

An Integrated Model of Social-Biological Systems for Analyzing The Impact of Settlement Expansion on Population Dynamics in Kendari City, Indonesia

Muhammad Obie

Department of Sociology, Faculty of Social and Political Science, Halu Oleo University, Indonesia

ABSTRACT: Urbanization in rapidly growing cities has intensified residential expansion and transformed socio-ecological conditions, particularly in secondary cities of the Global South. This study examines the impact of residential expansion on biological population dynamics through an integrated social-biological systems perspective, using Kendari City, Indonesia, as a case study. Employing a qualitative case study design, data were collected through in-depth interviews, field observations, and document analysis involving migrants, housing developers, local government officials, community leaders, and environmental observers. The findings reveal that urban migration, economic opportunity, and subsidized housing policies act as key social drivers accelerating residential expansion and land-use change. These processes contribute to habitat modification, fragmentation, and altered ecological conditions, which are reflected in changes in local biological systems, including vegetation patterns, small fauna presence, and adaptive species associated with urban environments. The study identifies a sequential relationship in which social pressures generate environmental change, followed by biological responses at the population level. Based on these findings, a conceptual social-biological systems model is developed to illustrate the interconnected pathways linking social dynamics, environmental transformation, and biological population responses. This study contributes to interdisciplinary urban and ecological research by demonstrating the value of qualitative approaches in constructing integrated system models and provides a conceptual foundation for future quantitative and dynamic modeling of urban socio-biological interactions.

KEYWORDS: Social-biological systems; Urban residential expansion; Biological population dynamics; Urbanization; Kendari City

1. INTRODUCTION

Urbanization is the dominant social process that shapes the dynamics of developing cities in Global South countries, including Indonesia. The displacement of populations towards urban centres is driven by the concentration of economic opportunities and public services, and results in increased population density and pressure on urban space (United Nations Department of Economic and Social Affairs [UN DESA], 2022; Scheba et al., 2021). This process not only changes the social and spatial structure of the city, but also triggers a significant transformation of environmental and biological systems.

As the capital of Southeast Sulawesi Province, Kendari City serves as a regional growth center that attracts economic migration flows from various surrounding districts. Rapid population growth is driving residential expansion, especially through the construction of subsidized housing with affordable installment schemes. Such settlement expansion accelerates land use change and spatial fragmentation, especially in suburban areas, which is a common pattern of urbanization in developing countries' medium-sized cities (Seto et al., 2012; Cohen, 2006).

Changes in land use due to settlement expansion have a direct impact on local biological systems. Studies of urban ecology show that urbanization affects habitat structure, resource availability, and organism population dynamics through mechanisms that are nonlinear and adaptive (Grimm et al., 2008; Patel et al., 2024). In this context, biological systems do not stand apart from social systems, but rather respond to social pressures as part of a coupled human-natural system (Alberti, 2017; Alberti et al., 2020).

Although the link between human activity and biological change has been widely discussed, most research still separates social and biological analysis into separate disciplinary frameworks. Integrated approaches that model social and biological systems as a single dynamic unit are still relatively limited, especially in qualitative-based studies that aim to understand the mechanisms of these relationships conceptually and contextually (Liu et al., 2015). As a result, the understanding of how social processes—such as urbanization and settlement expansion—shape biological population dynamics is often partial.

Based on these conditions, this study aims to analyze the impact of settlement expansion in Kendari City through the framework of an integrated model of the socio-biological system. Using a qualitative approach and a systems perspective, this study seeks to construct a conceptual understanding of the relationship between urban social dynamics and changes in biological systems.

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This approach is expected to enrich interdisciplinary discourses on population dynamics in the context of urbanization, as well as provide a conceptual basis for the development of quantitative models in the future.

II. RESEARCH METHODS

This study uses a qualitative approach with a case study design to analyze the relationship between social dynamics and biological system changes in the context of urban settlement expansion. The qualitative approach was chosen because it allows the exploration of processes, meanings, and relationships between elements of social-biological systems that are complex and contextual, and cannot be fully explained through a quantitative approach (Creswell & Poth, 2018).

The study focuses on Kendari City, a medium-sized city that is experiencing rapid urban growth as a regional economic migration hub. The analysis focused on areas with rapid settlement growth, the dominance of subsidized housing development, and land use change from non-residential to residential. This context-based approach is in line with the character of a case study that emphasizes understanding phenomena within specific spatial and social boundaries (Yin, 2018).

The research informants were selected using purposive sampling, taking into account their involvement and knowledge of the process of settlement expansion and environmental change. The informants include immigrant residents, housing developers, local government officials related to housing, spatial planning, and the environment, as well as community leaders and local environmental observers. This strategy aims to obtain a diverse but relevant perspective on the phenomenon being studied (Creswell & Poth, 2018).

Data was collected through in-depth interviews, field observations, and document analysis. In-depth interviews were used to explore the actors' experiences and interpretations of settlement dynamics and their impact on the environment. Field observations are carried out to capture spatial changes and environmental conditions directly. Document analysis includes spatial plans, population data, housing permit documents, and environmental reports to complement and contextualize field findings (Bowen, 2009; Kvale & Brinkmann, 2015).

Data analysis was carried out using thematic analysis, through an open coding process and grouping of key themes. These themes were then analyzed relationally to link social processes—such as urbanization and settlement expansion—to changes in biological systems, including habitat conditions and organism population dynamics. This approach allows for the construction of an integrated understanding of social-biological systems as systems that interact with each other (Corbin & Strauss, 2015).

The validity of the data is maintained through triangulation of sources and methods, as well as member checking of key informants. The entire research process is systematically documented as part of the trail audit to increase the transparency and reliability of research findings (Lincoln & Guba, 1985).

III. RESULTS

1. Social Dynamics of Settlement Expansion

The results of the study show that the expansion of settlements in Kendari City is closely related to the migration pattern of people from various districts in Southeast Sulawesi. This migration is driven primarily by economic considerations, including access to jobs, public services, and urban infrastructure. The city of Kendari serves as a regional growth hub that attracts population mobility on an intra-provincial scale, a pattern common to medium-sized cities in developing countries (United Nations Department of Economic and Social Affairs [UN DESA], 2022).

The availability of subsidized housing with affordable installment schemes has emerged as an important trigger for settlement expansion. The informant described that access to formal housing at relatively low prices encourages the acceleration of the development of new residential areas, especially in suburban areas. This process contributes to changes in the social structure of the region, characterized by increasing population density, social heterogeneity, and shifting patterns of interaction of local communities.

These findings suggest that settlement expansion is not merely a spatial process, but rather the result of an interaction between housing policy, economic dynamics, and the social mobility of the population, as also noted in the contemporary urbanization literature (Seto et al., 2012).

2. Changes in Local Biological Systems

The rapid expansion of settlements in Kendari City was followed by significant changes in the conditions of the local biological system. Field observations and document analysis showed changes in land cover, especially the conversion of non-residential land into residential areas. These changes have an impact on simplifying landscape structures and reducing green open spaces.

The loss or fragmentation of natural habitats is the main finding in this study. Habitat fragmentation reduces the continuity of ecological space and has the potential to disrupt the balance of local ecosystems. Information from local environmental observers and observation results show indications of changes in the presence of certain vegetation, a decrease in small fauna, and an increase

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in the presence of organisms that adapt to residential environments, such as disease vectors. This kind of pattern is consistent with findings in urban ecology studies that emphasize that urbanization triggers changes in the composition and dynamics of biological populations through mechanisms of adaptation and environmental selection (Grimm et al., 2008).

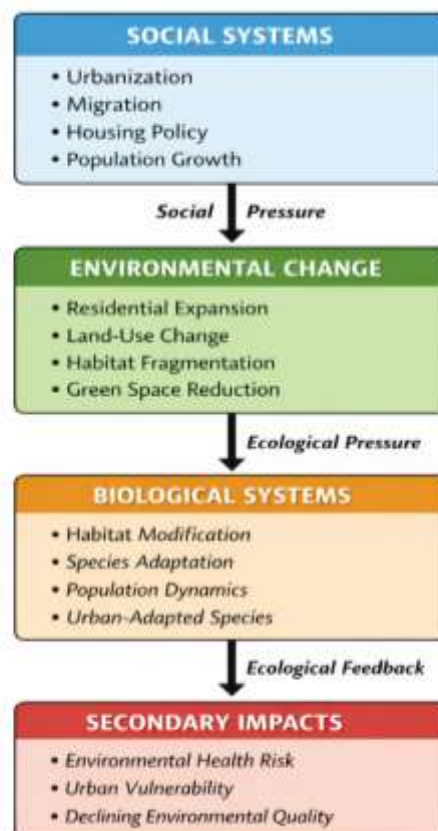
3. Social–Biological Relations in Settlement Expansion

The results show a clear link between social decisions—such as housing development, population migration, and land use change—with local biological system responses. Settlement development decisions that are oriented towards the rapid fulfillment of housing needs generate environmental pressures that directly affect the condition of habitats and the organisms that depend on them.

Field data show a gradual pattern of cause-and-effect, where social pressures in the form of increased population density and expansion of built space trigger changes in the physical environment, which are further responded to by biological systems through changes in the distribution and existence of organism populations. This relationship reflects the character of the social–biological system as an interconnected and dynamic system, as described in the framework of coupled human–natural systems (Alberti, 2017; Liu et al., 2015).

4. Construction of Social–Biological Conceptual Models

Based on the synthesis of empirical findings, this study constructs a conceptual model of social-biological systems that describes the relationship between settlement expansion and biological population dynamics. This model is presented in the form of a narrative schema and conceptual diagram to emphasize the flow of interaction between the components of the system.



The model shows that social pressures, stemming from urbanization, migration, and housing policies, trigger environmental change, primarily through land conversion and habitat fragmentation. These environmental changes then generate biological system responses, which are reflected in changes in habitat conditions and organism population dynamics. This flow asserts that the dynamics of biological populations in urban areas cannot be understood in isolation from the social processes that shape them, but rather as part of an integrated system that influences each other.

IV. DISCUSSION

The findings of this study confirm that settlement expansion in Kendari City is a social process that has direct and indirect implications for the dynamics of local biological systems. Urbanization and economic migration function as the main social drivers that trigger spatial changes, especially land conversion and population density. Within the framework of the system, these social

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processes do not stand alone, but rather form structural pressures that affect environmental conditions and biological responses in layers.

These results are in line with the perspective of urban ecology, which views cities as complex socio-ecological systems, in which human activities are the dominant factors in shaping the structure and function of ecosystems (Grimm et al., 2008; Landman, 2021; Des Roches et al., 2021). In the context of Kendari, housing development—especially subsidized housing—can be understood as an institutional mechanism that accelerates the expansion of built space. This mechanism reinforces the causal relationship between socio-economic policies and changes in the physical environment, which in turn affects local biological systems.

This discussion expands on previous findings on the impact of urbanization on biodiversity by showing that biological change is not only a passive ecological consequence but part of the adaptive response of biological systems to ever-increasing social pressures. The habitat fragmentation and simplification of the landscape identified in this study reflect a general pattern of global urbanization, in which urban expansion contributes to changes in species composition and organism population dynamics (Seto et al., 2012). Thus, the dynamics of biological populations in developing urban areas need to be understood as a result of the mutual interaction between social structures and environmental systems.

The social-biological conceptual model developed in this study makes an important contribution in bridging the gap between social and biological analysis. In contrast to the disciplinary approach that separates humans and nature, this model places the two within a single integrated systems framework, as developed in the coupled human–natural systems literature (Alberti, 2017; Liu et al., 2015). In this perspective, social pressures such as urbanization and settlement expansion serve as triggers for change, while biological systems respond through population adaptation, changes in organism distribution, and habitat transformation.

The use of a qualitative approach in this study suggests that understanding the dynamics of social–biological systems does not necessarily have to rely on quantitative modeling. The qualitative approach allows the identification of cause-and-effect mechanisms, key actors, and local contexts that are often reduced in large-scale statistical analysis. Thus, this study supports the argument that qualitative approaches have a strategic role in the development of conceptual frameworks and initial hypotheses that can be further tested through quantitative approaches or dynamic modeling.

Theoretically, these findings reinforce the view that the dynamics of biological populations in urban areas cannot be understood in isolation from the social processes that shape them. Practically, the results of this study imply the need to integrate social-biological considerations in urban planning, especially in settlement management and spatial planning. However, this study has limitations because it does not quantitatively measure biological changes, so generalization of findings needs to be done carefully. Further research can develop a quantitative model based on the variables identified in this study to deepen understanding of the dynamics of socio-biological systems in developing cities.

V. CONCLUSION

This study confirms that settlement expansion in Kendari City is a social process that plays a significant role in shaping changes in the local biological system. Urbanization, economic migration, and housing policies—especially subsidized housing development—drive increased population density and land conversion, which in turn triggers changes in environmental and habitat conditions. These findings suggest that the dynamics of biological populations in developing urban areas cannot be understood in isolation from the social processes that underlie them.

The results of the study summarize the existence of sequential and interrelated social-biological relationships, where social pressures produce changes in the physical environment, which are then responded to by biological systems through population adaptation, changes in organism distribution, and habitat transformation. This relationship affirms the character of the urban system as an integrated social-biological system, not just a stand-alone social or ecological space.

The main value of this research lies in the development of an integrated model of social-biological systems that integrates social dynamics and biological responses in a single conceptual framework. This model makes a theoretical contribution by bridging the disciplinary separation between social and biological analysis, as well as a methodological contribution by demonstrating the role of qualitative approaches in building contextual systemic understanding. As a conceptual framework, this integrated model provides a strong analytical basis for the development of advanced research, including quantitative modeling and the formulation of urban planning policies that are more sensitive to social–biological interactions.

REFERENCES

- 1) Alberti, M. (2017). *Cities that think like planets: Complexity, resilience, and innovation in hybrid ecosystems*. University of Washington Press.
- 2) Alberti, M., Palkovacs, E. P., Roches, S. D., Meester, L. D., Brans, K. I., Govaert, L., ... & Verrelli, B. C. (2020). The complexity of urban eco-evolutionary dynamics. *BioScience*, 70(9), 772-793.

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- 3) Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27–40. <https://doi.org/10.3316/QRJ0902027>
- 4) Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, 28(1–2), 63–80. <https://doi.org/10.1016/j.techsoc.2005.10.005>
- 5) Corbin, J., & Strauss, A. (2015). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (4th ed.). SAGE Publications.
- 6) Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.
- 7) Des Roches, S., Brans, K. I., Lambert, M. R., Rivkin, L. R., Savage, A. M., Schell, C. J., ... & Alberti, M. (2021). Socio-eco-evolutionary dynamics in cities. *Evolutionary Applications*, 14(1), 248-267.
- 8) Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. *Science*, 319(5864), 756–760. <https://doi.org/10.1126/science.1150195>
- 9) Kvale, S., & Brinkmann, S. (2015). *InterViews: Learning the craft of qualitative research interviewing* (3rd ed.). SAGE Publications.
- 10) Landman, K. (2021). Rapidly changing cities: Working with socio-ecological systems to facilitate transformation. *Urban Planning*, 6(2), 139-142.
- 11) Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE Publications.
- 12) Liu, J., Mooney, H., Hull, V., Davis, S. J., Gaskell, J., Hertel, T., ... Li, S. (2015). Systems integration for global sustainability. *Science*, 347(6225), 1258832. <https://doi.org/10.1126/science.1258832>
- 13) Patel, J. B., & Raval, Z. (2024). The impacts of urbanization on ecological systems: a comprehensive study of the complex challenges arising from rapid urban growth. *Research Review Journal of Indian Knowledge Systems*, 1(1), 1-10.
- 14) Seto, K. C., Güneralp, B., & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences*, 109(40), 16083–16088. <https://doi.org/10.1073/pnas.1211658109>
- 15) Scheba, A., Turok, I., & Visagie, J. (2021). Inequality and urban density: socio-economic drivers of uneven densification in Cape Town. *Environment and Urbanization ASIA*, 12(1_suppl), S107-S126.
- 16) United Nations Department of Economic and Social Affairs. (2022). *World urbanization prospects: The 2022 revision*. United Nations.
- 17) Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications.



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