

# The Governance of Semantic Resources for the FIG Community

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**Key words:** AGROVOC Multilingual Thesaurus (AGROVOC), Cadastre and Land Administration Thesaurus (CaLAtHe), FIG's International Office for Cadaster and Land Records (OICRF), The Linked Land Governance Thesaurus (LandVoc), Teaching Essentials for Responsible Land Administration (TERLA)

## SUMMARY

Knowledge Organization Systems (KOSs) or controlled vocabularies in terms of taxonomies, thesauri, and ontologies, among others, enable Semantic Web and Linked Data implementations by supporting the publishing of data in a relational, structured way. A number of KOSs are available for the FIG community, as outlined by Çağdaş et al. (2021). Among these, The Linked Land Governance Thesaurus (LandVoc) and Cadastre and Land Administration Thesaurus (CaLAtHe) are two thesauri developed specifically for the service of the land related discipline. The former is related to land governance; while the latter is related to the administrative, legal, and geospatial aspects of cadastre and land administration. These thesauri have some commonalities in terms of subject areas, yet are different regarding scope and level of detail; therefore, they support each other.

The LandVoc thesaurus is stored as a subschema of FAO's AGROVOC Multilingual Thesaurus (AGROVOC). Investigation on whether CaLAtHe should join the AGROVOC context as a subschema is ongoing. This effort may be adequate but would benefit from being supplemented with support for the explorative development and application of semantic resources, including ontologies, and the application of these in higher education.

The role of the FIG International Office for Cadastre and Land Records (OICRF) in documenting knowledge on land administration may also include the storing of semantic resources. Such semantic resources include FIG- and land-related ontologies, thesauri, taxonomies, as well as code lists and their values specified by ISO Land Administration Domain Model (cf. Kara et al., 2022). We therefore suggest the establishment of a working group with the support of FIG representation, in charge of the integration, maintenance and application of CaLAtHe and LandVoc as comprehensive, research-related semantic resources for FIG and the broader land sector. The proposed working group will include representatives of universities, mapping and cadastral agencies, and land and data practitioners working to improve interoperability of semantic resources. The governance of semantic resources related to cadastre, land administration and land governance will contribute to the improved understanding of linked land administration data. Publishing cadastral, land administration and governance data (cf. Stubkjær & Çağdaş, 2015) and LinkedSDG data contribute to better reporting on the land-related Sustainable Development Goals indicators. This underlines the

role that land administration can play in support of sustainable development (cf. Bayer & Meggiolaro, 2024).

The purpose of the paper is to (i) describe the importance of semantic web technology for the recording and the improved discoverability of land administration data and (ii) document the ongoing investigations regarding alignment of CaLAtThe and LandVoc for the benefit of FIG and the land administration community as a whole.

# The Governance of Semantic Resources for the FIG Community

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## 1. INTRODUCTION

The notion of *semantic resources* is introduced to the geospatial community referring to controlled vocabularies, specifically thesauri, which assist in providing interoperability among datasets in the surveying and the construction sector and support a wider e-governance perspective (Çağdaş et al., 2021). Compared to the uptake and application of geospatial tools for solving land-related problems and processes (Hull et al., 2022) the use of semantic resources lags, despite the paramount importance of researchers' and students' shared understanding of terms.

The introduction of thesauri to the largely science and technology-based geospatial domain might be supported by recalling that the zeal of structuring phenomena into hierarchies is as old as Western science: Aristotle (384-322 B.C.) devised a classification scheme for animals, which as Medieval 'Scala Naturae' formed the basis for Carl Linnaeus' Systema Naturæ from 1737, where he divided the physical components of the world into the three familiar kingdoms of minerals, plants and animals. Roget's Thesaurus of English Words and Phrases (1852) provided, according to Roget in his introduction, a "verbal classification . . . the same as that which is employed in the various departments of natural history" (Gilchrist, 2003). This structuring tradition is manifest also within the FIG community: Barry and Roux argue that a more rigorous, formally structured, approach to land tenure information systems theory development is desired. Therefore, they adapt Glazier and Grover's taxonomy, a hierarchy consisting of worldview, paradigm, grand theory, formal theory, substantive theory, hypothesis, research question, proposition, concept, definition, and symbol (2012). However, the following leaves the issue of theory development.

In the present context of research and education, the notion of *semantic resources* also refers to traditional lecturing material as well as to the *knowledge assets* or *intellectual capital* of an organization. The latter includes e.g., guides, standards, and tools mentioned in the Terms of Reference of the C7 Work plan 2023-26, e.g. the Cadastre 2014 (Kaufmann & Steudler, 1998) and ISO 19152:2012 Land Administration Domain Model (LADM) (ISO, 2012). An organization may create value through *knowledge management*, but this issue is not further explored.

This paper is a follow-up of previous work on controlled vocabularies, thesauri, and Knowledge Organization Systems (KOSs) (e.g. Stubkjær & Çağdaş, 2021). Working with thesauri changes the focus from solving problems in society or developing new technology to reflecting on the concepts of the domain of land, the relations among these concepts, and their structuring in various hierarchies. The ISO 19152-1:2024 LADM (ISO, 2024) provides for a normative structure, supplemented by code lists and national profiles. However, worldwide

diverse cultures and different languages exist. Translations of terms between languages can result in confusion, especially where terms are already poorly defined (Hull, 2024); therefore, the normative structure is supplemented through thesauri (Stubkjær et al., 2018; Stubkjær et al., 2019) as well as various alternative structures as unfolded in the following.

Linked Data refers to data published on the Web in such a way that it is machine-readable, its meaning is explicitly defined, it is linked to other external data sets and can in turn be linked to external data sets (Bizer et al., 2009). It is built upon a set of standards and specifications published by the World-Wide Web Consortium<sup>1</sup> (W3C) such as Resource Description Framework (RDF), RDF Scheme (RDFS), Simple Knowledge Organization Systems (SKOS), Web Ontology Language (OWL), and SPARQL Query Language for RDF (SPARQL). In Linked Data, a resource is accessed by Uniform Resource Identifiers (URI) over the Web, described by RDF based on standardised RDF vocabularies, connected with other semantically related resources by RDF links (Berners-Lee, 2006), and queried by SPARQL. The meaning of the concepts used in data and relationships between these concepts may be defined by KOSs such as taxonomies, thesauri, or ontologies, which are represented through RDF vocabularies such as OWL or SKOS.

Van den Brink et al. in *Best Practices for Publishing, Retrieving, and Using Spatial Data on the Web* (2019) notes that the linked data web technology, promoted by the W3C, adds vocabulary management and tooling to the principles, tools, and standards that enabled search engine results for consumer shopping. Authors describe best practices, and note unsolved questions related to representing geometry on the Web, with regard to recommendable serialization forms and formats, and the use of coordinate reference systems. OGC's GeoSPARQL offers a vocabulary that allows serialization of geometries as GML, but the lack of best practices on the consistent use of the existing spatial data vocabularies prevents interoperability. A proposed update of GeoSPARQL, Version: 1.1<sup>2</sup> has since been achieved.

Other researchers implemented the Linked Data approach to cadastre and land administration domain. For instance, Saavedra et al. (2014) integrated data coming from different cadastral data producers through the Linked Data approach in a Colombian case study. Abd Ghafar & Abu Hanifah (2014) introduce semantic technology supporting knowledge interoperability. Shi et al. (2017) described the publishing and integration of several cross-domain government datasets related to state-owned real estates as Linked Open Data. Ronzhin et al. (2019) presented experiences from building a Knowledge Graph by the Netherlands' Kadaster Land Registry and Mapping Agency and demonstrated the advantages of the Knowledge Graph in three different use cases. Vilches-Blázquez & Saavedra (2019), presented a framework for generating, enriching, and exploiting geospatial Linked Data from multiple and heterogeneous geospatial data sources. They further provided a case study where land administration information from two Colombian agencies were semantically integrated through knowledge graphs and enriched with other data according to Linked Data principles (Vilches-Blázquez & Saavedra, 2022). The above-mentioned research may indicate that we are facing a new (sub-)discipline. The databases of traditional GISs are being replaced by structures (triplestores), which hold concepts that are related through primitive sentences. This implies a new focus on concepts and the corresponding discipline of semantics. Bucher et al. in *EuroSDR Knowledge Graph about Geodata Products in Europe* (2024) offer an introduction to semantic web

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<sup>1</sup> <https://www.w3.org/>

<sup>2</sup> <http://www.opengis.net/doc/IS/geosparql/1.1>

technologies (section 1.2) and among others informs on the Dutch National Digital Heritage program (NDE) (cf. Schreiber, 2010).

Concept sets in a domain of interest, their definitions and relationships are specified by KOSs in different levels of complexity, such as term lists, taxonomies, classification schemes, thesauri, and ontologies. Researchers have developed various KOSs in the form of ontology based on ISO LADM, to realise Linked Data implementations in the domain of cadastre and land administration, e.g. Soon (2013), Sladić et al. (2013), Shi et al. (2017), Vilches-Blázquez and Saavedra (2022).

In addition to these ontologies, several land-related thesauri are available for the FIG community, as outlined by Çağdaş et al. (2021). Among these, The Linked Land Governance Thesaurus (LandVoc) and Cadastre and Land Administration Thesaurus (CaLAtHe) are two thesauri developed specifically for the service of the land-related disciplines. The former is related to land governance, while the latter is related to cadastre and land administration. These thesauri have some commonalities in terms of subject areas, yet are different regarding scope and level of detail; therefore, they support each other.

The governance of these two complementary semantic resources together with code lists and their values, specified according to the ISO LADM formalism, contribute to the improved understanding of linked land administration data. LinkedSDG<sup>3</sup> data also contribute to better reporting on the land-related SDG indicators. The FIG publication on the Digital Transformation of Land Administration highlights the necessity of clear definitions and uses of terminology referencing specifically LandVoc as well as FAO and FIG glossaries (FAO, UNECE and FIG, 2022). This underlines the role that land administration can play in support of sustainable development (cf. FAO & IFAD, 2022; Bayer & Meggiolaro, 2024). The above-mentioned extension of the focus on concepts suggest to engage and organise colleagues to manage and develop these semantic resources, support their integration into research, and to cooperate with related disciplines in developing courses which introduces next generation of students to the semantic technology (Čeh & Tekavec, 2023; Jovanovik & Spasić, 2019).

The rest of the paper is organised as follows. Section 2 introduces land-related semantic resources in terms of three thesauri: AGROVOC, LandVoc, and CaLAtHe, and in terms of FIG Sustained Semantic Resources: OICRF, ISO LADM, the FIG Standards Network, and The Responsible Land Administration Teaching Essentials. In section 3 the use of thesauri in research and (higher) education is reported, to motivate the appropriation of such practices. Section 4 summarises reflections on thesaurus relations and reports on the outcome of the intentions described in the submitted abstract; it is followed by Conclusions.

## 2. LAND RELATED SEMANTIC RESOURCES

### 2.1 Land Related Semantic Resources in terms of Thesauri

KOSs or controlled vocabularies are vital for cataloguing and indexing information resources. They also facilitate communication by providing basic terminology for the domain of interest and enable Semantic Web, Linked Data and Knowledge Graph implementations. Several controlled vocabularies focusing on different aspects of land management have been developed by the land-related disciplines including AGROVOC, LandVoc, and CaLAtHe. The

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<sup>3</sup> <https://linkedsdg.officialstatistics.org/#/>

content of these controlled vocabularies is described below, as basis for the discussion in Section 4.

#### 2.1.1 AGROVOC Multilingual Thesaurus<sup>4</sup>

AGROVOC is a multilingual thesaurus maintained by the Food and Agriculture Organization of the United Nations (FAO). It includes more than 41.000 concepts and 1.148.000 terms in 42 languages in all areas of interest to the FAO, such as food, nutrition, and agriculture to fisheries, forestry, and the environment. AGROVOC is expressed through the SKOS formalism and published as Linked Open Data. It can be accessed through the SKOSMOS browser<sup>5</sup> and a SPARQL endpoint<sup>6</sup>. AGROVOC concepts are organised under the following top concepts: Activities, Entities, Events, Factors, Features, Groups, Location, Measure, Methods, Objects, Organisms, Phenomena, Processes, Products, Properties, Resources, Site, Stages, State, Strategies, Subjects, Substances, Systems, Technology, Time.

AGROVOC is edited by the web-based platform, VocBench<sup>7</sup>, a free and open-source advanced collaboration environment for creating and maintaining KOSs. VocBench also allows the creation and management of domain-specific sub-vocabulary within AGROVOC. Therefore, other expert communities can express their own vocabularies within AGROVOC through a subscheme. This enables enriching AGROVOC with concepts belonging to other controlled vocabularies. However, each concept has to belong to the main AGROVOC scheme and must be located within the AGROVOC hierarchy. Flexibility is achieved by allowing each scheme to have a different concept hierarchy. Furthermore, when a concept is modified (e.g. adding or changing a translation) in a scheme, the data are not only edited for that scheme, because such update will now be seen in all schemes which include this concept. Currently, several sub-vocabularies have been developed within the AGROVOC frame including (i) Land Governance (LandVoc) by the Land Portal Foundation; (ii) Aquatic Sciences and Fisheries Abstracts (ASFA) by the ASFA secretariat at FAO; (iii) Legislative and Policy concepts (FAOLEX) by the Development Law Service (LEGN) of the FAO Legal Office; (iv) FAO Indigenous Peoples; and (v) One CGIAR (Subirats-Coll et al., 2022; FAO, 2023).

#### 2.1.2 The Linked Land Governance Thesaurus – LandVoc<sup>8</sup>

LandVoc is a thesaurus covering concepts related to land governance. It was created as an AGROVOC sub-vocabulary in 2012 by the Land Portal Foundation<sup>9</sup>. LandVoc builds on existing land glossaries, such as the FAO's Land Tenure Thesaurus (Ciparisse, 2003), the LADM, or the Global Land Indicators Initiative glossary. It can be accessed through the SKOSMOS browser<sup>10</sup> and the AGROVOC SPARQL endpoint<sup>11</sup>.

LandVoc consists of 310 concepts organised hierarchically under seven top concepts, namely land administration, land equity, land governance, land management, land markets, land

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<sup>4</sup> <https://www.fao.org/agrovoc/>

<sup>5</sup> <https://agrovoc.fao.org/browse/agrovoc/en/>

<sup>6</sup> <https://agrovoc.fao.org/sparql>

<sup>7</sup> <https://vocbench.uniroma2.it/>

<sup>8</sup> <https://landvoc.org/>

<sup>9</sup> <https://landportal.org>

<sup>10</sup> <https://explore.landvoc.org/landvoc/en/>

<sup>11</sup> <https://agrovoc.fao.org/sparql>

rights, and land stakeholders. It is available in English, French, Spanish, Portuguese, Khmer, Vietnamese, Burmese, Thai, Swahili, Hindi, Italian and Arabic. The content of LandVoc is updated periodically according to recommendations of the Community of Experts and in close coordination with the FAO AGROVOC editorial team. LandVoc thesaurus content is licensed under Creative Commons Attribution 3.0 IGO (CC BY 3.0 IGO).

LandVoc is currently part of FAO's AGROVOC, which is aligned with other vocabularies like EUROVOC, CaLAtHe, Chinese Agricultural Thesaurus (CAT), Aquatic Sciences and Fisheries Abstracts (ASFA), Linked Thesaurus fRamework for Environment (LusTRE), National Agricultural Library Thesaurus (NALT), United Nations Bibliographic Information System Thesaurus (UNBIS), General Multilingual Environmental Thesaurus (GEMET), etc. LandVoc can be explored through a SPARQL endpoint and downloaded in Excel, CSW or RDF.

### 2.1.3 Cadastre and Land Administration Thesaurus - CaLAtHe<sup>12</sup>

CaLAtHe is a domain thesaurus in the SKOS format. Following reviews of a comprehensive amount of recent PhD theses (Çağdaş & Stubkjær, 2009; Çağdaş & Stubkjær, 2011), it was issued in 2011. The identification and structuring of domain terms, covering legal, administrative, and technical (surveying and information) aspects, was originally intended to support the development of cadastral theory, perhaps a cadastral ontology (Stubkjær, 2001).

CaLAtHe's initial version was based on the then draft version of ISO LADM. However, it also included terms from other thesauri, such as the AGROVOC, the GEMET with INSPIRE Spatial Data Themes, the STW Thesaurus for Economics, Cycorp's OpenCyc ontology, and United Kingdom's Integrated Public Sector Vocabulary. Version 2, issued in 2012, was supplemented with terms representing the dynamic aspect of the domain, based on outcomes from the European research activity Modelling Real Property Transactions (ESF/COST G9, 2001–05). Version 3 and Version 4, released in 2019, extended CaLAtHe with new terms adopted from the Land Division, Condominium, and Survey parts of the OGC Land and Infrastructure Conceptual Model Standard (LandInfra) (Scarponcini & Stubkjær, 2017). Version 4 also included code lists of the Survey, Land division, and Condominium sections of the LandInfra standard.

From the outset in 2011, CaLAtHe was rendered in the English language. However, Version 5 in 2021 started a multi-lingual itinerary by adding terms in Danish and Turkish, the native language of the editors. In Version 6, new and revised concept definitions were provided. The intensional definition (also known as the genus-differentia definition) method recommended by ISO 704:2009 'Terminology work - Principles and methods' was applied in the preparation of definitions. Moreover, the multilingualism of CaLAtHe was further improved by Malay terms. Finally, the 2024 revisions complemented CaLAtHe with Common law concepts, and Dutch terms were added. The current Version 7 now includes about 250 concepts with their definitions and their equivalences in the Danish, Dutch, Malay, and Turkish languages. The concepts are organised through its top concepts that characterise the domain covered, namely Activity, Information, Land, Law, Party, and Survey.

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<sup>12</sup> <http://www.cadastralvocabulary.org/>

## 2.2 FIG Sustained Semantic Resources

### 2.2.1 OICRF - International Office for Cadastre and Land Records<sup>13</sup>

OICRF, Office International du Cadastre et du Régime Foncier, established 1958 (Henssen, 1981), is a study and documentation center for cadaster, land administration and affiliated fields of interest<sup>14</sup>. As of May 31, 2024, the OICRF digital Land Administration Library houses 21.414 publications, encompassing a diverse array of resources such as conference documents, magazine articles, and reports related to land administration. The contents of the library are accessible in multiple languages, incl. Italian, Russian, Spanish, and English.

OICRF is actively engaged in a significant quality enhancement initiative. This improvement focuses on several key areas: standardising country names according to ISO standards, resolving missing links and years in the database (where some of the most valuable resources are found), eliminating duplicate entries, and implementing standardised tags and keywords. With reference to these quality improvements, active promotion of OICRF is paused during 2024 (OICRF, 2024).

### 2.2.2 ISO 19152:2012 Land Administration Domain Model (LADM)<sup>15</sup>

LADM is a common standard for the land administration domain. It will stimulate the development of software applications and will accelerate the implementation of proper land administration systems that will support sustainable development. The LADM covers basic information-related components of land administration (including those over water and land, and elements above and below the surface of the earth).

The standard provides an abstract, conceptual model with four packages related to:

1. parties (people and organizations);
2. basic administrative units, rights, responsibilities, and restrictions (ownership rights);
3. spatial units (parcels, and the legal space of buildings and utility networks);
4. spatial sources (surveying), and spatial representations (geometry and topology);

The LADM revision process is ongoing. Expanding the scope of the standard motivated organising the standard into multiple parts. The first part focuses on the conceptual model, published as ISO 19152-1:2024 Geographic information, Land Administration Domain Model (LADM), Part 1: Generic conceptual model. Part 1 forms the basis and also provides a global overview of the conceptual models in parts 2 to 5. Part 3: Marine georegulation has been published as ISO 19152-3:2024, and others are following. The development of part 6, Implementation aspects, is planned in collaboration between ISO/TC 211 and the Open Geospatial Consortium. *WG 7.3 – LADM and 3D Land Administration (LADM/3D)* is mentioned, because applications of thesauri support the specification of LADM code lists. These potentials have been addressed in Stubkjær & Çağdaş (2021) and Kara et al. (2024).

### 2.2.3 FIG Standards Network<sup>16</sup>

The Network sees itself as at the hub of FIG standardisation activity, making the necessary linkages and providing the necessary advice to commissions and others. The following standards are introduced: ISO/TC211 Geographic information/Geomatics, ISO 19152:2012

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<sup>13</sup> <https://www.oicrf.org/>

<sup>14</sup> <https://www.fig.net/organisation/perm/index.asp>

<sup>15</sup> [https://fig.net/organisation/networks/standards\\_network/ladm.asp](https://fig.net/organisation/networks/standards_network/ladm.asp)

<sup>16</sup> [https://fig.net/organisation/networks/standards\\_network/index.asp](https://fig.net/organisation/networks/standards_network/index.asp)



LADM, ISO/TC 172 SC6 Survey Instrument Standards, International Property Measurement Standards Coalition (IPMS), International Land Measurement Standard (ILMS), International Construction Measurement Standards (ICMS), as well as Standards in Hydrography. It maintains the FIG Guide on Standardisation. The Terminology list of the Guide describes Official standards, Legal standards, and De facto standards<sup>17</sup>.

#### 2.2.4 The Responsible Land Administration Teaching Essentials

The Responsible Land Administration Teaching Essentials (ReLATE) are motivated by Du Plessis et al. (2020), assessed by Chigbu et al. (2021), and introduced by Enemark (2023a; 2023b). The achievement is described as a structured knowledge base, well designed for combining traditional lecture courses with digital learning material to be used as self-studies (cf. Chigbu et al., 2021). A review of ReLATE or alternatively, Teaching Essentials for Responsible Land Administration (TERLA), is in process (Hull et al., 2024). The core of the Teaching Essentials consists of six modules, each about 70 pages long. They are available on the GLTN e-learning platform in English and French. In the introducing report, they are supplemented with parts relating to the SDGs, providing practical guidance for applying the Teaching Essentials, and offering recommendations for applying the principles of responsible land administration at the country level. Thus, frameworks, approaches, and the LADM are seeking to bring many countries forward.

The ReLATE summary and guidance mentions the development of land administration, where in the 1990s ‘the emphasis was on information management, reflecting the computerization of the land information agencies in the 1970s. This focus on information remains, but in recent years the type and quality of information needed has changed, pushing the design of land-administration systems towards an enabling infrastructure for implementing land policies in support of sustainable development.’ (Enemark, 2023a). However, the focus in the present paper on semantic resources and technology prompts the observation that the claimed remaining ‘focus on information’ cannot be confirmed: Key concepts (Box 1) include ‘Spatial data infrastructure provides access to and interoperability of cadastral and other land related information on the natural and built environment’, but ‘interoperability’ is not found among learning objectives or elsewhere. The module that according to the title primarily addresses data and information: 4. Responsible land administration and information in practice, includes a lesson 4.4 on Tools to improve land administration effectiveness. ‘The lesson presents a range of tools and methods for reorganising land administration with a focus on strategy and strategic planning.’ The ‘tools’ deals with the ‘costs of running a land-administration system’, and not technologies for land tenure. These are related to in Module 2, titled ‘Land tenure security’, which includes a lesson 2.4 on Land administration processes with the learning objective: ‘Choose and apply appropriate tools from a range of options to improve land tenure security, such as enumeration, social tenure domain model, and pro-poor land registration systems.’ (all quotes from Enemark, 2023a). The observation is included in section 3.2 on domain knowledge.

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<sup>17</sup> <https://fig.net/resources/publications/figpub/pub28a/figpub28a.asp>

### 3. THE USE OF SEMANTIC RESOURCES

To motivate the present proposal for use of semantic resources, it is recalled that semantic resources in terms of thesauri are concept based. This focus on concepts and concept relations has triggered a learning approach called Concept mapping. Therefore, concept mapping is introduced to invite lecturers and students to apply this approach. Next, relations between the semantic resources AGROVOC, LandVoc and potentially CaLAtThe are specified through subschemes. Research is referred to which motivates the relevance of more subschemes concerning a shared domain.

#### 3.1 Concept mapping

Thesauri record knowledge; the challenge is to articulate that knowledge in a way that the person can apply it adequately, be it in the role as student, lecturer, or scientist. Concept mapping has been proposed as a learning approach, which gradually has gained wider acknowledgement. A concept map is a graphical representation of concepts (nodes) and relationships (in graph theory: edges) between them. The relationships can be conceptual (such as hierarchical) or empirical (such as cause and effect, influence) (Soergel, 2009). Concept maps display ideas in a hierarchical structure and tie them together with explanatory nodes and links. Two or more concepts can be linked together with words to form propositions (Machado & Carvalho, 2020).

In a concept-map based learning environment, students, individually or in groups, may construct a concept map showing their previous knowledge on a topic, and further develop a knowledge model that reflects their increased understanding (Cañas et al., 2023). A recent review by Machado and Carvalho (2020) motivates the inserting of concept maps into university teaching, as it contributes to developing critical thinking skills, promotes meaningful learning, and facilitates student collaboration. The article further aims to provide educators and researchers with a structured overview of the research on concept mapping as learning and assessment tools implemented with students in higher education. Figure 1 below may introduce the issue. Their review provides a basic introduction to the subject, not repeated here, and among others includes references to several disciplines. Geosciences are not mentioned, but a review by Xiaogang Ma (2022) entitled ‘Knowledge graph construction and application in geosciences’ details how to build knowledge graphs by designing conceptual models and mentions the CmapTools<sup>18</sup>. Knowledge graph construction requests skills, which are presently lectured primarily by computer scientists. However, like problem-based learning developed from something new and special to become a more general teaching practice, the computer-assisted knowledge construction may similarly become a more general practice.

Some applications of concept mapping have focused on using concept mapping for assessing student learning (Jacson et al., 2023). Others have explored its utilisation in problem-based learning (Alt et al., 2023) and learning technology, e.g. Moodle<sup>19</sup> (Pontes et al., 2012; Chen et al., 2023). From the perspective of improving land administration education, these are all relevant, but for problem-based learning, and Master and PhD. projects, Chakraborty et al.

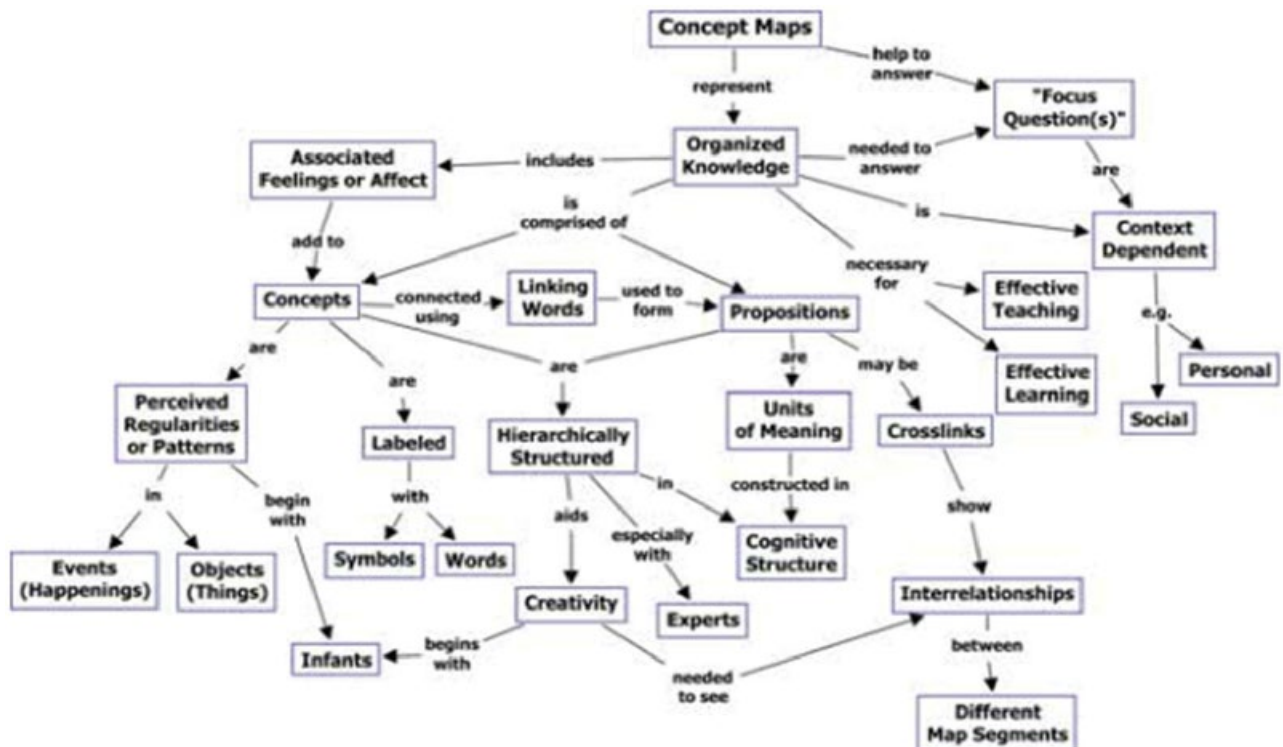
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<sup>18</sup> <https://cmap.ihmc.us/>

<sup>19</sup> <https://moodle.org/>

(2023) offer an important addition, as they apply concept mapping for systematising knowledge generated through interviews:

‘Through 8 Focus Group Discussions (FGD) and concept mapping we identified and systematised the underlying direct and indirect drivers of ecosystem change in the Nakatsu mudflat.’ (Abstract). ‘Each FGD lasted about two-three hours and started with a brief explanation of the activity at hand and the expected outcome. As the main goal of each FGD was to identify the main drivers of ecosystem change in Nakatsu mudflat and how they intersect (Section 1), we used a research approach borrowing from concept mapping (e.g. Moon et al., 2011) and modelling (Reed et al., 2013)’.



**Figure 1.** A concept map showing key features of concept maps. Note: Reprinted from Machado and Carvalho (2020)

This brief introduction to concept mapping suggests how the knowledge embodied in thesauri might enrich land administration teaching and learning. Concept maps created by individual students will reflect how students perceive the domain knowledge, e.g. domain concepts and relationships between those concepts as well as enable them to go deeper into the domain knowledge. The creation of concept maps may be based on the concept sets provided by CaLAtThe, LandVoc, and AGROVOC, supplemented by other land-related semantic resources. Also, such concept maps will include more relationship types than those provided by a thesaurus (e.g. Broader Terms, Narrower Terms, and Related Terms). Anyway, the concept mapping activity supports students learning by familiarising them with the domain terminology. Exploring the potential of concept maps thus calls for a more specific plan.

### 3.2 The structuring and presentation of domain knowledge in terms of subschemes

The effort to find an organisational context for CaLAtThe triggered attention to AGROVOC and its subschemes<sup>20</sup>. They include LandVoc<sup>21</sup>, ASFA<sup>22</sup>, FAOLEX<sup>23</sup>, and FAO Indigenous Peoples<sup>24</sup>, among others. LandVoc and CaLAtThe cover shared domains, but the structure of CaLAtThe as indicated by top concepts differs from the structure of LandVoc. This raises the question whether it is adequate to have one or more subschemes covering shared domains. Adequate answers to this question are sought by drawing on an analysis of the use of the terms land administration, land management, and land governance (Hull, 2024), a paper on validating knowledge structures (Steiner & Albert, 2017), and a concern of Barry and Roux (2012) and Hull (2024) to maintain creativity while pursuing concept rigor.

Hull performs a bibliometric and qualitative analysis of land-related publications from the past decade and concludes that ‘Land governance [LG] is suggested by several respondents as a suitable, all-encompassing descriptor of which land management [LM] and land administration [LA] could be described as sub-domains. Yet the bibliometric analysis highlights the distinctiveness and interconnectedness of the three concepts, suggesting that to favour one of them over the others as a domain identifier may be inappropriate.’ The findings of the bibliometric analysis are summarised (p. 9) as follows:

1. LA, LM and LG are distinct terms with their own meanings and applications.
2. LM appears to apply to sustainable management of Earth’s resources in the light of current global pressures such as climate change and its impact on food security.
3. LA applies to the conventional topics of cadastre and land registration, supported by innovative technologies.
4. The centrality of LG in the network indicates its importance in bridging the gap between the LA and LM clusters.

LandVoc provides a suitable, all-encompassing scope of LG (cf. Bayer & Meggiolaro, 2022), while CaLAtThe reflects the LA with its focus and applications (cf. Çağdaş & Stubkjær, 2015). The cautious assessment by Hull may be supported by asking whether ‘innovative technologies’ constitute a subdomain of LG? Keywords revealed through the analysis include ‘blockchain’ and ‘gis’ (Fig 11), and ‘UAV’ (unmanned aerial vehicles) and ‘digitalization’ (p. 9). The Introduction section mentions research on interoperability and ontology, but apparently this research was too scattered to amount to be mentioned. The same holds with terms like linked data, knowledge graph, and semantic web. Also, the observation made in the above presentation of ReLATE, that the ‘focus on information’ could not be confirmed suggest that LA and thus CaLAtThe covers ‘innovative technologies’ more completely. This may, in part, explain the difficulty in finding an organisational context for CaLAtThe.

Steiner & Albert (2017) offer introduction to concept maps and to ontologies. Interesting is their claim that ‘For one and the same knowledge domain it is not realistic to assume that only one correct representation of complete consensus exists ... [because] there is a range of alternative ways conceivable to describe and conceptualise the same domain’. They discern

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<sup>20</sup> <https://www.fao.org/agrovoc/multischeme-and-multihierarchy-management>

<sup>21</sup> <https://landvoc.org/>

<sup>22</sup> <https://www.fao.org/asfa/en>

<sup>23</sup> <https://www.fao.org/faolex/en/>

<sup>24</sup> <https://www.fao.org/agrovoc/multischeme-and-multihierarchy-management>

‘Content validity [which] refers to the correct building of the content of a concept map, .. .. [from] application validity, [which] refers to the practical usability and usefulness of a target concept map.’ [i.e. a concept map to be validated]. Without delving into the theoretical basis of their arguments it appears that application validity refers to the users’ previous knowledge and capacity for making sense of the presented knowledge. LandVoc editors structure their knowledge base to accommodate various user interests, while editors of CaLAtThe use resources to improve content validity.

Barry and Roux (2012) refer to Çağdaş & Stubkjær (2009) who motivate the development of standardised definitions as a step towards ‘a coherent and universal core cadastral theory’. They warn that ‘standardisation may stifle critical thinking and innovation, and it may indeed prove impossible to reach consensus over certain terms.’ (2012, p. 305). Research since 2009 demonstrates that this way of expression was not fortunate. The issuing of CaLAtThe in 2011 was made precisely because the review of theory and methods published in 2009 (Çağdaş & Stubkjær, 2009) and 2011 (Çağdaş & Stubkjær, 2011) presented a complexity, which made us focus on the concepts only. We applied terms and definitions from the LADM standard, but from alternative sources as well. Rather than heralding standardised definitions, our conception of standards, specifically LADM, is illustrated by our pointing to the supplementing role of code lists and thesauri.

We maintain what was stated in 2009 that ‘To serve their functions effectively, concepts have to be clear, precise, and agreed-upon (Frankfort-Nachmias and Nachmias, 1997, pp. 48–49).’ This is in line with Barry and Roux, contending that ‘a degree of consensus regarding semantics is necessary for modelling [information system] concepts and developing theory.’ Hull et al. (2024) likewise call for a ‘glossary of terms’, also to improve linkage between modules. However, Hull et al (2024) also note that ‘concepts are not static’ and are concerned ‘that some of the frameworks and principles informing TERLA are not working from the existing realities of country contexts in the Global South, but are instead dictating what ‘should be’ according to a particular set of lenses that reflect a generally ‘western’ outlook.’ In the present context of assessing, whether one or more concept structures or subschemes are needed, this call for flexibility may be the strongest support for the latter position. Whether CaLAtThe should be the alternative to LandVoc is not the issue here. An alternative concept structure may apply better to the Global South; the point is that one or more alternatives are needed.

The position that it is adequate to have both a LandVoc subscheme and a CaLAtThe subscheme is supported by Hull’s (2024) analysis, informing that LA with cadastre constitutes one of the distinct terms and subdomains. Also, Steiner & Albert (2017), open up for various subschemes by discerning content validity from application validity. Finally, the world-wide differences in land tenure realities of countries also calls for the flexibility provided by more subschemes.

#### **4. THE EMBEDDING OF CALATHE WITHIN AGROVOC WITH LANDVOC**

The initial abstract of the present paper stated that the role of FIG International Office for Cadastre and Land Records (OICRF) in documenting knowledge on land administration may also include the storing of semantic resources. It proposed a working group in charge of the

integration, maintenance and application of CaLAtHe and LandVoc as comprehensive, research-related semantic resources for FIG and the broader land sector, and anticipated a documentation of the ongoing investigations regarding alignment of CaLAtHe and LandVoc. However, OICRF and FIG have recently concluded that it is best not to proceed with the integration of CaLAtHe into OICRF. Moreover, the clarifying of interpretations of the notion of semantic resources, cf. sections 1 and 2, and the discussion on the role of these in research and education, cf. section 3, have as consequences that what can be presented is the status of discussions.

The FIG body in charge of curating the thesauri was suggested as a new unit in the submitted abstract. Alternatively, however, objectives and staffing of present WG(s) might be extended. The fact that the *WG 2.4/7.7 Land Administration Education*, a combined C2 / C7 working group, seeks to evaluate, support, and further develop the Teaching Essentials for Responsible Land Administration (TERLA), suggests a close connection to this activity. The *WG 7.8 – Comparative Land Administration* which seeks to demonstrate how FIG can best recommit to creating and disseminate comparative land administration information, as demonstrated through the LandPortal and LandVoc must remain in focus.

The curating activities include:

- The transfer of CaLAtHe from its present location to the selected technical solution, to be performed primarily by the present editors.
- The review and addition of terms, and the adding of more languages, for an AGROVOC-based solution for only the CaLAtHe terms that are not found in AGROVOC, to be performed by the present and extended circle of language representatives.
- The general development of CaLAtHe and LandVoc within the present 2023-26 plans, focusing on the needs of the chosen context.
- Contribute to a long-term curating solution through 2027-30 plan drafting.
- Engage in the further alignment of CaLAtHe and LandVoc with other FIG-related semantic resources.

## 5. CONCLUSION

The notion of *semantic resources* is introduced to the geospatial community referring to controlled vocabularies, specifically thesauri, which assist in providing interoperability among datasets in the surveying and the construction sector and support a wider e-governance perspective. Semantic resources in terms of thesauri are detailed and compared to other FIG-supported semantic resources. Thesauri and the corresponding concern for concepts and concept relations has triggered a learning approach called Concept mapping which is introduced to invite lecturers and students to apply this approach. Finally, the recent efforts to find an organizational context for CaLAtHe was documented. A solution including the embedding of CaLAtHe in AGROVOC raises the question whether concept relations in terms of subschemes can be sufficiently accounted for in terms of the existing LandVoc subscheme. A number of arguments, including the world-wide differences in land tenure realities of countries, call for the flexibility provided by more subschemes.

## REFERENCES

- Abd Ghafar, M.S., Abu Hanifah, F. (2014). MyGeoOntology – An Information-Focused Geospatial Ontology for SDI towards Knowledge Interoperability. FIG Congress 2014, Kuala Lumpur, Malaysia, 16 – 21 June 2014.
- Alt, D., Weinberger, A., Heinrichs, K., & Naamati-Schneider, L. (2023). The role of goal orientations and learning approaches in explaining digital concept mapping utilization in problem-based learning. *Current Psychology*, 42(17), 14175-14190.
- Barry, M. & Roux, L. (2012). A change based framework for theory building in land tenure information systems. *Survey Review*, 44(327), 301–314.
- Bayer, C.-T. & Meggiolaro, L. (2022). Open Data for Improved Land Governance. FIG Congress 2022, Warsaw, Poland, 11–15 September 2022.
- Bayer, C.-T. & Meggiolaro, L. (2024). Land Ownership. In S. Walker, T. Davies, M. Rubenstein, & F. Perini (Eds.), *The State of Open Data: Histories and Horizons* (2<sup>nd</sup> ed.). Ottawa, IDRC.
- Berners-Lee, T., 2006. Linked Data – Design Issues, <http://www.w3.org/DesignIssues/LinkedData.html>
- Bizer, C., Heat, T. & Berners-Lee, T. (2009). Linked data: the story so far. *International Journal on Semantic Web and Information Systems*, 1–22.
- Bucher, B., Latvala, P., Bookjans, E., Bus, N., Bouet, A., Folmer, E., et al. (2024). EuroSDR Knowledge Graph about Geodata Products in Europe. EuroSDR Linked Data Project Mid-Term Report. EuroSDR Office of Publication. 2024. <https://hal.science/hal-04601680/document>
- Çağdaş, V. & Stubkjær, E. (2009). Doctoral research on cadastral development. *Land Use Policy*, 26(4), 869-889.
- Çağdaş, V. & Stubkjær, E. (2011). Design research for cadastral systems. *Computers, Environment and Urban Systems*, 35(1), 77-87.
- Çağdaş, V. & Stubkjær, E. (2015). A SKOS vocabulary for linked land administration: Cadastre and land administration thesaurus. *Land Use Policy*, 49, 668-679.
- Çağdaş, V., Meggiolaro, L. and Stubkjær, E. (2021). Semantic Resources for the Geospatial Domain. FIG e-Working Week 2021, Netherlands, 21–25 June 2021.
- Cañas, A.J., Reiska, P. & Shvaikovsky, O. (2023). Improving Learning and Understanding through Concept Mapping. *Knowledge Management & E-Learning*, 15(3), 369-380.
- Čeh, M. & Tekavec, J. (2023). Geospatial Linked Data Proliferation in NMCAs: Systematic Literature Review. *Geodetski vestnik*, 67 (2), 213-234.
- Chakraborty, S., Yamamori, T., Su, J., Johnson, B.A., Kumar, P., Ashikaga, Y. & Gasparatos, A. (2023). Systematizing ecosystem change in coastal social-ecological systems: Perspectives from a multi-stakeholder approach in Nakatsu mudflat, Japan. *Ocean & Coastal Management*, 243, 106729.
- Chen, X., Zou, D., Xie, H., Chen, G., Lin, J. & Cheng, G. (2023). Exploring contributors, collaborations, and research topics in educational technology: A joint analysis of mainstream conferences. *Education and Information Technologies*, 28(2), 1323-1358.
- Chigbu, U.E., Enemark, S., Mabakeng, R.M., Du Plessis, J., Mitchell, D., Sait, S. & Zevenbergen, J. (2021). *Structured Knowledge Base and Teaching Essentials on*

- Responsible Land Administration: Assessment of Uses and Users. FIG Working Week 2021, Virtually in the Netherlands, 20-25 June 2021.
- Ciparisse, G. (Ed.). (2003). Multilingual thesaurus on land tenure. Food & Agriculture Organization of the United Nations, Rome.
- Du Plessis, J., Chigbu, U. E., Mitchell, D. & Sait, S. (2020). A Structured Foundation for Teaching and Training Land Actors in Responsible Land Administration. FIG Working Week, Amsterdam, the Netherlands, 10–14 May 2020.
- Enemark, S. (2023a). Teaching Essentials for Responsible Land Administration: Summary and Guidance for Education, Research, and Capacity Development. UN-Habitat, Global Land Tool Network, Nairobi, Kenya.
- Enemark, S. (2023b). Responsible Land Administration: A GLTN Synthesis Report and User Guidance. FIG Commission 7 & 2 Annual Meeting 2023. Deventer, the Netherlands, 2–4 October 2023.
- FAO (2023). AGROVOC 4: AGROVOC editorial guidelines. Rome, <https://doi.org/10.4060/cc0647en>.
- FAO & IFAD. (2022). GeoTech4Tenure – Technical guide on combining geospatial technology and participatory methods for securing tenure rights. FAO. <https://doi.org/https://doi.org/10.4060/cc1076en>
- FAO, UNECE and FIG. (2022). Digital transformation and land administration – Sustainable practices from the UNECE region and beyond. FIG Publication No. 80. Rome. 88 pp. FAO, UNECE and FIG. <https://doi.org/10.4060/cc1908en>
- Gilchrist, A. (2003) Thesauri, taxonomies and ontologies - an etymological note. *Journal of Documentation*, vol. 59 no. 1. <https://doi.org/10.1108/00220410310457984>
- Henssen, J.L.G. (1981). Die Geschichte Des Office International Du Cadastre Et Du Regime Foncier (O.I.C.R.F.), FIG XVI International Congress, Montreuz, Switzerland. <https://www.oicrf.org/documents/40950/43224/Die+Geschichte+des+Office+International+du+Cadastre+et+du+Regime+Foncier+OICRF.pdf>
- Hull, S. A. (2024). All for one and one for all? Exploring the nexus of land administration, land management and land governance. *Land Use Policy*, 144, 107248.
- Hull, S., Liversage, H., Rizzo, M. P. & Evtimov, V. (2022). An Overview of Frontier Technologies for Land Tenure: How to Avoid the Hype and Focus on What Matters. *Land*, 11(1939), 1–15. <https://doi.org/https://doi.org/10.3390/land11111939>.
- Hull, S., Mabakeng, M., Rugema, D., Wijek-Roy, G. & Kingwill, R. (2024) Teaching Essentials for Responsible Land Administration – a SWOT analysis. 3rd International Land Management Conference, 14-15 March 2024, Bristol, UK.
- International Organization for Standardization (ISO), 2012. ISO 19152:2012, Geographic Information–Land Administration Domain Model (LADM), 1st ed. ISO, Geneva, Switzerland. ISO 690.
- International Organization for Standardization (ISO), 2024. ISO 19152-1:2024, Geographic information — Land Administration Domain Model (LADM) Part 1: Generic conceptual model. ISO, Geneva, Switzerland.
- Jovanovik, M. & Spasić, M. (2019). Transforming Geospatial RDF Data into GeoSPARQL-Compliant Data: A Case of Traffic Data. <https://repository.ukim.mk/bitstream/20.500.12188/10162/1/geosparqldata-ciit2019.pdf>



- Kara, A., Lemmen, C., van Oosterom, P., Kalogianni, E., Alattas, A. & Indrajit, A. (2024). Design of the new structure and capabilities of LADM edition II including 3D aspects. *Land use policy*, 137, 107003.
- Kaufmann, J. & Steudler, D. (1998). *Cadastrre 2014 A vision for a future cadastral system*. International Federation of Surveyors (FIG). <https://www.fig.net/resources/publications/figpub/cadastrre2014/translation/c2014-english.pdf>
- Ma, X. (2022). Knowledge graph construction and application in geosciences: A review. *Computers & Geosciences*, 161, 105082.
- Machado, C. T., & Carvalho, A. A. (2020). Concept mapping: Benefits and challenges in higher education. *The Journal of Continuing Higher Education*, 68(1), 38-53.
- OICRF, 2024. Annual Report 2024, FIG Working Week 2024, 19-24 May, Accra, Ghana. [https://www.fig.net/organisation/general\\_assembly/agendas\\_and\\_minutes/2024/agenda/app\\_17\\_01-OICRF%20Annual%20Report%202024.pdf](https://www.fig.net/organisation/general_assembly/agendas_and_minutes/2024/agenda/app_17_01-OICRF%20Annual%20Report%202024.pdf)
- Pontes, E., Kofuji, S., & Guelfi, A. (Eds.). (2012). *Methodologies, Tools and New Developments for E-Learning*. BoD–Books on Demand. <https://www.opentextbooks.org.hk/ditatopic/22845>.
- Ronzhin, S., Folmer, E., Maria, P., Brattinga, M., Beek, W., Lemmens, R. & Van't Veer, R. (2019). Kadaster Knowledge Graph: Beyond the Fifth Star of Open Data. *Information* 10 (10): 310.
- Saavedra, J., Vilches-Blázquez, L.M. & Boada, A. (2014). Cadastral data integration through Linked Data. In Huerta, Schade, Granell (Eds): *Connecting a Digital Europe through Location and Place*. Proceedings of the AGILE'2014 International Conference on Geographic Information Science, Castellón, June, 3-6, 2014. ISBN: 978-90-816960-4-3.
- Scarponcini, P. & Stubkjær, E. (2017) OGC InfraGML 1.0 Part 7 – LandInfra Land Division - Encoding Standard.
- Schreiber, G. (2010). Web Science: The Digital-Heritage Case. In *International Conference on Current Trends in Theory and Practice of Computer Science* (pp. 108-111). Berlin, Heidelberg: Springer Berlin Heidelberg. <https://www.cs.vu.nl/~guus/papers/Schreiber10a.pdf>
- Shi, L., Sukhobok, D., Nikolov, N. & Roman, D. (2017). Norwegian State of Estate Report as Linked Open Data. In *OTM Confederated International Conferences on the Move to Meaningful Internet Systems*, 445–462. Cham: Springer.
- Sladić, D., Govedarica, M., Pržulj, D., Radulović, A. & Jovanović, D. (2013). Ontology for real estate cadastre. *Survey Review*, 45(332), 357-371.
- Soergel, D. (2009). Knowledge organization systems: overview. <https://www.dsoergel.com/UBLIS514DS-08.2a-1Reading4SoergelKOSOverview.pdf>
- Soon, K.H. (2013). Representing roles in formalizing domain ontology for land administration. 5th Land Administration Domain Model Workshop 24-25 September 2013, Kuala Lumpur, Malaysia.
- Steiner, C.M. & Albert, D., (2017) Validating domain ontologies: A methodology exemplified for concept maps, *Cogent Education*, 4:1, 1263006, DOI: 10.1080/2331186X.2016.1263006.
- Stubkjær, E. (2001). Integrating ontologies: Assessing the use of the Cyc ontology for cadastral applications. In *Integrating ontologies* (pp. 171-184). Norway.

- Stubkjær, E. (2001). Integrating ontologies: Assessing the use of the cyc ontology for cadastral applications. In Bjørke, Jan Terje; Tveite, Håvard (eds.) (Ed.), *ScanGIS'2001: Proceedings of the 8th Scandinavian Research Conference on Geographical Information Science*, June, 25-27, 2001, Ås, Norway (pp. 171-184). Norway. <http://www.umb.no/conf/scangis2001/papers.html>
- Stubkjær, E. & Çağdaş, V. (2021). Alignment of standards through semantic tools–The case of land administration. *Land Use Policy*, 104, 105381.
- Stubkjær, E., Gruler, H. C., Simmons, S., & Cagdas, V. (2019). Code list management supported through a controlled domain vocabulary. *The 8th Land Administration Domain Model Workshop*. 1-3 October 2019, Kuala Lumpur, Malaysia.
- Stubkjær, E., Paasch, J., Çağdaş, V., van Oosterom, P. J. M., Simmons, S., Paulsson, J., & Lemmen, C. H. J. (2018). International Code List Management: The Case of Land Administration. *7th International FIG Workshop on the Land Administration Domain Model*, 11-13 April 2018, Zagreb, Croatia.
- van den Brink, L., Barnaghi, P., Tandy, J., Atezing, G., Atkinson, R., Cochrane, B., et al. (2019). Best practices for publishing, retrieving, and using spatial data on the web. *Semantic Web*, 10(1), 95-114.
- Vilches-Blázquez, L.M. & Saavedra, J. (2019). A framework for connecting two interoperability universes: OGC web feature services and linked data. *Transactions in GIS*, 23(1), 22-47.
- Vilches-Blázquez, L.M. & Saavedra, J. (2022). A graph-based representation of knowledge for managing land administration data from distributed agencies – A case study of Colombia. *Geo-spatial Information Science*, 25:2, 259-277.

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