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A crowdsourced valuation of recreational ecosystem services using social media data: An application to a tropical wetland in India

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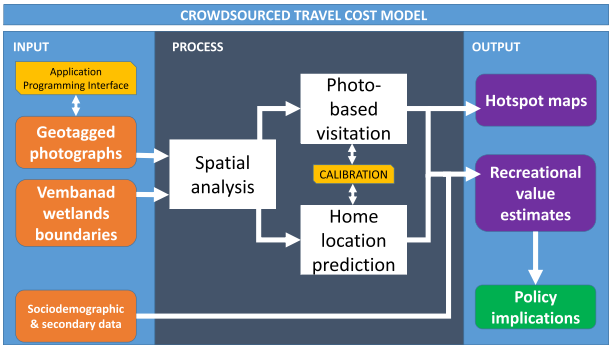
HIGHLIGHTS

- Crowdsourcing proves suitable for valuation of recreational ecosystem services.
- Geotagged data successfully applied to single site Individual Travel Cost method.
- Economic modelling using social media consistent with economic theory.
- Flickr user's public library predicts home state with 98% accuracy and 22 km error.
- Recreational benefits in Vembanad wetlands are estimated in 2227–3953 Rs per visit.

GRAPHICAL ABSTRACT



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ABSTRACT

Online social media represent an extensive, opportunistic source of behavioral data and revealed preferences for ecosystem services (ES) analysis. Such data may allow to advance the approach, scale and timespan to which ES are assessed, mapping and valued. This is especially relevant in the context of developing regions whose decision support tools are often limited by a lack of resources and funding. This research presents an economic valuation tool for recreational ES, suitable at wide spatial scales, relying on crowdsourced metadata from social media with a proof of concept tested on an Indian tropical Ramsar wetland. We demonstrate how geotagged photographs from Flickr can be used in the context of a developing country to (i) map nature-based recreation patterns, (ii) value recreational ecosystem services, and (iii) investigate how recreational benefits are affected by changes in ecosystem quality. The case-study application is the Vembanad Lake in Kerala, India, and the adjacent backwaters. Geographic Information Systems are implemented to extract 4328 Flickr photographs that are used to map hot spots of recreation and infer the home location of wetland visitors from within Kerala state with good accuracy. An individual, single-site travel cost demand function is generated and estimated using both Poisson and Negative Binomial regressions, which results in mean consumer surplus estimates between Rs. 2227–3953 ($34–$62) per visit and annual domestic recreation benefits of Rs. 7.53–13.37 billion ($115.5–$205 million) in the investigated wetlands. Improvement in water quality to a level that supports wildlife and fisheries is projected to result in a Rs. 260 million ($4 million) annual increase in recreational benefits, while restoring previously encroached lake area would result in almost Rs. 50 million ($760,000) in yearly value increase.

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1. Introduction

The issue of how to map, measure and value cultural Ecosystem Services (ES) continues to challenge environmental researchers (Nahuelhual et al., 2013). An emerging approach uses spatial information embedded in the metadata of social media, such as geotagged photographs, to understand interactions between humans and the natural environment and analyse cultural ESs at wide scales and with limited investment of resources (Keeler et al., 2015; Wood et al., 2013). Such development makes accessible the evaluation of ES also to developing regions whose natural assets can face complex and evolving socio-economic drivers that require decision support tools for adequate conservation decisions, but where tools are often limited by a lack of resources and funding. The major strength in developing ES evaluation tools using social media, other than the associated cost and resource savings, is the versatility in application to a wide variety of ecosystem types.

Inland and coastal wetland ecosystems are the chosen case study ecosystem as they provide many valuable cultural services to human beings by offering spaces for recreation, promoting mental and physical health, catalysing tourism or inspiring culture, spiritual experiences and sense of place (Haines-Young and Potschin, 2012; TEEB, 2010). Such benefits are often not economically valued in market exchanges, leading to under-representation in the decision making process (Plieninger et al., 2013) and, consequently, under-investment and degradation of these natural resources (de Groot et al., 2012). Though increasing numbers of valuations focus on wetland ecosystems, as reflected in the several meta-analyses that have been published in the scientific literature (Brander et al., 2006; Brouwer et al., 1999; Chaikumbung et al., 2016; Ghermandi et al., 2010; Ghermandi, 2015; Woodward and Wui, 2001), wetland ES in developing regions are inadequately represented (Chaikumbung et al., 2016) and valuations of cultural services make up only a small fraction of the total studies. The TEEB Ecosystem Service Value Database (de Groot et al., 2012), for instance, identifies 507 valuations of wetland ecosystem services but only 90 are directly relatable to wetland cultural ESs, out of which 40 pertain to eco-tourism and recreation.

The recognition, valuation and adequate internalization of the benefits of ecosystems in supporting nature-based recreation and the rapidly growing (eco-)tourism industry, could play an important role in poverty alleviation, especially in developing countries, where much of the world's natural capital is located. Tourism is generally recognized as a driver of economic growth (Brida et al., 2014) but its benefits do not necessarily transform into benefits for the local populations (Webster and Ivanov, 2014), hence the need for schemes to appropriately reward and share the benefits of ecosystem conservation and restoration. Milder et al. (2010) estimate that 5–8 million low-income households worldwide could directly benefits from the establishment of payments for ecosystem services (PES) for landscape beauty and recreation, in addition to other payments deriving from benefit-sharing schemes or community-based natural resource management.

The lack of appreciation of the full range of economic benefits of wetlands is particularly relevant in India, where only a limited number of wetland ES valuations are available (Ghermandi et al., 2016), in spite of the wealth and diversity of its wetland habitats and the considerable stress they experience from anthropogenic sources (Bassi et al., 2014; Parikh and Datye, 2003). Kerala state, in southern India, has the largest proportion of land area under wetlands among all the states of India, covering 160,590 ha (Abraham, 2015). The lakes, rivers and backwaters of Kerala are internationally renowned for their uniqueness and aesthetic value and make Kerala one of India's top tourist destinations. These ecosystems have been shown to be a major driver of tourism to Kerala (Sinclair, 2017). Vembanad Lake and its backwaters, are among the most iconic of Kerala's wetlands, being the largest of Kerala's three sites protected under the Ramsar Convention on Wetlands of International Importance and having been listed by National Geographic among the 50 places of a lifetime (National Geographic, 2009). Overall, the state hosts a growing tourism industry, with 14 million overnight visitors in 2016 contributing over 296.5 billion rupees to the local economy, 11% more than in 2015 (Kerala Department of Tourism, 2015). Kerala's wetlands are however subjected to substantial anthropogenic pressures from fast growing urbanization, tourism development, agricultural intensification, and land reclamation (Srinivasan, 2010), which may compromise their future ability to sustain healthy ecosystems and provision of ESs. Without adequate measurement of their values, there is a high risk that these unique ecosystems will not receive the appropriate level of protection and conservation.

The innovation of using social media data to understand human behaviour in relation to the natural environment is a product of various technologies, both software and hardware, coming to fruition in the same period. The global penetration of smart phones and the integration of Global Positioning System (GPS) technology in various portable devices have led to vast amounts of photos which are tagged with precise information about the time and location where they were taken. The development of social media networks, including photo-sharing websites, makes publicly available a wealth of such user-provided, geotagged metadata for retrieval and analysis. This technique has been used in the context of marine and coastal ecosystems (Howarth, 2014), inland wetlands (Keeler et al., 2015), natural areas (Wood et al., 2013; Tenerelli et al., 2016) and urban areas (Sun et al., 2013) for the study of spatial and temporal patterns of recreation (Tenerelli et al., 2016), characterization of visitation rates in national parks (Wood et al., 2013; Heikinheimo et al., 2017; Tenkanen et al., 2017; Sessions et al., 2016), demand for tourism based on country of origin (Da Rugna et al., 2012), and continental-scale quantification of landscape values (Van Zanten et al., 2016). Geotagged photos from popular photo-sharing sites such as Flickr (https://www.flickr.com), Panoramio (https://panoramio.com) and Instagram (https://www.instagram.com) have also been used to map aesthetic value in the state of Nebraska in the US (Figueroa-Alfaro and Tang, 2017), to estimate visitation to the Cairngorms National Park in Scotland (Mancini et al., 2016), recreational demand for clean water in the US (Keeler et al., 2015), cultural ESs obtained from urban mangroves in Singapore (Richards and Friess, 2015), and recreation in man-made wetlands (Ghermandi, 2016, 2017). Previous research demonstrated that geotagged photographs are a suitable proxy for recreation in Kerala's wetlands and explored how visitation rates are affected by changes in ecosystem quality (Sinclair, 2017). Insofar as Vembanad Lake is concerned, Sinclair (2017) estimates that the partial restoration of previously encroached wetland area, equivalent to 10% of its current area, and water quality restoration to a level that is compatible with the protection of wildlife and fisheries, would result in a 10% (corresponding to 50,000 annual visitors, of which 31,000 from Kerala) and 11% increase in visitation rates (corresponding to 53,000 annual visitors, of which 33,000 from Kerala), respectively.

A promising potential development of the technique is the creation of a tool which involves the combined analysis of information about visitation frequency (based on geotagged photo counts) with distance and travel time from the users' home location in Geographic Information Systems (GIS). This may allow to infer monetary estimates of the recreational benefits of ecosystems through the application of the travel cost method (TCM) and the effect thereupon of changes in ecosystem quality or quantity, such as water quality improvement. TCM uses techniques based on on-site or off-site surveys to model the demand for recreational experiences based on the insight that the number of visits made to a site is expected to be negatively related to the travel cost incurred, inclusive of direct out-of-pocket costs and opportunity cost of time (Parsons, 2003). It has been widely used for assessing the value of recreational visitation to natural sites (Hakim et al., 2011; Lamsal et al., 2016; Martínez-Espiñeira et al., 2006; Vijayan and Job, 2015; Wieland and Horowitz, 2007). In its single-site variant, TCM derives a demand curve for users' access to a specific site, as opposed to multi-