Modeling Spatial Units Class for Spatial Planning map for the future of ISO 19152 on Land Administration Domain Model (LADM)

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ABSTRACT

The International Standards Organization (ISO) published ISO 19152:2012 on The Land Administration Domain Model (LADM) aims to provide guidelines to develop a 3D spatial representation of Rights, Restrictions, and Responsibilities (RRRs). The multidimensional representation is useful for improving stakeholders' ability to understand the relationship between land and people. In 2017, the working group on LADM revision proposed extension of the standard by integrating land valuation and spatial planning information into its scope. The spatial planning information package proposed in LADM revision facilitates RRRs derived from spatial planning by reusing information defined in zoning regulation. Knowing that land administration and land management are matters, we examine the process of how to manage RRRs information from spatial planning and to publish it trough 3D web GIS. This paper aims to present the method for integrating land use and land development aspects in land management and visualize its RRRs with real data of Bandung City, Indonesia.

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1 INTRODUCTION

Land management plays a significant role in solving the challenges faced in most countries (The World Bank 2006). Since 1997, the International Federation of Surveyors (FIG), in collaboration with international bodies, has initiated global calls for land administration and land management. The joint UN-FIG Bathurst Declaration on Land Administration for Sustainable Development acknowledged the interlinkage between four functions of land management: land markets, land registration, spatial planning and valuation (Williamson & Grant 2002). Consequently, these four functions should be managed within the Land Administration System (LAS) for supporting countries (and cities) in achieving sustainable development. Enemark et al. (2005) proposed this interconnection as the "*Land Management Paradigm*." Further, they recommend countries to modernize their LAS for handling the land management functions to manage information about the relationship between land and people. International Federation of Surveyors (FIG) discussed the type of information to describe the relationship between land and people comprehensively in Cadastre 2014 initiative (Kaufmann & Steudler 1998). Eight years later, Bennet et al. (2006) introduced the term RRRs (Rights, Restrictions and Responsibilities). UN-Habitat (2017) recommends spatial planning to include collective values, form and functionality of land and space towards smart and sustainable development. Cities define criteria for each land and space and relate them with prescribed RRRs information sourced from the spatial planning process. Therefore, the interoperability of RRRs information on land management functions is needed to make land management and land administration efficient and effective (Kaufmann & Steudler 1998, Enemark 2006, Kalantari et al. 2006 and Onsrud 2010).

The International Standards Organization (ISO) published ISO 19152:2012 on The Land Administration Domain Model (LADM) to provide an extensible foundation for interoperability in making LAS efficient and effective (Lemmen & Van Oosterom 2011). LADM also provides guidelines to develop a 3D spatial representation of RRRs for a better understanding of the relationship between land and people. Starting in 2017, LADM is revised and extended by integrating land valuation and spatial planning information into its scope. The spatial planning information package proposed in LADM revision facilitates RRRs derived from spatial planning by reusing information defined in zoning regulation, including restriction (in the form of specification) imposed on activities or physical construction on each land or space (Lemmen et al. 2019). Knowing that land administration and land management are matters that involve experts and non-experts from many disciplines[1], we present the process of how to manage RRRs information from spatial planning and to publish it trough 3D web GIS. We implement action design research in this paper to answer how to manage 3D RRRs information from the spatial planning process based on the LADM standard and to make it accessible to broader society. In the second section, we present the reconstruction of RRRs from spatial planning. The third section is discussing the spatial planning information package in LADM revision. The implementation process of representing 3D RRRs from the spatial plan using this package is described in the fourth section. The last section presents conclusions and recommendations for

[1] https://en.geofumadas.com/recomendaciones-al-momento-implementar-ladm/

future research. We dedicate this paper to planners, local governments, mapping authorities, and LAS developers in integrating land use and land development aspects in land management into their LAS.

2 SPATIAL PLANNING AND RRR

Spatial planning establishes institutional frameworks and regulatory processes that provide necessary infrastructure (e.g., roads and utility networks) and regulates the construction and use of land or space (Sliuzas et al. 2010). UN-Habitat (2015) defines spatial (urban and territorial) planning as "*a decision-making process aimed at realizing economic, social, cultural and environmental goals through the development of spatial visions, strategies and plans and the application of a set of policy principles, tools, institutional and participatory mechanisms, and regulatory procedures*." There is an increasing trend of using a holistic approach in spatial planning for integrating ranges of interlinked sectors, strategies, and policies concerning social, economic, and environmental aspects to achieve sustainable development (Biesbroek et al. 2009). Authorities develop spatial planning to establish zoning regulations that shape and regulate land and space. Spatial planning can also be considered as a mechanism to manage the supply of land for ranges of interests (Jacob 1993). In this mechanism, zoning regulation populates and accommodates every aspect that influences physical development and land, including advising preferred functions and activities on land or space to authorities (Fischel 2000). Although spatial planning is one of the most critical methods for local government in managing resources of the land to put into good effect, not all countries standardized their spatial planning information. Baross (1987) classifies spatial (urban) planning into two phases: city development and site development. The city development plan consists of land use planning, infrastructure planning, and land assembly. Site development planning covers site plan/land use allocation, local servicing infrastructure, construction of the building, and occupation planning.

Citywide and site development plan requires different specifications for spatial representation for planning, controlling, and monitoring purposes. Hierarchy in spatial planning classifies it into territorial levels with a degree of coherence between them (Hall & Tewdwr-Jones 2010). In a top-down approach, zoning plans shall comply with sector (national) regulations (i.e., Environment Act, Disaster management Act). At the lowest level, the zoning plan must be aligned with the planning decisions at upper levels (Pissourios 2014) by providing guidelines and criteria for each lot. Sectoral regulation specifies criteria for a particular area, which can be classified as RRRs information. For example, the Environment Act regulates RRRs for natural conservation zone which is different from industry. Thus, each lot (contains single or more land parcels) has RRRs information. This paper assumes the developed zoning plans are already accommodating all sectoral regulations or policies.

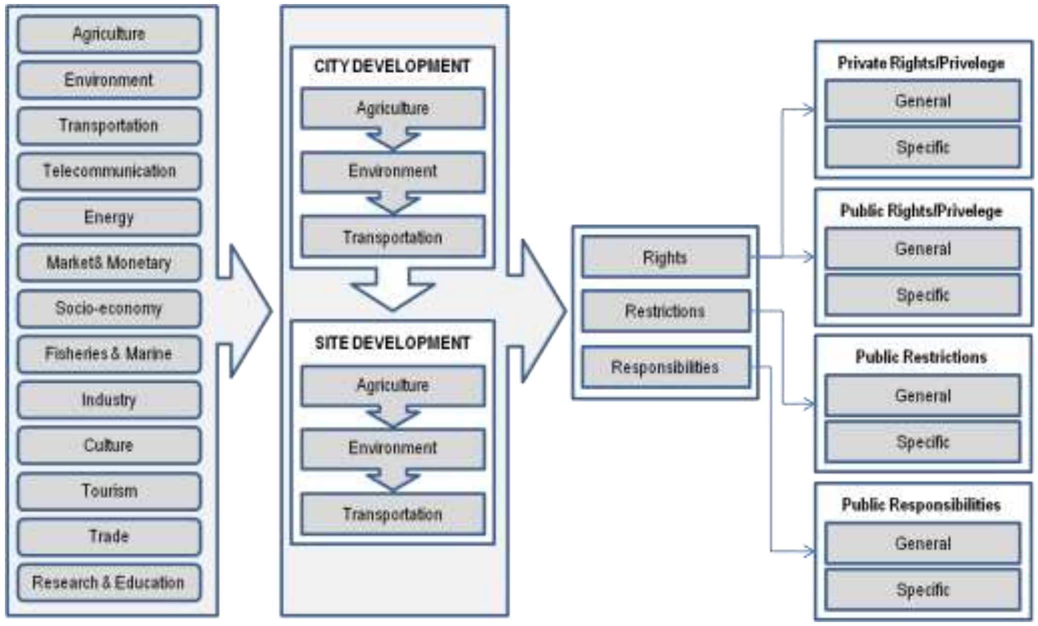

Figure 1. RRR derived from Holistic Spatial Planning Processes using LADM.
(Adapted from Barros 1987, and Paasch 2012)

Zoning regulation is resulted from the complicated process of sectoral policy integration at the regional and local levels to achieve sustainable development (Healey 2006 and Schmidt-Thomé et al. 2005) that may influence property rights and value (Van der Molen 2015). Zoning regulation confers the function of land or space (i.e., residential, industry, commercial, green space or public space) to landowners in the form of RRRs. Some cities prescribe indications, for example, height or depth as multidimensional restrictions, schedule or interval as temporal restrictions, more/fewer taxes as financial responsibilities, or additional regular reporting of usage as conservation responsibility, or any conditional use in its zoning regulation. Therefore, RRRs need to have 3D spatial representation to provide clear and transparent information supporting decision-making for all stakeholders. Paasch (2012) introduces the extension into RRRs classification. The extension consolidates rights as private and public privileges and restrictions and responsibilities for public classes. Restrictions in this classification are the limitation of performing specific activities on land/property or space. Responsibilities refer to necessary actions to be executed by landowners. In some cases, public laws may also grant a privilege (permission/rights/dispensation) to a landowner in conducting certain activities (see Figure 1). This paper will present the standardization of spatial planning information using ISO 19152:2012 in the next section.

3 SPATIAL PLANNING INFORMATION PACKAGE IN LADM

In European countries, a spatial plan is classified as "*a set of documents that indicates a strategic direction for the development of a given geographic area, states the policies, priorities, programs and land allocations that will implement the strategic direction and influences the distribution of people and* *activities in spaces of various scales.*[2]" Spatial representation of city development is at map scale 1: 10,000-1:25,000 (or in Level Of Detail/LOD 0) aiming for describing land use, existing conditions, and primary infrastructure (Sliuzas et al. 2010). The site development plan shall be represented spatially with maps at scale 1:500 to 1:1,000. However, in developing countries or emerging economies, such as Indonesia and Thailand, the Spatial Planning Act may specify spatial representation at map scale 1:5,000 (Bishop et al. 2000 and Moeliono 2011).

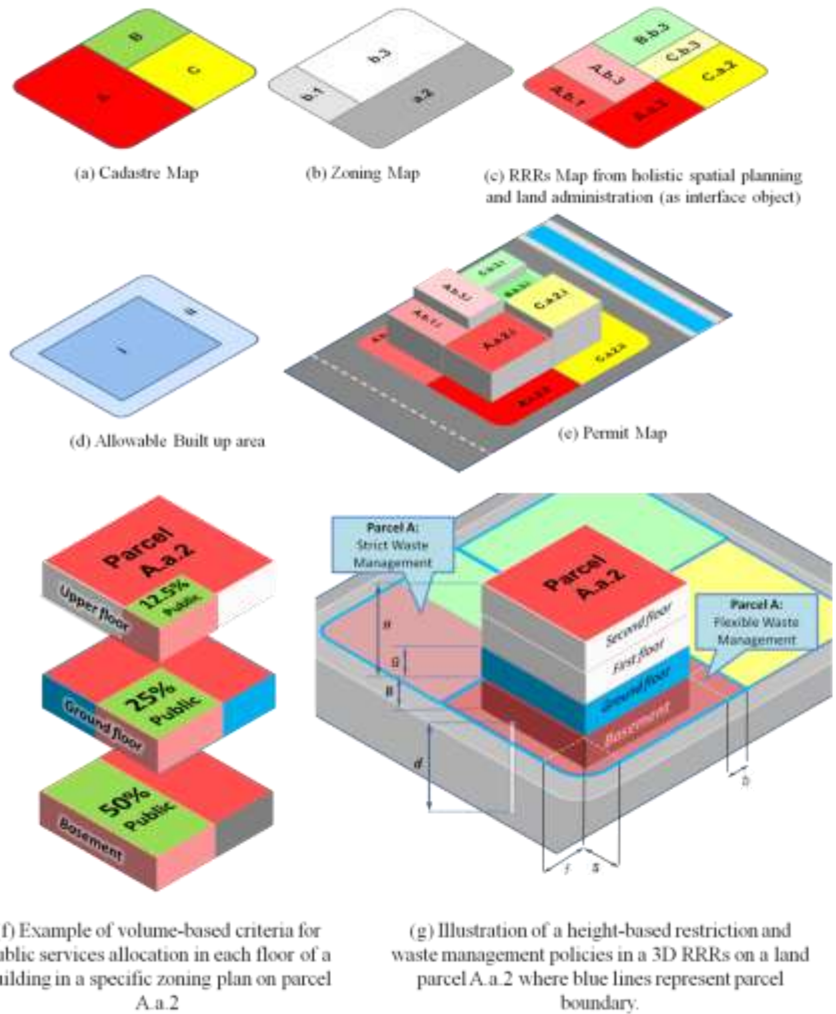

Figure 2. Construction of 3D representation of RRRs from spatial planning and cadastre (Indrajit et al. 2020).

[2] https://inspire.ec.europa.eu/featureconcept/SpatialPlan

In developing a 3D spatial plan for the city with complicated urban settings, land parcel maps (Figure 3.a) and the zoning plan (Figure 3.b) may confer various types of restrictions and responsibilities on a land parcel or even sub-parcel (Figure 3.c). In this case, information about restrictions derived on zoning regulation (e.g., residential, commercials, industry). Authorities use distances from land parcel boundary for delineating buildable area (Figure 3.d). A 3D buildable space can be constructed by integrating height or depth from '*height indication*' sourced from zoning regulation (Figure 3.e). A 3D representation of the spatial plan can be useful in the city's permit system or urban planning monitoring system. The 3D RRRs information can be integrated with other information sourced from zoning regulation Integration of four aspects of land management will benefit stakeholders in understanding RRRs in 3D visualization, such as building height limits (H), ground floor height (G), basement depth (B), groundwater access depth limit (d). The integration can also facilitate the prescription of an area that can be built on a specific land parcel, side free distance (s), distance to road centerline (r), front free distance (f), and back free distance (b) (see Figure 3.g).

Spatial Planning Information (SP) Package used in this paper is still under development and will be included in the LADM revision. This package is the continuation of the progress made by INSPIRE's land use data model (INSPIRE 2012) and the Plan4All project (Čerba 2010). This package employs the existing data modeling of the spatial planning information with improvement in three following areas: multidimensional (3D) spatial representation, interrelation to administrative sources, and integration of RRRs from land tenure, land valuation, and land development. The SP package has three main classes, which are *SP_PlanningBlock*, *SP_PlanningGroup*, and *SP_PlanningUnit* (Figure 3). The *SP_PlanningUnit* contains zoning plans from urban or detailed planning. This class is *featureType*, where specific functions and indications are stored. *SP_PlanningBlock* class accommodates RRRs information derived from the upper spatial plan resulted from spatial planning processes in upper levels in the hierarchy. *SP_PlanningGroup* class accommodates aggregation and hierarchy of spatial planning from all levels of spatial planning, namely national plan, provincial plan, and city/municipality plan.

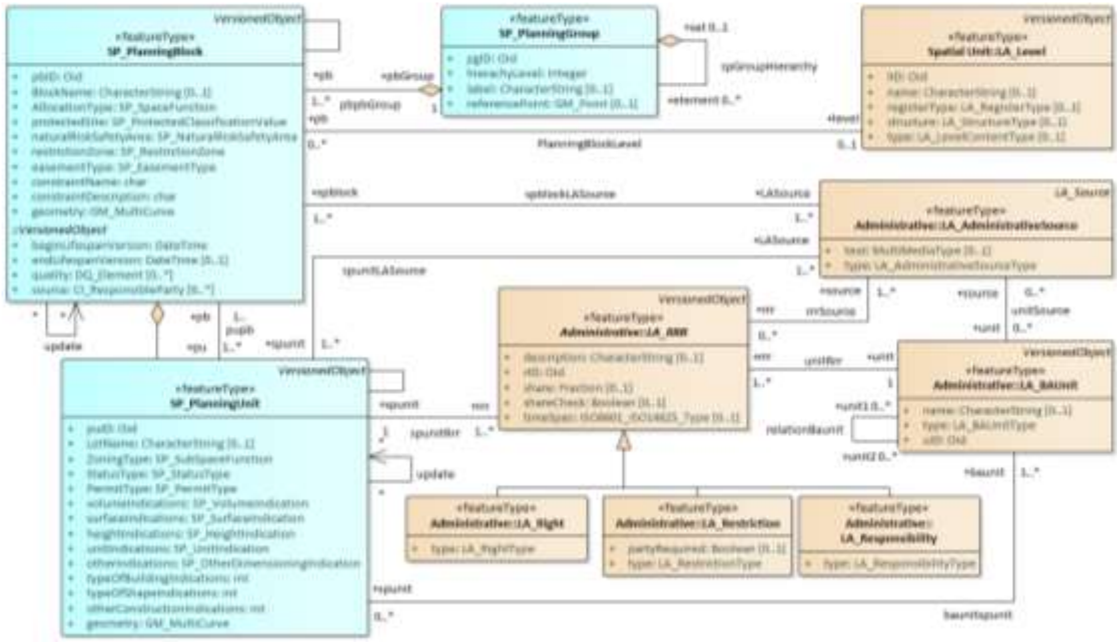

Figure 3. Classes in spatial planning information package (SP_PlanningBlock, SP_PlanningUnit, and SP_PlanningGroup) and their relationship in constructing RRRs from spatial planning (Indrajit et al. 2020)

A 3D spatial representation for urban information models is useful to integrate time, cost, accessibility, sustainability, and maintainability requirements (Hamilton et al. 2005). The use of 3D visualization is increasing in cities around the world (Köninger & Bartel, 1998; Gröger & Plümer, 2012; and Batty 2018). Open Geospatial Consortium (OGC) publishes CityGML for enabling users to employ virtual 3D city models for advanced analysis and visualization. CityGML specifies geometry, topology, semantics and appearance of objects in urban or regional contexts (Gröger & Plümer 2012). CityGML standards aim to improve information interoperability for exchanging data through the web and Spatial Data Infrastructures (SDI) (Kolbe et al. 2005). The stable version and already implemented in many software is CityGML 2.0. CityGML provides three classes in the form of attributes that can be used for incorporating spatial planning information: class, function, and usage. OGC regulate Land used to be defined geometrically in GML3 *MultiSurface* and can be represented in all type of LOD (LOD 0-4). Spatial planning is partly accommodated in CityGML as in thematic model-land (Groeger et al. 2012). Spatial planning information is partly accommodated as (future) land use in CityGML. Therefore we add more attributes according to the SP package. Although in theory, land use has a different concept than the land cover, CityGML version 2 regarded these concepts into the land-use model. In 2018, Kutzner & Kolbe (2018) reported that the next version of CityGML (version 3.0) contains improvement and will better accommodating many standards, including for LADM. The next standard will update the previous LOD concept and core model with the addition of construction and versioning modules. This standard contains thematic models to represent class definition for types of city objects within the 3D city model. We attached *LandUseType* and *LandUse* classes from OGC in XML format with code lists in the appendix.

4 VISUALIZING 3D RRRS INFORMATION FOR SPATIAL PLANNING IN BANDUNG CITY, INDONESIA

This paper attempts to analyze the usefulness and level of difficulty in implementing SP Package. We acquired zoning regulation documents and detailed spatial plan of Bandung City from the local authority. Bandung City is the capital of West Java province. It is Indonesia's fourth most populous city, with 2.5 million inhabitants in 168 km^2 (BPS 2019). Bandung is located 768 meters above sea level on a river basin surrounded by volcanic mountains that provides a natural defense system. Bandung City applies height indication on each lot that limits (restrictions) landowners and developers in constructing a building. The height restriction is aiming for complying with safety regulations, aesthetics, land management strategies and other public interests[3].

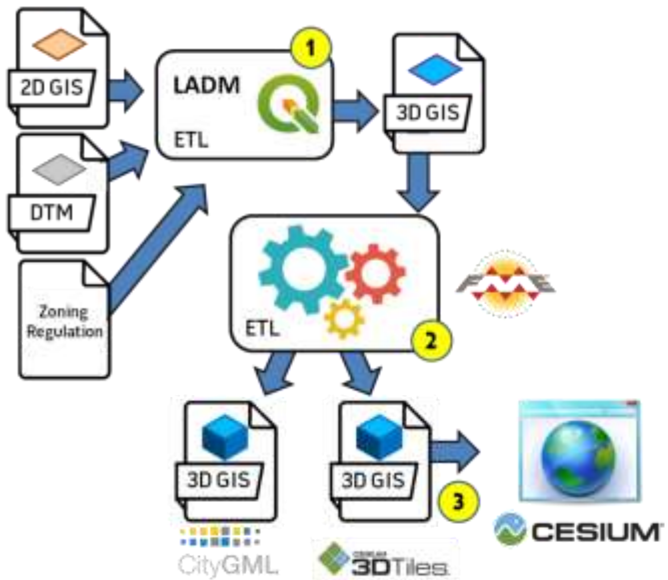

Figure 4. The workflow of developing a 3D representation of RRRs from the 2D spatial plan: (1) 3D surface conversion; (2) 3D solid conversion; and (3) 3D visualization

The available zoning plan is in a 2D shapefile format containing 6,964 zones for the entire Bandung City. We use Quantum GIS and FME software to construct 3D representation by extruding with height indication sourced from zoning regulation. In this process, we transform the result in CityGML format by adding spatial information specified in SP Package. We assign elevation data from DTM data provided by the Geospatial Information Agency (Badan Informasi Geospasial/BIG) for creating a 3D surface. The 3D spatial plan is constructed using the height value sourced from building regulation under Local Regulation No. 5/2010 and zoning regulation under Local Regulation No 10/2015. There are two end products: CityGML and Batched 3D model (b3dm) formats containing the same3D spatial plan representation (Figure 6). We implement LOD1 (Multisurface) for CityGML format to comply with OGC standards. The

3 http://jdih.setjen.kemendagri.go.id/files/Kota_Bandung_5_2010.pdf

land-use model of CityGML was implemented for accommodating planners that familiar with its standard. We provide b3dm format for 3D visualization through the web using Cesium® to allow users to view it in 3D visualization (Figure 5) interactively.

5 CONCLUSION

This main objective of this research is to analyze the implementation of the Spatial Planning Information Package in LADM revision for creating a 3D representation of RRRs from spatial planning by using real data (Bandung City). Two key areas are analyzed in this research: Complexity and Interoperability.

5.1 Complexity

This paper presents the creation of 3D RRRs information in a standardized format specified in Spatial Planning Information (SP) Package from the existing 2D spatial map. We present how to make the 3D representation of RRRs in 3 steps: 3D surface conversion, 3D solid conversion, and 3D visualization. Transforming existing spatial plans into 3D representation can be straightforward (not complicated) with the advancement of geoinformation technology. This package will be capable of assists planners in representing RRRs information from the spatial planning process together with land tenure, land valuation, and land development. We experience no (or minimal) difficulty in implementing Spatial Planning Information Package from LADM and for constructing 3D RRRs representation and visualize it through the 3D web. However, planners and developers may face challenges in assigning height in the spatial planning process. So far, only a few cities are implementing 3D spatial planning despite treating land and space as a multidimensional object.

5.2 Interoperability

This study acknowledges the importance of interoperability of spatial planning information to improve understandability and to allow re-use of information for broader application. We conclude that SP Package will improve semantic interoperability. By using LADM and common standards (CityGML and b3dm), technical interoperability can be achieved. Both semantic and technical interoperability enables spatial planning information to be machine-readable and machine-actionable. Our approach uses the open standard that can be processed through commercial software (FME and Cesium) or Open Source software (Quantum GIS), which are readily available in the market or downloaded through the internet.

5.3 Future works

The improvement (refinement and extension) of LADM opens a wide area of research and implementation, particularly in standardizing, managing and visualizing spatial plan (and zoning plan) around the world. We recommend city planners to implement this package for making their spatial plan standardize as well as providing 3D representation and publish it through the 3D web for improving outreach to broader society. We hope that in the future, research in the management of 4D spatial plan information and its visualization can emerge using spatial planning information package from the LADM revision.

Figure 5. Visualization of 3D Spatial Planning in Bandung City, Indonesia. Height sourced from indication regulated in Zoning regulation.

REFERENCE

Badan Pusat Statistik (BPS) (2019) Kota Bandung Dalam Angka 2019. Badan Pusat Statistik. Jakarta. ISSN: 0215.2320

Baross P (1987) Land supply for low income housing: issues and approaches. Regional Development Dialogue 8(4):29–45

Bennett, R., Wallace, J., & Williamson, I. (2006). Managing rights, restrictions and responsibilities affecting land. Combined 5th Trans Tasman Survey Conference & 2nd Queensland Spatial Industry Conference 2006, 18-23 September 2006. Cairns, Australia.

Biesbroek, G. R., Swart, R. J., & Van der Knaap, W. G. (2009). The mitigation–adaptation dichotomy and the role of spatial planning. Habitat international, 33(3), 230-237.

Bishop, I. D., Escobar, F. J., Karuppannan, S., Suwarnarat, K., Williamson, I. P., Yates, P. M., & Yaqub, H. W. (2000). Spatial data infrastructures for cities in developing countries: Lessons from the Bangkok experience. Cities, 17(2), 85-96.

Čerba, O. (2010). Conceptual Data Models For Selected Themes. Plan4All. ECP-2008-GEO-318007. eContentplus. ECP-2008-GEO-318007

Enemark, S., Williamson, I., & Wallace, J. (2005). Building modern land administration systems in developed economies. Journal of Spatial Science, 50(2), 51-68.

Enemark, S. (2006). Spatially Enabled Land Administration–Bridging the Gap. In International Conference of the Global Spatial Data Infrastructure. 6-10 November 2006, Santiago, Chile.

Fischel, W. A. (2000). Zoning and land use regulation. Encyclopedia of law and economics, 2, 403-423.

Gröger, G., Kolbe, T. H., Nagel, C., & Häfele, K. H. (2012). OGC City Geography Markup Language (CityGML) encoding standard. Version 2.0. OGC 12-019. Open Geospatial Consortium.

Gröger, G., & Plümer, L. (2012). CityGML–Interoperable semantic 3D city models. *ISPRS Journal of Photogrammetry and Remote Sensing*, *71*, 12-33.

Hall, P., & Tewdwr-Jones, M., 2010. Urban and Regional Planning. Routledge.

Hamilton, A., Wang, H., Tanyer, A. M., Arayici, Y., Zhang, X., & Song, Y. (2005). Urban information model for city planning. Journal of Information Technology in Construction (ITCon), 10(6), 55-67.

Healey, P. (2006). Urban complexity and spatial strategies: Towards a relational planning for our times. Routledge.

Indrajit, A., van Loenen, B., Ploeger, H., & van Oosterom, P. (2020). Developing a spatial planning information package in ISO 19152 land administration domain model. Land Use Policy, 104111.

INSPIRE, 2012. Data Specification on Land Use – Draft Guidelines. D2.8.III.4. INSPIRE Thematic Working Group Land Use

Jacobs, M. (1993). Sense and Sustainability: Land Use Planning and Environmentally Sustainable Development: a Report. Council for the Protection of Rural England.

Kalantari, M., Rajabifard, A., Wallace, J., & Williamson, I. (2006). An interoperability toolkit for e-Land administration. Sustainability and Land Administration Systems, Department of Geomatics, Melbourne, 213-222.

Kaufmann, J., & Steudler, D. (1998). Cadastre 2014: A vision for a future cadastral system. Working Group 1 of FIG Commission 7.

Kolbe, T. H., Gröger, G., & Plümer, L. (2005). CityGML: Interoperable access to 3D city models. In Geo-information for disaster management (pp. 883-899). Springer, Berlin, Heidelberg.

Köninger, A., & Bartel, S. (1998). 3D-GIS for urban purposes. *Geoinformatica*, *2*(1), 79-103.

Kutzner, T., & Kolbe, T. H. (2018). CityGML 3.0: sneak preview. In PFGK18-Photogrammetrie-Fernerkundung-Geoinformatik-Kartographie, 37. Jahrestagung in München 2018 (pp. 835-839).

Lemmen, C., & Van Oosterom, P. J. M. (2011). ISO 19152-The Land Administration Domain Model. In 11th South East Asian Survey Congress (SEASC 2011) (pp. 22-24).

Lemmen, C. H. J., van Oosterom, P. J., Kara, A., Kalogianni, E., Shnaidman, A., Indrajit, A., & Alattas, A. (2019, October). The scope of LADM revision is shaping-up. In 8th Land Administration Domain Model Workshop 2019.

Moeliono, T. P. (2011). Spatial management in Indonesia: From planning to implementation. Leiden: Leiden University.

Paasch, J. (2012). Modelling Public Regulations-A Theoretical Approach. Nordic Journal of Surveying and Real Estate Research, 9(1).

Pissourios, I. A., 2014. Top-down and bottom-up urban and regional planning: Towards a framework for the use of planning standards. European spatial research and policy, 21(1), 83-99

Sliuzas, R., Kuffer, M., & Masser, I. (2010). The spatial and temporal nature of urban objects. In Remote sensing of urban and suburban areas (pp. 67-84). Springer, Dordrecht.

Schmidt-Thomé, P. (2005). The spatial effects and management of natural and technological hazards in Europe. Final Report of the European Spatial Planning and Observation Network (ESPON) project, 1(1), 1-197.

The World Bank (2006). Sustainable land management: Challenges, opportunities, and trade-offs. World Bank. Washington, DC. DOI: 10.1596/978-0-8213-6597-7.

UN-Habitat (2015). International guidelines on urban and territorial planning. HS/059/15E. United Nations Human Settlements Programme, Nairobi.

UN-Habitat (2016). New urban agenda. A/RES/71/256*. ISBN: 978-92-1-132731-1. United Nations. Quito, Ecuador.

Van der Molen, P. (2015). Property and administration: Comparative observations on property rights and spatial planning with some cases from the Netherlands. *Administration & society*, *47*(2), 171-196.

Williamson, I. P., & Grant, D. M. (2002). United Nations-FIG Bathurst Declaration on Land Administration for Sustainable Development: Development and Impact. FIG XXII International Congress. Washington, D.C. USA, April 19-26 2002.

APPENDIX

Tabel 1: LandUseType and LandUse classes in XML according to CityGML standards (Groeger et al. 2012).

```
<xs:complexType name="LandUseType">
    <xs:complexContent>
        <xs:extension base="core:AbstractCityObjectType">
            <xs:sequence>
                <xs:element name="class" type="gml:CodeType" minOccurs="0"/>
                <xs:element name="function" type="gml:CodeType" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element name="usage" type="gml:CodeType" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element name="lod0MultiSurface" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
                 <xs:element name="lod1MultiSurface" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
                <xs:element name="lod2MultiSurface" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
                <xs:element name="lod3MultiSurface" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
                <xs:element name="lod4MultiSurface" type="gml:MultiSurfacePropertyType" minOccurs="0"/>
                <xs:element ref="_GenericApplicationPropertyOfLandUse" minOccurs="0" maxOccurs="unbounded"/>
            </xs:sequence>
        </xs:extension>
    </xs:complexContent>
 </xs:complexType> <!--
========================================================================================== -->
<xs:element name="LandUse" type="LandUseType" substitutionGroup="core:_CityObject"/> <!--
========================================================================================== -->
<xs:element name="_GenericApplicationPropertyOfLandUse" type="xs:anyType" abstract="true"/>
```

Tabel 2: Code list of the LandUse attribute class based on CityGML standards (Groeger et al. 2012).

http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse_class.xml			
1000	Settlement Area	3000	Vegetation
1100	Undeveloped Area	4000	Water
2000	Traffic		

Tabel 3: Code list of the *LandUse* attributes *function* and *usage* based on CityGML standards (Groeger et al. 2012).

http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse_function.xml http://www.sig3d.org/codelists/standard/landuse/2.0/LandUse_usage.xml			
1010	Residential	2050	Track
1020	Industry and Business	2060	Square
1030	Mixed use	3010	Grassland
1040	Special Function Area	3020	Agriculture
1050	Monument	3030	Forest
1060	Dump	3040	Grove
1070	Mining	3050	Heath
1110	Park	3060	Moor
1120	Cemetery	3070	Marsh
1130	Sports, leisure and recreation	3080	Untilled land
1140	Open pit, quarry	4010	River
2010	Road	4020	Standing Waterbody
2020	Railway	4030	Harbour
2030	Airfield	4040	Sea
2040	Shipping		