3D Marine Cadastre within Land Administration - Review

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Abstract. Cadastre was used to identify the dimension and position of the properties defined in legal documents. It consists of the geometric description of the parcels that describing the interests and ownerships including the property's value. Cadastre plays an important role in land administration for state authorities and federal organizations in terms of ownership (rights, restrictions, and responsibilities). Meanwhile, cadastre in the marine area is still quite unclear due to separate working systems between land and marine region. Coastal and maritime spaces with various uses regularly lead to overlapping rights issues in the water surface, water column, and seabed as well as conflict in technical, legal, and stakeholder management. Since some part of the marine area is considered as land space, there were a few ideas that have been proposed in managing marine area within land administration to overcome those issues. The current land standard data model that has been referred to, is Land Administration Domain Model (LADM). This standard has been proven relevant to 3D cadastre inland and marine environments. Some works discussed the probabilities of managing the marine environment within land administration. Thus, this paper attempted to review the possibilities of integrating marine cadastre within land administration.

1. Introduction

Marine projects, such as resorts and aquaculture areas, have been managed by various agencies, stakeholders and registered owners. Thus, this scenario triggered the decision making becomes complex and uncertain (Omar et al., 2017). Due to conceptual limitations, technical problems, and budgetary constraints for the complex registration systems, cadastral institutions have difficulties in registering water bodies (Alberdi & Erba, 2020). Being a coastal state, the country's economic activities rely to a large extent on its ability to control marine resources. Thus, an efficient management system for example a framework that able to manage the marine data integration between three ecosystems (land, coastal and marine) is needed. Considering the marine environment is volumetric by nature, a good representation is required to portray an accurate picture of marine properties. 3-Dimensional (3D) elements need to be considered since marine properties involve sea-surface, water column as well as the seabed. Since some part of the marine area is considered as land space, some of the studies believed that marine cadastre can be integrated within land administration. Land and marine systems that ran by different agencies triggered confusion and a lack of coastal zone management (Strain et al., 2004). Any information system that manages legal, including informal, marine, and coastal information, as well as related spatial quantities, will be referred as a marine cadastre (M. Sutherland, 2005). The current land administration standard that has been practiced is Land Administration Domain Model (LADM). This standard has been said applicable to marine cadastre as well. As mentioned by (Lemmen et al., (2019) in his revision regarding LADM version II, the scope of LADM is extended to the marine cadastre with special attention to the land-to-sea transition region. The expanded framework of the conceptual model that supports marine spaces, urban planning, or zoning with legal implications such as coastal zone is

one of the outlines for LADM expansion. Hence, this paper will discuss the ability to integrate marine cadastre within the administration.

2. Marine Cadastre

Marine cadastre allows spatial information of maritime rights can be controlled and managed. This includes the rights, restrictions, and responsibilities (RRRs) practiced by the legal authorities in the marine area. It is an information system in which interest and spatial data (boundaries) and non-spatial data were recorded, managed, and visualized. Marine cadastre in various countries (e.g. Australia, United States, and Malaysia) operate under a state or federal system of governance. In marine management, state jurisdiction responsible for the coastal zone which is from the low watermark out to a limit of three nautical miles (5.6 km). In a meantime, there are zoning issues in marine alienation for the right purposes because of no provision established for marine spatial management (Abdullah A. et al., 2017); (Abdullah A. et al., 2014).

2.1. Needs of Marine Cadastre

Human activities can be handled through an effective marine administration. For these activities to take place, they required a legal interest in the form of a lease or a license as reported by Widodo et al., (2002). In Malaysia, water lot building around the coastal area, fish cages projects, and ocean recreation areas need to apply for a lease or license, for example, Temporary Occupation License (TOL) which needs to be renewed annually (Arof & Abdullah, 2015). TOL is a temporary license that allows the holder to occupy certain land for a limited period provided by the state authority. This approach is closely related to the land cadastre and therefore could adapt the practice gained from the study of land administration to the marine region. A marine cadastre is needed to deal with marine parcel spatial information on the natural and spatial context of interests and property ownerships in terms of property, value, and uses from a maritime perspective (Widodo, 2003). The marine cadaster's functions comprise the rights' allocation within society and among government associations; marine resources ownership; rights of use, ownership, and management control; and prevent and adjudicate disputes with effective provision. Given its importance to coastal and marine stakeholders, the marine cadastre should be regarded as part of the spatial data infrastructure, where spatial data needs are constantly growing and expanding. The bounding coordinates and metadata (e.g. datum) should be described in marine policy with adequate precision to accurately establish the spatial data layer (Fowler & Treml, 2001). Then, to get the information, spatial data could be readily accessed. In Europe, Multipurpose Marine Cadastre (MMC) has been applied to handle all the marine activities (Michalak, 2018). MMC acts like a land cadastre in managing the system for activities RRRs located in the marine and coastal space.

Some issues when it comes to marine cadastre are dynamic coastline; marine areas that need to be handled; dynamic spatial and temporal relationships in the marine environment; frameworks to allow precise and effective updating of marine spatial data; a virtual registry of marine environmental to facilitate decision-making; and the wide range of marine activities and stakeholders that need to be addressed and their existence. It is necessary to know where and when certain activities are going to take place to better monitor the operational and legal limits of these operations. Therefore, it is important to document the rights and restrictions that go along with those limits (Rajabifard et al., 2006). Moreover, most of the countries (e.g. Turkey) still lacking on administration and management of the marine areas by using spatial data information. The data generated by the administration and management of marine institutions is not real-time and lacks sufficient precision. (Bilgi et al., 2019). There are several rights in a marine environment (water surface, water column, and seabed). The area of marine water surface area used to define a marine parcel does not provide an accurate picture of all the rights that might occur in the area. Nearly everything marine activities or properties take place in the water column. Marine rights such as aquaculture and fishing naturally involved in 3D nature which makes 2D representation are improper. However, the diversity of marine activities resulted in ambiguous and conflicting positions among the organizations (Yatim et al., 2018). Thus, to have an accurate portrayal of the marine rights involved, 3D representation is needed (Ng'ang'a et al., 2004).

2.2. 3D Marine Cadastre

Activities involving the water surface, water column, seabed, and subsoil rights need to be treated in a 3D environment. Geometric parcels in a marine area connected to other records defining the existence of the interests, rights, and value of the parcels (FIG, 2014). Mapping the physical parcels seems challenging as it may result in overlapping activities in that area. Most marine rights, such as aquaculture, fishing, and building developments (above-water resort), are three-dimensional, making a two-dimensional concept of those rights inadequate legally.

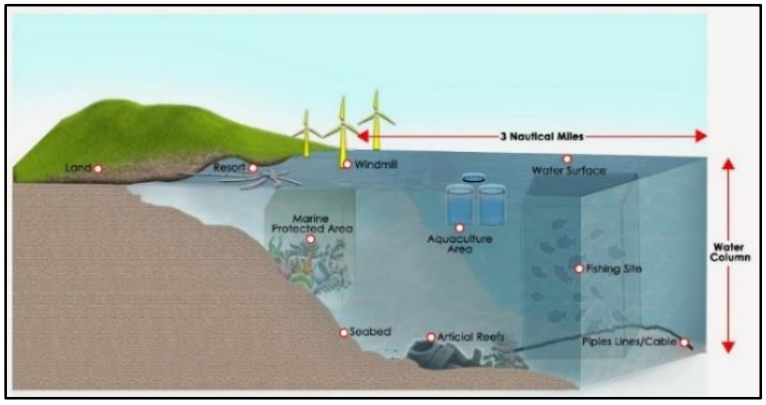

Figure 1. Marine Properties in 3D View

Figure 1 shows how 3D representation makes the property rights in marine space more precise. Private ownership of parcels is uncommon in the marine environment. Government control, public rights, and international law could seize the existed private rights, exterminating a person's right to exclude others from the land. The features of marine areas in the registers can be used to classify them. Identification of semantic attributes can be an effective way to define marine regions if attributes are consistently structured and registered. The required analysis may consist of a simple explanation or a more complicated analysis is required depending on the number of attribute types and the amount of data (Amsyar et al., 2011). To work with these 3D attributes, land administration practice seems applicable since the current practice of marine alienation follows almost the same protocol as that applied onshore. (Arof Z. M. et al., 2015). Currently, the land standard that has been applied in most of the countries is Land Administration Domain Model (LADM). Luckily, this standard is applicable for 3D attributes too.

3. Land Administration Domain Model

Land Administration Domain Model (LADM) is an international standard that has been used to support land administration. This international standard focuses on the part of the land administration that deals with geometric objects that have an interest in land and water rights, responsibilities, and restrictions (ISO 19152, 2012). It consists of three packages: parties (individuals and organizations); basic administrative units, RRRs; and spatial units (parcels and legal space for buildings and service networks), with a sub-package for surveying and representation (Lemmen C. et al., 2013) as can be seen in Figure 2.

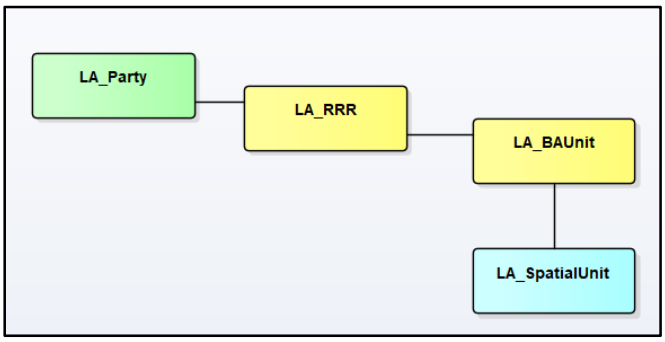

Figure 2. LADM Packages (ISO 19152, 2012)

LADM is a reference model for the people-land relationship pattern for land administration development (Lemmen C. et al., 2015). It comprises basic details on the components of land management, such as water and elements above and below the surface of the earth, as well as individuals (ISO, 2012), and has been cited in scholarly and technical works such as Griffith-Charles et al.,(2014), and Sutherland M. et al., (2016) to be explicitly relevant to inland 3D cadastre. Several researches on LADM and marine cadastre have been published in scholarly or professional journals such as Lemmen C. et al., (2019), Sutherland M. et al., (2016), A. Athanasiou et al., (2017), K. Athanasiou et al., (2016), and Griffith-Charles et al., (2014). The relevance of LADM to the marine cadastre is often acknowledged within those publications, both explicitly and implicitly. LADM has been upgraded to LADM version II, which provides more comprehensive land management and marine cadastre support. The scope of LADM is expanded to include the marine cadastre, with special attention on land-to-sea transition zones and marine spatial planning as reported by Lemmen C. et al., (2019). Marine spatial planning considering how various economic interests will be balanced against each other accessible and democratic process, while still considering human rights and other rights (Grip & Blomqvist, 2020). As this standard has been in use for so long, it has been proposed to include assessment, planning and development (planned land use), marine environments and detailed 3D visualization (van Oosterom et al., 2020).

3.1. Marine Cadastre based Land Practices Issues

The different datums used inland and marine space lead to the discontinuity between the areas. Traditionally, land topography and bathymetric data have been collected for specific purposes and quite separate. Where topographic mapping ends, bathymetric charting begins. The chart's bathymetry (depth) is based on the Chart Datum meanwhile land elevation (height) is referenced to Mean Sea Level (MSL). This different datum would result in inconsistencies in datasets and make analyzing data from the coastal zone more difficult (Amsyar et al., 2011). The depth datum varies from the vertical datum of the topographical survey in nature as the sea level changes continuously. As a consequence, it needs its datum. Moreover, since the datum of the chart is often different between countries and regions, it may express different depths (Cui et al., 2019). The relationship between land and sea has a direct effect on the marine environment (Tsilimigkas & Rempis, 2018). States should have collaborated on a national standard and procedures to ensure coherence preparation across marine areas. Sutherland M. et al., (2016) addressed the perspective of accommodating different types of conflicting RRRs and the ability of LADM to incorporate spatial and non-spatial attributes plus information of stakeholders in marine spaces Meanwhile, (K. Athanasiou et al., 2017) addressed several international marine environmental standards. One of the international standards is LADM. A concept for developing and implementing marine data modeling practices based on LADM has been addressed, since LADM is capable of providing a formal language for describing current structures based on their differences and similarities. The use of attributes code list ensures the standard consistency and it is possible to adapt and modify those code list followed the suitability needed.

Besides, (K. Athanasiou et al., 2016) also mentioned the ability of LADM in supporting both 2D and 3D objects by introducing external classes for BuildingUnit and UtilityNetwork. Next, A. Athanasiou et al., (2017) examined RRRs packages relating to marine space based on LADM. The concept of the people-land relationship is acceptable in marine area. Meanwhile, (Flego & Roi, 2018) assumed that exchanging and integrating marine data through seamless land management systems would be made easier and straightforward. The use of LADM in registers can help with data integration and the monitoring of insufficient or redundant information. Based on the outcome, several publications have developed a marine-land data model using the marine cadastre-based land practice definition to point out the importance of LADM to marine cadastre using reasonably parameters. The multipurpose function of the data model can be evaluated for its sufficiency. Of course, some criteria need to be considered to make sure it facilitates the management of marine spatial information. However, different countries need to have different kinds of data models based on their administration and management. The findings can be seen below.

Previous studies have highlighted the fact that cadastral features such as adjudication, survey elements such as boundary and datum considerations, and concepts of ownership rights often apply to coastal regions (Sutherland M. et al., 2016). Figure 3 shows the conceptual schema of the LADM based Marine Cadastre for Canada. The created classes (MC_MaritimeZone, MC_MarineResource, and MC_MarineLayer) are the new classes added in the LADM. This conceptual schema became a reference because it involves marine layers (sea surface, water column, and seabed).

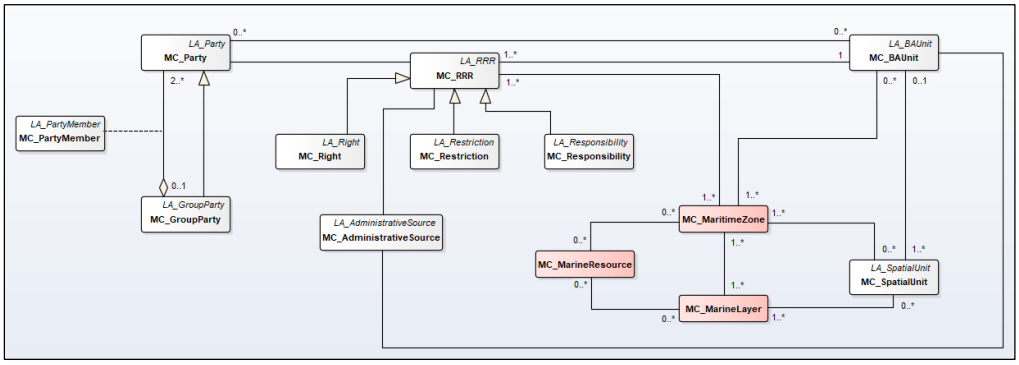

Figure 3. Land Administration Domain Model-based Marine Cadastre Conceptual Schema (Canada)

A. Athanasiou et al., (2017) have come out with linking 3D marine administration within LADM. Figure 4 represents the 3D Marine Administration Model-based LADM for Greece. They focused on how the marine environment RRRs should be structured. Gas pipeline and aquaculture area became their case studies on overlapping rights. This model was developed for the legal purposes of marine spatial management, with the potential of storing 3D data.

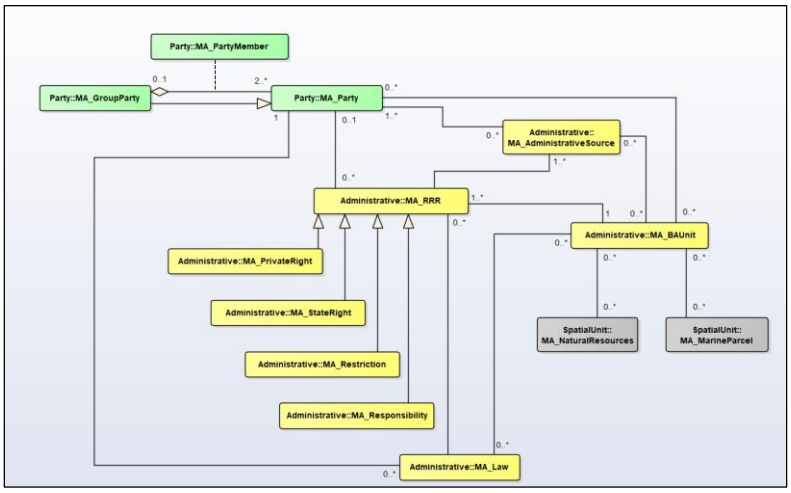

Figure 4. 3D Marine Administration based LADM (Greece)

The concept of LADM has the potential to be linked with the marine cadastre to sustain marine management from any aspects such as economic, environmental, and social. However, both of these studies were using Canada and Greece as their case studies. It might be quite different from other countries because of different administrations. For instance, Greece is applying Deed System as their land registration meanwhile Malaysia is applying Torrens System. Hence, it is important to find out which part of the existing data model resembles c's marine administration.

4. Discussion

From the works of literature, it founds that the marine environment can be managed within land administration as mentioned in the further standardization of LADM (edition II). LADM Edition II proposes a normative relation to IHO S121 (Marine Limits and Boundaries) based on the LADM concepts. Despite the issues when it comes to link land with marine space, there are a few elements that can be considered and applied. Briefly, LADM able to be adapted into marine cadastre in terms of managing and modeling the variety of RRRs. It will support those RRRs involved in the marine space and can accommodate stakeholder information (party or individual) in the marine environment. The conflicts between the stakeholders (properties' rights ownership) happened when there is no proper standard in the marine environment that can be followed. Next, LADM is flexible in terms of additional attributes, operators, associations, and classes needed. If the attributes are structured and documented consistently, semantic attribute recognition can be a useful tool for identifying marine regions. It will support other relevant spatial information components such as datum, projections, etc. Towards the end, LADM able to incorporate non-spatial elements such as administrative parts (RRRs). Fortunately, LADM is supporting 2D and 3D concept which is needed when it comes to the marine environment. Because most marine resources naturally in 3D, so that the ownership of marine properties should be illustrated properly by using 3D representation. Fairly concluded that the LADM-based marine cadastre can be designed and deployed. This could be good news for those communities that intend to create a marine cadastre in considering LADM as an acceptable conceptual standard.

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