Land Use Policy 98 (2020) 104111

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Developing a spatial planning information package in ISO 19152 land administration domain model

Agung Indrajit[a,c,*], Bastiaan van Loenen[b], Hendrik Ploeger[b], Peter van Oosterom[a]

[a] GIS Technology, Faculty of Architecture and Built Environment, TU Delft, the Netherlands
[b] Environmental Modelling, Department of Urbanism at Faculty of Architecture and Built Environment, TU Delft, the Netherlands
[c] Center for Spatial Data Management and Dissemination, Badan Informasi Geospasial, Indonesia

ARTICLE INFO

Keywords:
Land Administration Domain Model
Spatial planning
3D spatial planning
Spatial Information Infrastructure
RRRs

ABSTRACT

Cities establish and maintain Land Administration Systems (LAS) to manage information about the land and urban space. Recognizing the importance of the urban space for sustainable development, information from spatial planning will affect land administration and vice versa. Therefore, every aspect that influences land use, both from spatial planning and land administration should be identified, documented, and standardized as they contain legally binding rules for governments and citizens. The Land Administration Domain Model (LADM), ISO standard 19152:2012, offers guidelines to ensure interoperability in the representation of Rights, Restrictions, and Responsibilities (RRRs). LADM is also capable of standardizing multi-dimensional representation, including the temporal capability for documenting and visualizing all legal aspects of land use or space. This paper discusses how to construct interoperable information between the spatial plan and land administration. We present the standardization of spatial planning information and land administration as subsets of land-related information. The paper proposes the development of a spatial planning package within the existing LADM standard.

1. Introduction

Rapid urbanization leads to a rise in burdens on urban areas in an unprecedented way, pressing cities to improve their land management to maintain their economy on sustainable growth and at the same time to preserve social harmony and environmental sustainability. Anticipating this challenge, the UN (2015) puts land management at the center of its 2030 Agenda for Sustainable Development Goals (SDGs). As Corbett and Mellouli (2017) point out, urban areas should prepare to host the great battle of the SDGs. Indeed, nowadays many local governments adopt the sustainable cities model (Hall and Tewdwr-Jones, 2010) and a holistic view in integrating different priorities of spatial planning, using a triangular model of society, economy, and environment (Campbell, 1996). The identification of existing Rights, Restrictions, and Responsibilities (RRRs) of each stakeholder is essential in the spatial planning process (McLoughlin, 1969 and Enemark et al., 2014). For policymaking, governments at all levels also require a continuous inflow of land-related information to reflect the dynamism of land use in real-time.

This article presupposes that all stakeholders are entitled to have a complete view of land-related information sourced from both spatial planning and land administration. Therefore it is urgent to standardize this information to ensure interoperability and better integration. In 2012, the ISO standard 19,152:2012 – Geographic Information – Land Administration Domain Model (LADM) (Van Oosterom et al., 2013) was published, defining the basic information related components of land administration and their impact to RRRs. LADM aims to provide a guideline to develop and maintain the Land Administration System (LAS) to support national and local objectives, including spatial planning (Lemmen et al., 2013). One of the primary objectives of LADM is to document RRRs of those who are entitled to or have an interest in land or spaces. However, the LADM does not address an important source of RRRs: the spatial plan. This article proposes the integration of the RRRs information from the spatial plan, as an additional package, into the LADM. We study several initiatives in the standardization of RRRs information in European countries and Indonesia as case studies. In Section 2, we introduce a holistic perspective on spatial planning in integrating sectoral policies. The State of the Art of LAS and its relation to spatial planning is described in Section 3. We present our findings and the design of a spatial planning package for LADM in Section 4. In Section 5, the proposed package is discussed and a country profile is presented as an example of the implementation of the spatial planning

* Corresponding author at: GIS Technology, Faculty of Architecture and the Built Environment, TU Delft, Julianalaan 134, 2628 BL, Delft, the Netherlands.
E-mail address: A.Indrajit@tudelft.nl (A. Indrajit).

https://doi.org/10.1016/j.landusepol.2019.104111
Received 19 April 2019; Received in revised form 20 July 2019; Accepted 23 July 2019
Available online 22 January 2020

package provided. Section 6 concludes this paper.

2. Sectoral integration in spatial planning: a holistic viewpoint

Spatial planning facilitates the integration of multisectoral policies, such as socio-economic and environmental considerations across a range of human activities (Biesbroek et al., 2009) to meet development goals. In practice, spatial planning using the holistic approach for integrating different views, strategies, and policies proposed by various stakeholders from different levels of authorities and interests. Holistic means the whole is more than the sum of composing elements and highlights the importance of the relationship between elements (Antrop, 2000). The Food and Agriculture Organization FAO (1993) provides a widely accepted definition of spatial planning as "*systematic assessment of land and water potential, alternatives for land use, and economic and social conditions in order to select and adopt the best land-use options.*" Hierarchy distinguishes spatial planning into national, regional, and local levels of government, with various degree of coherence among them (Murray et al., 2009 and Hall and Tewdwr-Jones, 2010). In a top-down approach, local spatial plans, being the lower levels, must comply with the planning decisions at upper levels (Pissourios, 2014) (see Fig. 1). In this arrangement, the most detailed spatial plan is the local plan (zoning plan) that provides guidelines and criteria for each zoning type.

Jacobs (1993) highlights the use of spatial planning as an ideal mechanism to manage the supply of land for multiple ranges of interests. In an ideal condition, every aspect that influences the physical development and land use should be well consulted and documented in the spatial plan (Fig. 1). At the same time, spatial planning enables the integration of multi-sector considerations in the policy-making into spatial expression (Carter, 2007). However, it is nearly impossible to find a success story for the perfect integration of all policies in a complex environment, particularly in urban areas. The need for sectoral integration into spatial planning is, therefore, apparent to anticipate social-economy and environmental problems as well as accommodating new policies, changes in national priorities, and disaster management directives. Allmendinger and Haughton (2010) highlight the reasoning and best practices on how sectoral policy integration can co-exist with sustainable development. Spatial planning has a strong influence on property rights, especially by imposing land-use policies that limit the right to utilize (Van der Molen, 2015). However, countries manage tenurial rights and land use rights as such in a separate system than spatial planning (Enemark, 2014). In order to develop an effective way to relate the fields of land tenure and spatial planning policies, the integration of these two information silos is needed. In this article, we focus on sectoral integration where different public policy domains apply and influence RRRs within spatial planning of an area.

3. Land administration system and spatial planning

Land tenure consists of allocating and securing rights of land or space, conducting cadastral surveys, transferring the rights in land from one party to another through sale or lease, and conflict management regarding land rights and boundaries (Enemark 2005 and Van Oosterom, 2013). However, a complete view of information about people and their land need also to accommodate restrictions and responsibilities on land or 3D space. This view is essential for sustainable land use and needs to be represented and shared with the public. A Land Administration System (LAS) should provide and manages this kind of information. Further, a well managed LAS shall support land tenure, land value, land use, and land development (United Nations on Global Geospatial Information Management (UN-GGIM, 2015). Since two decades ago, the International Federation of Surveyors (FIG) already acknowledge LAS as "*the processes of determining, recording and disseminating information about the tenure, value, and use of land when implementing land management policies*" (FIG, 1999). Countries establish LAS to manage land-related information as framework datasets or key registers (Van Loenen, 2006 and Van Oosterom et al., 2009) through a Spatial Information Infrastructure (SII).

The UN has acknowledged the urgency for member nations to have an information system for managing land-related information. Following this recognition, the UN and FIG (1999) highlight the role of LAS and SII to facilitate the sharing of information among government institutions and to the citizens in supporting land management. The 2030 Agenda for sustainable development implicitly calls for a commitment to use of information technology and to enable all stakeholders to participate in land administration and spatial planning in order to protect rights, to improve lives, as well as to ensure better land management (UN, 2015). Many countries have strengthened spatial planning with enforcing regulations to ensure policies into reality (Nadin

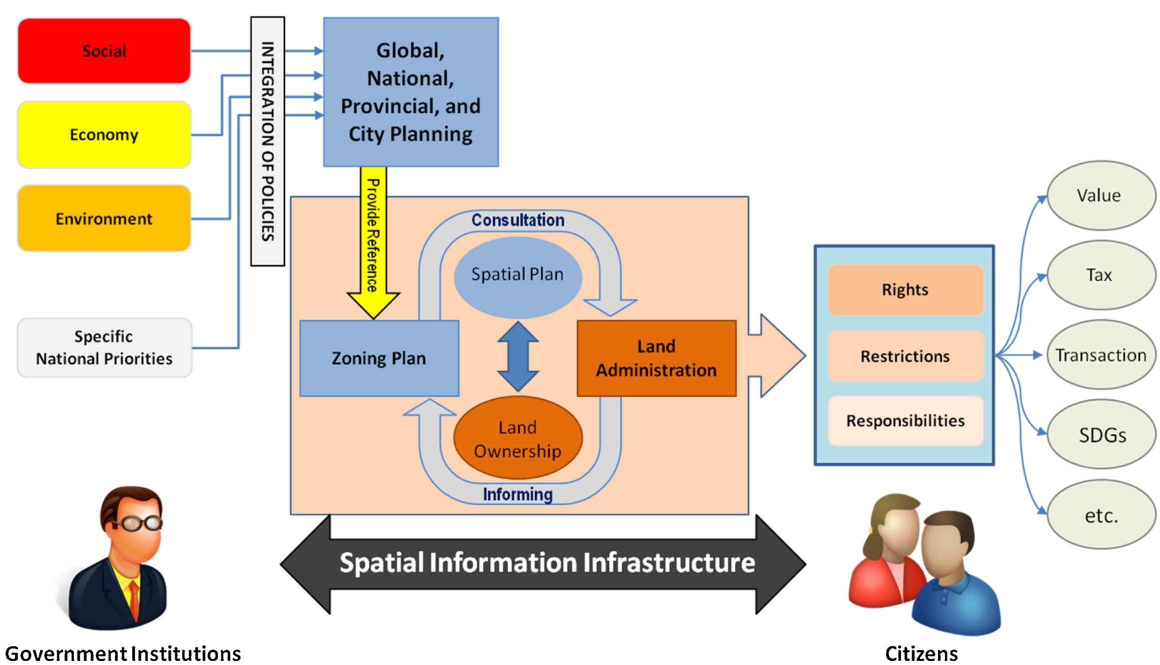

Fig. 1. Integration of multisectoral policies of sustainable development with Rights, Restrictions, and Responsibilities (RRRs) of land administration.

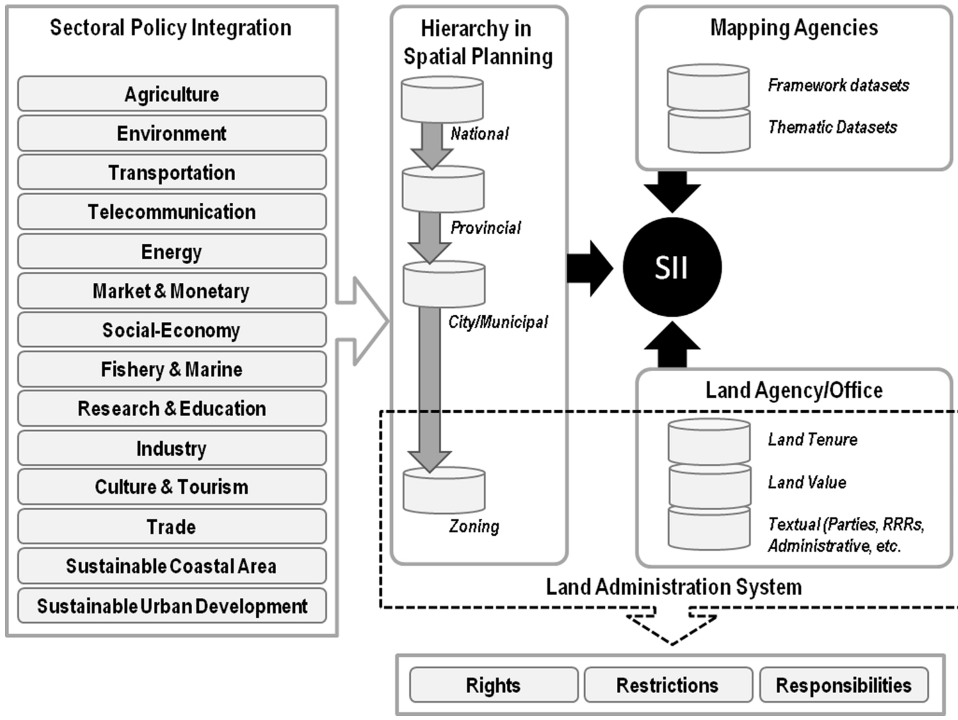

Fig. 2. A holistic approach to Spatial Planning in European Countries. Land Administration System and Spatial Information Infrastructure (SII) can support land-use management and Spatial Planning (Black arrows).

and Stead, 2008; Hudalah and Woltjer, 2007). Information about land ownership, land use policy, and RRRs are vital in spatial planning processes, particularly in densely and intensive-use of spaces, particularly in the urban area. Therefore, authorities should improve their LAS by integrating RRRs resulting from land administration and spatial planning processes. Authorities should facilitate access to land-related information for businesses and citizens through the SII and enabling the multidimensional representation of RRRs. In recent years, there are many countries categorize the cadastral map and the spatial plan map as a fundamental dataset in their SII (Van Oosterom et al., 2009 and Campagna and Craglia, 2012). Better understanding and re-use of land-related information can be achieved with the standardization approach that ensures unambiguous definitions, consistency, and integrity of information within SII (Van Oosterom et al., 2009). This standardization can be done using the common spatial reference (e.g., topographic maps) shared from mapping authority and cadastral agency (red arrow in Fig. 2). Consequently, it is imperative for both land tenure and spatial planning to be interoperable and standardized in securing land administration goals (Enemark et al., 2005) (see the dashed box in Fig. 2). FIG (1995) recommends LAS to provide an up-to-date record of the relationship between people and land, including land allocation, subdivision, or consolidation. Since spatial planning also leads to RRRs on a land parcel, it is crucial to consider 3D and temporal aspects in zoning objects to ensure a better representation of the zoning regulation (see Van Oosterom and Stoter, 2010). LAS (building on the SII) should have the 3D and temporal capabilities to represent valid geometric and time-bound information about RRRs to the landowners, investors and authorities, including information about permissions, prohibitions, obligations, and incentives sourced from the spatial planning process.

It is typical for authorities to enforce spatial planning through legally binding zoning policies and permits. The sectoral policy integration is implemented in land-use programs that provide the foundation for comprehensive planning on land parcel level (see Fig. 2). Each of these sectors may represent its policy on spatial information or in textual. The spatial plan is derived from land-related information, for example, from the cadastre map, land use map, zoning map, development plan map, and a land value map. There are many cases where the information from the land registry (Fig. 3a) and the zoning plan (Fig. 3b) impose various restrictions on a land parcel or sub-parcel (Fig. 3c). In this case, restrictions and responsibilities depend on specific land-use (e.g., factory, commercials) (Fig. 3d). City governments may use the cadastre map and the zoning map to construct responsibilities derived from permits (Fig. 3e). Examples are an obligation to preserve water (Carter, 2007), an obligation to preserve open-space on a parcel (Koomen et al., 2008), prescribing a set of responsibilities to prevent and mitigate natural and artificial hazards (Fell et al., 2008), or to contribute to the environment, biodiversity and quality of life (Geneletti et al., 2007).

In a competitive and interconnected world, there is an increasing demand for cities and municipalities to provide complete and updated land-related information. Specific ratio and intricate arrangements in a land parcel need to be well defined, particularly in a mixed uses case (Fig. 3f). A complex arrangement Integration of spatial planning and land administration can provide complete information of restriction for landowners, such as building height limits (H), ground floor height (G), basement depth (B), groundwater access depth limit (d) (see Fig. 3g). The integration also facilitates to determine the maximum buildable area on a specific land parcel; side free distance (s), distance to road centerline (r), front free distance (f), and back free distance (b) (see Fig. 3g). It is indisputable that information from spatial planning should be included in LAS and shared to the landowners and businesses. This inclusion of spatial planning into LAS will provide an updated zoning regulation to construct more complete RRRs, which is crucial for all stakeholders in decision-making on land or spaces. The spatial dimensions are becoming more and more critical, especially in dense urban areas, involving multiple uses of space (Louw and Bruinsma, 2006; Groetelaers and Ploeger, 2007). Many countries and cities are working on standardization of land-related information and development of a 3D cadastre (Van Oosterom, 2013) to provide more realistic, secure and sustainable RRRs over land and space in a sophisticated setting. There are three possible strategies to improve the level of interoperability between spatial planning and land administration. The first strategy is not to standardize spatial planning information and regard it as a

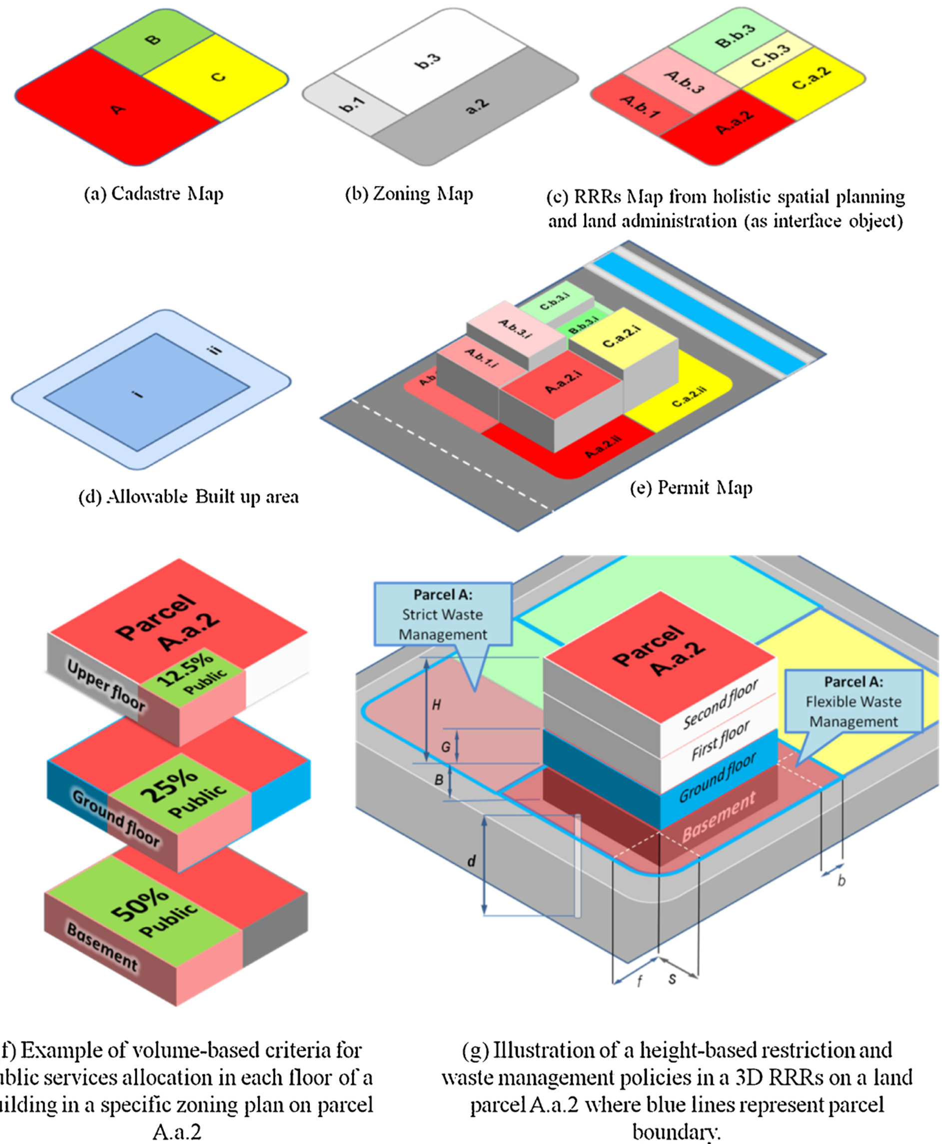

Fig. 3. The importance of 3D aspects in integration spatial planning and cadastre for constructing more realistic Rights, Restrictions, and Responsibilities (RRRs).

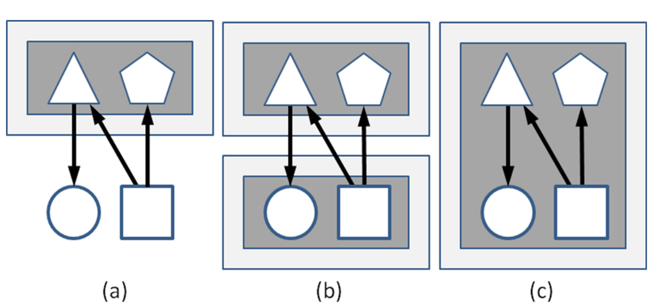

Fig. 4. Strategies for improving interoperability of spatial planning information (spatial and textual): a) without standardization; b) as a new domain ISO standard; and c) as a package in LADM standard.

document or sources as part of the existing LADM (Fig. 4a). By applying this strategy, spatial planning information will be unstructured and difficult to represent and visualize RRRs in a more realistic format, particularly for multistory or high rise buildings and complicated sectoral policies in an urban area (see Fig. 3g). A second strategy is to construct a new ISO standard for the spatial planning domain model (light blue box) (Fig. 4b). The new standard should refer to LADM classes for representing RRRs in the spatial planning process (circle and square). Developing a new standard is a hard task, involving a series of complex procedures, takes considerable time, and requires involvement from experts worldwide (ISO 2014). The third strategy is to introduce a spatial planning package (dashed blue box in Fig. 4c) into LADM (green box) as an extension of ISO 19152:2012.

This paper attempts to ensure interoperability between spatial planning and land administration by adding a spatial planning package into LADM (Fig. 4c) to improve interoperability since land administration information and spatial planning information are produced from the different sectors in the government and to avoid redundancy in the form of same features coming from a different process. This strategy will simplify objects used in cadastre and spatial planning by reusing existing LA classes for both applications. The main reason to propose spatial planning into a package as an improvement of ISO 19152:2012 is practicality and efficiency in achieving interoperability. Also, by introducing spatial planning as a package of LADM, users can see more complete and realistic information about RRRs for land management activities. This article incorporates both the characteristics of spatial planning of developed and developing countries for construction of the new spatial planning package into LADM. Our model derived from INSPIRE and Indonesia based on the volume of land parcel and the existence of SII.

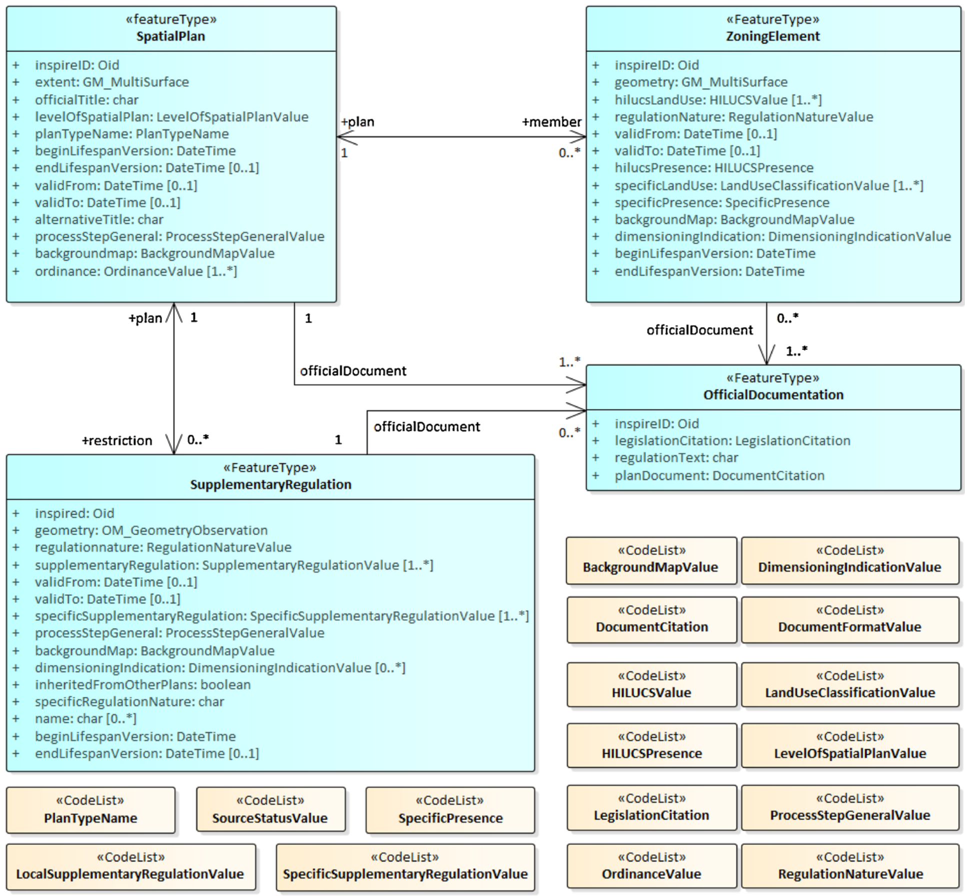

Fig. 5. Overview of the INSPIRE's Planned Land Use schema (INSPIRE, 2012).

3.1. Development of spatial planning data model in developed countries: European Countries

The Directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) (INSPIRE, 2007) and legislation directly stemming from INSPIRE addresses the interoperability of spatial planning information. The INSPIRE legislative suite provides standards for spatial planning information in five areas: Metadata, Data Specifications, Network Services, Data, and Service Sharing, and Monitoring and Reporting. INSPIRE defines a spatial plan 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*" (European Commission (EC, 2014). Both spatial planning datasets and official documents are facilitated in the INSPIRE's planned land use conceptual schema (Fig. 5). There are two main classes in the INSPIRE's Planned Land-Use data model: *SpatialPlan* and *ZoningElement*. These classes contain geometry and information related to spatial planning. The *SpatialPlan* class consists of the characteristic of the spatial plan as attributes (*planTypeName* and *levelOfSpatialPlan*) and legally binding documents. *ZoningElement* is part of SpatialPlan which represents the provision of a zoning plan on a specific area or space. The *ZoningElement* class facilitates detailed regulation on land parcel level. This class provides sectoral policy integration of land use through *hilucsLandUse* and *regulationNature* (Fig. 5). A *HILUCSValue* is provided in the form of codelist to ensure semantic interoperability within the INSPIRE registry (INSPIRE, 2012). Both government and landowners can use a *regulationNature* attribute in *ZoningElement* class to correspond with spatial planning regulation. The INSPIRE planned land use data model also provides *SupplementaryRegulation*, a FeatureType of that contain documents and criteria determined by zoning regulation. The SupplementaryRegulation contains useful information for stakeholders about obligation, prohibition, or permission attached on specific land.

In 2009, the European Union (EU) initiated the *Plan4All* project to achieve interoperability of spatial planning information (Murgante et al., 2011). *Plan4All* model distinguishes existing land use and planned land use (spatial plan). This project proposes two main classes in the Planning Information group: *PlanObject* and *PlanFeature*. *PlanObject* consists of geometric information of the spatial plan of an area (Čerba, 2010). *Plan4All's* spatial planning data model considers *PlanFeature* as a subgroup of *PlanObject*. The *PlanObject* class provides geometry, textual, and administrative/process information for spatial planning. The *PlanFeature* class contains land use indication on a specific area, such as status, type of regulation imposed on, references, criteria. The *Plan4All* does not prescribe a minimum geometric unit of the spatial plan (i.e., land parcel), but the area covered by *PlanFeature* may correspond with many land parcels or in some cases with none. The Administrative Information group represents administrative situation and process in spatial planning (parties, date of adoption, steps of the spatial planning process, legal validity). A specification of the paper-based outputs is facilitated in the Graphical Information group while Textual Information contains the textual part of a spatial plan.

3.2. LAS and spatial planning information system in developing countries: Indonesia

Land administration in Indonesia is governed by the Basic Regulation on Agrarian Principles Act (1960) and has three components: land registers (written legal instruments), cadastral mapping, and land registration. Through the National Land Agency (Badan Pertanahan Nasional/BPN) the government of Indonesia develops and maintains land administration information which is considered as part of cadastre: land parcels, land tenure, and land value. Until 2018, the land registration program has covered 51 million out of 126 million land parcels (Kantor Staf Presiden (KSP, 2018). However, in this program, BPN only records rights in land (including landowners). The ministries and local governments hold information on most restrictions and responsibilities within the spatial planning and sectoral database system.

BPN established the Komputerisasi Kantor Pertanahan/KKP (Computerized Land Office) as the National Land Information System in 1997. Since then, BPN continues several initiatives in improving NLIS with focus on automation. The current version of KKP (KKP-web) is managed centrally by the Center of Land Data and Information, a governmental unit under BPN organization. Following the establishment of the national geoportal in 2011, BPN is improving the KKP system gradually using national standards. As a formal response to the publication of ISO 19152:2012, BPN initiated the gradual migration of the national parcel database toward compliance to LADM packages (Pinuji, 2016). Further, the current KKP database system was built based on BPN interpretation of LADM. A prototype of the LADM profile for Indonesia has been developed and presented in ISO 19152:2012 as Annex (International Standard Organization (ISO, 2012). According to the Spatial Planning Act, 2007, the government is responsible for managing space and natural resources in an integrated manner. This law divides spatial planning into a hierarchy which is similar to administrative leveling (Fig. 6). Spatial planning at the provincial and municipal levels perform the preparation and establishment of a spatial plan containing spatial structure (urban development) plan and zoning policy. The spatial structure plan contains existing and planned infrastructure to support socio-economic activities while the zoning plan regulates the distribution of functions. Further, the Spatial Planning Act, 2007; Local Government Act, 2014, and Capital Investment Act, 2007 instruct the local government to establish a Spatial Planning Information System (SPIS) and to disseminate spatial plans to all.

Spatial zoning is used as a reference to include criteria for developing physical infrastructure and activities in using a space or a land parcel. The integration of land-related information is mandated in the Capital Investment Act, 2007 for simplifying permit issuances (Deloitte, 2018). This Act instructs government institutions explicitly to integrate the process of approving and issuing permits. The urgency for interoperability is recharged by the Online Single Submission (OSS) regulation, which mandates government to develop a system that incorporates information from spatial planning and land administration. The OSS system is expected to ensure access to land-related information supporting the acceleration of the issuance of business permits. Spatial information plays a critical role in the core of the OSS system, particularly for location permits, land ownership registration, spatial planning compliance, and environmental assessments to assist both the authorities and investors in obtaining information for investment submission. To some extent, this information describes Rights, Restrictions, and Responsibilities (RRRs) on a land parcel of space. The authorities configured Land Administration and Spatial Planning systems to support the issuance of permits on a parcel and business licensing. However, these systems contain information that is classified as public information. Indonesian citizens ‘rights to access information are protected by the Constitution and laws and regulation, namely the Basic Agrarian Principle Act, Spatial Planning Act, 2007, Environment Protection Law, and Public Information Openness Act. In reality, authorities, businesses, and citizens are still struggling to provide a complete overview of the RRRs. Silos of information often hinder landowners or investors in prospecting and transferring rights in land (see National SII in Fig. 6). Interoperability is the key to integrate land-related information, especially in providing complete RRRs from KKP and SPIS. However, many local governments are having difficulty in accessing and understanding land-related information from KKP due to the absence of unambiguous protocol and lack of information infrastructure. This situation makes it difficult for SPIS to fully support local government in managing land and space (Pinuji, 2016). This all is closely related to land administration. Indonesian (i.e., KKP's) interpretation of ISO 19152:2012 has resulted in an incomplete representation of RRRs for BPN since most restrictions and responsibilities are managed in SPIS (see Fig. 6). Currently, BPN is implementing 3D information at the operational level for apartments, commercial, and high-rise buildings (Suhattanto, 2018) and is transforming its 2D geometric description of the land parcel and RRR into a 3D representation (Hendriatiningsih et al., 2007, and Safitri et al., 2016). In 2016, the Government of Jakarta developed 3D SiPraja, a 3D visualization model for spatial planning using ESRI technology (Fig. 7). The 3D Sipraja implements a 3D aspect for preserving and presenting spatial planning information (see Table 1) to their citizens in a more realistic format. A 3D spatial planning model is implemented mainly to visualize floor building coefficient (Koefisien Lantai Bangunan/KLB) and building height (Ketinggian Bangunan/KB) which require height information and 3D views. However, this model was not developed based on LADM as the purpose is to visualize spatial planning in 3D to provide better navigation and cognitive understanding for the user.

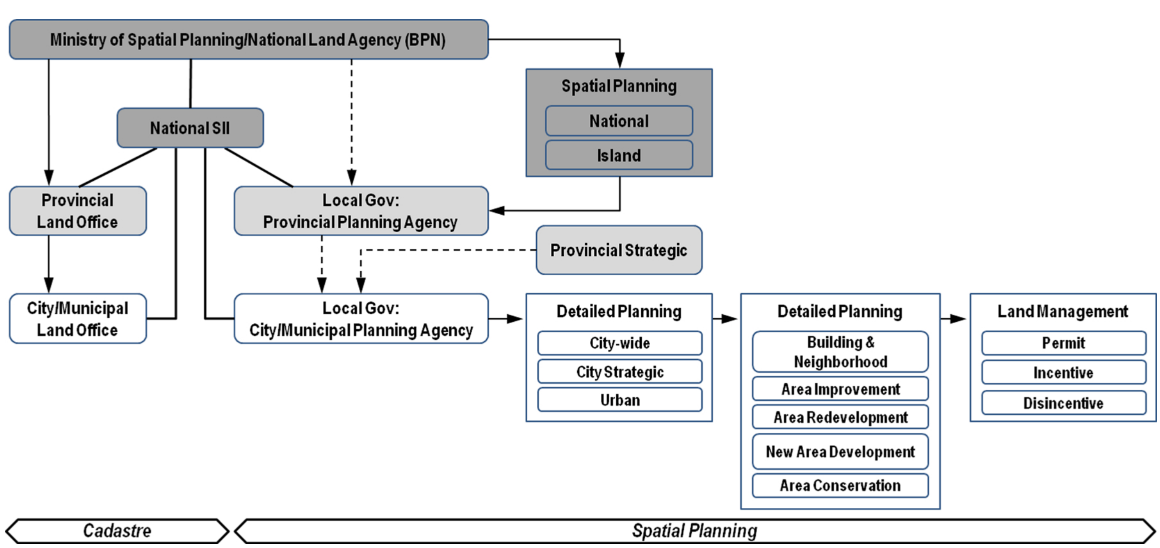

Fig. 6. Hierarchy in Indonesian Spatial Planning based on Spatial Planning Act No. 26 (2007) and Government Regulation No. 15 (2010) Dark grey boxes are Central government, Light grey boxes for Provincial Government, and white boxes are City/Municipal Government.

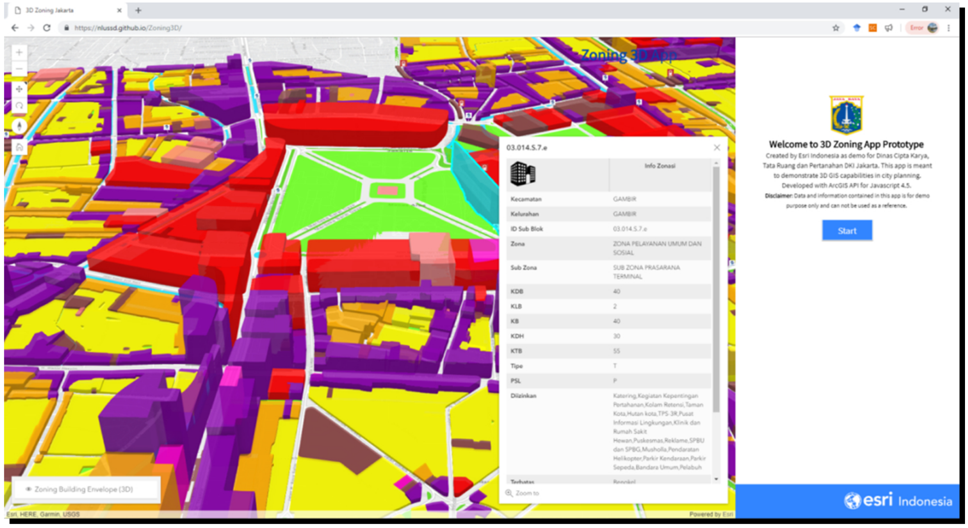

Fig. 7. 3D SiPraja Apps, a web-based visualization of 3D urban planning of Province of Jakarta (available online through https://nlussd.github.io/Zoning3D/).

4. Spatial planning package in the land administration domain model

Lemmen et al. (2013) note that a LAS requires a standardized domain model to deal with its complexity and interoperability for use and re-use of land-related information. The ISO 19152:2012 specifies references covering basic components of information to develop, implement, and efficiently maintain LAS. The LADM standard aims to enable the combination of land information from different sources in a coherent manner (International Standard Organization (ISO, 2012). LADM contains abstract and conceptual models with four packages that enable identification of parcels, documents, persons, transactions, and other issues in land administration (Fig. 8).

As a spatial domain standard, LADM provides a shared ontology which is used as a primary standard for many aspects of land administration, such as geometry, temporal, metadata, and observation and measurements from cadastral survey and mapping activities. These aspects will be used in LAS to registers land rights and to assist land-use control, land development, and land valuation. RRR derived from the spatial plan will be based on both individual and collective rights, privileges, restrictions, and responsibilities. Spatial representations and temporal aspects in public laws may be classified into advantages, restrictions (prohibitions) and responsibilities (obligations) into restriction and responsibility classes. Paasch et al. (2015) propose an extended abstraction of RRRs based on the type of interest in European countries. The new spatial package as extension of LADM provides a full relationship between land and people. It contains planning information in three main classes: *SP_PlanningBlock*, *SP_PlanningGroup*; and

Table 1
RRRs Information maintained in the Spatial Planning Information System in the City of Jakarta (Province of DKI Jakarta, 2012).

City Planning Information (*Informasi Rencana Kota*)

ID Column	EN Colum	Detail
ID_SubBlok	ID_SubBlock	Identifier of sub-block
Sub Zona	SubZone	Spatial Planning Sub Zone
Zona	Zone	Spatial Planning Zone
KDB	BuildingBaseCoefficient (percent)	A percentage number comparison between the entire floor area of a building that can be built with the available land area. KDB is determined from the area of a roofed room that has a wall of more than 1.2 m and projected buildings. If the projected area has a height of less than 1.2 m, KDB will count 50% with a record not exceeding 10% of the specified KDB value.
KLB	FloorBuildingCoefficient (percent)	A percentage number comparison between the total areas of all building floors that can be built with the available land area.
KB	FloorAmountBuilding (floor)	The limit of the number of building floors. If the vertical distance from the full floor to the next full floor is more than 5 m, then the height of the building is considered as two floors, except for the use of lobby rooms, or meeting rooms in commercial buildings (including hotels, offices, and shops)
KDH	BasicGreenCoefficient (ratio)	The ratio between open space outside the building for reforestation, against an area of parcels. Natural open space is part of the space outside the building that is not covered by concrete, or there is no barrier for water to seep into the ground.
KTB	BuildingBasementCoefficient (percent)	A percentage number comparison between the area of the footprint and the area of parcel/controlled space.
Tipe	IntensityType	Limitation of the intensity of building according in a parcel.
PSL	IntensityPatternType	An intensity pattern grouping in a neighborhood according to the city plan.
TPZ	ZoningArrangementType	The level of flexibility towards the general provisions of the Zoning Regulations (*Pengaturan Zonasi/PZ*) and the basis for providing incentives for development.
GSJ	RoadDemarcationLine (meter)	The distance from road centerline to front yard fence that is allowed to be established. Therefore, usually, there are lines for installation of water, electricity, gas, and sewerage along the GSJ. Buildings cannot be erected on GSJ unless the GSJ coincides with the building boundary line (GSB).
GSM	BuildingFrontDemarcationLine (meter)	A demarcation line for developing a building on a parcel. This line limits the physical building to the front, back, or side. The width of the GSB is calculated as one-quarter of the width of the Road-Owned Area (*Daerah Milik Jalan/DMJ*) and drawn from the boundary of the Fence Line (GSP). For trading areas and commercial services, the minimum GSB is 5 m from the GSP boundary.
GSS	BuildingFrontDemarcationLine (meter)	A demarcation line that limits the closest distance of a building to the side or rear boundary of a land parcel. GSB is calculated from the boundary line to the outer or rear outline of a building that functions as space and safety factors.

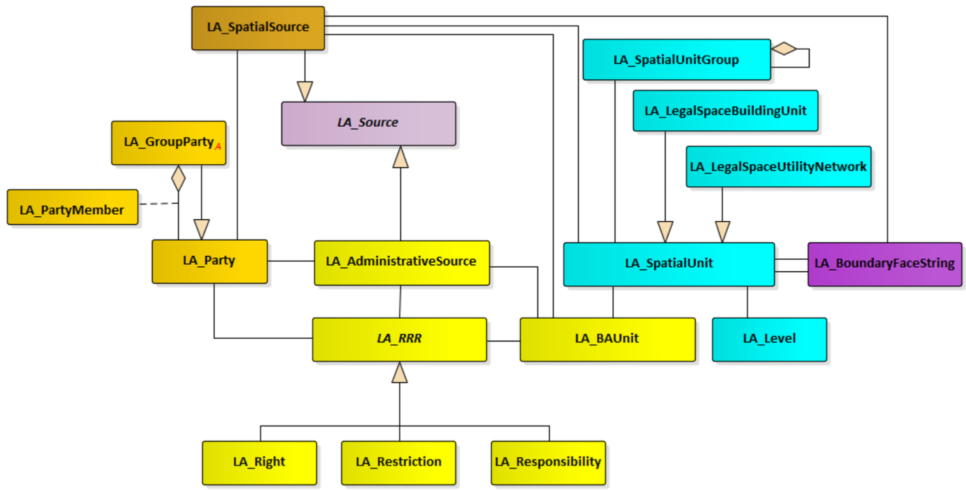

Fig. 8. Overview of classes in ISO 19152:2012 on Land Administration Domain Model (LADM) (International Standard Organization (ISO, 2012).

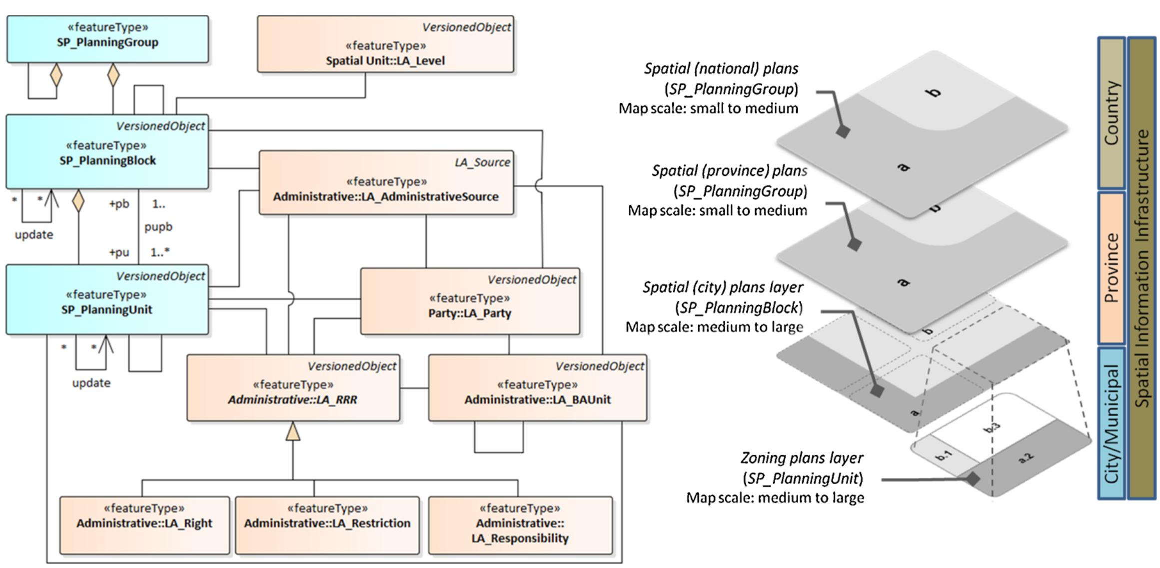

Fig. 9. Classes in spatial planning package: SP_PlanningBlock; SP_PlanningUnit; and SP_PlanningGroup.

Table 2
Classes in Spatial Planning Information Package.

Class	Stereotype	Detail
SP_PlanningBlock	FeatureType	A class is containing "Polygon" to a characterized boundary of planned land use policy of an area. Typical representations are *Residential Area*, *Commercial*, *Industry*, and so forth.
SP_PlanningUnit	FeatureType	A class is containing "Polygon" to the characterized boundary of zoning plan of an area. Typical representations are *High-Density Residential Area*, *Banking*, *Heavy Industry*, and so forth.
SP_PlanningGroup	FeatureType	A class representing the hierarchy in spatial planning
SP_EasementType	Enumeration	A list of rights to do an activity or use a land parcel or space owned by others for a specified purpose.
SP_ProtectedClassification Value	Enumeration	A list about the type of protected area
SP_RestrictionZone	Enumeration	A list about the type of restriction in doing an activity or using or developing a specific building on a land parcel or space.
SP_PermitType	Codelist	A list of intensity in doing an activity or using or developing a certain building on a land parcel or space.
SP_HeightIndication	Codelist	A list of height indication or limit of height of a building on a specific area
SP_SurfaceIndication	Codelist	A list of area indication or limit of the size of a building on a specific area
SP_VolumeIndication	Codelist	A list of volume indication or limit of the volume of a building on a specific area
SP_SpaceFunction	Codelist	A list about the type of function on a specific area
SP_Sub space function	Codelist	A list about the type of function of a building on the specific area
SP_StatusType	Codelist	A list about the type of states of usage of a land parcel or space.

SP_PlanningUnit (Fig. 9). Re-use of existing land administration classes will maximize the integration of spatial planning information into LADM. Both *SP_PlanningBlock* and *SP_PlanningUnit* have geometry to represent sectoral policies integration through spatial planning processes. *SP_PlanningBlock* contains the spatial plan resulted from spatial planning processes. These plans guide city/municipal governments to construct a zoning/detailed plan. The *SP_PlanningUnit* represents the zoning/detailed plan as featureType to accommodate criteria derived from sectoral policies integration. A zoning plan refers to a spatial plan (in most cases) both are legally binding for all stakeholders. The

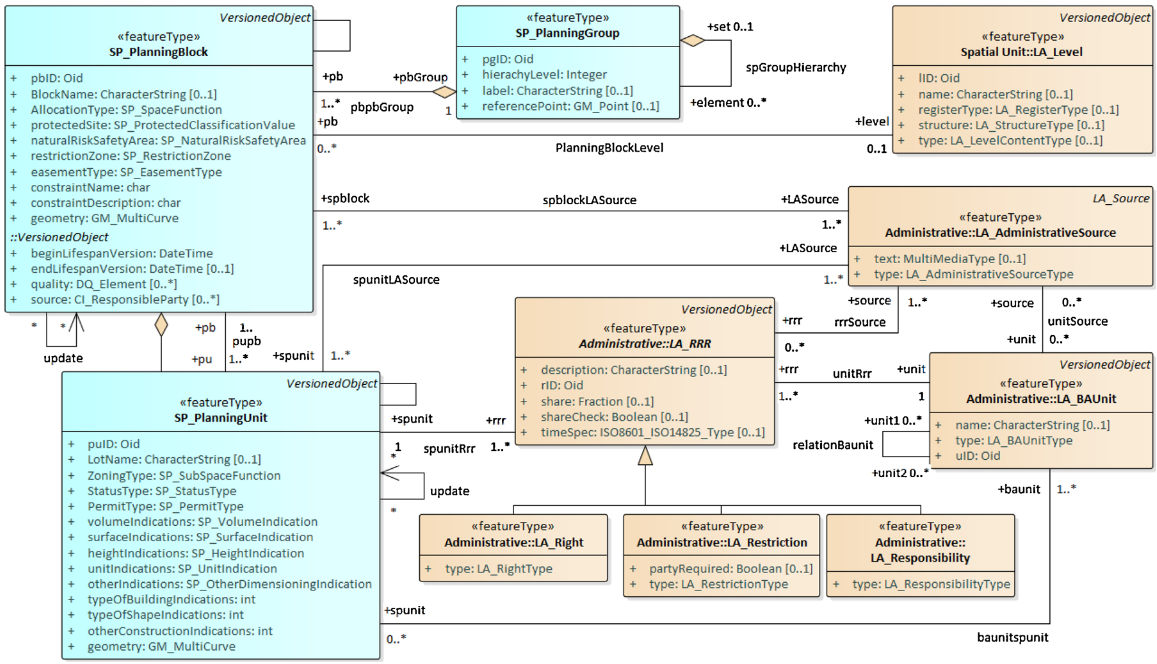

Fig. 10. Classes in spatial planning information package (*SP_PlanningBlock*, *SP_PlanningUnit*, and *SP_PlanningGroup*) and their relationship in constructing RRRs from spatial planning.

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. In reality, *SP_PlanningBlock* is represented by a spatial plan map, while SP_PlanningUnit refers to the zoning map (Fig. 9). Overall classes proposed in Spatial Planning Information Package are explained in Table 2 and Fig. 10.

The LADM consists of five basic packages (International Standard Organization (ISO, 2012) that ensure standardization of LAS, both in 2D and 3D. Van Oosterom and Stoter (2010) advocate that LADM also considers 3D (spatial) and 4D (temporal) dimensions in the representation of cadastral objects. Knowing that spatial planning also leads to RRRs on a land parcel, it is crucial to consider the 3D and 4D aspects in zoning objects to ensure optimal representation of the zoning regulation. The proposed spatial planning package is capable of representing the results of spatial planning dealing with the visualization of 3D zoning objects on, above, or below the earth surface (Fig. 11). The changes regarding spatial representations and sectoral policies occur on the 3D zoning objects should be recorded continuously to prevent conflicts, disputes, or fraud. A local government may update the zoning plan in responding to socio-economic and environmental change, such as political adjustment, natural disaster, climate changes, and so forth. Increasing pressure on urban areas needs awareness of the importance of the development and maintaining 3D urban information could raise the concept of 4D urban planning. Consequently, the 4D representation of zoning regulations will increase the usability of the spatial planning information by providing better insight and will, therefore, reduce conflicts over the zoning object. The proposed spatial planning package in LADM can facilitate the representation of various sectoral policies in the form of geometry (3D zoning objects on, above and below earth surface) and official documents containing the policies attached on a specific area (Fig. 11).

5. Discussion

The rapid advancement of the Geo-ICT creates opportunities in land administration and spatial planning to provide integrated and interoperable land-related information to broader stakeholder groups. LAS shares the same objective as SII in facilitating land-related information sharing. In most cases, the nature of both land administration and spatial planning involves various parties, inter-related roles, and a variety of spatial information. As both land administration and spatial planning impose RRRs on the same land parcel, their integration in a single domain standard creates a straightforward implementation model of both processes. By the development of classes in spatial planning information package as an attempt to enable a 4D (3D + time) representation of spatial plan and zoning plan (Fig. 12), we incorporate two considerations for maintaining the completeness and preserving usability for land administration and spatial planning: interoperability and capability to represent RRRs at a sub-parcel level.

5.1. Interoperability

Harmonization and standardization are believed to be capable of increasing the level of interoperability and reusability of land-related information. Consequently, there is a need to standardize this kind of information in order to provide comprehensive and understandable land-related information to broader stakeholder groups, particularly for specialists and experts in the development of land administration and spatial planning systems. ISO 19118: 2011 specifies interoperability as "*capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units.*"

5.2. Presenting RRR into sub parcels view

Most sectoral policies in spatial planning are being applied to a specific area of jurisdiction to control intervention in the form of social or physical development, from the country level to a land parcel (Nadin, 2007). The land registry database, as the fundamental element of LAS, provides an administrative boundary for land administration and spatial planning purposes. A sub-parcel division could be crucial to represent more realistic RRRs resulting from sectoral policy integration (Verbeeck et al., 2011 and Inan et al., 2010). Therefore, it is necessary to allow a sub-parcel division for better visualization of information from the integration of spatial planning and land administration. Also, a 3D visualization of spatial planning is useful for planners and citizens to

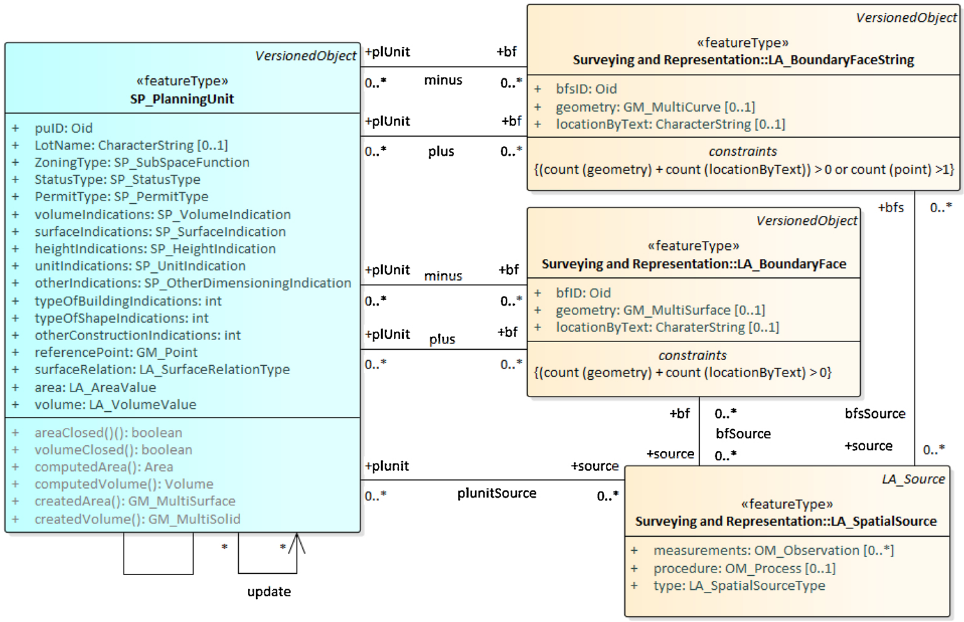

Fig. 11. Geometry in Spatial Planning Information. SP_PlanningUnit contains the geometry of the zoning plan, both in 2D and 3D.

provide optimal information and insight, especially in dense urban areas involving multiple uses of space (Van Oosterom, 2013; Ahmed and Sekar, 2015). Based on the work of Bydłosz et al. (2018) on a 3D Cadastral model for spatial planning objects, our proposal allows a 3D representation in sub-parcel based on the zoning plan regulation and delivering RRRs from spatial planning into a land parcel. We consider that the sub-parcel information is better not to be stored but derived "*on-the-fly*" as an interface object. An interface object is a subset of an interface in software development (Puerta, 1997) but can reference each other in a specific way. Fig. 3 shows that spatial planning can create different RRRs in a land parcel (Fig. 3.c). Further, a sub-parcel unit may also be useful for representing RRRs for vertical urban space, such as strata title. The proposed spatial planning information package has a relationship to *LA_SpatialUnit*, a class providing spatial representation for sub-parcel. The *LA_SpatialUnit* has a relationship with *LA_BAUnit*, *SP_PlanningUnit*, and LA_RRR. With this arrangement, RRRs derived from spatial planning process can be contained in LA_RRR through *SP_PlanningUnit* and *SP_PlanningBlock*.

5.3. Developing country profile for LADM using spatial planning package: Indonesia

In order to assess the proposed Spatial Planning Information Package, we implemented its use in developing LADM profile for a country in a real-world situation. In the case of Indonesia, we found that the package can enrich the quality of RRRs by adding restrictions and responsibility derived from spatial planning processes. Also, it is of national interest for a country to develop and to maintain LAS that are capable of recording, managing, and publishing RRR for all citizens. Current leadership and government institutions recognize the importance of both spatial planning and land administration for national and SDG agenda (Abidin, 2017). Indonesia's interpretation of LADM has been constructed in Annex D of ISO 19152:2012 document. In the first version, the Indonesian country profile has incomplete RRR information caused by excluding Restrictions (*LA_Restriction*) and Responsibilities (*LA_Responsibilities*). Separate laws and exclusion of relevant authorities in land administration and spatial planning were the reason of this incompleteness of RRRs.

6. Conclusion

This paper proposes the integration of the Rights, Restrictions, and Responsibilities (RRRs) information from the spatial plan, as an additional package, into the ISO 19152:2012 – Geographic Information – Land Administration Domain Model (LADM) standard. Spatial planning plays an essential role in land management. Integration of physical and sectoral planning at the local level usually produces some degree of permissions, authorizations, restrictions, obligations and sanctions. However, it is typical in many countries to establish land administration and the spatial plan processes through different regulations, authorities, and processes. Integration of spatial planning information into a package in the LADM is essential to add certainty that ensures that stakeholders have the complete picture of RRRs of land or space. The standard development approach was selected so that our model represents and documents the complete view of RRRs from land administration, and the spatial planning process is. Through the data modeling process, it can be concluded that the LADM can accommodate a standardized zoning plan and correlate it with the land administration classes to develop the country profile. The zoning objects resulting from a spatial planning process are presented in three classes: *SP_PlanningUnit*, *SP_PlanningBlock*, and *SP_PlanningGroup*. The developed spatial planning package was successfully applied to the Indonesian LADM country profile. Therefore, our research is the first to suggest that it is appropriate to include these classes into a package in the LADM in order to better represent RRRs, particularly in countries that arrange spatial planning and land administration information in separate processes.

7. Recommendations

Our approach is capable of reconstructing restrictions and responsibilities derived from the spatial planning process and sectoral integration on a specific land parcel or space (2D and 3D) using classes of the Spatial Planning Information Package. However, we realize that spatial planning has many interpretations and variations in many countries. Our work could not cover all aspects representing spatial planning information into the land administration. Continuation of research is recommended which focus on these areas:

- Study on 4D (3D + time) spatial planning information to represent

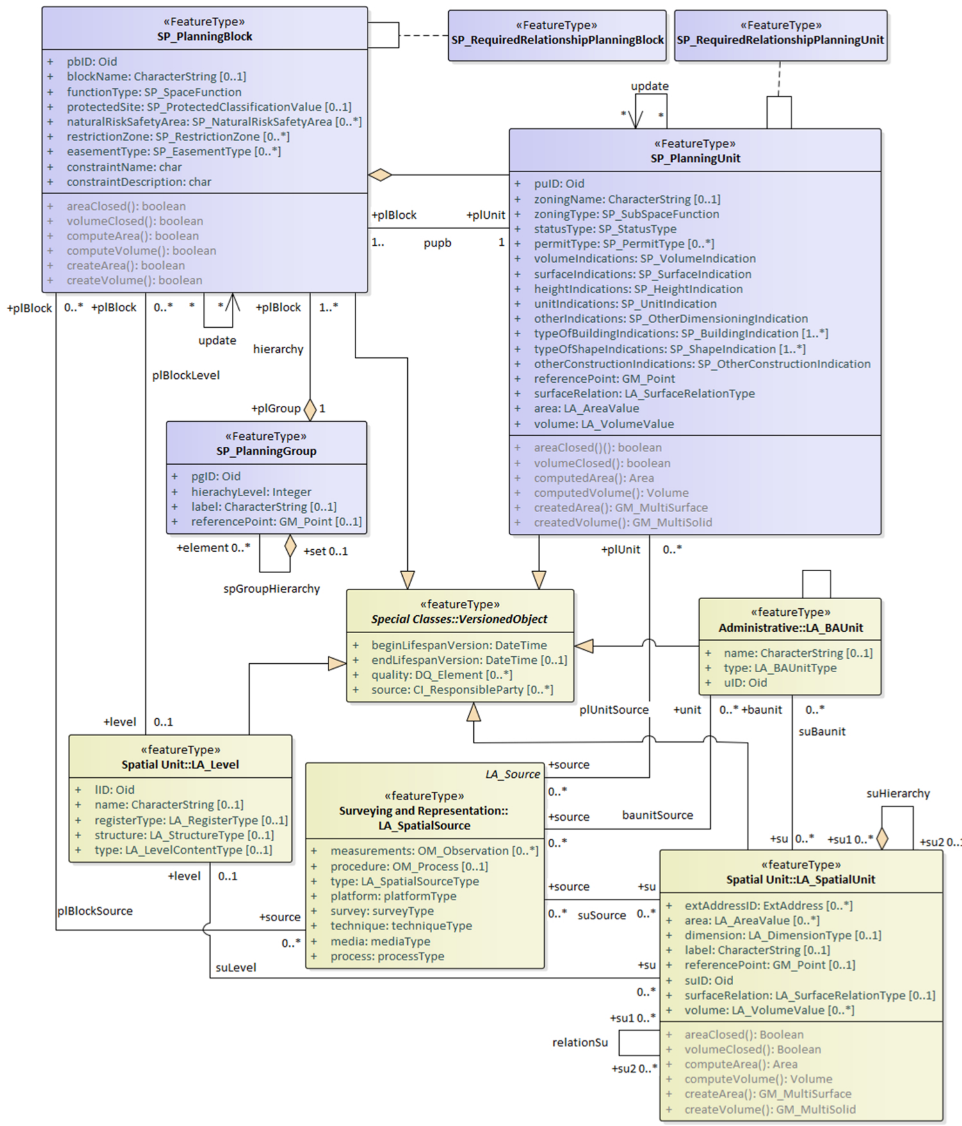

Fig. 12. Classes in spatial planning package and their relationship with *LA_SpatialUnit* class and *VersionedObject* class to construct 4D (3D + time) urban planning.

the dynamism of the spatial planning object following the update by the local government.

- Investigation on disaggregation of RRRs in the sub-parcel division, since the zoning plan may not share the same boundaries as the cadastral parcel boundaries.
- Development of a 3D spatial planning information database in city SII.
- Implementation of the Spatial Planning Information Package in the permit system and urban planning monitoring.

Funding

The first author was supported by the Program for Research and Innovation in Science and Technology Project (RISET-Pro), Ministry of Research and Higher Education, Republic of Indonesia.

Declaration of Competing Interest

The authors declare no conflict of interest. The funding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

Acknowledgments

The first author acknowledges ISO TC 211-LADM and Badan Informasi Geospasial, Republic of Indonesia for this study.

References

Abidin, H.Z., 2017. Strengthening geospatial information management in Indonesia. geospatial information for national sustainable development. Proceedings of the 5th High Level Forum United Nations: Global Geospatial Information Management 28–30.
Ahmed, F.C., Sekar, S.P., 2015. Using three-dimensional volumetric analysis in everyday urban planning processes appl. Spatial Analysis 8, 393–408. https://doi.org/10.1007/s12061-014-9122-2.
Allmendinger, P., Haughton, G., 2010. Spatial planning, devolution, and new planning spaces. Environ. Plann. C Gov. Policy 28 (5), 803–818.
Antrop, M., 2000. Background concepts for integrated landscape analysis. Agric. Ecosyst. Environ. 77 (1-2), 17–28.
Basic Regulation on Agrarian Principles Act, 1960. Basic Regulation on Agrarian Principles Act Act No. 5 Year. Republic of Indonesia.
Biesbroek, G.R., Swart, R.J., Van der Knaap, W.G., 2009. The mitigation–adaptation dichotomy and the role of spatial planning. Habitat Int. 33 (3), 230–237.
Bydłosz, J., Bieda, A., Parzych, P., 2018. The implementation of spatial planning objects in a 3D cadastral model. ISPRS Int. J. Geoinf. 7 (4), 153.
Campagna, M., Craglia, M., 2012. The socioeconomic impact of the spatial data infrastructure of Lombardy. Environ. Plann. B Plann. Des. 39 (6), 1069–1083.
Campbell, S., 1996. Green cities, growing cities, just cities?: urban planning and the

contradictions of sustainable development. J. Am. Plan. Assoc. 62 (3), 296–312.
Capital Investment Act, 2007. Capital Investment Act Act No. 25 Year.
Carter, J.G., 2007. Spatial planning, water and the water framework directive: insights from theory and practice. Geogr. J. 173 (4), 330–342.
Čerba, O., 2010. Conceptual Data Models For Selected Themes. Plan4All. ECP-2008-GEO-318007. eContentplus.
Corbett, J., Mellouli, S., 2017. Winning the SDG battle in cities: how an integrated information ecosystem can contribute to the Achievement of the 2030 Sustainable Development Goals. Inf. Syst. J. 27 (4), 427–461.
Deloitte, 2018. Investment Window Into Indonesia. Deloitte.
European Commission (EC), 2014. Commission Regulation (EU) No 1312/2014 of 10 December 2014 Amending Regulation (EU) No 1089/2010 Implementing Directive 2007/2/EC of the European Parliament and of the Council As Regards Interoperability of Spatial Data Services.
Enemark, S., Williamson, I., Wallace, J., 2005. Building modern land administration systems in developed economies. J. Spat. Sci. 50 (2), 51–68.
Enemark, S., Hvingel, L., Galland, D., 2014. Land administration, planning and human rights. Plan. Theory 13 (4), 331–348.
Fédération Internationale des Géomètres (FIG), 1995. The FIG Statement on the Cadastre. International Federation of Surveyors.
Fell, R., Corominas, J., Bonnard, C., Cascini, L., Leroi, E., Savage, W.Z., 2008. Guidelines for landslide susceptibility, hazard and risk zoning for land use planning. Eng. Geol. 102 (3), 85–98.
FIG, 1999. The Bathurst Declaration on Land Administration for Sustainable Development. 22nd October 1999. International Federation of Surveyors.
Food and Agriculture Organization (FAO), 1993. Guidelines for Land Use Planning. Food and Agriculture Organization of the United Nations, Rome, Italy.
Geneletti, D., Bagli, S., Napolitano, P., Pistocchi, A., 2007. Spatial decision support for strategic environmental assessment of land use plans. A case study in southern Italy. Environ. Impact Assess. Rev. 27 (5), 408–423.
Groetelaers, D.A., Ploeger, H.D., 2007. Juritecture of the built environment: a different view on legal design for multiple use of land. Struct. Surv. 25 (3/4), 293–305.
Hall, P., Tewdwr-Jones, M., 2010. Urban and Regional Planning. Routledge.
Hendriatiningsih, S., Soemarto, I., Laksono, B.E., Kurniawan, I., Dewi, N.K., Soegito, N., 2007. Identification of 3-Dimensional Cadastre Model for Indonesian Purpose. FIG Working Week.
Hudalah, D., Woltjer, J., 2007. Spatial planning system in transitional Indonesia. Int. Plan. Stud. 12 (3), 291–303.
Inan, H.I., Sagris, V., Devos, W., Milenov, P., van Oosterom, P., Zevenbergen, J., 2010. Data model for the collaboration between land administration systems and agricultural land parcel identification systems. J. Environ. Manage. 91 (12), 2440–2454.
INSPIRE, 2007. Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) OJ L 108.
INSPIRE, 2012. Data Specification on Land Use – Draft Guidelines. D2.8.III.4. INSPIRE Thematic Working Group Land Use.
International Standard Organization (ISO), 2012. ISO 19152 Geographic Information—Land Administration Domain Model (LADM). Geneva, Switzerland, ISO.
Jacobs, M., 1993. Sense and Sustainability: Land Use Planning and Environmentally Sustainable Development: a Report. Council for the Protection of Rural England.
Kantor Staf Presiden (KSP), 2018. Presiden Bagikan 4.000 Sertifikat Tanah Untuk Rakyat Kepada Warga Bogor Dan Sukabumi. Office of Presidential Staff of Republic of Indonesia (in Bahasa).
Koomen, E., Dekkers, J., van Dijk, T., 2008. Open-space preservation in the Netherlands: planning, practice and prospects. Land Use Policy 25 (3), 361–377.
Lemmen, C.H.J., Van Oosterom, P.J.M., Uitermark, H.T., De Zeeuw, K., 2013. Land administration domain model is an ISO standard now. Proceedings of the Annual World Bank Conference on Land and Poverty 8–11 April, 2013. World Bank.
Local Government Act, 2014. Local Government Act Act No. 23 Year. Republic of Indonesia.
Louw, E., Bruinsma, F., 2006. From mixed to multiple land use. J. Hous. Built Environ. 21, 1–13.
McLoughlin, J.B., 1969. Urban & Regional Planning: a Systems Approach. Faber & Faber.
Murray, M., Greer, J., Houston, D., McKay, S., Murtagh, B., 2009. Bridging top down and bottom up: modelling community preferences for a dispersed rural settlement pattern. Eur. Plan. Stud. 17 (3), 441–462.
Murgante, B., Di Donato, P., Berardi, L., Salvemini, M., Vico, F., 2011. Plan4all: European network of Best practices for interoperability of spatial planning information. Computational Science and Its Applications (ICCSA).
Nadin, V., 2007. The emergence of the spatial planning approach in England. Plan. Pract. Res. 22 (1), 43–62.
Nadin, V., Stead, D., 2008. European spatial planning systems, social models and learning. disP-The Planning Review 44 (172), 35–47.
Paasch, J.M., Van Oosterom, P., Lemmen, C., Paulsson, J., 2015. Further modelling of LADM's rights, restrictions and responsibilities (RRRs). Land Use Policy 49, 680–689.
Pinuji, S., 2016. Integrasi sistem informasi pertanahan dan infrastruktur data spasial dalam rangka perwujudan one map policy. Bhumi: Jurnal Agraria dan Pertanahan 2 (1).
Pissourios, I.A., 2014. Top-down and bottom-up urban and regional planning: towards a framework for the use of planning standards. Eur. Spat. Res. Policy 21 (1), 83–99.
Province of DKI Jakarta, 2012. . Frequently answered question. Dinas Cipta Karya, Tata Ruang Dan Pertanahan (in Bahasa).
Puerta, A.R., 1997. A model-based interface development environment. IEEE Softw. 14 (4), 40–47.
Safitri, S., Riqqi, A., Deliar, A., Norvyani, D.A., 2016. The Conceptual Architecture for 3D Cadastral Data Management Based on Land Administration Domain Model (LADM).
Spatial Planning Act, 2007. Act No. 26 Year. Republic of Indonesia.
Suhattanto, M.A., 2018. Improving organizational work process of land registration based on 3D cadastre and cadastre 2014 concepts (Case study apartment unit registration). BHUMI: Jurnal Agraria dan Pertanahan 1 (38), 201–219.
United Nations, 2015. Transforming our world: the 2030 agenda for sustainable development (A/RES/70/1). Resolution Adopted by the General Assembly. Department of Economic and Social Affairs, United Nations. New York.
United Nations on Global Geospatial Information Management (UN-GGIM), 2015. The application of geospatial information – Land administration and management. United Nations Committee of Experts On Global Geospatial Information Management.
Van der Molen, P., 2015. Property and administration: comparative observations on property rights and spatial planning with some cases from the Netherlands. Adm. Soc. 47 (2), 171–196.
Van Loenen, B., 2006. Developing Geographic Information Infrastructures: the Role of Information Policies. IOS Press ISBN 90-407-2616-7.
Van Oosterom, P., 2013. Research and development in 3D cadastres. Comput. Environ. Urban Syst. 40, 1–6.
Van Oosterom, P., Stoter, J., 2010. 5D data modelling: full integration of 2D/3D space, time and scale dimensions. International Conference on Geographic Information Science 310–324.
Van Oosterom, P., Groothedde, A., Lemmen, C., van der Molen, P., Uitermark, H., 2009. Land administration as a cornerstone in the global spatial information infrastructure. IJSDIR 4, 298–331.
Van Oosterom, P., Lemmen, C., Uitermark, H., 2013. FIG Working Week 2013 in Nigeria–Environment for Sustainability. ISO 19152: 2012, Land Administration Domain Model Published by ISO, Abuja, Nigeria, pp. 6–10 May 2013.
Verbeeck, K., Van Orshoven, J., Hermy, M., 2011. Measuring extent, location and change of imperviousness in urban domestic gardens in collective housing projects. Landsc. Urban Plan. 100 (1-2), 57–66.