

Assessing geodiversity in the coastal area of Naples (Southern Italy): insights for nature-based solutions

Anna Giulia Castaldo¹, Filomena Monica Vella², Agostino Navarro³, Bruna Laratta², Marina Maura Calandrelli⁴

¹Department of Architecture and Urban Studies (DASTU); Politecnico di Milano, Milan, 20133 (Italy); ² Institute of Biosciences and BioResources (IBBR), National Research Council (CNR), Naples, 80131 (Italy); ³ Prevention and Protection Unit (SPP), National Research Council (CNR), Naples, 80131 (Italy); ⁴ Research Institute on Terrestrial Ecosystems (IRET), National Research Council (CNR), Naples, 80131 (Italy).

INTRODUCTION & AIM

In recent years, environmental research has increasingly emphasized the importance of geodiversity supporting biodiversity studies, particularly in the context of rapid environmental and climatic changes (Tukiainen et al., 2023). The need for integrated approaches is especially pressing in urban areas, where biodiversity preservation and restoration face significant challenges, among which spatial planning must operate across multiple geographical scales, from preserving core areas at regional and metropolitan scales, and establishing permeable zones which maintain ecological connectivity across urban and peri-urban landscapes. Linking geodiversity and biodiversity offers valuable insights into these planning endeavors to support higher biodiversity preservation by providing variety of habitats and niches (Lawler et al., 2015, Tukiainen et al., 2023). Integrating geodiversity support actions toward global conservation targets, such as the commitment to protect 30% of Earth's terrestrial, marine, coastal, and inland water areas by 2030 (CBD, 2022). Nevertheless, despite advances in geodiversity research over the past decade and the development of geodiversity assessment methodologies, major challenges remain. Notably, there is still a lack of methodological consistency and insufficient geodiversity data to comprehensively evaluate physical landscape diversity (Toivanen et al., 2023). This study underscores the significance of the geodiversity–biodiversity relationship in Campania Region, with a focus on the municipalities within the Gulf of Naples, as areas characterized by intense urbanization, making preservation and restoration interventions urgently necessary. According to the Italian Geodiversity Map (Casaburi et al., 2024), Campania Region is characterized by very high geodiversity but shows medium to low geodiversity values in coastal plains. The objective of this research has been to provide a pilot-test that supports the development of a methodology for landscape-scale geodiversity assessment, as detailed geodiversity data at landscape-scale are still missing for the Gulf's cities and surrounding municipalities, despite their importance for biodiversity conservation.

METHOD

This initial testing phase was carried out to explore the potential relationship between geodiversity and biodiversity, combining geodiversity and biodiversity data. The methodology employed data from the “Georichness Index” (Toivanen et al., 2023), European geodiversity dataset that aggregates geodiversity information at 1 km resolution. This data was then combined with biodiversity data, using data from the regional dataset “Carta della Natura”, produced by the Italian Institute for Environmental Protection and Research (ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale). The index of the “Ecological Value” of biotopes was selected. The workflow (fig. 1) included four steps, conducted with ArcGIS Pro software (v. 3.1.0). In the first step, the Georichness index data for the coastal municipalities were extracted, and the same operation was applied to the biodiversity data. In the second step, a hexagonal grid with cell area of 10 ha was created, and a spatial join was performed to integrate the two variables. Both variables were classified into three categories (low, medium, high) to enable comparison. In the third step, a bivariate analysis was carried out. This produced a bivariate map illustrating the two variables spatially distributed and their relationship. The final step involved data observation and discussion, as described in the following section.

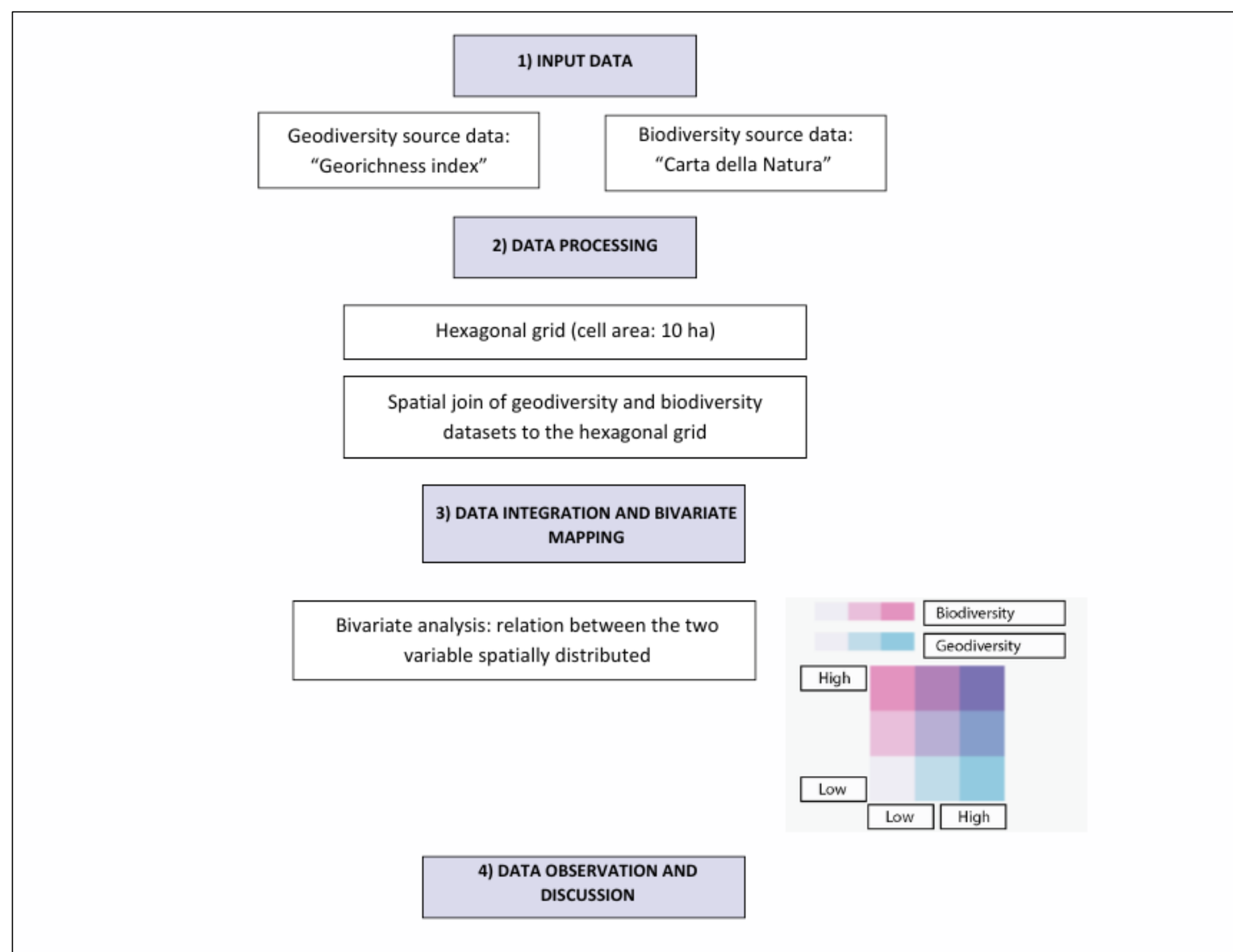


Fig. 1 – Method: workflow linking geodiversity to biodiversity

RESULTS & DISCUSSION

This method allowed for representing the distribution of the two variables within a matrix (see fig. 1 and 2), identifying the following combinations with low, medium and high geodiversity and biodiversity values (e.g. high geodiversity / high biodiversity, high biodiversity / low geodiversity). The municipalities analyzed included Naples, Portici, Ercolano, Torre del Greco, and Torre Annunziata, and for them the principal regional and metropolitan natural reserves have been observed. In Naples, the Regional Park of the Phlegraean Fields (*Parco Regionale dei Campi Flegrei*) and the Hills of Naples Metropolitan Park (*Parco Metropolitan delle Colline di Napoli*) represent landscape and ecological assets of high geodiversity and biodiversity value. Within the Hills of Naples Metropolitan Park, the Capodimonte Forest shows areas of high geodiversity and biodiversity on the western side, while the eastern side presents high biodiversity but medium geodiversity. These findings are particularly interesting and can be only highlighted at the landscape scale not at the input data. The Astroni Crater State Nature Reserve (*Riserva Naturale Statale Cratere degli Astroni*) shows high values for both biodiversity and geodiversity. In this specific case, the linkage between the two variables appears this way and coherent with the input data, however, in more localized areas—such as the crater rim—high biodiversity values are paired with medium geodiversity. The values observed in spots in the other municipalities generally show medium levels of geodiversity overall. However, this may be influenced by the fact that biodiversity data are only available for specific areas (as indicated in the *Carta della Natura*), while the geodiversity indicator covers the full extent of each municipality. This is one of the point of having geodiversity and biodiversity dataset for full integration. In Portici, the area surrounding the Royal Palace of Portici (*Reggia di Portici*) shows higher biodiversity than geodiversity. In Ercolano, Torre del Greco, and Torre Annunziata, the highest geodiversity–biodiversity relationships are observed along the coastline and toward the area adjacent to the Vesuvius nature reserve. In conclusion, the analysis of the geodiversity–biodiversity relationship revealed positive and insightful findings, providing new territorial and landscape-level information compared to the input biodiversity data. Further refinement and detailed investigation with a follow-up study will be necessary to confirm and expand these results. This is not only related to geodiversity data but also biodiversity that will be further integrated for full comparison. Obtaining geodiversity information at the landscape scale is crucial for supporting landscape management, biodiversity preservation, and strategies such as nature-based solutions.

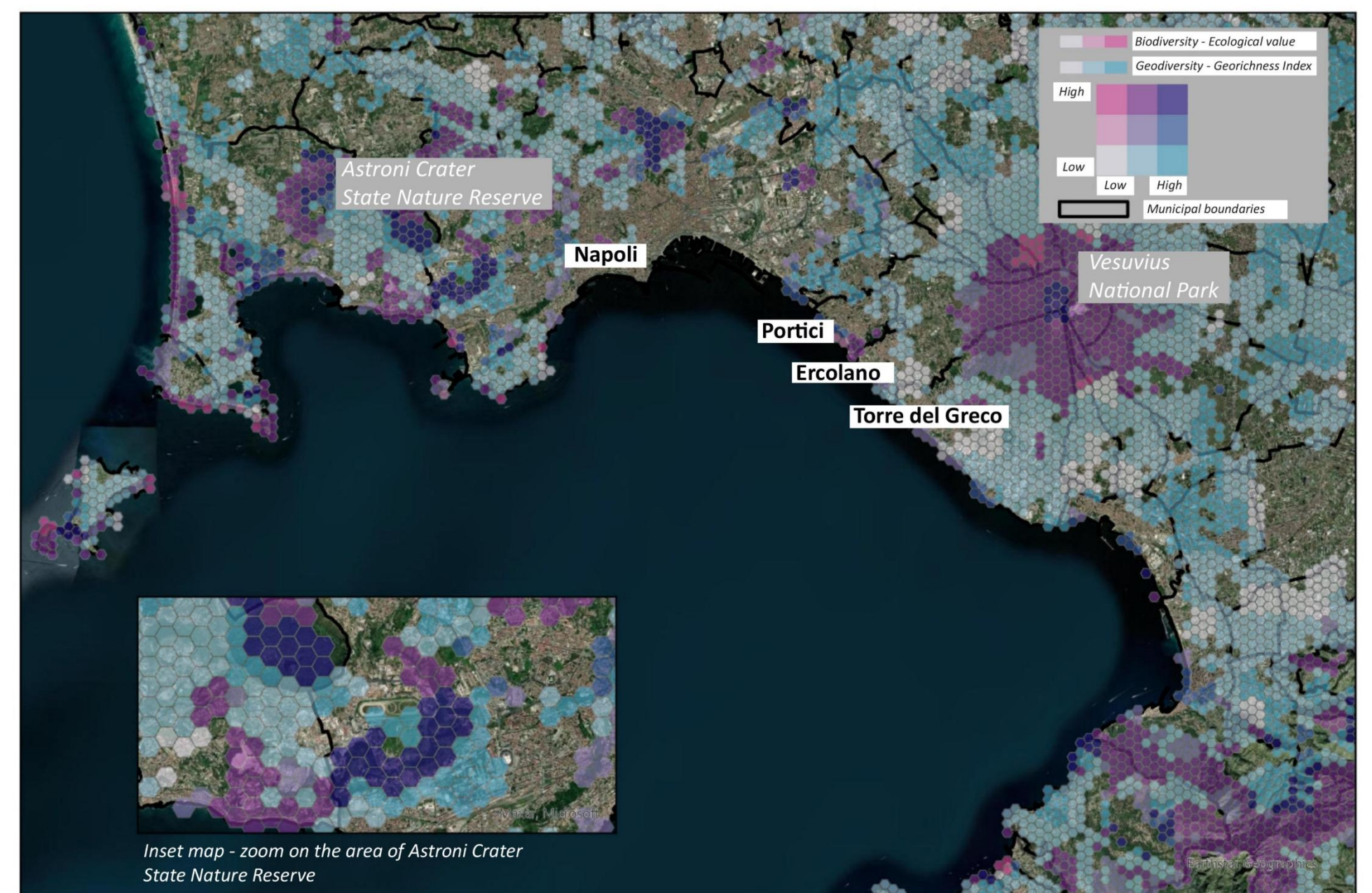


Fig. 1 – Bivariate map with inset of the Astroni Crater

CONCLUSION

- This work revealed interesting results not evident from the input biodiversity and geodiversity data;
- At the landscape scale, contrasting situations emerged, such as areas with high geodiversity but low biodiversity;
- By enriching the available geodiversity information at the landscape scale, this research contributes to supporting planning and management strategies for the municipalities involved.

FUTURE WORK / REFERENCES

Lawler, J. J., Ackerly, D. D., Albano, C. M., Anderson, M. G., Dobrowski, S. Z., Gill, J. L., ... & Weiss, S. B. (2015). The theory behind, and the challenges of, conserving nature's stage in a time of rapid change. *Conservation Biology*, 29(3), 618-629.
Tukiainen, H., Toivanen, M., & Maliniemi, T. (2023). Geodiversity and biodiversity.
Toivanen, M., Maliniemi, T., Hjort, J., Salminen, H., Ala-Hulkko, T., Kemppinen, J., ... & Tukiainen, H. (2024). Geodiversity data for Europe. *Philosophical Transactions of the Royal Society A*, 382(2269), 20230173.
Casaburi, A., Alberico, I., & Matano, F. (2024). Geodiversity of Italy. *Journal of Maps*, 20(1), 2340988.