D-environments. The current laws that will be relevant to are 3D-cadastral system were outlined and their limitations were discussed in Section 6.4.1. If they cannot be amended, new laws will need to be draft and passed onto the statute books. The overall aim of any new laws and regulations, or amendments to existing ones, will be to make them able to register 3D-properties in order to provide strong legal security to titleholders. This is not without precedent, a new law was required in Norway to deal with a 3D-cadastre (Onsrud 2003). The legal modification required is, in the opinion of the researcher, the most important step in introducing a 3D-cadastre.

A related aspect is that the legal sections of BPN that will handle 3D-property management will also need to reflect the new situation. The fact that 3D-sections not available in land offices outside Jakarta means that BPN will have to make decisions as to whether legal experts on 3D-laws remain in the legal sections of BPN or in special 3D-sections (*cf.* Section 7.3.3).

7.3.2 Economic benefits

A key benefit of a 3D-cadastre system is that it will lead to economic growth. There will several threads to this. First, apartment values could rise with stronger legal guarantees of ownership. Secondly, the increase in property values could stimulate developers to build more apartments and commercial premises to fulfill the needs of growing urban populations. This, in turn, would create more direct employment in the construction sector, and there would be trickle-down economic effects.

There is a basis for such an argument. Economic research has shown that the introduction of new technologies can improve economic growth (Hall & Khan 2003). The diffusion of any new system will be affected by the balance of personal considerations about a new system that is weighed against uncertainty about the benefits and the costs of adopting new technology. If this argument is applied in this research, the contribution of 3D-cadastre implementation in Indonesia should improve economic growth nationally, especially as the 3D-cadastre diffuses across the country.

Despite these benefits, concerns about the high cost of providing a new system emerged from the interviews, which will derive, in part, from high set-up and training costs. However, this set-up activities and training will create business opportunities, e.g., delivery 3D-surveying and software training in Indonesia.

7.3.3 Technology adoption

Acceptance and use of the 3D-cadastre system will be improved by incorporating it into Building Information Modelling (BIM). BIM is a process that involves the generation and management of digital representations of physical and functional characteristics of places (Blacklock et al. 2017). If a 3D-cadastre were to be implemented in Indonesia it should be integrated into BIM. Soon BIM and the architectural, engineering, and construction professions will transform the way that building, and infrastructure are designed, constructed, and operated. If integrated in this way a 3D-cadastre system will be able to be used for other applications such as asset management, and in improving decision making and performance analysis throughout the lifespan of building and infrastructure in Indonesia.

BIM can be considered as a technological advance, as can 3D-surveying and model building. Researchers have investigated technology adoption by introducing a distinction between technological breakthroughs (‘innovations’) and the engineering refinements (‘improvements’) that follow breakthroughs. Firms do not necessarily wait for a future technological breakthrough. In fact, some delay the adoption of a new technology until it is sufficiently advanced (Doraszelski 2004). This relates to the situation that the researcher feels would apply in Indonesia with the introduction of a 3D-cadastre system. The technological breakthroughs or innovations in this context can be explained as using 3D-surveying methods that are very different from 2D- methods. Interviewees were ambiguous about whether they would adopt 3D-as many appeared comfortable and familiar with the current 2D- system.

The optimal timing of technology adoption under abatement through R&D was explored by Guo and Zhu (2016) who found that it was affected by changes in parameter values reflecting output, R&D investment, and adoption time. The methods allowed some technologies to be missed out and more advanced ones adopted in their place. The optimal time of the adoption of the 3D-cadastre system in Indonesia would therefore be affected by output, R&D investment and timing that what would need to optimized together; particularly given that many stakeholders feel that the 2D-system is still adequate and that BPN is still attempting to complete the 2D- land registration over the entire country by 2025. Moreover, most potential stakeholders do not fully understand the workings and benefits of a 3D-cadastral system at the present time. Indonesia needs more R&D investment in the 3D-cadastre and a longer adoption time before the desired output of introducing a full 3D-cadastral system nationally can be reached.

Chalioti and Serfes (2017) examined how agency theory with market competition can be used to reduce R&D costs by managers who decide that risk or incentives will be either positive or negative. Risk also affects incentives and has implications on the effects of innovations that are introduced. In Indonesia, adoption of 3D-cadastral technologies conducted with cost-reduced R&D may lead to both negative or positive incentives as part of the new innovation.

Mahathi et al. (2016) discussed how strategic managerial delegation influences the timing of a company's adoption of new technology in various modes of product market competition. This also influences the implications of a company's choice of the type of managerial incentive scheme and the speed of diffusion of new technology. Its application in Indonesia to 3D-cadastral technology would be in the timing of technology adoption in relation to various competing technologies. The implications depend on the managerial incentive scheme chosen, which will influence the speed of diffusion in land offices across the country.

In summary, the introduction of a 3D-cadastral system in Indonesia must take into account:

- upgrading legal and institutional frameworks and provision of adequate laws related to 3D-cadastral objects, which will lead to economic growth; and
- promotion of the new technology, in particular through the use of Building Information Modelling (BIM) because it would be beneficial asset management, decision making, and building performance analysis

7.4 CONTRIBUTIONS OF THE RESEARCH PROJECT

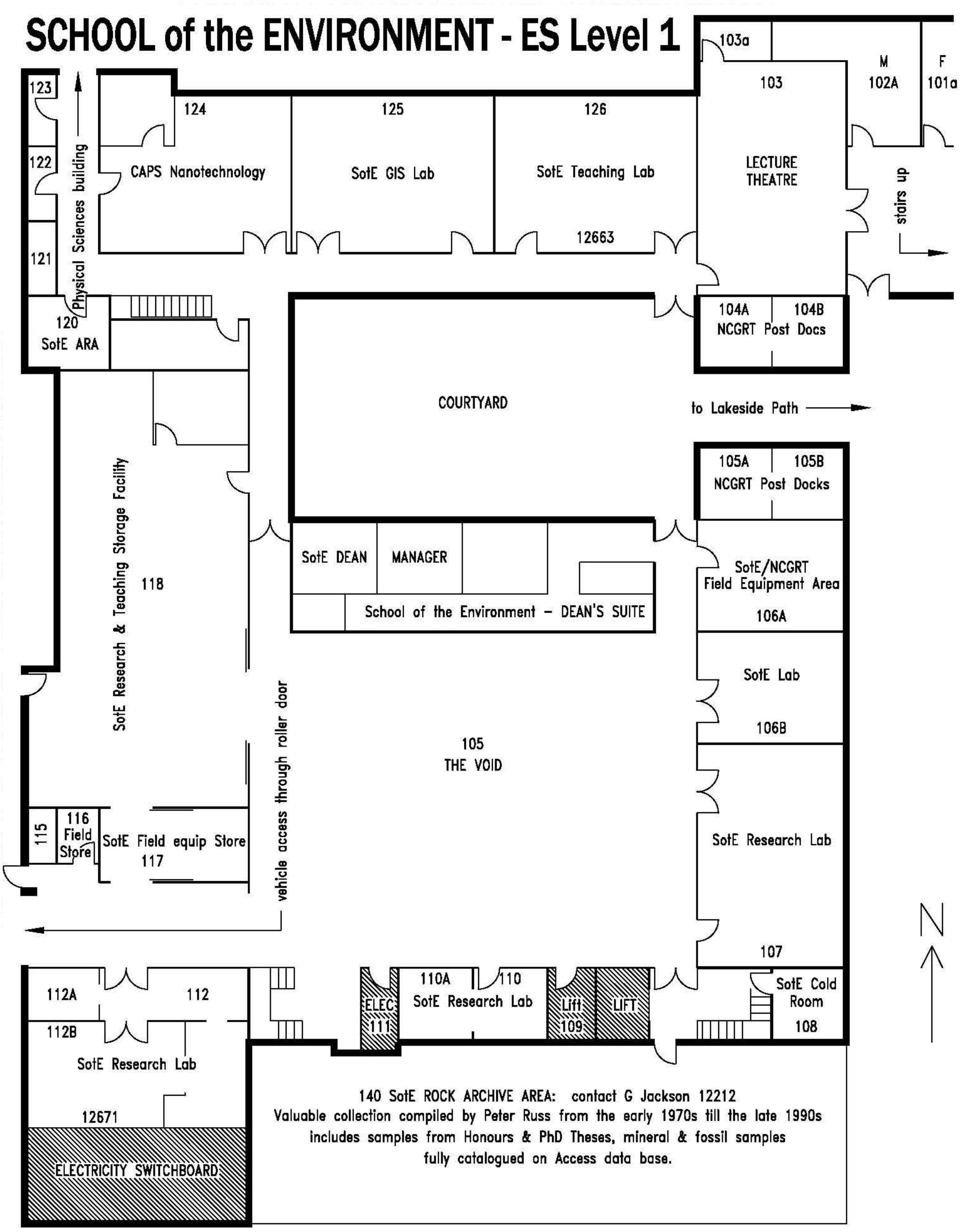
This thesis contributes to both theory and practice in land surveying. It also advances academic knowledge. The focus is on a contemporary study of the potential to introduce a 3D cadastral model in a developing country that is experiencing rapid urbanization, and which is increasingly limiting areas for development due to the accelerating urban population density and the scarcity of available land for residential and business places. It will be a valuable addition to the body of literature reviewed in Chapter 2.

This research is also a valuable contribution for the government agency responsible for the land cadastre in Indonesia – BPN. In its role as a government ministry with a mandate to conduct land registration, administration and management in Indonesia, it is grappling with the issues caused by the absence of a 3D cadastre. BPN's ideas surrounding the planned implementation of a 3D cadastral system in Indonesia (Section 7.3) are supported by research carried out in this thesis. If implemented, this research will ensure that the 3D cadastre that Indonesia will create will have a vision that recognizes salient laws, human resources and organizational improvements; and the need to increase security of land ownership. If such aspects are incorporated into the 3D cadastre it will provides economic benefits for the nation by encouraging increased and secure investments.

APPENDICES

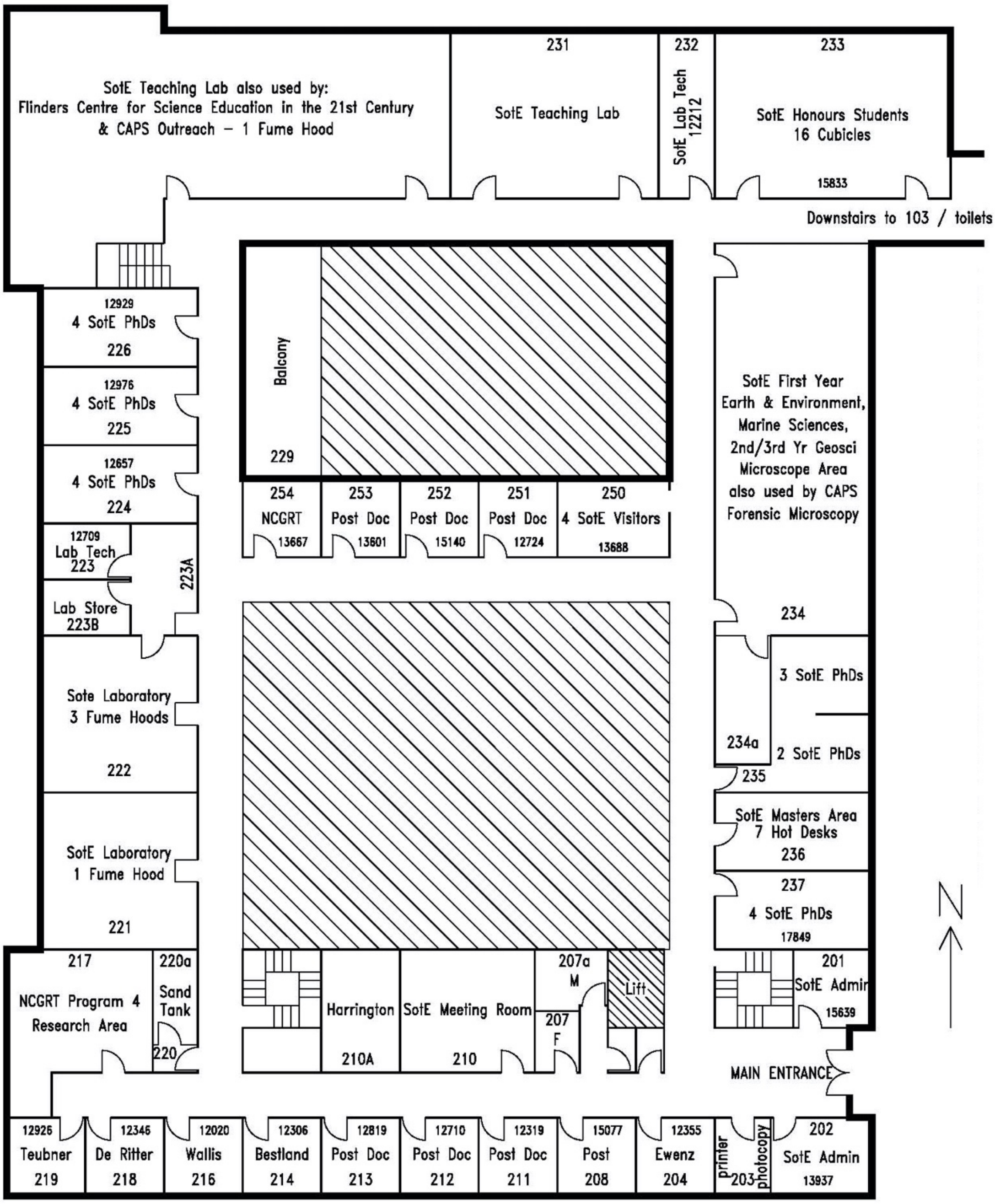
Appendix 3.1 Each level 2D- floor plan

LEVEL 1

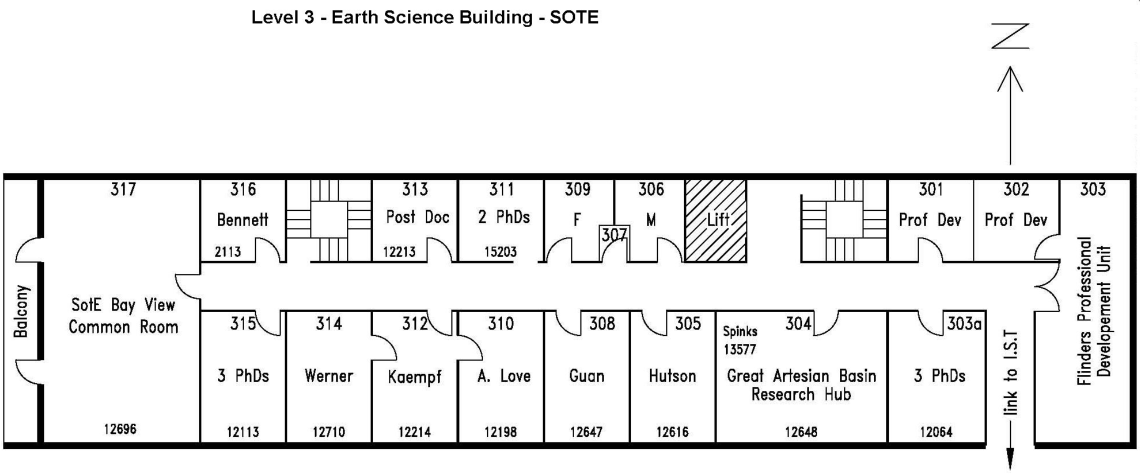


LEVEL 2

SCHOOL of the ENVIRONMENT - ES Level 2



LEVEL 3


Level 3 - Earth Science Building - SOTE
N
317
SotE Bay View
Common Room
12696
Balcony
316
Bennett
2113
313
Post Doc
12213
311
2 PhDs
15203
309
F
307
306
M
Lift
301
Prof Dev
302
Prof Dev
303
Flinders Professional
Developement Unit
315
3 PhDs
12113
314
Werner
12710
312
Kaempf
12214
310
A. Love
12198
308
Guan
12647
305
Hutson
12616
Spinks
13577
304
Great Artesian Basin
Research Hub
12648
303a
3 PhDs
12064
link to I.S.T

Appendix 3.2 interview sheets

LETTER OF INTRODUCTION

School of the Environment
Bedford Park
Adelaide SA 5042

GPO Box 2100
Adelaide SA 5001
Tel: +61 8 82017577
Fax: +61 8 82013567
Email: dean.sote@flinders.edu.au

www.flinders.edu.au
CRICOS Provider No. 00114A

LETTER OF INTRODUCTION

Dear Sir/Madam,

This letter is to introduce **Dicky Caesar Muharawan** who is a **PhD student** in the **School of the Environment, Faculty of Science and Engineering at Flinders University, Australia**. He will produce his student card, which carries a photograph, as proof of identity. He is also on leave of his duty as a staff in the Ministry of Agrarian and Spatial Planning in Directorate General of Agrarian Infrastructure.

He is undertaking research leading to the production of a thesis or other publications on the subject of **Evaluation of the potential for the implementation of a 3D Cadastre in urban areas in Indonesia**. He would like to invite you to assist with this project by agreeing to be involved in an interview to discuss this topic. The interview should last about 30 minutes.

Be assured that any information provided will be treated in the strictest confidence and none of the participants will be individually identifiable in the resulting thesis, report or other publications. You are, of course, entirely free to discontinue your participation at any time or to decline to answer particular questions.

Since he intends to make a tape recording of the interview, he will seek your consent, on the attached form, to record the interview, to use the recording or a transcription in preparing the thesis, report or other publications, on condition that your name or identity is not revealed, and to make the recording available to other researchers on the same conditions.

Any enquiries you may have concerning this project should be directed to me at the address given above or by telephone on +61 8 82017577 (Prof. Andrew Millington) or e-mail andrew.millington@flinders.edu.au.

Thank you for your attention and assistance.

Yours sincerely,

Prof. Andrew Millington
Professor
School of the Environment

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee. For more information regarding ethical approval of the project the Secretary of the Committee can be contacted by telephone on 8201 5962, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

inspiring achievement

Dicky Muharawan
School of the Environment
Faculty of Science and Engineering
Room: Social Science North 257
Bedford Park SA 5042
GPO Box 2100
Adelaide SA 5001
Tel: +61 413 921 670
Fax: +61 8 82013567
Email: dicky.muharawan@flinders.edu.au
www.flinders.edu.au
CRICOS Provider No. 00114A

INFORMATION SHEET

Title: 'Evaluation of the potential for the implementation of a 3D Cadastre in urban areas in Indonesia'

Investigators:
Mr. Dicky Caesar Muharawan
School of the Environment – Faculty of Science and Engineering
Flinders University
Ph: +61 413 921 670

Supervisor:
Professor Andrew Millington
School of the Environment – Faculty of Science and Engineering
Flinders University
Ph: +61 8 82017577

Description of the study:
This study is part of the project entitled 'Evaluation of the potential for the implementation of a 3D Cadastre in urban areas in Indonesia'. This project will investigate the potential for a 3D Cadastre implementation at different urban location in Indonesia, with a focus on 3D cadastre implementation on home/apartment/multi storey building. This project is supported by Flinders University, School of the Environment – Faculty of Science and Engineering.

Purpose of the study:
This project aims to:

- Find evidence of circumstances in which the existing 2D surveying is inadequate in the face of increasing infrastructure complexity in Indonesian urban cities.
- Apply and critically review the use of 3D laser scanning to support a full 3D application for a complex multi-floor building, as an example of 3D cadastral system.
- Investigate how 3D cadastral system can be implemented in Indonesia and to provide policy advice on this issue.

What will I be asked to do?
You are invited to attend a one-on-one interview with Dicky Muharawan who will ask you a few questions about your views about 3D cadastre system based on the your experiences.

inspiring achievement

The interview should last about 30 minutes. The interview will be recorded using a digital voice recorder to help with looking at the results. Once recorded, the interview will be transcribed (typed-up) and stored as a computer file and then destroyed once the results have been finalised. This is voluntary.

What benefit will I gain from being involved in this study?
The sharing of your experiences will understand of 3D cadastre system, and also to evaluate the potential implementation in urban areas in Indonesia.

Will I be identifiable by being involved in this study?
We do not need your name and you will be anonymous. Once the interview has been typed-up and saved as a file, the voice file will then be destroyed. Any identifying information will be removed and the typed-up file stored on a password protected computer that only the coordinator (Dicky Caesar Muharawan) will have access to. Your comments will not be linked directly to you.

Are there any risks or discomforts if I am involved?
The investigator anticipates few risks from your involvement in this study. If you have any concerns regarding anticipated or actual risks or discomforts, please raise them with the investigator.

How do I agree to participate?
Participation is voluntary. You may answer 'no comment' or refuse to answer any questions and you are free to withdraw from the interview at any time without effect or consequences. A consent form accompanies this information sheet. If you agree to participate please read and sign the form and send it back to me at dicky.muharawan@flinders.edu.au or give it back to me before start the interview.

How will I receive feedback?
Outcomes from the project will be summarised and given to you by the investigator if you would like to see them.

Thank you for taking the time to read this information sheet and we hope that you will accept our invitation to be involved.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project number 6638). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

CONSENT FORM

Flinders
UNIVERSITY

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(by interview)

Evaluation of the potential for the implementation of a 3D Cadastre in urban areas in Indonesia

I …..

being over the age of 18 years hereby consent to participate, as requested, in the ………………………………… for the research project on ……………………….

1. I have read the information provided.
2. Details of procedures and any risks have been explained to my satisfaction.
3. I agree to audio recording of my information and participation.
4. I am aware that I should retain a copy of the Letter of Introduction, the Information Sheet and Consent Form for future reference.
5. I understand that:
   - I may not directly benefit from taking part in this research.
   - I am free to withdraw from the project at any time and is free to decline to answer particular questions.
   - While the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.
   - I may ask that the recording/observation be stopped at any time, and I may withdraw at any time from the session or the research without disadvantage.

Participant's signature……………………………………Date…………………...

I certify that I have explained the study to the volunteer and consider that he/she understands what is involved and freely consents to participation.

Researcher's name: Dicky Caesar Muharawan

Researcher's signature…………………………………..Date…………………….

Appendix 3.3 Ethics approval

From: Human Research Ethics
To: Dicky Muharawan; Andrew Millington
Subject: 7013 SBREC final approval notice (21 October 2015)
Date: 21 October 2015 12:24:59 PM
Importance: High

Dear Dicky,

The Chair of the Social and Behavioural Research Ethics Committee (SBREC) at Flinders University considered your response to conditional approval out of session and your project has now been granted final ethics approval. This means that you now have approval to commence your research. Your ethics final approval notice can be found below.

FINAL APPROVAL NOTICE

Project No.:	**7013**
Project Title:	Evaluation of the potential for the implementation of a 3D Cadastre in urban areas in Indonesia
Principal Researcher:	Mr Dicky Muharawan
Email:	muha0045@flinders.edu.au

Approval Date:	21 October 2015	Ethics Approval Expiry Date:	**19 March 2018**

The above proposed project has been **approved** on the basis of the information contained in the application, its attachments and the information subsequently provided.

RESPONSIBILITIES OF RESEARCHERS AND SUPERVISORS

1. Participant Documentation

Please note that it is the responsibility of researchers and supervisors, in the case of student projects, to ensure that:

- all participant documents are checked for spelling, grammatical, numbering and formatting errors. The Committee does not accept any responsibility for the above mentioned errors.
- the Flinders University logo is included on all participant documentation (e.g., letters of Introduction, information Sheets, consent forms, debriefing information and questionnaires – with the exception of purchased research tools) and the current Flinders University letterhead is included in the header of all letters of introduction. The Flinders University international logo/letterhead should be used and documentation should contain international dialling codes for all telephone and fax numbers listed for all research to be conducted overseas.
- the SBREC contact details, listed below, are included in the footer of all letters of introduction and information sheets.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project Number 'INSERT PROJECT No. here following approval'). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au.

2. Annual Progress / Final Reports

In order to comply with the monitoring requirements of the *National Statement on Ethical Conduct in Human Research (March 2007)* an annual progress report must be submitted each year on the **21 October** (approval anniversary date) for the duration of the ethics approval using the report template available from the Managing Your Ethics Approval SBREC web page. *Please retain this notice for reference when completing annual progress or final reports.*

If the project is completed *before* ethics approval has expired please ensure a final report is submitted immediately. If ethics approval for your project expires please submit either (1) a final report; or (2) an extension of time request and an annual report.

Student Projects

The SBREC recommends that current ethics approval is maintained until a student's thesis has been submitted, reviewed and approved. This is to protect the student in the event that reviewers recommend some changes that may include the collection of additional participant data.

Your first report is due on **21 October 2016** or on completion of the project, whichever is the earliest.

3. Modifications to Project

Modifications to the project must not proceed until approval has been obtained from the Ethics Committee. Such proposed changes / modifications include:

- change of project title;
- change to research team (e.g., additions, removals, principal researcher or supervisor change);
- changes to research objectives;
- changes to research protocol;
- changes to participant recruitment methods;
- changes / additions to source(s) of participants;
- changes of procedures used to seek informed consent;
- changes to reimbursements provided to participants;
- changes / additions to information and/or documentation to be provided to potential participants;
- changes to research tools (e.g., questionnaire, interview questions, focus group questions);
- extensions of time.

To notify the Committee of any proposed modifications to the project please complete and submit the *Modification Request Form* which is available from the Managing Your Ethics Approval SBREC web page. Download the form from the website every time a new modification request is submitted to ensure that the most recent form is used. Please note that extension of time requests should be submitted prior to the Ethics Approval Expiry Date listed on this notice.

Change of Contact Details

Please ensure that you notify the Committee if either your mailing or email address changes to ensure that correspondence relating to this project can be sent to you. A modification request is not required to change your contact details.

4. **Adverse Events and/or Complaints**

Researchers should advise the Executive Officer of the Ethics Committee on 08 8201-3116 or human.researchethics@flinders.edu.au immediately if:

- any complaints regarding the research are received;
- a serious or unexpected adverse event occurs that effects participants;
- an unforeseen event occurs that may affect the ethical acceptability of the project.

Kind regards
Andrea

Mrs Andrea Fiegert and Ms Rae Tyler
Ethics Officers and Executive Officer, Social and Behavioural Research Ethics Committee
Andrea - Telephone: +61 8 8201-3116 | Monday, Tuesday and Wednesday
Rae – Telephone: +61 8 8201-7938 | ½ day Wednesday, Thursday and Friday

Email: human.researchethics@flinders.edu.au
Web: Social and Behavioural Research Ethics Committee (SBREC)

Manager, Research Ethics and Integrity – Dr Peter Wigley
Telephone: +61 8 8201-5466 | email: peter.wigley@flinders.edu.au
Research Services Office |Union Building Basement
Flinders University
Sturt Road, Bedford Park | South Australia | 5042
GPO Box 2100 | Adelaide SA 5001

Appendix 3.4 permit from BPN Central Office

**KEMENTERIAN AGRARIA DAN TATA RUANG/
BADAN PERTANAHAN NASIONAL**

Nomor : 3464/3.1-100/VIII/2015 Jakarta, 19 Agustus 2015
Lampiran :
Hal : Izin Melakukan Riset

Yth. Sdr. Dicky Caesar Muharawan, S.T., M.T.
di -
Tempat

Memperhatikan surat Saudara tertanggal 10 Agustus 2015 perihal Permohonan Izin Untuk Melakukan Riset di Kementerian Agraria dan Tata Ruang/Badan Pertanahan Nasional, bersama ini disampaikan bahwa pada prinsipnya kami dapat menyetujui dan memberikan izin kepada Saudara untuk melakukan riset di di lingkungan Kementerian Agraria dan Tata Ruang/Badan Pertanahan Nasional dalam rangka penyusunan Disertasi dengan judul "Evaluasi Terhadap Potensi Penerapan Kadaster 3 Dimensi di Wilayah Perkotaan di Indonesia".

Demikian untuk menjadi maklum.

a.n. Menteri Agraria dan Tata Ruang/
Kepala Badan Pertanahan Nasional
Plt. Sekretaris Jenderal,

Drs. Heri Santoso
NIP. 19600522 198603 1 003

Tembusan:
Menteri Agraria dan Tata Ruang/Kepala Badan Pertanahan Nasional, di Jakarta.

JALAN SISINGAMANGARAJA NO 2 JAKARTA SELATAN TELP : 021-7228901, 7393939 : www.bpn.go.id

BPN RI

BHUMIBHAKTI ADHIGUNA

BADAN PERTANAHAN NASIONAL REPUBLIK INDONESIA
KANTOR PERTANAHAN KOTA ADMINISTRASI JAKARTA BARAT
PROVINSI DAERAH KHUSUS IBUKOTA JAKARTA

Komplek Perumahan Permata Buana, Jl. Kembangan Utama, Telp. 5825868-69

SURAT TUGAS

Nomor : 7098/100.31.73/ XII/2015

Berdasarkan Surat Izin Melakukan Riset dari Menteri Agraria dan Tata Ruang/ Kepala Badan Pertanahan Nasional Nomor : 3464/3.1-100/VIII/2015 Tanggal 19 Agustus 2015, Kepala Kantor Pertanahan Kota Administrasi Jakarta Barat, dengan ini menugaskan :

Nama : **DICKY CAESAR MUHARAWAN, S.T., M.T**

Untuk melakukan riset dan wawancara dalam rangka penyusunan Disertasi dengan judul "Evaluasi Terhadap Potensi Penerapan Kadaster 3 Dimensi di Wilayah Perkotaan di Indonesia", pada Kantor Pejabat Pembuat Akta Tanah (PPAT) Wilayah Kerja Kota Administrasi Jakarta Barat sebagai berikut :

No.	Nama PPAT	Alamat Kantor
1	Ilmiawan Dekrit Supatmo, SH	Jl. Meruya Ilir Raya No. 04 Srengseng, Kembangan, Jakarta Barat. Telp. 021-5858002, 021-5847475,
2	Tan Susy, SH	Ruko Taman Palem Lestari Blok D-10 No.19, Jl. Kamal Raya Outering Road, Cengkareng, Jakarta Barat. Telp. 021-5561222, 55957433
3	Emmy Halim, SH	Jl. Mandala Utara No.24-C Tomang, Jakarta Barat. Telp. 021-5634348
4	Martina, SH	Jl. Tomang Raya No. 25 Jakarta Barat. Telp. 021-5654989, 5657383
5	Nilam Purnamawaty Januarso, SH, SPN	Gedung Graha Kencana, Jln. Raya Perjuangan No. 88, Blok EJ Lantai 3, Jakarta Barat. Telp. 021-5348282
6	Setiawan, SH	Jl. KH Zainal Arifin Komplek Ketapang Indah B1 No.7 Jakarta Barat. Telp. 021-6338848, 021-76341249
7	Eny Haryanti, SH	Plaza Kedoya Elok Blok DE No.3 Jalan Panjang Jakarta Barat. Telp. 021-5812783, 58301545
8	Eka Purwanti, SH	Ruko Taman Kb. Jeruk Blok A 9/3 Jl. Meruya Ilir Raya Jakarta Barat. Telp. 021-5863282
9	Agnes Angelika, SH, MKN	Jl. K. H. Zainul Arifin, Komplek Ketapang Indah Blok A2 No. 6, Jakarta Barat. Telp. 021-6347262/021-63869491-93
10	Ina Rosaina, SH	Jl. Meruya Ilir No. 33-A, Kebon Jeruk Jakarta Barat. Telp. 021-5860208

Demikian Surat Tugas ini untuk dilaksanakan dengan penuh tanggung jawab.

Jakarta, 15 Desember 2015
A.n Kepala Kantor Pertanahan
Kota Administrasi Jakarta Barat
Kasubag Tata Usaha

KANTOR PERTANAHAN KOTA ADMINISTRASI JAKARTA BARAT

SUSYANTO A.Ptnh., M.M.
NIP. 196309301985031004

Tembusan :
- Arsip.

Appendix 3.5 permit from BPN West Java Regional Office

BADAN PERTANAHAN NASIONAL
REPUBLIK INDONESIA
KANTOR WILAYAH PROVINSI JAWA BARAT
JL. SOEKARNO - HATTA NO. 586 TELP. (022) 7562057 BANDUNG

NOTA DINAS
NOMOR : 2 /ND-100.2/I/2016

Kepada Yth.	:	1. Kepala Bidang Survei Pengukuran dan Pemetaan; 2. Kepala Bidang Hak Tanah dan Pendaftaran Tanah;
Dari	:	Kepala Kantor Wilayah BPN Provinsi Jawa Barat
Sifat	:	
Tanggal	:	05 Januari 2016
Hal	:	Izin melakukan riset

Membaca surat Sekretaris Jenderal Kementerian Agraria dan Tata Ruang/BPN Nomor: 3464/3.1-100/VIII/2015 tanggal 19 Agustus 2015 perihal tersebut pada pokok surat diatas, bersama ini disampaikan bahwa pada prinsipnya kami menyetujui permohonan izin untuk melakukan penelitian dilingkungan Kantor Wilayah Badan Pertanahan Nasional Provinsi Jawa Barat An. Sdr. Dicky Caesar Muharawan, S.T., M.T. dalam rangka penyusunan Disertasi dengan judul "Evaluasi Terhadap Potensi Penerapan Kadaster 3 Dimensi di Wilayah Perkotaan di Indonesia". Sehubungan dengan hal tersebut, kami minta bantuan Saudara untuk dapat memberikan data dan informasi terkait dengan penyusunan disertasi dimaksud.

Demikian untuk menjadikan maklum.

An. Kepala Kantor Wilayah Badan Pertanahan Nasional
Provinsi Jawa Barat
Kepala BagianTata Usaha,

Elijas B. Tjahajadi
NIP. 19670414 199310 1 001

Tembusan disampaikan Kepada Yth.:
Kepala Kantor Wilayah BPN Provinsi Jawa Barat.

BADAN PERTANAHAN NASIONAL
REPUBLIK INDONESIA
KANTOR WILAYAH PROVINSI JAWA BARAT

JL. SOEKARNO - HATTA NO. 586 TELP. (022) 7562057 BANDUNG

Bandung, 05 Januari 2016

Nomor : 5 /2-32/I/2016
Lampiran : -
Perihal : Izin Melakukan Riset

Yth. :
Kepala Kantor Pertanahan Kota Bandung

di -
tempat

Membaca surat Sekretaris Jenderal Kementerian Agraria dan Tata Ruang/BPN Nomor: 3464/3.1-100/VIII/2015 tanggal 19 Agustus 2015 perihal tersebut pada pokok surat diatas, bersama ini disampaikan bahwa pada prinsipnya kami menyetujui permohonan izin untuk melakukan penelitian dilingkungan Kantor Wilayah Badan Pertanahan Nasional Provinsi Jawa Barat An. Sdr. Dicky Caesar Muharawan, S.T., M.T. dalam rangka penyusunan Disertasi dengan judul "Evaluasi Terhadap Potensi Penerapan Kadaster 3 Dimensi di Wilayah Perkotaan di Indonesia". Sehubungan dengan hal tersebut, kami minta bantuan Saudara untuk dapat memberikan data dan informasi terkait dengan penyusunan disertasi dimaksud.

Demikian untuk menjadikan maklum.

An. Kepala Kantor Wilayah Badan Pertanahan Nasional
Provinsi Jawa Barat
Kepala Bagian Tata Usaha

Elijas B. Tjahajadi
NIP. 19670414 199310 1 001

Tembusan, disampaikan kepada:
Kepala Kantor Wilayah BPN Provinsi Jawa Barat;

Appendix 3.6 questions of interview for each group of stakeholders

Interview

Location/Address/email:

Job/position held and organisation/company (if applicable):

Date (D/M/Y) : ______/______/20______ Time started : ______/________.___Time completed : ______/______.

A. Pre-interview guide
Researcher (interviewer) introducing himself

B. List of interview questions

Hello, my name is Dicky Caesar Muharawan. I am a PhD student at Flinders University in Adelaide, Australia on leave from the Ministry of Agrarian and Spatial Planning Agency/BPN. The research I am undertaking for my PhD thesis on the evaluation of potential implementation of a three dimensional land cadastral system in Indonesia. Indonesia currently has a two dimensional system. The purposes of my study are to evaluate the potential for implementing this new – three-dimensional system – in the future. I am seeking your help to answering some questions that will advance my research. Please read the letter of introduction and the accompanying information sheet, and then, if you agree to participate, please sign the consent form which I have given to you. You are free to ask questions at any time during the interview and, if at any time you do not wish to continue, please ask me to stop. None of your responses will be used in any way that identifies you.
Clarification about participation Have you received and read the letter of introduction and information sheet? (if **Yes** – start the interview – sign the consent form) (if **No** – provides the participants with the letter of introduction and information sheet – then sign the consent form)

List of Interview questions

A. Interview schedule for BPN Officers (and other government officers):

No.	Question	Question aimed at:
1	From a professional point of view, I'd like to ask you to comment in the current Indonesian cadastral system? Do you know that Indonesia uses a 2-dimensional survey and cadastral system, and do you know what a 2D cadastral system consists of? (*if not, I will explain any aspects that they do not know or understand*) What are the advantages and limitations of the current 2D system in the job that you do? How do you manage improvements to buildings and infrastructure developments above and below the land surface?	Understanding how the 2D cadastre is used and its advantages/limitations
2	From a professional point of view, I'd like to ask you to comment on the possible introduction of a 3-dimensional cadastral system in Indonesia the future? Do you understand what 3-D measurements are in respect of land and property surveying? (*If no, I will explain*). Given your/this knowledge of 3-D measurements, do you feel there is a need for 3-D measurements rather than the current 2 dimensions? What would the advantages and disadvantages of 3 dimensions be in your opinion?	Need for a 3D cadastre.
3	If a 3-D surveying system were introduced for apartment blocks and office blocks, the land certificates would describe the floor plan (as they do at present) and room heights. In your professional opinion, what would be balance between the extra costs of obtaining such land certificates with the benefits that additional rights might guarantee?	Costs and benefits
4	In your work, have you experienced conflicts between property owners and renters that are based around for 3-dimensional aspects of their properties (floor plan and height) rather than simply floor plan? I will ask them how frequently the two types of dispute occur and to explain some disputes they can recall.	Conflicts
5	Do any national or local laws and/or regulations exist for 3-D parcels? If yes, does the jurisdiction have generic legislation (law and/or regulations) for construction or building units and is the law describing the requirements for Plans of Survey in 3D? If yes, *ask for specific laws and article(s) or regulations and get copies of these*	Laws and regulations
6	Are 3-D measurements currently being performed in your section of BPN? If so, how is 3D data acquisition acquired (*prompts: CAD, terrestrial surveying, sketching, stereo/oblique images, laser scanning*) and how accurate are the measurements?	Current use, if any, and 3D aspects
7	What software do you use for creating and processing survey plans (in 2D or 3D)? Do the plans of survey show X/Y coordinates and are they relative or in an absolute spatial reference system? If the latter, what spatial reference system is used?	Current use, if any, and 3D aspects

	Are the cadastral coordinates authoritative? If not, what is the source? ***If the section is involved in 3-D survey/plans, ask***: What 3-D capabilities in the software are used? Are the z (height) coordinates of 3D parcels relative to local ground? Are z coordinates reduced to a standard datum?	
8	***Only ask if the section is involved in 3-D survey/plans***: How is field data saved to the cadastral database after making 3D measurements? What spatial database is used? How can internal and external users visualize content? How is your cadastral database organised? (prompt: Multi-Layers or Object Oriented or another data model)	Current use, if any, and 3D aspects
9	***Only ask if the section is involved in 3-D survey/plans***: What software (GIS/CAD) is used for updating, editing, analysis, and visualization of the cadastral data? What 3D capabilities are used? Can 3D parcels be subdivided, consolidated or nullified? What web software is used for remote data access/distribution and visualization? What 3D capabilities are used?	Current use, if any, and 3D aspects
10	***Only ask if the section is involved in 3-D survey/plans***: Are the 3D parcels checked for spatial validity? (prompts: *volume is closed, does not overlap with neighbouring volume, no unwanted 3D gaps*)?	Current use, if any, and 3D aspects
11	***Only ask if the section is involved in 3-D survey/plans***: How is 3D cadastral information presented on current legal documents? (prompts: *map, certificate, software, web*). In what format are the 3-D parcels submitted for registration?	Current use, if any, and 3D aspects
12	***Only ask if the section is involved in 3-D survey/plans***: Do you have an example of typical 3D parcels; either 'prototype' or 'operational'? How about 3D parcels of the network model? If the network object passes through the surface of the parcels, how do you cope on parcels that overlap each other?	Example
13	Where do you think the 3-D boundaries in an apartment/retail space be: (a) the walls, floor and ceiling should be shared between adjacent properties with the limit of ownership being in the middle of the walls, floor and ceiling, or (b) the walls, floor/ceiling should be neutral space in 3D space, i.e. the property title would end at the wall, floor and ceiling. What advantages and disadvantages do you see for yourself with these two types of boundary?	Boundaries
14	Would it be advantageous in your legal opinion for there to be any limitations on the range of rights? (e.g. underground land parcels must be owned by Government).	Limitations
15	Is there a technical circular or directive to assist surveyors in 3D data collection? *Ask for a copy*	Technical directions
16	What other advantages or disadvantages could you foresee with 3D survey systems if they were introduced in Indonesia?	
17	Do you have any further observations?	

B. Interview schedule for Legal Deeds Officers (LDOs):

No.	Question	Question categorized
1	From a professional point of view, I'd like to ask you to comment in the current Indonesian cadastral system? Do you know that Indonesia uses a 2-dimensional system and do you know what a 2-D cadastral system consists of? (*if they do not I will explain to them the aspects that they do not know or understand*) What are the advantages and limitations of the current 2D system in terms of your profession?	Understanding how the 2D cadastre is used and its advantages/limitations
2	From your position as an LDO, I'd like to ask you to comment in the possible introduction of a 3D cadastral system in the future? Do you understand what 3-dimensional measurements are in respect of land and property surveying? (*If no, I need to explain*). Given your/this knowledge of 3-D measurements, do you feel there is a need for 3-D measurements rather than the current 2-dimensions? What would the advantages and disadvantages of 3-D be in your profession?	Need for a 3D cadastre.
3	If a 3-dimensional land surveying system were introduced for complex buildings with multiple owners/tenants (i.e. apartment or office blocks, retail spaces) what information should the land certificates contain? (prompt: *should they describe the floor plan (as they do at present) and room heights*). In your professional opinion, what would be balance between the extra costs of obtaining such land certificates with the benefits that additional rights might guarantee?	Costs and benefits
4	How frequently do you encounter conflict between adjacent owners or tenants in complex, multiple owner/tenant buildings? (*Ask LDO to explain the most common types/aspects of conflicts*)? Do you feel that 3-D survey measurements incorporated in a land certificate or rental agreement would reduce the number of conflicts, and why?	Conflicts
5	In your legal opinion, would 3-dimensional plans ensure better legal certainty of land rights compared to 2-D? What other legal benefits accrue from 3-dimensional measurements?	Legal aspects
6	Do any national or local laws and/or regulations exist for 3-D parcels? If yes, does the jurisdiction have generic legislation (law and/or regulations) for construction or building units and is the law describing the requirements for Plans of Survey in 3D? If yes, *ask for specific laws and article(s) or regulations and get copies of these*	Laws and regulations
7	Where do you think the 3-D boundaries in an apartment/retail space be: (a) the walls, floor and ceiling should be shared between adjacent properties with the limit of ownership being in the middle of the walls, floor and ceiling, or (b) the walls, floor/ceiling should be neutral space in 3D space, i.e. the property title would end at the wall, floor and ceiling. What advantages and disadvantages do you see for yourself with these two types of boundary?	Boundaries
8	Would it be advantageous in your legal opinion for there to be any limitations on the range of rights? (e.g. underground land parcels must be owned by Government).	Limitations
9	Do you have any further observations?	

C. Interview schedule for Licensed Surveyors (LSs):

No.	Question	Question categorized
1	From a professional point of view, I'd like to ask you to comment in the current Indonesian cadastral system? Do you know that Indonesia uses a 2D system and what a 2D cadastral system consists of? (*if they do not I will explain to them the aspects that they do not know or understand*) What are the advantages and limitations of the current 2D system in the job that you do? How they managed the improvement of the building and infrastructure development above and below land surface?	Understanding how the 2D cadastre is used and its advantages/limitations
2	From a professional point of view, I'd like to ask you to comment in the possible introduction of a 3D cadastral system in the future? Do you understand what 3-dimensional measurements are in respect of land and property surveying? (*If no, I need to explain*). Given your/this knowledge of 3-dimensional measurements, do you feel there is a need for 3-dimensional measurements rather than the current 2-dimensions? What would the advantages and disadvantages of 3-dimensions be in your opinion?	Need for a 3D cadastre.
3	If a 3-D surveying system were introduced for apartment blocks and office blocks, the land certificates would describe the floor plan (as they do at present) and room heights. In your professional opinion, what would be balance between the extra costs of obtaining such land certificates with the benefits that additional rights might guarantee?	Costs and benefits
4	Do any national or local laws and/or regulations exist for 3-D parcels? If yes, does the jurisdiction have generic legislation (law and/or regulations) for construction or building units and is the law describing the requirements for Plans of Survey in 3D? If yes, *ask for specific laws and article(s) or regulations and get copies of these*	Laws and regulations
5	Does your company undertake 3-D surveying, if not – why? If yes, what form of 3D data acquisition does your company use (prompts: *CAD, terrestrial surveying, sketches, stereo/oblique images, laser scanning*)? How accurate are the devices used for 3-D surveying?	3D data acquisition
6	***Only ask if the section is involved in 3-D survey/plans***: How is field data saved to the cadastral database after making 3D measurements? What spatial database is used? How can internal and external users visualize content? How is your cadastral database organised? (prompt: Multi-Layers or Object Oriented or another data model)	Current use, if any, and 3D aspects
7	***Only ask if the section is involved in 3-D survey/plans***: What software (GIS/CAD) is used for updating, editing, analysis, and visualization of the cadastral data? What 3D capabilities are used? Can 3D parcels be subdivided, consolidated or nullified? What web software is used for remote	Current use, if any, and 3D aspects

	data access/distribution and visualization? What 3D capabilities are used?	
8	***Only ask if the section is involved in 3-D survey/plans***: Are the 3D parcels checked for spatial validity? (prompts: *volume is closed, does not overlap with neighbouring volume, no unwanted 3D gaps*)?	Current use, if any, and 3D aspects
9	***Only ask if the section is involved in 3-D survey/plans***: How is 3D cadastral information presented on current legal documents? (prompts: *map, certificate, software, web*). In what format are the 3-D parcels submitted for registration?	Current use, if any, and 3D aspects
10	***Only ask if the section is involved in 3-D survey/plans***: Do you have an example of typical 3D parcels; either 'prototype' or 'operational'? How about 3D parcels of the network model? If the network object passes through the surface of the parcels, how do you cope on parcels that overlap each other?	Example
11	Where do you think the 3D boundaries in a unit space be: (a) the walls, floor and ceiling should be shared between adjacent properties with the limit of ownership being in the middle of the walls, floor and ceiling, or (b) the walls, floor/ceiling should be neutral space in 3D space, i.e. the property title would end at the wall, floor and ceiling. What advantages and disadvantages do you see with these two types of boundary?	Boundaries
12	Is there a technical circular or directive to assist surveyors in 3D data collection? *Ask for a copy*	Technical directions
13	From a technical viewpoint, what other advantages or disadvantages could you foresee with 3D survey systems if they were introduced in Indonesia?	
14	Do you have any further observations?	

D. Interview schedule for Property Managers:

No.	Question
1	I would like to ask you some questions about the property that you manage: I would like you to answer these in your capacity as a property manager? First, does your company have a land certificate for the entire property or do individual units within the building have land certificates. Does they do these land certificates guarantees property rights for your company and/or individual owners (if they exist); and does this have details of the size of the property/space? If your company rents apartments and units in the building, do the rental agreements does this have details of the size of the property/space? Is your company satisfied with the information that you have on the land certificates, if not what other information would you like to see on land certificates?
2	Do you understand what 3-dimensional measurements are in respect of land and property surveying? (*If no, I will explain*). Given your/this knowledge of 3-D survey, do you feel there is a need for 3-D survey rather than the current 2-D surveys? What would the advantages and disadvantages of 3-D be in your opinion, and how might this be reflected on land certificates or in rental agreements?
3	If a 3-D land surveying system were introduced for buildings such as the one you manage, the land certificates would describe the floor plan (as they do at present) and heights. How would you as a manager/or your company balance the extra cost of obtaining such a land certificate with the benefits that additional rights might guarantee for your company and for owners/tenants?
4	Where do you think the 3-D boundaries in an apartment/retail space be: (a) the walls, floor and ceiling should be shared between adjacent properties with the limit of ownership being in the middle of the walls, floor and ceiling, or (b) the walls, floor/ceiling should be neutral space in 3D space, i.e. the property title would end at the wall, floor and ceiling. What advantages and disadvantages do you see for yourself with these two types of boundary?
5	Now some short questions: (a) Who owns the common property (e.g., lobby, mezzanine, store rooms) inside the apartment or office building/retail centre you manage? (b) Who owns the land on which the building is built? (c) Do you manage the below ground level spaces (e.g. underground car parks), if not who owns or manages this space? (d) What is the lot numbering convention for units in this building? (e) To your knowledge have their been any conflict between property renters/owners and the renters/owners in adjacent units (above, below or on the same floor) or boundary disputes? If so, was a resolution reached? If yes, *I will ask them to expand on this* *Ask if I can have a copy of the property plans.*
6	From the viewpoint of the industry in which you work (property management), what other advantages or disadvantages could you foresee with 3D survey systems if they were introduced in Indonesia?
7	Do you have any further observations? *Thank them for their time and leave my contact details.*

E. Interview schedule for Owners/Renters:

No.	Question
1	I would like to ask you some questions about the property that you own or rent? First, do you own or rent this apartment/retail space/office space? Do you have a land certificate that guarantees your property rights and does this have details of the size of the property/space? Are you satisfied with the information that you have, if not what other information would you like to see on land certificates or rental agreements?
2	Do you understand what 3-dimensional measurements are in respect of land and property surveying? (*If no, I will explain*). Given your/this knowledge of 3-D survey, do you feel there is a need for 3-D survey rather than the current 2-D surveys? What would the advantages and disadvantages of 3-D be in your opinion, and how might this be reflected on land certificates or rental agreements?
3	If a 3-D land surveying system were introduced for buildings such as the one you live/work, the land certificates would describe the floor plan (as they do at present) and heights. How would you balance the extra cost of obtaining such a land certificate with the benefits that additional rights might guarantee?
4	Where do you think the 3-D boundaries in an apartment/retail space be: (a) the walls, floor and ceiling should be shared between adjacent properties with the limit of ownership being in the middle of the walls, floor and ceiling, or (b) the walls, floor/ceiling should be neutral space in 3D space, i.e. the property title would end at the wall, floor and ceiling. What advantages and disadvantages do you see for yourself with these two types of boundary?
5	Now some short questions: (f) Who owns the common property (e.g., lobby, mezzanine, store rooms) inside your apartment or office building/retail centre? (g) Who owns the land on which the building is built? (h) Do you know if any below ground level spaces (e.g. underground car parks) are owned by different people to those who own the land and the building above ground level)? (i) What is the lot numbering convention for units in this building? (j) Have you ever had conflict with yours neighbours directly adjacent (above, below or on the same floor) or boundaries and, if so, was a resolution reached? If yes, *I will ask them to expand on this*
6	From a personal viewpoint, what other advantages or disadvantages could you foresee with 3D survey systems if they were introduced in Indonesia?
7	Do you have any further observations? *Thank them for their time and leave my contact details.*

Appendix 5.1 Question about 2D CADASTRE ISSUE

Table

	2D1	2D2	2D3
C1	1b	1c	1d
C2	1b	1c	1d
C3	1b	1c	1d
C4			
C5			

List of question related to 2D Cadastre Issue

Qcode	Questions
2D1	Do you know that Indonesia uses a 2-dimensional survey and cadastral system, and do you know what a 2D cadastral system consists of?
2D2	What are the advantages and limitations of the current 2D system in the job that you do?
2D3	How do you manage improvements to buildings and infrastructure developments above and below the land surface?

Appendix 5.2 Questions about Legal Frameworks

Table

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16
C1			5a	5b	13a	14	15								4a	
C2	5a	5b	6a	6b	7a	8										
C3			4a	4b	11a		12									
C4					4a			1a	1b	1c	5a	5b	5c	5d	5e	5f
C5					4a				1a		5a	5b	5c	5d	5e	5f

List of questions related to Legal Frameworks

Qcode	Questions
L1	In your legal opinion, would 3-dimensional plans ensure better legal certainty of land rights compared to 2-D?
L2	What other legal benefits accrue from 3-dimensional measurements?
L3	Do any national or local laws and/or regulations exist for 3-D parcels?
L4	If yes, does the jurisdiction have generic legislation (law and/or regulations) for construction or building units and is the law describing the requirements for Plans of Survey in 3D? If yes, ask for specific laws and article(s) or regulations and get copies of these.
L5	Where do you think the 3-D boundaries in an apartment/retail space be: (a) The walls, floor, and ceiling should be shared between adjacent properties with the limit of ownership being in the middle of the walls, floor, and ceiling, or (b) The walls, floor/ceiling should be neutral space in 3D space, i.e. the property title would end on the wall, floor and ceiling.
L6	Would it be advantageous in your legal opinion for there to be any limitations on the range of rights? (E.g. underground land parcels must be owned by Government).
L7	Is there a technical circular or directive to assist surveyors in 3D data collection? Ask for a copy

L8	I would like to ask you some questions about the property that you manage: I would like you to answer these in your capacity as a property manager? First, does your company have a land certificate for the entire property or do individual units within the building have land certificates.
L9	Does they do these land certificates guarantees property rights for your company and/or individual owners (if they exist); and does this have details of the size of the property/space?
L10	If your company rents apartments and units in the building, do the rental agreements does this have details of the size of the property/space?
L11	Who owns the common property (e.g., lobby, mezzanine, store rooms) inside your apartment or office building/retail center?
L12	Who owns the land on which the building is built?
L13	Do you know if any below ground level spaces (e.g. underground car parks) are owned by different people to those who own the land and the building above ground level)?
L14	What is the lot numbering convention for units in this building?
L15	Have you ever had conflict with yours neighbours directly adjacent (above, below or on the same floor) or boundaries?
L16	Was a resolution reached? Please explain more

Appendix 5.3 Question about Human Resources

Table

	HR1	HR2	HR3	HR4	HR5	HR6	HR7	HR8	HR9	HR10	HR11	HR12	HR13	HR14	HR15	HR16	HR17	HR18	HR19	HR20	HR21	HR22	HR23
C1	6b	6c	7a	7b	7c	7d	7e	7f	8a	8b	8c	8d	9a	9b	9c	9d	9e	10	11a	11b	12a	12b	6a
C2																							
C3	5b	5c							6a	6b	6c	6d	7a	7b	7c	7d	7e	8	9a	9b	10a	10b	5a
C4																							
C5																							

List of questions related to Human Resources

Qcode	Questions
HR1	How is 3D data acquisition acquired (prompts: CAD, terrestrial surveying, sketching, stereo/oblique images, and laser scanning)?
HR2	How accurate are the measurements?
HR3	What software do you use for creating and processing survey plans (in 2D or 3D)?
HR4	Do the plans of the survey show X/Y coordinates and are they relative or in an absolute spatial reference system?
HR5	What spatial reference system is used?
HR6	Are the cadastral coordinates authoritative? If not, what is the source?
HR7	What 3-D capabilities in the software are used? Are the z (height) coordinates of 3D parcels relative to the local ground?
HR8	Are z coordinates reduced to a standard datum?
HR9	How is field data saved to the cadastral database after making 3D measurements?
HR10	What spatial database is used?
HR11	How can internal and external users visualize content?
HR12	How is your cadastral database organized? (prompt: Multi-Layers or Object Oriented or another data model)
HR13	What software (GIS/CAD) is used for updating, editing, analysis, and visualization of the cadastral data?
HR14	What 3D capabilities are used?
HR15	Can 3D parcels be subdivided, consolidated or nullified?

Qcode	Questions
HR16	What web software is used for remote data access/distribution and visualization?
HR17	What 3D capabilities are used?
HR18	Are the 3D parcels checked for spatial validity? (Prompts: volume is closed, does not overlap with neighboring volume, no unwanted 3D gaps)?
HR19	How is 3D cadastral information presented on current legal documents? (Prompts: map, certificate, software, the web).
HR20	In what format are the 3-D parcels submitted for registration?
HR21	Do you have an example of typical 3D parcels; either 'prototype' or 'operational'?
HR22	How about 3D parcels of the network model? If the network object passes through the surface of the parcels, how do you cope on parcels that overlap each other?
HR23	Does your company undertake 3-D surveying, if not – why?

Appendix 5.4 Question about Organization

Table

	O1	O2	O3
C1	6a	6b	6c
C2			
C3	5a	5b	5c
C4			
C5			

List of questions related to Organization

Qcode	Questions
O1	Are 3-D measurements currently being performed in your organization?
O2	Is there any specific department which manage 3D Cadastre?
O3	Is there any problem with the organisational structure in your company?

Appendix 5.5 Question about public awareness

Table

	PA1	PA2	PA3	PA4
C1	2c	3	16	
C2	2c	3		
C3	2c	3	13	
C4	2b	3	6	1d
C5	2c	3	6	1b

List of questions related to public awareness

Result

Qcode	Questions
PA1	Given your/this knowledge of 3-D measurements, do you feel there is a need for 3-D measurements rather than the current 2 dimensions?
PA2	In your professional opinion, what would be a balance between the extra costs of obtaining such land certificates with the benefits that additional rights might guarantee?
PA3	What other advantages or disadvantages could you foresee with 3D survey systems if they were introduced in Indonesia?
PA4	Is your company satisfied with the information that you have on the land certificates, if not what other information would you like to see on land certificates?

5.6 Questions about 3D Issues

Table

	3D1	3D2	3D3	3D4	3D5	3D6	3D7
C1	2a	2b	2c	2d	3	4a	4b
C2	2a	2b	2c	2d	3	4a	4b
C3	2a	2b	2d	2d	3		
C4		2a	2b	2c	3	5e	5f
C5		2a	2b	2c	3	5e	5f

List of questions related to 3D issues

Qcode	Questions
3D1	From a professional point of view, I'd like to ask you to comment on the possible introduction of a 3-dimensional cadastral system in Indonesia the future?
3D2	Do you understand what 3-D measurements are in respect of land and property surveying?
3D3	Given your/this knowledge of 3-D measurements, do you feel there is a need for 3-D measurements rather than the current 2 dimensions?
3D4	What would the advantages and disadvantages of 3 dimensions be in your opinion?
3D5	In your professional opinion, what would be a balance between the extra costs of obtaining such land certificates with the benefits that additional rights might guarantee?
3D6	In your work, have you experienced conflicts between property owners and renters that are based around for 3-dimensional aspects of their properties (floor plan and height) rather than simply floor plan?
3D7	If so, was a resolution reached? Please explain more

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