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Shannon Entropy-based urban spatial fragmentation to ensure sustainable development of the urban coastal city: A case study of Semarang, Indonesia

Dimas Danar Dewa [a], Imam Buchori [b, *], Anang Wahyu Sejati [b], Yan Liu [c]

[a] Doctoral Program in Architecture and Urbanism, Universitas Diponegoro, Indonesia
[b] Department of Urban and Regional Planning, Faculty of Engineering, Universitas Diponegoro, Indonesia
[c] School of Earth and Environmental Sciences, The University of Queensland, Australia

ARTICLE INFO

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ABSTRACT

This study examines the extent to which the Shannon Entropy Index (H) can be used to ensure urban growth sustainability by measuring the spatial dispersion pattern of a built-up area. The Shannon Entropy Index was calculated based on the proximities to the city center (HCC) and the main road (HMR), which divide the study area into 17 zones. Data from Landsat 5- TM Imagery 2011 and Landsat 8- OLI Imagery 2016 and 2021 were used to extract urban built-up areas through image classification using the Support Vector Machine (SVM) Algorithm and measure their growth over time. The results show the normalized Shannon Entropy Index for the proximities to the city center (HCC′) and the main road (HMR′). HCC′ was found to be 0.93 in 2021 and increased by 0.44 during 2011–2021, while HMR′ was recorded to be 0.68 in 2021 and increased by 0.27 during 2011–2021, indicating that urban development in Semarang City has become increasingly fragmented. Among the 17 existing zones, the peri-urban areas of southeast part zones in Semarang (III-BP and IV-AP) were found to have the largest relative Shannon Entropy Index (H') of 0.98 and 0.96, respectively, indicating that this area is developing irregularly and spreading out compared to the city center, which is unsustainable built-up area growth. We call for an integrated space utilization control strategy between the city center and the peri-urban area. Our study demonstrates the capacity of using the Shannon Entropy Index to detect potential areas of unsustainable development in a coastal city with diverse development dynamics, which can also be applied in other coastal cities to prevent unsustainable development.

1. Introduction

In the last decade, urbanization is still a big challenge for urban development in the world, especially in developing countries (Abu Hatab et al., 2019; Cao et al., 2017; Das et al., 2021; Duque et al., 2019; K and Angadi, 2021; Mohammed et al., 2019). Rapid and uncontrolled population growth is the main cause of continuous urbanization (Cengiz et al., 2022; Dadashpoor et al., 2019; Zhong et al., 2019). An increase in the population usually determines the growth and direction of urban development (Buchori et al., 2017; Kinoshita et al., 2008; Sumari et al., 2020), and rapid population growth with limited land resources has been reported to be a challenge in urban areas (Buchori et al., 2017; Handayani and Rudiarto, 2014; Sejati et al., 2018; Zha et al., 2003). This is also accompanied by urbanization which is characterized by a concentration of urban population (Lakshmana, 2014; Liu et al., 2020; Zambon and

* Corresponding author.
E-mail address: i.buchori@live.undip.ac.id (I. Buchori).

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Two decades of land cover mapping in the Río de la Plata grassland region: The MapBiomas Pampa initiative

S. Baeza [a, *], E. Vélez-Martin [b], D. De Abelleyra [c], S. Banchero [c], F. Gallego [d], J. Schirmbeck [b], S. Veron [c, e], M. Vallejos [f], E. Weber [g], M. Oyarzabal [e], A. Barbieri [h], M. Petek [c], M. Guerra Lara [i], S.S. Sarrailhé [c], G. Baldi [j], C. Bagnato [k], L. Bruzzone [d], S. Ramos [h], H. Hasenack [l]

[a] *Departamento de Sistemas Ambientales, Facultad de Agronomía, UdelaR, Montevideo, 12900, Montevideo, Uruguay*
[b] *GeoKarten Consultoria em Tecnologia da Informação Ltda. Roca Sales, 95735-000, Rio Grande do Sul, Brazil*
[c] *Instituto de Clima y Agua, Instituto Nacional de Tecnología Agropecuaria (INTA) Hurlingham, 1686, Buenos Aires, Argentina*
[d] *Instituto de Ecología y Ciencias Ambientales, Facultad de Ciencias, UdelaR, Montevideo, 11400, Montevideo, Uruguay*
[e] *Departamento de Métodos Cuantitativos y Sistemas de Información, LART, IFEVA, Facultad de Agronomía, UBA/CONICET, Buenos Aires, 1417, Buenos Aires, Argentina*
[f] *Programa de Investigación en Producción y Sustentabilidad Ambiental, Instituto Nacional de Investigación Agropecuaria. El semillero, 70006, Colonia, Uruguay*
[g] *Departamento Interdisciplinar e Programa de Pós-Graduação em Sensoriamento Remoto, Universidade Federal do Rio Grande do Sul, Campus Litoral Norte. Tramandaí, 95590-000, Rio Grande do Sul, Brazil*
[h] *Departamento de Geografía, Facultad de Ciencias, UdelaR, Montevideo, 11400, Montevideo, Uruguay*
[i] *Instituto de Matemática Aplicada San Luis, Universidad Nacional de San Luis y CONICET, San Luis, 5700, San Luis, Argentina*
[j] *Instituto de Matemática Aplicada San Luis, Universidad Nacional de San Luis and CONICET, San Luis, 5700, San Luis, Argentina*
[k] *IRNAD, UNRN, CONICET, San Carlos de Bariloche, 8400, Río Negro, Argentina*
[l] *Departamento de Ecologia, IB e Programa de Pós-Graduação em Agronegócios, CEPAN, Universidade Federal do Rio Grande do Sul. Porto Alegre, 91501-970, Rio Grande do Sul, Brazil*

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ABSTRACT

The Río de la Plata Grasslands (RPG) region is the largest area of the temperate humid and subhumid grasslands biome in South America and one of the largest in the world. The region is located on fertile soils, generally very suitable for agricultural development, so it is undergoing an intense land cover change process. Our knowledge of these changes remains incomplete. Most regional-scale studies have been conducted over specific periods, limited subsets of the RGP, coarse resolution and, in general, used land cover classes that are not readily compatible. In this work we described and analyzed the land cover changes in the entire RPG region for the first two decades of the 21st century, especially those related to grasslands loss. We generated annual land cover maps with 30-m resolution that discriminate between 8 categories: native woody formation, forest plantation, swampy areas and flooded grassland, grassland, farming, non-vegetated area, water and non-observed. The map series was evaluated for the years 2001 and 2018 using a completely independent dataset, selected by stratified randomized sampling. Overall accuracy

* Corresponding author.
E-mail addresses: sbaeza@fagro.edu.uy (S. Baeza), evelezmartin@gmail.com (E. Vélez-Martin), deabelleyra.diego@inta.gob.ar (D. De Abelleyra), banchero.santiago@inta.gob.ar (S. Banchero), fgallego@fcien.edu.uy (F. Gallego), schirmbeck.j@gmail.com (J. Schirmbeck), veron@agro.uba.ar (S. Veron), mvallejos@inia.org.uy (M. Vallejos), eliseu.weber@ufrgs.br (E. Weber), oyarzabal@agro.uba.ar (M. Oyarzabal), abarbieri@fcien.edu.uy (A. Barbieri), mpetek@agro.uba.ar (M. Petek), guerralara@agro.uba.ar (M. Guerra Lara), ssarrailhe@agro.uba.ar (S.S. Sarrailhé), baldi@unsl.edu.ar (G. Baldi), bagnato@agro.uba.ar (C. Bagnato), lolibruzzone@gmail.com (L. Bruzzone), sebastianramos897@gmail.com (S. Ramos), hhasenack@ufrgs.br (H. Hasenack).

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MODIS sensors can monitor spatiotemporal trends in fog and low cloud cover at 1 km spatial resolution along the U.S. Pacific Coast

Zackary Werner [a, *], Christopher Tsz Hin Choi [a, b], Anna Winter [a], Anthony G. Vorster [a, b], Anika Berger [a], Kristen O'Shea [a], Paul Evangelista [a, b], Brian Woodward [a, b, c, d]

[a] NASA DEVELOP National Program, NASA Langley Research Center MS 307, Hampton, VA, 23681, USA
[b] Natural Resource Ecology Laboratory, Colorado State University, 1499 Campus Delivery, Fort Collins, CO, 80523, USA
[c] Graduate Degree Program in Ecology, Colorado State University, 1499 Campus Delivery, Fort Collins, CO, 80523, USA
[d] Conservation Science Program, Santa Lucia Conservancy, Carmel-by-the-Sea, CA, 93923, USA

A B S T R A C T

Fog and low cloud cover (FLCC) provide critical moisture for ecosystems along the Pacific Coast during the summer months and it is currently unclear how climate change has affected FLCC occurrence. Additionally, FLCC impacts visibility and transportation safety for both road and air traffic. As such, a method for the monitoring of FLCC is necessary to inform land management decisions for fog-obligate species and to improve transportation safety, among other applications. Several gaps exist in current FLCC detection methodologies and while the Moderate Resolution Spectroradiometer (MODIS) sensor has previously been used to detect fog, its utility has not been validated. In this study, we create a 20 year (2000–2020) FLCC dataset using the Terra MODIS cloud flags and examine its effectiveness in detecting daily and monthly FLCC presence along the California and southern Oregon coast for the summer months (June–September). We validate the accuracy of this method using an existing FLCC dataset derived from Geostationary Operational Environmental Satellite (GOES) observations collected at 15 min intervals from 2000 to 2009. The two FLCC datasets have a strong linear relationship for FLCC frequency for each summer month, with an average r^2 of 0.82 and p-value of <0.01. This strong relationship demonstrates the ability of Terra MODIS to reliably and accurately detect FLCC. Finally, we demonstrate a case study application of our FLCC dataset in a time series analysis over five coast redwood (*Sequoia sempervirens*) state parks in the Big Sur region of coastal California. This case study highlights the benefits provided by a 1 km resolution FLCC dataset for ecological applications and for monitoring spatiotemporal FLCC patterns across summer months over two decades. Our case study results showed that the number of foggy days fluctuates considerably year-to-year with no discernible positive or negative trend occurring between 2000 and 2020. Finally, we present a freely-accessible Google Earth Engine application to view and download the monthly FLCC data for all summer months for the years 2000–2020. The methods and dataset presented in this paper provide a means for efficient, daily FLCC monitoring at 1 km^2 resolution, as well as the capacity for historical FLCC analyses.

1. Introduction

Fog and low cloud cover (FLCC) play an important role along the western coast of the United States. In coastal environments, FLCC provides critical moisture for plants through fog drip, and lowers land surface and stream water temperatures by scattering shortwave radiation and reducing net incoming radiation (Johnstone and Dawson, 2010; Torregrosa et al., 2020). FLCC reduces plant water demand and evapotranspiration while increasing watershed subsurface recharge and overall increased stream flow (Torregrosa et al., 2020). FLCC drives species distribution patterns in coastal ecosystems where species such as the coast redwood (*Sequoia sempervirens*) often rely on fog to meet the summer portion of their annual water requirements when moisture is otherwise scarce (Dawson 1998; Johnstone and Dawson 2010; Francis et al., 2020). The documented importance of FLCC in coastal ecosystems creates the need for more information regarding the distribution and spatiotemporal trends of FLCC.

* Corresponding author.
E-mail address: zwerner.author@gmail.com (Z. Werner).

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