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Urban change in Goa, India

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ABSTRACT

Sustainable management of urban regions in coastal areas has become vital particularly in developing countries. Uncontrolled urban sprawl has the potential to be detrimental to coastal regions, irreversibly damaging vulnerable and valuable natural landscapes. This paper analyzes spatiotemporal trends in urban development of four municipalities in Goa, India. Landscape metrics were conducted based on urban land use classification. In the last decade, Goa has experienced rapid urbanization, which has been closely linked to their paralleled expansion in the tourism industry corresponding to the largest sector of the state's economy. Tourism development and policy in Goa largely focus on coastal regions, leading to a decline in tourist activity further inland. This has accelerated urban development and put pressure on the coastal landscapes. Current planning policies implemented by the state suggests that proper attention is given to mitigation of anthropogenic activity, however the dynamics of the urban sprawl continue to be uncontrolled and sporadic. Thus, sustainable development is crucial to the continued welfare of the state, and particularly within the reach of economic drivers such as tourism in Goa. The methods and techniques adopted in this paper, combine spatial metrics along with urban footprints, to obtain a complex understanding of the impacts urban development has on potentially vulnerable coastal stretches. The increase of urban areas has been predominantly found along the existing historical urban areas of Goa and the implementation of landscape metrics has allowed to shape an objective vision of the consequences of Goa's urbanization processes along its vulnerable coastal stretches.

1. Introduction

Land use change has been increasingly experienced in developing countries over the last decades e.g., (Cheng & Masser, 2003; Jokar Arsanjani et al., 2013a,b; Vaz, Nijkamp, Painho, & Caetano, 2012). Countries such as India, need to develop system economic, social and planning strategies to cope with its beneficial future (Bergenwall, 2016). The link between population growth and land use change must therefore be carefully assessed, as to avoid unnecessary strains on fragile ecosystems while maintaining a sound diversity of land use (Vaz, 2014). In this sense, land use change has been a rising concern in abridging India's growth. India, particularly given its intentions of becoming a leading economy in the coming decades, must establish adequate policies and decision support systems to mitigate risk of unmanned urbanization processes (Taubenböck, Wegmann, Roth, Mehl, & Dech, 2009). The rapidly changing urban landscapes of India increase the need to assess its ecological zones (Kothari, 2013). Its urban polycentrism as well as urban fragmentation are having an adverse effect on land use and environmental sustainability (Dave, 2010). Many of its new urban metropolises lack the existing policy and infrastructural support that may help coastal landscapes become more resilient in the future, whilst maintaining continuous growth of economic activity (Ouellette & Getinet, 2016). These disparities have led to the present volatility of urban and environmental dynamics. As a result of recent advances in the fields of geocomputation and spatial analytical methods, land use can now be more adequately addressed, given the abundance of available spatial data at local and regional level. This leads to a ubiquitous impact on planning and monitoring that should be continuously nurtured (Lambin et al., 2001).

From a regional perspective, these spatially-explicit methods contribute for a combined assessment of land use dynamics, and particularly an improved understanding of socio-economic impacts

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on the urban footprint (Jiang et al., 2016). The adequacy of Geographic Information Systems recognised by planners and decision makers alike, suggest the trend of refined quantitative methodologies that lead to more sustainable urbanization patterns (Wang, Shen, & Tang, 2014). While such methods have been largely explored in developed countries, developing countries can greatly benefit from such methods given their rapid economic growth in countries such as the BRICS. Furthermore, assessing urban policies may have a cyclical effect on the adequate opportunities of sustainable economic options, integrating regional decision support tools that enhance the economy, while avoiding the backlash of unsustainable anthropogenic patterns. In developing countries, this is of utmost importance, given the volatility of the carrying capacity of the land, and the at present unavailable structural resources that allow for the existence of integrated support systems and planning strategies.

Goa, a unique region in India, is famous for its scenic landscapes as well as its diversified and rich environmental and historical heritage (Ahmed & Shankar, 2011, pp. 11–15). It has witnessed unprecedented economic growth due to tourism (Noronha, Siqueira, Sreekesh, Qureshy, & Kazi, 2002; Sawkar, Noronha, Mascarenhas, Chauhan, & Saeed, 1998), mining (Desousa, 1999) resulting in a significant population increase in the last decades. Its continued growth, and changing land use patterns due to anthropogenic activity, suggests the importance of a detailed spatial analysis of the impacts of land use at the regional level. Such an assessment will allow for mitigation of processes that jeopardize Goa's natural, historical and coastal habitats. This research uses landscape metrics for an integrative land use assessment of coastal regions affected by anthropogenic activity at regional level (Vaz, Painho, & Nijkamp, 2015). The conflict between urban expansion and future coastal risk is explored through advanced spatial analytical methods.

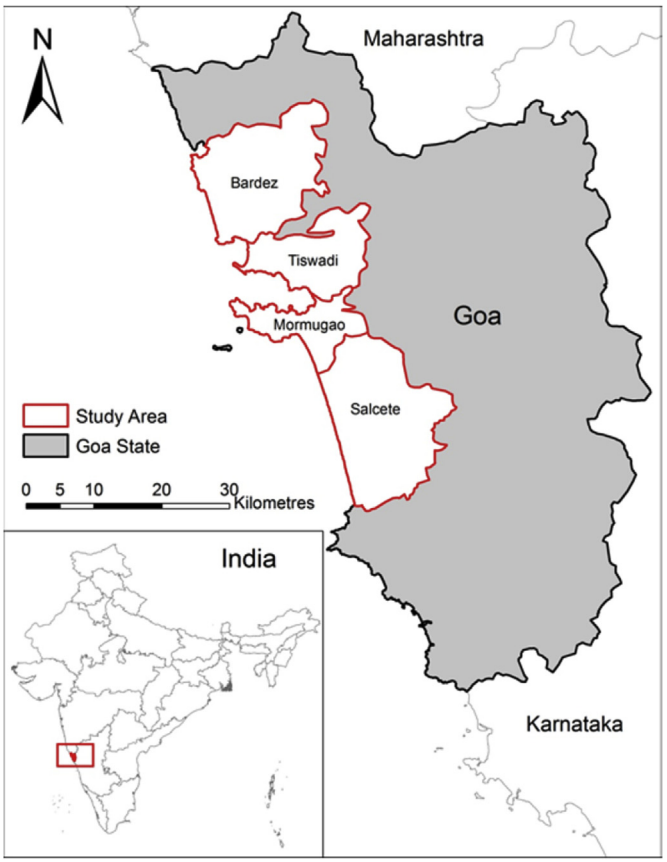

Fig. 1. Location of Goa state.

2. Study area

Goa is located in the western coastal region of India, bordered by the states of Maharashtra in the north and Karnataka in the east and south, while the Arabian Sea forms its western coastline. For the purpose of the study, four municipalities were assessed - Bardez, Tiswadi, Mormugao and Salce. These municipalities were selected due to the concentrated touristic activity and fast urbanization rates relative to the region, particularly in close proximity to the scenic coastal areas. Their combined area holds 815 km^2 and extends from 15.682050° to 15.135821° N and 73.730973°–74.083396° E (Fig. 1).

The four selected municipalities account for the majority of Goa's population, as well as most of its urban footprint. The study area encompasses the state's three largest urban areas - the state capital Panaji, Margao and Vasco da Gama. Margao, rich with tourist attractions, is effectively the commercial and cultural capital of the state, as well as its second largest city. Dabolim airport located in Vasco da Gama is the only international airport in the region, serving as the major entry point for tourists, resulting in a high number of visitors to a city otherwise devoid of major tourist attractions (Department of Tourism, Government of Goa, 2015). Proximity to water has also facilitated the growth of Verna Industrial Estate east of Vasco - the largest industrial cluster in the region. Goa one of India's smallest states, is also one of its wealthiest. Mining and agriculture offer employment to a sizeable portion of the population, however the state's prosperity and growth are fueled largely by the tourism industry. The state is classified as a biodiversity hotspot and has implemented numerous preservation initiatives, however most target inland forested areas and avoid coastal regions, much more lucrative for tourism. This dynamic has put substantial strain on Goa's coastal landscapes and ecosystems, as these municipalities have experienced faster rates of urban sprawl over the last four decades. Development of beach resorts has also greatly increased anthropogenic activity along the coastline of the study area.

3. Data

Understanding the impacts of urban growth is of utmost importance for more sustainable land use change as well as regional planning within India's growing smart city debate. Measuring changes in the urban fabric within certain periods ay support to understand the space-time dynamics of land use change, and integrate important planning decision that mitigate adverse effects at ecological level (Tayyebi, Pijanowski, & Tayyebi, 2011). Remote sensed imagery becomes an important instrument, particularly in developing countries, to measure cost-efficiently and with a relatively high accuracy the land use transitions at geographical level. The urban footprint of coastal Goa was assessed for the following years: 1975, 1990, 2000 and 2010 (Fig. 2).

The analysis was carried forth using datasets incorporated from urban footprints that were created with a pixel-based classification approach using TerraSAR-X data and resampled at 15 m (Taubenböck et al., 2009). The available data from 1975 was linked to a geometric resolution of 78.5 m (multispectral scanner), 28.5 m (thematic scanner) or 15 m (enhanced thematic mapper). This data set latter served to incorporate the assessment of land use coverage on a multi-temporal basis through additional classification of land use categories. The TerraSAR-X imagery provides an adequate representation, given the size of the study area, although its spatial

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