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Application of LADM for disaster prone areas and communities

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ABSTRACT

Disaster prevention, response and recovery require information about land tenure. Though, in many high-risk contexts, such records are non-existent or not up to date. As a result, vulnerable groups are often passed over by the government during risk management activities. At present there exists no dedicated tool for supporting land tenure recordation of all people-to-land relationships for the purposes of disaster risk management. More specifically, the required supportive data models and standards that could enable integration of concepts from the respective domains of land administration and disaster risk management are also lacking. Standardized data models could support software and service designs. This paper introduces a model linking the domains of land administration and disaster risk management – with the goal of supporting resilience against natural disasters and providing an approach for collecting data once, and using it multiple times. A design approach was used to develop the model – with adaption of the international Land Administration Domain Model (LADM) standard acting as a basis. Key features of the model include the support of interoperability through standardisation, the inclusion of all people-to-land relationships including those specific to disaster contexts, and the potential of the model to contribute to each of the disaster phases. The model is suggested to be highly applicable in natural disaster contexts where no land tenure information exists or the national mapping authority already uses a land administration system compatible with LADM. Overall, the model is considered as a step toward an implementable strategy for applying responsible land administration in the context of disaster risk management.

1. Introduction

Responsible land administration[1] and disaster risk management both focus on empowering vulnerable groups to become resilient communities. When land administration is implemented responsibly, it underpins good land governance and ultimately supports sustainable land administration by providing strategies and tools to document all people-to-land relationships (Zevenbergen et al., 2015). Disaster risk management and especially community based disaster risk management (CBDR) aim to evaluate and manage natural disaster risks at the local level – and highlights the role of communities when it comes to disaster risk reduction (Asian Disaster Preparedness Center, 2016).

Contemporary research suggests a relationship between different levels of land tenure security and the negative consequences experienced by groups of people in the context of natural disasters (Mitchell et al., 2017; Unger et al., 2017; UN-Habitat, 2010; Rajabifard et al., 2018). The impact is argued as most severe at the community and household levels, and can be witnessed, for example, through loss of income, loss of shelter and minimal measures for disaster preparedness and mitigation. Moreover, these impacts are greater if land tenure is not secured and if the people-to-land relationships are neither known nor documented (Mitchell, 2011).

On a global level, significant effort remains focused on securing land and property rights for all, seeking to accelerate the proportion of recognized and recorded people-to-land relationships. The 2030 Agenda for Sustainable Development with its defined Sustainable Development Goals (SDGs), together with the Sendai Framework for Disaster Risk Reduction, stimulate innovative and transformative approaches to secure land and property rights for all (UN, 2015). The Sendai Framework (UN, 2015) specifically calls for investments in research and the development of a methodology and models for disaster risk assessment. In (Rajabifard et al., 2018) a World Bank and FAO funded research project is exploring ways to improve resilience and resilience impact of national land and geospatial information systems.

At a more theoretical level, (Unger et al., 2017) argues that a relationship between the two disciplines can be understood conceptually

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[1] In this paper, the term 'responsible land administration' is used to refer to the definition in (Zevenbergen et al., 2015) addressing all people to land relationships.

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via three driving forces - people, land, and disaster - and three disaster risk drivers - exposure, vulnerability and hazard. Combined, these elements provide an entry point for developing integrated land administration and DRM activities that adequately prepare, prevent, mitigate and respond to natural disasters. Further the need for data modelling is driven by the fact that well-designed and documented conceptual and logical models support and allow stakeholders to identify areas for improvements. Consequently the demand for a shared ontology, which allows all stakeholders to act globally, increases with any software development requiring alignment and standardisation to achieve data compatibility and interoperability (West and Fowler, 1999). Within the land administration domain a globally agreed ISO standard exists, the Land Administration Domain Model (LADM) (ISO et al., 2012). Within disaster risk management many frameworks already exist that are used to develop practical approaches in DRM. However, none of these models deal directly with the overlap between land and disaster related data.

Potentially complicating the landscape of data management domain relating to land and disasters, in recent years a new wave of data modeling and data provision techniques emerged. Developments such as predictive modeling, algorithm intelligence, self-describing data formats, design adaptive databases (Barry and Roux, 2012) are likely to impact on future data modelling efforts in the land and disaster domains. Although, as yet most initiatives remain only experimental or at the demonstrator level (Bennett et al., 2018). Moreover, standardized models such as the LADM (ISO et al., 2012) can continue to decrease the complexities of achieving efficient data interoperability and storage.

Synthesizing the above-mentioned issues, demand for a data model linking the land and disaster related data appears high. Accordingly, the aim of this research is not to develop yet another data model, but build on what is already developed so that standardisation efforts are further met and used conditionally. It is suggested by the authors that this integrated LA-DRM[2] model should be capable of capturing the people-to-land relationships in supporting disaster risk management objectives. The model has to encompass attributes describing the nature and scale of vulnerability, exposure and hazard – in order to be used for disaster risk management as well as deliver land tenure security for all. It needs to enable involved stakeholders to communicate over disciplines and institutions. The model further needs to be flexible in order to include bottom up and top down land data governance approaches, in regards to data acquisition, provision and sharing of data (at municipality, regional, national but also global level).

Therefore, in this paper an experimental LA-DRM model that seeks to support land tenure security issues in disaster prone areas is presented in terms of design and applicability. First, the motivation and background of the intended model are provided. Justification and an outline of the selected methodology used to develop the model are presented. Subsequently, the section 'Starting Points' examines and compares existing models from each domain, available for adaptation. This leads to a description of the outcomes of the data modelling, including a representation of required classes and attributes. The potential application of the model in different contexts and phases of disaster risk management is then explored. Finally, the limitations of the LA-DRM model are drawn, preceding the conclusion and encapsulation of future research opportunities.

2. Methodology

In order to develop an experimental LA-DRM model, a methodology called 'design approach', as shown in Fig. 2 Design Approach, was followed. Justification of the approach is found in similar research related to tenure security (Lemmen, 2012) (Hay, 2014), and (Lemmen et al., 2015) and related to disaster risk management (Li et al., 2007; UNISDR, 2015). Throughout this design approach Unified Modeling Language (UML) diagrams, along with textual and graphical descriptions, were used for the representation of all activities, processes, classes, attributes and associations. Especially with regards to the research area of disaster risk management a flexible approach has to be considered: reality is dynamic and with that all the data representing the reality is under constant change, which brings limitations to modelling the real world. The key to address this complexity as well as a constant change in data is to work with standards and conceptual models. The conceptual model as defined in (Unger et al., 2017) identified already the associations between different classes at the highest, most abstract level (Fig. 1). The conceptual model, developed through knowledge acquisition, determination of objectives and definition of requirements, and conceptual modelling techniques, was used as the base for the LA-DRM model.

Following on, the design approach was applied (Fig. 2). The first step of the design approach was a review (1) of existing standards, models and tools used in both disciplines. Theses findings lead to the draft model abstraction (2), followed by an initial definition (3) of classes, attributes and associations. These outputs were used to develop questionnaires and methods to identify tenure security issues in a post disaster context. A preliminary version of the model was then piloted in Nepal within a project, named 'Support for Land Reform in Nepal and Land Tenure Initiative' (SILTIP) in Dolakha. Dolakha is one of the most affected districts from the earthquakes, which hit Nepal in 2015. Therefore Kadaster[3], UN-Habitat Global Land Tool Network (GLTN), UN-Habitat Nepal and Human Rights Awareness and Development Centre (HURADEC) implemented a project in 3 sites of Bhimeswor Municipality, and one in Bigu rural Municipality in 2017, to address land tenure issues in the post-disaster context. The model's ability to support the process was tested, and data gaps revealed, which were previously not identified, but were seen to be required for an adequate representation of reality. Thereafter, various experts from UN-Habitat, GLTN, University Twente Faculty ITC and Kadaster discussed the developed questionnaires and the underlying data model. The outputs from the resulting Expert Group Discussion were seen as the first validation of the first draft model (4). Findings of the discussion proceeded in a re-definition (5) of classes, attributes and associations. The integrated model was then implemented through the Social Tenure Domain Model (STDM) tool, a plugin for QGIS (an open source geographic information system), which is based on the LADM (GLTN, 2014). At the data level, a separate data validation was conducted by the enumerators and communities who and where the model was implemented. The final validation was conducted through the analysis of the generated data using queries (6). Through the analysis, the potential and limitations of such an integrated model were assessed. Combined, the findings from the questionnaire development, the expert group discussion and the physical implementation, using GIS software, as well as the validation at data level are considered the fundamental validation and foundations for the design and development of the final draft of the integrated model, as presented in this work.

3. Starting points

When a structured approach to data modelling is accepted, then standards are needed for such an integrative and interdisciplinary approach. Both domains, land administration and disaster risk management work with various data and process models, implemented within Geographic Information System (GIS) tools, to generate land or disaster related data. But as far as the authors are aware this research is the first attempt to combine the concept of land administration, specifically

[2] LA-DRM Land Administration – Disaster Risk Management

[3] Cadastre, Land Registry and Mapping Agency of the Netherlands – with its International Branch Kadaster International