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Spatio-temporal analysis of biodiversity, land-use mix and human population in a socio-ecological production landscape: A case study in the Hokuriku region, Japan

Yuta Uchiyama[a]*, Ryo Kohsaka[a]

[a]*Kanazawa University, Graduate School of Human and Socio-Environmental Studies, Kakuma, Kanazawa 920-1192, Japan*

Abstract

In the development of City Biodiversity Index (CBI) database, it was necessary to overcome technical challenges, including the collection of information for biological indicators. To overcome the lack of data, methods to utilize land-use data have been developed. For example, distribution and abundance of species correlate with the degree of land-use mix. The research site, the Hokuriku region of Japan, has a developed Satoyama, a socio-ecological production landscape based on mixed land use. A part of the region, Noto, has been designated as a Globally Important Agricultural Heritage Systems (GIAHS) site in 2011 by the Food and Agriculture Organization of the United Nations (FAO). We found it is necessary to consider the biological type in order to refer to land-use mix as an indicator of biodiversity because the diversity of some species had a negative correlation with degree of land-use mix. We also determined that some species were correlated with land use changes over time. By applying the methods developed in this study to other Monsoon Asian regions with rapid population increases, it might be possible to develop a database as a platform for sharing the findings and knowledge to implement the conservation of biodiversity under changing conditions of land use and human population size.

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Keywords: Land-use mix; biodiversity; population; City Biodiversity Index; Satoyama.

* Corresponding author. Tel.: +81-76-264-5507; fax: +81- 76-234-4100.
E-mail address: y-uchiyama@staff.kanazawa-u.ac.jp

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1. Introduction

The impacts of human activities in an area can affect areas beyond the boundaries of the activities through leakage effects [1]. Thus, the effects of human activities on biodiversity should be evaluated in areas where the activities occur, as well as in the surrounding areas. In the case of the effects of urbanization, evaluation of biodiversity in areas beyond the city is required. Therefore, indicators of human impacts on biodiversity need to be developed not only for developed areas but also for the larger area surrounding the main evaluation site.

To evaluate the biodiversity of the larger area, the development of biological indicators (e.g., birds, frogs, and insects) has been attempted in several countries, including Japan. However, collecting and organizing data for use as biological indicators is challenging for most national and local governments because of budget and human resource limitations [2].

In this context, a land-use indicator, specifically, the degree of land-use mix is proposed for utilization in the evaluation of biodiversity. Land-use indicators are correlated with biodiversity and data can be obtained for large regions [3,4]. However, relationships between the diversity of individual species (e.g., mammals and dragonflies) and degree of land-use mix have not been fully identified. In addition, in the analysis of land-use mix, relationships between land-use mix and the distribution of human populations, which profoundly affects land-use distribution, have not been elucidated. Accordingly, methods to evaluate biodiversity based on land-use mix indices are not established. The development of biodiversity indices, could allow national and local governments to estimate and evaluate biodiversity without the need for substantial data for biological indicators. As a result, city or regional management decisions could be based on biodiversity evaluations. Through the development and utilization of a global biodiversity data platform for city and regional areas, we predict that efficient and effective information and knowledge sharing could be implemented among cities and regions within similar ecological contexts [4].

Regions in the “Monsoon Asia region”, including Japan, have similar ecological contexts. In the region, the complex landscape is composed of several land-use categories, including paddy fields, croplands, forestlands, and built-up areas. The region with this landscape is called the “desakota” region, and it includes both urban and rural areas [5]. Boundaries of urban and rural areas are not well defined in this region, and areas with a high degree of land-use mix are distributed from the periphery of urban areas to rural areas. In Japan, areas with a high degree of land-use mix or mosaicness of the land mainly exist in rural areas, and these landscapes are called the Satoyama and Satoumi landscapes or the Socio-ecological Production Landscape. The Noto region of the Hokuriku region in Japan has a representative Satoyama landscape, and the regional agricultural systems have been extensively evaluated by the global agricultural societies in terms of sustainability. The Noto region was designated as a site in the Globally Important Agricultural Heritage Systems (GIAHS) in 2011 because of its richness in unique biodiversity [6].

In this study, we analyzed the relationships among biodiversity, land uses, and the distribution of human populations in a representative Satoyama landscape in the Hokuriku region. The results will further the development of evaluation methods of for biodiversity at the city level and beyond.

2. Review

In this section, to provide the context for the analysis of the relationships among biodiversity, land use, and human population distribution in the Hokuriku region of Monsoon Asia, we review information pertaining to cities and biodiversity, city biodiversity indices, and the characteristics of the Monsoon Asia region.

2.1. City and biodiversity

Cities negatively affect biodiversity both inside and outside of their boundaries. However, biodiversity can be enhanced through appropriate management of these areas. For example, urbanization of natural lands and fragmentation of forestlands cause degradation of biodiversity [7]. Conversely, in the peripheral zones of urban areas, which have a high degree of land-use heterogeneity, composed of natural lands, agricultural lands, and residential areas, biodiversity can be maintained by human intervention and conserved by appropriate management [8]. Ecosystem services in city centers do not necessarily decline [9,10]. Thus, it is necessary to reduce the negative aspects of cities and enhance the potential of cities that can contribute to conservation of biodiversity. The goal of