

# Development of Biology Teaching Material Supplements Based on the Potential of Gorontalo Karst Vegetation using a Biodiversity Literacy Approach

Abubakar Sidik Katili<sup>1,2\*</sup>, Yuliana Retnowati<sup>1</sup>, Ilyas H. Husain<sup>1</sup>

<sup>1</sup>Department of Biology, Universitas Negeri Gorontalo, Indonesia.

<sup>2</sup>Center for Coastal Ecology Studies based on Local Wisdom MIPA, Universitas Negeri Gorontalo, Indonesia.

Received: June 15, 2024

Revised: November 05, 2024

Accepted: January 25, 2025

Published: January 31, 2025

Corresponding Author:

Abubakar Sidik Katili

[abubakarsidik@ung.ac.id](mailto:abubakarsidik@ung.ac.id)

DOI: [10.29303/jppipa.v11i1.9640](https://doi.org/10.29303/jppipa.v11i1.9640)

© 2025 The Authors. This open access article is distributed under a (CC-BY License)



**Abstract:** Vegetation is a community of plants of various species that live in a certain environmental condition and interactions occur in it. The fact of the vegetation analysis course material and has implications for students in vegetation analysis lecture activities. The development of teaching materials based on the potential of karst ecosystems can be carried out with a biodiversity literacy approach. The aims of this study to develop vegetation analysis materials supplements, by utilizing the results of vegetation analysis and their interaction with plant root microorganisms in karst ecosystems. The research methods used R&D method with the ADDIE model. The stages of research are analysis, design, development, implementation and evaluation. The results obtained showed that the form of supplement materials based on biodiversity literacy in the vegetation analysis course, had a validation result of 93.75% which was included in the range of 81% to 100%, in the aspect of design the supplement materials was 91.67% that indicated very good quality, with in the range 81% to 100%, the student response to the overall aspect in 94%, where this value is included in the very good category because it is in the range of 81 to 100%.

**Keywords:** Biodiversity literacy; Karst; Material supplements; Vegetation analysis.

## Introduction

Vegetation refers to a community of plants from various species living under specific environmental conditions, interacting within these conditions. Vegetation consists of various plant species that adapt and interact with each other (Farhan, 2019; Golding, 2012). In the context of the global ecosystem, vegetation plays a crucial role in the carbon cycle, water resource management, and supporting biodiversity (McPhearson et al., 2022; Schimel & Schaeffer, 2012). The presence of vegetation in an area positively impacts ecosystem balance, including the biological component of soil,

particularly microorganisms (Brown et al., 2021; Turner et al., 2007). Vegetation is one of the main geographical features across most of Earth's surface. It consists of various plants forming communities. Vegetation involves only plants; when physical and other biotic components are integrated with vegetation, an ecosystem is formed.

Various forest types, gardens, grasslands, and tundra are examples of vegetation (Garnier et al., 2016). Vegetation studies have been developed using various methods to analyze vegetation, aiding in characterizing it for specific purposes. Both natural and artificial ecosystems always consist of two main components:

### How to Cite:

Katili, A. S., Retnowati, Y., & Husain, I. H. (2025). Development of Biology Teaching Material Supplements Based on the Potential of Gorontalo Karst Vegetation using a Biodiversity Literacy Approach. *Jurnal Penelitian Pendidikan IPA*, 11(1), 770-773. <https://doi.org/10.29303/jppipa.v11i1.9640>

biotic and abiotic components. Vegetation, or plant communities, is one of the biotic components occupying specific habitats, such as forests, grasslands, shrubs, and others (Umar, 2018). Vegetation is essential for sustaining life on Earth. Besides serving as a primary producer and energy driver by capturing solar energy, vegetation performs various roles and functions in different regions, adapting to existing vegetation types (Regita et al., 2021). Vegetation functions include shading, directing, pollutant absorption, and aesthetic functions (Robinson, 2017; Werner, 2011). Moreover, vegetation contributes to balancing carbon dioxide and oxygen levels in the air, improving soil's physical, chemical, and biological properties, and managing groundwater (Andini et al., 2018; Schimel & Schaeffer, 2012).

One ecosystem with diverse vegetation is the karst ecosystem. Vegetation in karst areas effectively protects groundwater recharge areas and underground springs (Canedoli et al., 2022; Zhang et al., 2019). Karst regions are characterized by extensive and diverse natural features, steep slopes, numerous sinkholes, prominent and irregular limestone formations, caves, underground flow systems, and varying structures at different elevations (Williams, 2008). The uniqueness of karst areas also leads to diverse biota inhabiting them (Perring et al., 2013; Thomas et al., 2004). The International Union for Conservation of Nature (IUCN) designates karst areas as protected zones due to their role as groundwater reservoirs, biodiversity, and non-renewable karst resources. Gorontalo is one region in Indonesia with significant karst potential (Syahril et al., 2023).

Vegetation studies are often used to understand ecosystem dynamics and their impact on environmental changes locally and globally (Dendoncker et al., 2023; Turner et al., 2007). This fact constitutes the substance of the vegetation analysis course and has implications for students' activities in vegetation analysis studies. The development of teaching materials based on karst ecosystem potential can use a biodiversity literacy approach (Amin & Nath, 2023; Katili et al., 2021). Biodiversity literacy aspects can serve as an approach to developing vegetation analysis materials. Biodiversity literacy refers to the ability to understand biodiversity and apply this knowledge to explore aspects related to biodiversity, including interactions between vegetation and soil biotic components (Katili et al., 2021; Schultz & Zelezny, 1998). In the next stage, this will influence students' attitudes and sensitivity when making decisions based on scientific considerations.

## Method

The method used in this research is the Research and Development (R&D) method. Research and Development (R&D) is a basic research activity aimed at obtaining information about user needs (needs assessment). The next stage involves development activities to produce a product, followed by product testing. The Research and Development method was chosen because it is considered capable of providing solutions and solving existing problems.

The use of the Research and Development (R&D) method with the ADDIE model was employed to develop supplementary teaching materials for the vegetation analysis course. The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation. This ADDIE model is a general instructional design with an organized process for developing various learning materials applicable to both traditional (face-to-face) classrooms and online learning environments. However, this research is limited to the Development stage.

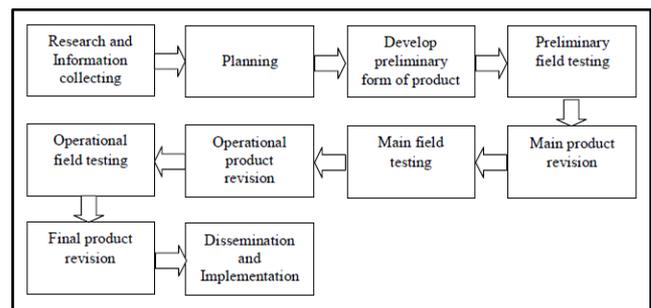


Figure 1. The Flowchart of Development stage

## Result and Discussion

The development of biodiversity literacy-based teaching material supplements for the vegetation analysis course resulted in a teaching material supplement. The content in the developed teaching material supplement is derived from previous research on vegetation analysis in the Gorontalo karst ecosystem. This development aligns with the Merdeka Belajar Kampus Merdeka (MBKM) curriculum based on case studies and the latest information needs in vegetation analysis learning (Nasrudin & Parikesit, 2020; Syahril et al., 2023).

Validation of the teaching materials showed excellent results, with a score of 93.75%. This reflects the success of the ADDIE model in designing and developing teaching materials relevant to student needs and the curriculum (Branch, 2009). The ADDIE model provides a systematic structure from needs analysis to

final evaluation, ensuring the quality of teaching materials (Brown et al., 2021; Kartawinata & Abdulhadi, 2016). Student responses to the teaching material supplement were also very positive, with a percentage of 94%. This indicates that the biodiversity literacy approach in teaching materials successfully enhanced students' understanding. Biodiversity literacy facilitates students in comprehending the complex relationships between vegetation, soil, and microorganisms in karst ecosystems (Katili et al., 2021; Turner et al., 2007).

The teaching material supplement also provides insights into the relationship between vegetation structure, karst topography, and soil microorganisms, as previously explained in Syahril et al. (2023). Karst topography, with unique characteristics such as steep slopes, caves, and underground flow systems, influences vegetation distribution patterns and overall ecosystem interactions. Perring et al. (2013) indicated that topographic variations could create microhabitats supporting high biodiversity, while Thomas et al. (2004) highlighted how specific adaptations in karst ecosystems maintain ecosystem stability despite extreme conditions. By providing real-world case-based understanding, students can develop critical thinking skills necessary for solving ecological problems (Perring et al., 2013; Schultz & Zelezny, 1998).

Given the validation results and student responses, this supplement is not only relevant for vegetation analysis learning but also contributes to conservation education in Gorontalo. Students, as conservation agents, can use this material to enhance awareness and protection actions for vulnerable and unique karst ecosystems (Canedoli et al., 2022).

## Conclusion

The developed material supplement, containing research findings on karst vegetation analysis and based on biodiversity literacy in the vegetation analysis course, has been validated as suitable for use according to design experts and content experts. The supplement materials based on biodiversity literacy in the vegetation analysis course, had a validation result 93.75% which included in the range of 81% to 100%, in the aspect of design the supplement materials showed 91.67%, that indicated very good quality, with in the range 81% to 100% and the student response to the overall aspect in 94%, where this value is included in the very good category because it is in the range of 81 to 100%. The practicality of this developed product has been tested based on evaluations by biology students at FMIPA, State University of Gorontalo .

## Acknowledgments

The authors very grateful to Mathematic and Natural Science Faculty, Universitas Negeri Gorontalo was funded for this research. The research was funded by RKAPT 2024 FMIPA Universitas Negeri Gorontalo on contract number 494/UN47.B4/PT.01.03/2024 of August 23-2024. Also grateful thanks to the research team, YR that give the result of data karst vegetation dan IH to formal analysis. Also thanks to HM for the contributed to communication between author team and publisher management.

## Author Contributions

This research consists of three authors i.e A. S. K., Y. R., and I. H. H. All author members work together to carry out each stage of the research.

## Funding

This research received no external funding.

## Conflicts of Interest

The authors declare no conflict of interest.

## References

- Amin, R., & Nath, H. (2023). Environmental Justice and Education: Bridging the Gap between Ecology, Equity, and Access. *Journal of Advanced Zoology*, 44. Retrieved from <https://shorturl.asia/VTg47>
- Andini, S. W., Prasetyo, Y., & Sukmono, A. (2018). Analisis sebaran vegetasi dengan citra satelit sentinel menggunakan metode NDVI dan segmentasi. *Jurnal Geodesi Undip*, 7(1), 14–24. <https://doi.org/10.14710/jgundip.2017.19295>
- Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer. <https://doi.org/10.1007/978-0-387-09506-6>
- Brown, C. J., Adame, M. F., Buelow, C. A., Frassl, M. A., Lee, S. Y., Mackey, B., McClure, E. C., Pearson, R. M., Rajkaran, A., Rayner, T. S., & others. (2021). Opportunities for improving recognition of coastal wetlands in global ecosystem assessment frameworks. *Ecological Indicators*, 126, 107694. <https://doi.org/10.1016/j.ecolind.2021.107694>
- Canedoli, C., Ficotola, G. F., Corengia, D., Tognini, P., Ferrario, A., & Padoa-Schioppa, E. (2022). Integrating landscape ecology and the assessment of ecosystem services in the study of karst areas. *Landscape Ecology*, 1–19. <https://doi.org/10.1007/s10980-021-01351-2>
- Dendoncker, M., Taugourdeau, S., Messier, C., & Vincke, C. (2023). A functional trait-based approach to evaluate the resilience of key ecosystem functions of tropical savannas. *Forests*, 14(2), 291. <https://doi.org/10.3390/f14020291>
- Farhan, A. M. (2019). Mengidentifikasi perubahan kerapatan vegetasi pada Kota Semarang. *Jurnal Geografi Vol*, 8(2). Retrieved from

- <http://geografi.pjj.unp.ac.id/index.php/geo/article/view/848>
- Garnier, E., Navas, M.-L., & Grigulis, K. (2016). *Plant functional diversity: organism traits, community structure, and ecosystem properties*. Oxford University Press.
- Golding, C. (2012). *An interdisciplinary approach*. Cambridge University Press.
- Kartawinata, K., & Abdulhadi, R. (2016). *Ekologi Vegetasi: Tujuan dan Metode*. Bogor, Indonesia: LIPI Press & Yayasan Pustaka Obor Indonesia.
- Katili, A. S., Utina, R., Yusuf, F. M., Pikoli, M., & Dama, L. (2021). Biodiversity literacy in science education. *Journal of Physics: Conference Series*, 1968(1), 12024. <https://doi.org/10.1088/1742-6596/1968/1/012024>
- McPhearson, T., Cook, E. M., Berbés-Blázquez, M., Cheng, C., Grimm, N. B., Andersson, E., Barbosa, O., Chandler, D. G., Chang, H., Chester, M. V., & others. (2022). A social-ecological-technological systems framework for urban ecosystem services. *One Earth*, 5(5), 505–518. Retrieved from [https://www.cell.com/one-earth/fulltext/S2590-3322\(22\)00208-1](https://www.cell.com/one-earth/fulltext/S2590-3322(22)00208-1)
- Nasrudin, A., & Parikesit. (2020). Vegetation analysis of karst in Padjadjaran University Campus area Cintaratu, Pangandaran, West Java. *Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia*, 6(1). Retrieved from <https://smujo.id/psnmbi/article/view/4426>
- Perring, M. P., Standish, R. J., & Hobbs, R. J. (2013). Incorporating novelty and novel ecosystems into restoration planning and practice in the 21st century. *Ecological Processes*, 2, 1–8. <https://doi.org/10.1186/2192-1709-2-18>
- Regita, R. S., Simangunsong, N. I., & Chalim, A. (2021). Kajian Peletakan Fungsi Vegetasi Terhadap Kondisi Ruang Terbuka Kampus (Studi Kasus: Indonesia Port Corporation University, Ciawi, Bogor). *Jurnal Lanskap Indonesia*, 13(2), 38–44. <https://doi.org/10.29244/jli.v13i2.33327>
- Robinson, N. (2017). *The planting design handbook*. Routledge.
- Schimel, J. P., & Schaeffer, S. M. (2012). Microbial control over carbon cycling in soil. *Frontiers in Microbiology*, 3, 348. <https://doi.org/10.3389/fmicb.2012.00348>
- Schultz, P. W., & Zelezny, L. C. (1998). Values and proenvironmental behavior: A five-country survey. *Journal of Cross-Cultural Psychology*, 29(4), 540–558. <https://doi.org/10.1177/0022022198294003>
- Syahril, L. M. Y., Uno, W. D., Katili, A. S., & Retnowati, Y. (2023). Distribution of Rhizospheric actinomycetes on Karst Ecosystem of Gorontalo, Indonesia. *Microbiology Indonesia*, 17(1), 24–30. Retrieved from <https://jurnal.permi.or.id/index.php/mionline/article/view/763>
- Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., Erasmus, B. F. N., De Siqueira, M. F., Grainger, A., Hannah, L., & others. (2004). Extinction risk from climate change. *Nature*, 427(6970), 145–148. Retrieved from <https://www.nature.com/articles/nature02121>.
- Turner, B. L., Lambin, E. F., & Reenberg, A. (2007). The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences*, 104(52), 20666–20671. <https://doi.org/10.1073/pnas.0704119104>
- Umar, U. Z. (2018). *Analisis Vegetasi Angiospermae Di Taman Wisata Wira Garden Lampung (Sebagai Alternatif Sumber Belajar Biologi Pada Materi Tumbuhan Tingkat Tinggi Kelas X Di Sekolah Menengah Atas)* [Thesis: UIN Raden Intan Lampung]. Retrieved from <https://repository.radenintan.ac.id/3072/>
- Werner, P. (2011). The ecology of urban areas and their functions for species diversity. *Landscape and Ecological Engineering*, 7(2), 231–240. <https://doi.org/10.1007/s11355-011-0153-4>
- Williams, P. (2008). *World heritage caves and karst* (Vol. 57). IUCN, Gland, Switzerland. Retrieved from <http://ftp.fredsakademiet.dk/ordbog/lord/Karst.pdf>
- Zhang, J., Zhao, X., Chen, Z., & Lu, Z. (2019). A review of deep learning-based semantic segmentation for point cloud. *IEEE Access*, 7, 179118–179133. <https://doi.org/10.1109/ACCESS.2019.2958671>