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How do individuals and groups perceive wetland functioning? Fuzzy cognitive mapping of wetland perceptions in Uganda

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ABSTRACT

Wetlands are critical natural resources around the globe, providing many direct and indirect benefits to local communities. However, wetland degradation and conversion to other land uses are widespread. Sustainable wetland management requires an understanding of stakeholders' perceptions of the ecosystem and its management. This paper uses fuzzy cognitive mapping to capture individual stakeholder perceptions and group knowledge of wetland ecosystems in order to assess areas of consensus and opposing interests between different stakeholders and to develop future management scenarios. For this purpose, the Rushebeya-Kanyabaha wetland, which is one of the few wetlands in southwest Uganda that is still largely intact, is used as a case study. Our findings reveal differences in perceptions between different resource users. Papyrus harvesters, beekeepers, fishermen, wetland non-users, and hunters associate the largest livelihood benefits with a wetland conservation scenario, while farmers and government officials perceive increased agricultural production in the wetland area to be more livelihood enhancing. This poses a challenge to sustainable wetland management. The scenario results also suggest that centralized top-down laws and rules on wetland use are not sufficient for maintaining the wetland ecosystem. Therefore, there is a need to develop shared understanding through bottom-up approaches to wetland management that are nested within national regulatory frameworks, ideally combined with awareness building and knowledge sharing on the ecological benefits of the wetland.

1. Introduction

Wetlands are one of the most valuable and productive ecosystems on this planet (Moreno-Mateos et al., 2012; Nabahungu and Visser, 2011), providing up to 40 per cent of the world's renewable ecosystem services (Zedler and Kercher, 2005); yet, they are among the most threatened (Rebelo et al., 2010). Human activity has significantly altered the dynamics of wetlands (Barbier et al., 1997) and the rate at which these ecosystems degrade and convert to other land uses is higher than any other ecosystem (Millennium Ecosystem Assessment, 2005). Population growth, agricultural expansion, increasing access to markets, upland soil degradation, and weak regulation are just a few of the common pressures driving wetland degradation and land use change (Chapman et al., 2001; Hartter and Southworth, 2009; Langan and Farmer, 2014). Wetland degradation reduces the ecosystem's productivity, which results in reduced water supply and causes a sudden release of CO_2 (Joosten, 2009; Saunders et al., 2012). In addition, soil nutrient levels, biodiversity and wildlife rapidly decrease, water pollution increases, and wetland vegetation and provision of associated products, including medicinal plants, are lost (Dugan, 1993; Schuyt, 2005). Ultimately, wetland degradation affects peoples' livelihoods and their well-being (Morrison et al., 2013; van Dam et al., 2011; Schuyt, 2005).

Explaining the drivers of wetland degradation and loss requires a better understanding of the complex human-nature interactions within these socio-ecological systems. Resource decision-making contexts are often characterized by high social, economic and ecological stakes, low levels of control, heterogeneity of stakeholders, and a lack of data (Gray et al., 2015). To capture the complexity of these socio-ecological systems and their dynamics, there is a need for more inclusive participatory approaches. These approaches can also help to identify potential management solutions in a studied (Gray et al., 2015; Hartter and Ryan, 2010; Özesmi and Özesmi, 2004). In addition, participatory approaches can provide important insights into the functioning of the system and highlight areas of consensus and diverging views between different types of users and uses. In this study, we use fuzzy cognitive mapping (FCM) as a bottom-up and systems approach to elicit stakeholder's internal constructs of their environment.

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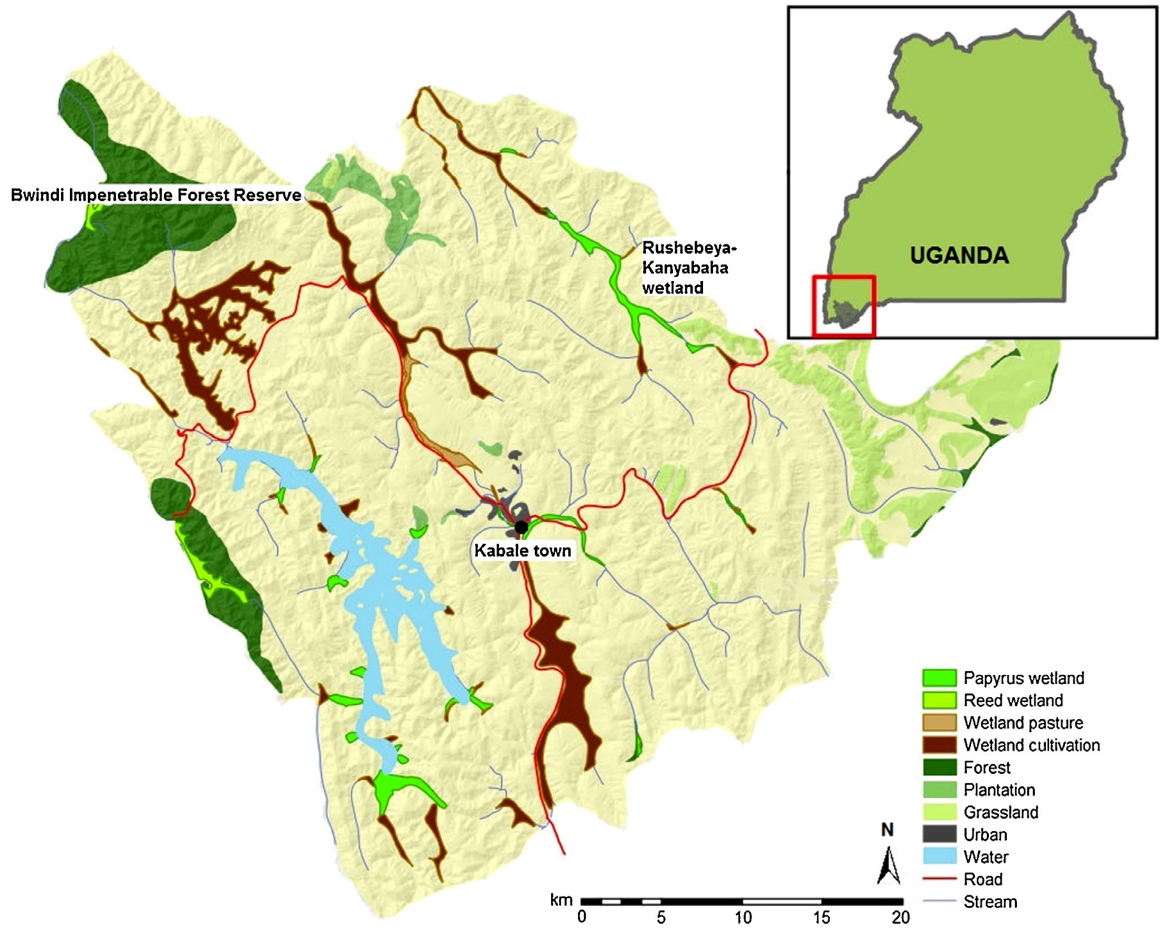

Fig. 1. Map of the Kabale District and the case study area. The Rushebeya-Kanyabaha wetland area is located in the north-east of the District and is indicated on the map. Source: Langan et al. (2015).

FCM is a semi-quantitative dynamic modelling approach to structure knowledge and perceptions (Gray et al., 2015; Kok, 2009). FCM was developed by Kosko (1986) and has its roots in graph theory (Biggs et al., 1976) and cognitive mapping theory (Axelrod, 1976). Fuzzy cognitive maps are directed graphs that exist of concepts – also named variables – which are represented as points or nodes in the system, and links between those variables (Axelrod, 1976; Harary et al., 1965; Kosko, 1986). The variables can be anything from a quantitative measure of a natural ecosystem aspect, such as pH levels in a water body, to abstract ideas like political or cultural forces (Mouratiadou and Moran, 2007). Each link is described by the direction (positive or negative) of the relationship and its strength, measured in a weight in the interval of $[-1, 1]$ (Kosko, 1986; Novak and Cañas, 2008). Cognitive mapping aims to reveal people's cognitive models of a studied system. FCM is built on the foundations of constructivist psychology (Gray et al., 2014) and assumes that individuals have mental models, which internally and interactively construct knowledge by creating associative representations that help structure and interpret the external environment (Gray et al., 2015; Halbrendt et al., 2014). Fuzzy cognitive maps can thus be considered organized internal representations (structured understanding and knowledge of workings) of an external reality (a general or specific context or system). Consequently, they can be used analyse the perceived structure of a system, and also to analyse its perceived functioning through the development of semi-quantitative scenarios (Henly-Shepard et al., 2015) that enable comparison between current and projected states in the case of a change or intervention in the system. Whereas FCM research has traditionally made predominant use of expert respondents (e.g. Amer et al., 2011; Hobbs et al., 2002; Radomski and Goeman, 1996), an increasing number of FCM applications include non-expert and local stakeholders to inform the development of management strategies and policies (e.g. Gray et al., 2012a; Meliadou et al., 2012; Mouratiadou and Moran, 2007; Özesmi and Özesmi, 2004; Papageorgiou and Kontogianni, 2012).

This paper presents an application of FCM to elicit stakeholder's perceptions in the Rushebeya-Kanyabaha wetland in southwest Uganda, which is one of the few relatively intact wetlands in the area. The study includes local stakeholders, such as direct wetland users (e.g. farmers and fishermen) and government officials. The aim of this paper is twofold. First, the study elicits local stakeholders' perceptions on wetland functioning. In order to do this, both individually and collectively constructed fuzzy cognitive maps are used to understand perceptions, attitudes and beliefs between different wetland stakeholder groups. To do this, individually elicited maps are aggregated by stakeholder category. This analysis is complemented by a map constructed jointly by different stakeholders. The outcome of this map is thus based on negotiated group knowledge and therefore might capture some stakeholder dynamics not reflected on individual maps (Özesmi and Özesmi, 2004). Individually constructed maps are not subjected to group dynamics and may therefore represent group knowledge in a more equitable way (Gray et al., 2014). Our study aims to point out whether interesting differences between both approaches emerge, as most studies have used group-developed maps to understand a social-ecological system. Second, aggregated stakeholder's fuzzy cognitive maps are