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Assessing multiple approaches for modelling land-use conflict potential from participatory mapping data

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ABSTRACT

Spatial social data collected through participatory mapping are increasingly used to assess social dimensions for land use planning and management. However, there has been limited research to evaluate alternative approaches to identify potential land-use conflict. Using data from Queensland, Australia, we applied multiple approaches (land-use preferences, weighted preferences, combined place values and land-use preferences, and value compatibility scoring to identify land-use conflict potential and to assess these methods for four different land uses (residential development, tourism development, mining, and conservation). The performance of these approaches were evaluated using selected reference sites in the study area to determine which spatial attributes and methods were most predictive of conflict potential. Weighted preferences, and combined place values and land-use preferences were most effective for all land use types. The conflict mapping results for mining and conservation were sensitive to the number of place value and land-use preference points available for analysis and the number of individuals participating in the mapping process. To determine the inferential quality of conflict mapping results, we operationalised confidence levels based on the number of unique participants that mapped preferences in a given location. Overall, the highest confidence in mapped results was observed for tourism development, followed by mining, conservation, and residential development. Confidence levels varied across the study area and by reference sites. The findings of this study increase the external validity of preference-based conflict mapping methods while demonstrating a means to assess the inferential quality of conflict mapping results. The generation of confidence levels can assist in the prioritization and allocation of planning resources to places with both high conflict potential and high confidence.

1. Introduction

In a regional planning process, land uses should be allocated to meet multiple and sometimes incompatible community demands and expectations. Conflict over land use may emerge because proposed developments and land use changes can affect landscape qualities that are valuable for people (Bengston et al., 2004). Land-use conflict is also the result of different views and perceptions about landscapes and their services (Brody et al., 2004). Over the last two decades, a number of studies have explored new methods to identify regional and community values and land-use preferences to incorporate them into a land use planning process; however, there is limited research on how these spatially-explicit social data can be used to assess potential conflict over various land uses that could result in more socially acceptable decisions.

From a psychological perspective, land-use conflicts occur because of two factors, interpersonal and social values conflicts (Vaske et al., 1995). Interpersonal conflict occurs when different individuals or groups have different goals and sometimes these goals may interfere with the goals of other individuals or groups (Jacob and Schreyer, 1980). Social values conflict occurs between different groups of stakeholders who do not share the same norms and/or values (Vaske et al., 2007). In this study, we operationalise and analyse place-based values and land-use preferences to explore the practical implications of these theoretical arguments for land-use conflict that often characterises local and regional planning activity and outcomes.

Participatory mapping refers to a wide range of methods where spatial information is collected or used as part of a participatory process. Participatory mapping, as applied to land-use conflict, typically differs between *developed* and *developing* countries. In *developing* countries, participatory mapping, termed “participatory GIS” or PGIS, has been used to map indigenous lands and resources (Chapin et al., 2005;

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Ramirez-Gomez et al., 2013; Reyes-García et al., 2012), empower and build capacity in communities (Rambaldi et al., 2006), manage natural resources (McCall and Minang, 2005), and enhance conservation (Bernard et al., 2011; Ramirez-Gomez et al., 2016). In developing countries, participatory mapping is often engaged as a means to mediate contemporary land-use conflicts resulting from the inequitable distribution of natural resources. For example, Kyem (2006) used PGIS to manage conflicts between local groups competing for access to local forest resources in Ghana and Cronkleton et al. (2010) used participatory mapping to reduce conflict over access to forest resources in Bolivia.

In contrast, participatory mapping in *developed* countries, when applied to land-use conflict, seeks to identify the potential for conflict based on the expression of spatially-explicit values and land-use preferences that operationalize the psychological theories of conflict. The values in participatory mapping have been called *landscape values* (Brown, 2004), *social values for ecosystem services* (Sherrouse et al., 2011), or simply *place values*. Place values consist of both *held* and *assigned* values. Held values represent enduring beliefs about the importance of a specific mode of conduct or an end state of existence (Rokeach 1973). Assigned values express the importance of an object relative to other objects (Brown 1984). Held values can influence assigned values through the subjective evaluation of objects (Brown 1984; Lockwood 1999). Brown and Weber (2012) refer to mapped values as *relationship* values because they bridge held values and assigned values. In the process of mapping values, what is personally important to a participant (*held* value) is cognitively related to what appears important to the individual in the physical landscape (*assigned* value).

Mapping values have been used in multiple applications for natural resource and environmental planning and management (see Brown and Kyttä, 2014). For example, Reed and Brown (2003) described a process whereby place values can be incorporated into a national forest planning process using value suitability analysis (VSA), a variant of traditional land suitability analysis that includes mapped values data from PPGIS. In another example, PPGIS data was used to identify the compatibility of different types of place values with prospective land uses such as motorized recreation (Brown and Reed, 2012). This analysis was called values compatibility analysis (VCA) but appears similar to VSA. Both VSA or VCA provide a systematic method for incorporating human dimensions data into land use planning decision frameworks. In a recent study, Moore et al. (2017) also used value compatibilities to identify potential conflict to inform marine spatial planning in the Kimberly region in Western Australia.

The mapping of *preferences* seeks to identify the spatial locations where various types of land use appear acceptable (or not) to participants. In contrast to values, mapped land-use preferences are simpler psychological constructs that are used to identify where people agree or disagree with current or future land use. One of the earliest applications of mapping land-use preferences was to identify the spatial locations where tourism and residential development was acceptable to residents living on Kangaroo Island, South Australia (Brown, 2006). In another application, Nielsen-Pincus et al. (2010) assessed the social acceptability for residential development based on mapped pReferences

Brown and Raymond (2014) integrated both place values and land-use preferences to conceptualize land-use conflict and applied this approach to measure the potential conflict for residential and industrial development in the Lower Hunter region in Australia. According to the model, the level of agreement or disagreement in land-use preferences is a proxy for social value conflict while the intensity of place values mapped in the area is a proxy for interpersonal conflicts. The integration of PPGIS mapped place values and land-use preferences to identify land-use conflict potential has been applied in multiple geographic locations and contexts. For example, Brown and Donovan (2013) developed a conflict potential index for the Chugach National Forest (Alaska) that used both mapped place values and forest use preferences. In another study in Norway, Hausner et al. (2015) measured the level of land-use conflict potential using both mapped place values and land-use preferences to assess whether conflict potential differed by land tenure. The conflict indices were based on the differences between mapped preferences to increase or decrease a specific land use that were weighted by the number of mapped preferences or place values. In another PPGIS study in Finland, Brown et al. (2017) used both place values and land-use preferences to identify conflict potential for multiple land uses (e.g., mining and tourism development) and the effect of participant social group (resident, visitor, holiday home owner). That study found more similarities than differences in preferences by social group.

This study expands on previous conflict mapping research by applying and comparing four approaches to identify potential conflict for four land uses: residential development, tourism development, mining, and conservation using place values exclusively, land-use preferences exclusively, and both attributes combined to calculate aggregated scores as suggested by Brown and Raymond (2014). The data for this research were collected in a participatory mapping process located in the Baffle Basin in Australia. Using place values as indicators of potential conflict, we applied value compatibility analysis (VCA) as the fourth method that incorporates a broad range of place values mapped by different individuals and stakeholders into a land-use trade-off analysis. One of the key steps in VCA is assessing the relationship between place values and different types of land uses to assign compatibility scores to these relationships. Previous studies have used researcher judgement to determine the compatibility between place values and prospective land uses (Brown and Raymond, 2014). In this study, we used a new approach by assessing place value and land use compatibility relationships using an expert elicitation technique rather than researcher judgment. After generating output maps based on multiple conflict mapping approaches, we measured their spatial correlations to determine the extent to which conflict/compatibility models yielded similar or different results. We further evaluated how well these different approaches predicted conflict potential using reference sites identified by key informants in the participatory mapping process. To conclude this study, we discuss the performance of the different conflict mapping approaches relative to strengths and limitations in the participatory mapping data.

2. Methods

2.1. Study area

The Baffle Basin is located at the southern end of Great Barrier Reef (GBR) catchment and falls within the Burnett Mary Natural Resource Management (NRM) region in central Queensland, Australia (Fig. 1). The Baffle Basin covers a total of 4114 km^2 (Binney, 2008) with a population of 5822 people in 2011 (Australian Bureau of Statistics, 2013). The region encompasses two local government areas, Gladstone and Bundaberg and contains several coastal cities such as Agnes Water and Seventeen Seventy that attract tourists to this part of Australia.

The Baffle Basin, as part of GBR catchment, comprises multifunctional landscapes with multiple land uses such as residential areas, agriculture, protected areas (conservation), tourism, and mining. The major land uses of this region are grazing, intensive agriculture, water supply, road and rail infrastructure, and urban residential areas (Reef Water Quality Protection Plan, 2013). This region also contains areas of high ecological importance including near pristine estuaries, threatened species of fauna and flora, two critically-endangered ecological communities, and 26 protected areas, national parks, conservation, and forest parks (Great Barrier Reef Marine Park Authority, 2012a).

Past development and current land uses such as intensive agriculture, grazing, mining, ports and industry in the GBR catchment have brought about a significant decline in water quality, coastal ecosystem functions and processes and hence, loss of inshore biodiversity. There