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Gresik's biodiversity: A potential learning resource to support Sustainable Development Goals 14 and 15

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ABSTRACT

Gresik has a diverse terrestrial and aquatic ecosystem that supports high biodiversity. However, the available biodiversity data remains fragmented and have not been optimally utilized as a contextual learning resource in biology education. This study aims to describe the biodiversity of Gresik and analyze its potential as a learning resource for biodiversity topics to support Sustainable Development Goals 14 and 15. A qualitative descriptive approach was employed through three integrated phases: (1) biodiversity inventory based on 394 student research reports from Animal Systematics courses conducted between 2021 and 2023; (2) a survey involving 31 senior high school biology teachers in Gresik using a validated questionnaire; and (3) a PRISMA-based literature review of articles published between 2017 and 2025. The results identified that Gresik's biodiversity has 225 animal species from 7 groups of invertebrates and 2 groups of vertebrates spread across 10 types of ecosystems. Furthermore, 84% of teachers have utilized biodiversity in their teaching, but these activities are dominated by observation in the school environment. Literature review findings suggested that Outdoor Learning, Discovery Learning, Guided Inquiry, and Project-Based Learning are effective approaches for integrating Gresik's biodiversity into lessons. This study contributes a synthesized biodiversity database for integrating local biodiversity into contextual biology learning, thereby strengthening environmental literacy, supporting the implementation of the Merdeka Curriculum and Deep Learning principles, and contributing to Sustainable Development Goals 14 and 15. Future studies are recommended to develop and evaluate biodiversity-based learning resources derived from the biodiversity potential of Gresik.

Keywords: Biodiversity, biology education, Gresik, Sustainable Development Goals

INTRODUCTION

Biodiversity includes genetic, species, and ecosystem diversity, which play a vital role in maintaining ecological balance while also serving as a source of contextual learning relevant to students' lives (Marianingsih et al., 2023). In biology education, particularly when teaching biodiversity, utilizing biodiversity as a learning resource has proven effective in fostering environmental awareness, developing scientific process skills, and achieving better learning outcomes (Ameliya, 2023; Febrianti et al., 2019; Nursidin et al., 2022; Sembiring et al., 2024; Siregar et al., 2025).

Various studies on the use of biodiversity as a learning resource have been conducted in Indonesia, including the use of marine Bivalve diversity along the Pasuruan coast, fish diversity in the irrigation canals of the Tanipah Village swamp, fauna in the areas of Bengkulu and Mulawarman Universities, also flora and fauna in Way Kambas and Gunung Leuser National Parks,

which have been incorporated into modules, handouts, student worksheets, and booklets (Agustriana et al., 2023; Fitriani et al., 2023; Muthoharoh, 2023; Nasution et al., 2024; Prasetyo et al., 2023; Tarigan, et al., 2025; Yani et al., 2020). However, these studies largely remain focused on developing biodiversity-based learning materials specific to limited locations. In other words, studies that explicitly link the inventory of a wider region's diverse biodiversity with its potential as a source of learning material on biological diversity remain limited.

Gresik is one of the regions with high biodiversity potential as a resource for learning about biodiversity. This region is a regency located northwest of Surabaya, covering an area of 1,191.25 km^2, divided into 18 districts, 330 villages, and 26 urban villages, and features a unique geography characterized by a blend of coastal, mangrove, rice field, and island ecosystems (Pemerintah Kabupaten Gresik, 2024). Previous studies have documented various aspects of Gresik's biodiversity, including avian, crab, and Gastropod diversity in the Ujungpangkah mangrove forest; coral reef ecosystems on Bawean Island; and insect diversity in the rice fields of Randupadangan Village (Arifianti et al., 2021; Masitoh et al., 2024; Mubarrok & Ambarwati, 2019; Nisa et al., 2025; Syaifuddin, 2023). These findings confirm that Gresik possesses high biological diversity. However, this data remains scattered across various publications with differing taxonomic focuses and locations; consequently, no study has yet specifically integrated Gresik's biodiversity into a single comprehensive overview to serve as a learning resource on biological diversity.

This gap is underscored by the findings of a survey of 31 high school biology teachers in Gresik, which showed that although 84% of teachers have incorporated biodiversity into their teaching, the majority still limit their use to the school environment. This situation indicates that the lack of compiled biodiversity data for Gresik poses a significant obstacle for teachers in utilizing it as a broader and more diverse learning resource.

To address this gap, this study utilizes animal biodiversity data sourced from articles resulting from a student research project in the Animal Systematics course, Department of Biology, Surabaya State University. The use of this data source is based on several considerations: the data is primary and up-to-date, and it covers a more diverse range of animal groups and locations spread across various regions of Gresik, thus reflecting the current state of biodiversity in Gresik more accurately than previous individual studies. Furthermore, the collected data adheres to scientific procedures and verification, as well as academically accountable validation under the supervision of the supervising lecturers. This consideration is supported by the fact that CURE (Course-Based Undergraduate Research Experience)-based data collection has been internationally recognized as a valid source of data for biodiversity research (Baker et al., 2024; Funkhouser et al., 2024).

The novelty of this study is its integrative approach, which not only catalogs Gresik's biodiversity across taxa and ecosystems but also explicitly analyzes its potential as a learning resource on biodiversity through a literature review of relevant learning models. This approach simultaneously supports the achievement of Sustainable Development Goals (SDGs) 14 (Life Below Water) and 15 (Life on Land) by providing baseline data that can support efforts toward the conservation and sustainable use of biological resources. Thus, this study aims to describe the fauna biodiversity of Gresik Regency and analyze its potential as a learning resource for biodiversity, while also serving as a bridge between local biodiversity research and sustainable biology education practices.

METHOD

This study used a qualitative descriptive approach with the aim of identifying the fauna

biodiversity of Gresik Regency and analyzing its potential as a learning resource for biodiversity education. The research was conducted through three integrated stages: an inventory of Gresik's biodiversity, an identification of how high school biology teachers in Gresik utilize biodiversity, and a literature review on the use of biodiversity in biology education. The results from these three stages were then integrated through data triangulation to provide a comprehensive picture of Gresik's biodiversity potential as a contextual learning resource. The research flowchart is shown in Figure 1.

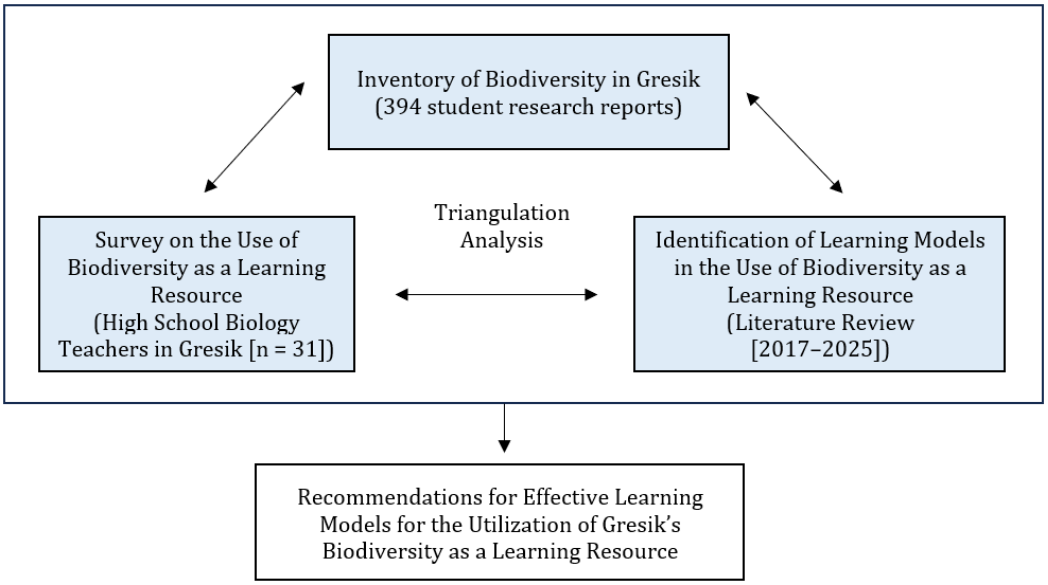

Figure 1. Research flowchart

Phase I. Gresik biodiversity inventory

In this phase, data for the Gresik biodiversity inventory were obtained through a literature review of 394 research project reports by students in the Biology Department at Surabaya State University from the 2021–2023, with a total of 28 classes (16 classes from the Biology Education Program and 12 classes from the Biological Sciences Program). The data resulted from the course project assignment "Animal Systematics" based on field research, which required students to conduct observations, identifications, documentation, and classification of animals at specific locations and compile them into scientific reports. The validity of all data in these reports is guaranteed because they underwent supervision by the supervising lecturer, as well as verification of scientific names using taxonomic literature and the latest scientific databases. All reports were then screened using the following inclusion criteria: (1) the research location is within the Gresik region; (2) specimens are identified down to the species level; (3) observation location information is provided; and (4) the report includes documentation of observation results. Meanwhile, the exclusion criteria included: (1) the research location was not described in detail; (2) organism identification could not be verified; and (3) there was data duplication at the same location and for the same object. Data meeting the criteria were then analyzed descriptively through tabulation and taxonomic classification covering phylum, class, order, and species, as well as grouping based on ecosystem type. The results of this inventory serve as the basis for identifying Gresik's biodiversity potential, which can be utilized as a learning resource.

Phase II. Analysis of the use of gresik's biodiversity by high school biology teachers

In this phase, data on the use of Gresik's biodiversity in teaching biodiversity-related material was collected using a Google Forms-based questionnaire distributed in August 2025. Respondents were selected using purposive sampling, with the criterion being active high school biology teachers in Gresik. Subsequently, snowball sampling was used to obtain a larger sample. A total of 31 high school biology teachers participated in this study. The research instrument consisted of 10 open-ended questions designed to gather data on the frequency with which teachers have incorporated biodiversity into their teaching, the forms of incorporation, the learning resources used, and the need for the development of biodiversity-based learning resources. The questionnaire was validated through expert judgment by two biology education faculty members, who assessed the alignment of the items with the research objectives, the clarity of the language, and the ease with which respondents could understand the questions. The validation results indicated that the instrument was deemed "valid" and "suitable for use" following minor revisions to the language clarity in accordance with the validators' recommendations. The questionnaire data were analyzed descriptively using thematic analysis, presented as percentages reflecting the frequency of occurrence of a particular word or pattern among respondents. The findings from this stage were used to identify actual needs in the field and to compare the biodiversity potential identified in Stage I with the extent of its utilization in teaching.

Phase III. Literature review on the use of biodiversity as a learning resource

In this phase, data on the use of biodiversity in biology education—as reported in previous studies—were collected through a literature review based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) protocol, using the Publish or Perish application with the keywords "learning models," "learning resources," and "biodiversity" in the Google Scholar database, with the publication year range limited to the period 2017–2025 to obtain references more relevant to 21st-century learning developments, up-to-date and relevant to the current educational context. The PRISMA Flowchart is shown in Figure 2.

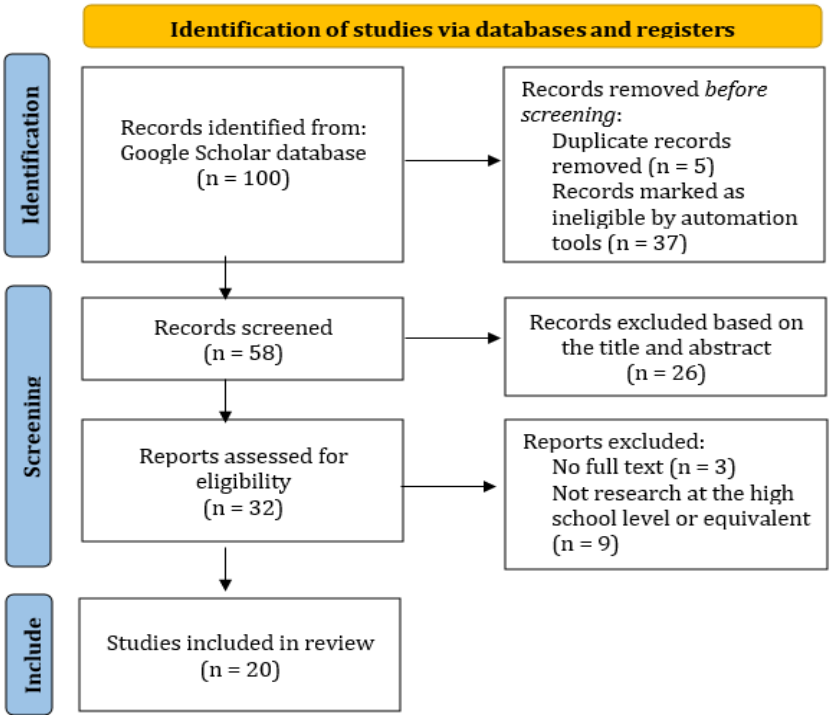

Figure 2. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) flowchart.

From the 100 articles retrieved from the database, 42 were excluded prior to screening, leaving 58 articles that proceeded to the title and abstract screening stage based on the following inclusion criteria: (1) Discussing the utilization of biodiversity or the environment in learning; (2) Written in Indonesian or English. Following this, the 32 remaining articles were further selected based on the following inclusion criteria: (1) Possess a full-text version that is accessible; (2) Clearly describe the form of biodiversity utilized; (3) Present the utilization of biodiversity as a learning resource, learning object, instructional medium, or teaching material; (4) Presenting the instructional model used. Furthermore, 22 articles were excluded, with the following breakdown: 3 articles lacked full-text access, and 9 articles were not research studies at the high school level or equivalent. The remaining 20 articles were deemed relevant for analysis, covering the types of biodiversity utilized, the instructional models employed, and their impacts.

Data integration and triangulation

The three research phases were integrated through data source triangulation. The results of the fauna biodiversity inventory in Gresik Regency from Phase I were used as the basis for identifying available learning resources. These findings were then compared with the results of the teacher survey from Phase II to determine the extent to which local biodiversity has been utilized in teaching. Furthermore, the results of the literature review in Phase III were used to identify effective learning models and strategies for utilizing biodiversity. These three data sources were then triangulated to produce recommendations for a learning model that utilizes Gresik's biodiversity as a learning resource on biodiversity, supporting the achievement of SDGs 14 and 15.

RESULTS AND DISCUSSION

Based on a document study of 394 articles on animal systematics research projects by students of the Biology Department at Universitas Negeri Surabaya, 45 articles were found to focus on animal diversity in the Gresik region. From these 45 articles, data on Gresik's biodiversity were obtained, including animal types, the number of species found, and their locations, as presented in Table 1.

Table 1. Gresik biodiversity data

Animal Types	Number of Species	Location
Snail Phylum: Mollusca Class: Gastropoda	Seven species of freshwater snails	The Fields of Ngebret Hamlet, Morowudi Village; Karangcangkring Village, Dukun Subdistrict; and Wedani Village, Cerme Subdistrict. The Reservoir in Mojosarirejo, Driyorejo District.
	Twenty-one species of sea snails	Tanjung Kemukem Putih Beach, Bungah District. Mangrove Ecosystem, Karangkiring Village, Kebomas District.
Shellfish Phylum: Mollusca Class: Bivalve	Thirty-three species of shellfish	The Beach of Banyu Urip Village, Ujung Pangkah Subdistrict; Delegan, Delegan Village, Panceng Subdistrict; Plengsengan, Ngemboh Village, Ujung Pangkah Subdistrict; and Tanjung Kemukem Putih, Kramat Village, Bungah Subdistrict.
Butterflies Phylum: Arthropoda Class: Insecta Order: Lepidoptera	Forty-eight species of butterflies	The Area of Menganti Village, Menganti Subdistrict; Nongko Kerep Hamlet, Bungah Subdistrict; and Gresik Square. The Fields of Gadung Village, Driyorejo Subdistrict. The Farms of Panggang Hamlet, Lebanisuko Village, Wringinanom Subdistrict. The Park in Jati Sewu, Bongso Wetan Village, Menganti District; World Park.

Animal Types	Number of Species	Location
		The Housing complex in Pondok Permata Suci, Manyar District; and Sabunga, Ngipik Village, Karangpoh, Gresik District.
Grasshoppers Phylum: Arthropoda Class: Insecta Order: Orthoptera	Fourteen species of grasshoppers	The Fields of Mulung Village, Driyorejo District; Morowudi Village, Cerme District; and Sumari Village, Duduksampeyan District.
Dragonflies Phylum: Arthropoda Class: Insecta Order: Odonata	Twenty-two species of dragonflies	The Marsh in Dukuhan Hamlet, Menganti Village, Menganti Subdistrict. The Fields in Tenaru Village, Driyorejo Subdistrict and Kedanyang Village, Kebomas Subdistrict. Kali Lamong River, Kebomas Subdistrict.
Water strider Phylum: Arthropoda Class: Insecta Order: Hemiptera	Three species of water striders	The Fishpond in Pranti Village, Menganti Subdistrict.
Crabs Phylum: Arthropoda Class: Crustacea Order: Decapoda	Forty-two species of crabs	The Beach of Ayang-Ayang Mangrove Forest, Bungah District; Delegan, Panceng District; and Karangkering, Kebomas District. The Mangrove Ecosystems of Karangkering Beach, Kebomas District; Alas Bakau Mengare, Bungah District; and Banyuurip, Ujungpangkah District.
Fish Phylum: Chordata Superclass: Pisces Class: Osteichthyes	Thirty-two species of fish	The River in Putat Lor Village, Menganti Subdistrict; Kasiyan Hamlet, Kedamean Subdistrict; Tanjung Widoro Mengare Village, Bungah Subdistrict; Lamong, Napes Hamlet, Sukorejo Subdistrict; Brantas, Wringinanom Subdistrict. Karangkering Beach, Kebomas Subdistrict. The Mangrove Ecosystems in Karangkiring Village, Kebomas Subdistrict.
Lizards Phylum: Chordata Superclass: Tetrapoda Class: Reptile	Three species of lizards	Bundaran Gresik Kota Baru Park.

Based on the data in Table 1, it can be seen that various types of animals can be found in various ecosystems in Gresik. The Insecta group found consisted of 48 species of butterflies, 22 species of dragonflies, 14 species of grasshoppers, and 3 species of water striders, which were found in the pond area because they are aquatic insects (Setiawan et al., 2022). The Insecta group was the most dominant because insects are the most dominant class of animals on Earth, accounting for approximately 80% of all known animal species worldwide (Armania & Nugroho, 2026). Additionally, the Gresik region features diverse ecosystems, including approximately 2.854,32 hectares of mangroves, around 32,000 hectares of fish ponds, extensive rice-farming areas in several districts, and around 160,15 km^2 green open spaces in the city center that support insect life (Aisyah et al., 2023; Maulana et al., 2024; Sari et al., 2021; Sodikin et al., 2024). Then there are 42 species of crustaceans (crabs), 33 species of Bivalves (shellfish), and 21 species of marine Gastropods (snails) found in coastal areas such as mangrove ecosystems and beaches. The diversity of animals in coastal areas is inseparable from the geographical location of Gresik, part of which is a coastal area (Pemerintah Kabupaten Gresik, 2024). Meanwhile, seven species of freshwater

Gastropods (snails) can be found in fields. There are 32 species of Pisces (fish) found in rivers because Gresik is the estuary of three major rivers, namely the Bengawan Solo River, the Brantas River, and the Kali Lamong River (Mochammad, 2018). Finally, there are 3 species of reptiles (lizards) found in parks.

Biodiversity inventories are a crucial first step in conservation efforts because they provide information on species composition, organism distribution, and ecosystem conditions, which form the basis for the sustainable management of biological resources (Jetz et al., 2019; Stephenson & Stengel, 2020). Biodiversity data also serves as a key indicator in evaluating progress toward the Sustainable Development Goals (SDGs), particularly SDG 14 (Life Below Water), which focuses on protecting aquatic ecosystems, and SDG 15 (Life on Land), which emphasizes the conservation of terrestrial ecosystems and the prevention of biodiversity loss (Li et al., 2023; Wiranti & Nugraheni, 2024). Therefore, the biodiversity inventory of Gresik makes a strategic contribution by providing baseline data that can support efforts toward conservation and the sustainable management of ecosystems. hese various types of animals are components of the aquatic and terrestrial ecosystems.

In addition to serving as a foundation for management and conservation, biodiversity data also holds significant educational value. From the perspective of contextual learning and place-based education, students' surrounding environment can be utilized as a learning resource that connects scientific concepts with the real-world conditions they encounter (Fu & Komatsu, 2024; Gonzalez, 2023). In line with the concept of Education for Sustainable Development (ESD), the use of local biodiversity data in learning not only helps students understand the concept of biodiversity but also fosters ecological awareness, critical thinking skills, and a sense of responsibility toward environmental sustainability (Supratman et al., 2025; Suryawati et al., 2020; Vioreza et al., 2023).

Based on this, it is clear that Gresik's biodiversity not only offers potential for sustainable ecosystem management but also provides scientific data that can be used as a context for learning. Presenting scientific data in learning and assessment through various forms such as tables, graphs, diagrams, infographics, text, or videos can encourage students to observe empirical facts and conditions in the field, thereby stimulating them to think critically and creatively, as well as to understand the various issues occurring around them (Santoso et al., 2024). This is in line with one of the principles of future education, which is that learning must be able to encourage students to grow as citizens who can make decisions based on empirical data (Pratiwi et al., 2025). Even the presentation of research data related to surrounding issues or problems will stimulate students to improve their claims and evidence for their arguments. Thus, the presentation of research data can improve students' scientific argumentation skills (Santoso et al., 2022). Therefore, it can be concluded that Gresik's biodiversity has great potential that can be useful in education as a source of contextual learning.

Data on the use of Gresik's biodiversity as a learning resource in biodiversity education were collected through a Google Forms-based questionnaire consisting of 10 items that had been validated through expert judgment by two Biology Education lecturers based on the alignment of the items with the research objectives, clarity of language, and ease of understanding for respondents. The validation results indicated that the instrument was deemed "valid" and "suitable for use" following minor revisions to language clarity based on the validators' recommendations. Respondents were selected using purposive sampling targeting high school Biology teachers actively teaching in Gresik, with the sample subsequently expanded via snowball sampling. A total of 31 high school Biology teachers served as

respondents in this study. The analysis results showed that of the 31 respondents, 84% had utilized Gresik's biodiversity as a learning resource for the biodiversity curriculum. Based on the 84% of respondents who had utilized the surrounding environment in their teaching, information regarding the types of environments and learning activities conducted is presented in Figure 3, while the types of biodiversity utilized as learning resources for the biodiversity curriculum are presented in Figure 4.

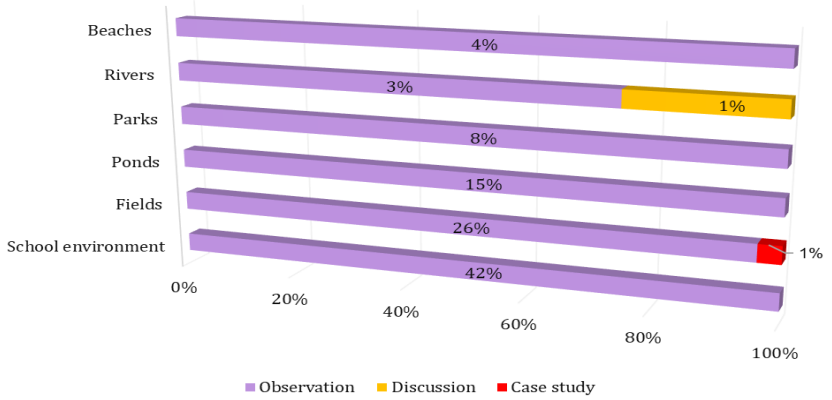

Figure 3. Types of environments utilized and types of activities carried out in teaching biodiversity material.

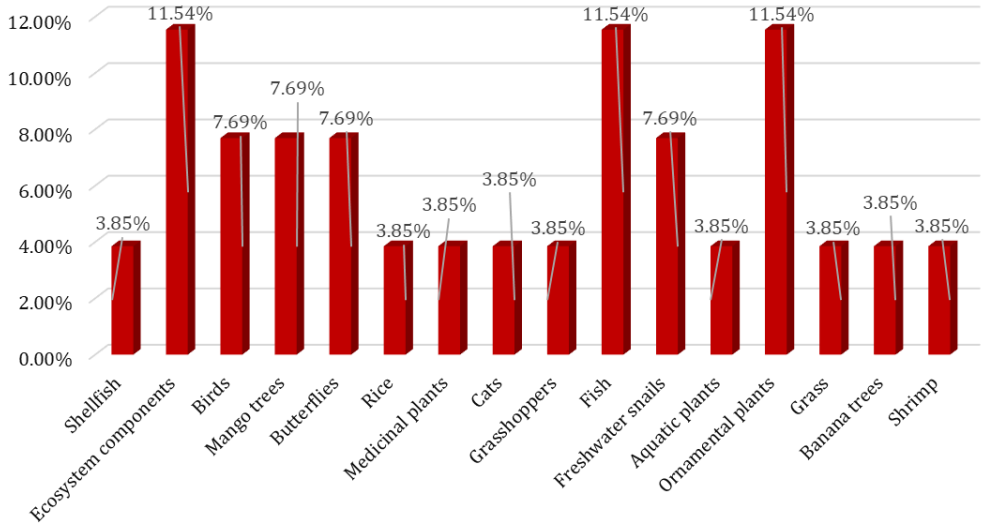

Figure 4. Biodiversity was used as a learning resource in teaching biodiversity material.

The learning outcomes for the biodiversity material in phase E of grade 10 high school in the latest curriculum emphasize that students should be able to apply classification principles through direct learning in the environment and undertake biodiversity conservation efforts through project-based learning (Widodo et al., 2025). Based on the analysis in Figure 3 and Figure 4, it can be seen that the most dominant type of environment used is the school environment, which is 42%, followed by fields, ponds, parks, rivers, and beaches with biodiversity in the form of various types of flora and fauna such as ornamental plants, mango and banana trees, fish, butterflies, birds, and others.

The types of learning activities carried out are still dominated by observation activities, while discussion, case studies, and even projects are rarely conducted. Thus, it is evident that learning outcomes have only been partially achieved and are not yet optimal. This is unfortunate because learning activities in

problem-based and project-based environments have been proven to provide more meaningful learning experiences, encourage higher-level thinking, improve science skills, and increase environmental awareness (Hadi, 2017; Lubis & Nababan, 2025; Siregar et al., 2025). Overall, it can be seen that high school biology teachers in Gresik have utilized Gresik's biodiversity in teaching biodiversity as a learning resource, but they still focus on observation activities within a limited scope without following up with analysis, projects, or more in-depth application of concepts with a broader scope of biodiversity.

Supporting data from the literature review on various types of biodiversity in Indonesia that have been utilized in biology learning activities as a broader learning resource using various learning models are presented in Table 2.

Table 2. Utilization of biodiversity in learning activities.

Source	Learning Model	Biodiversity	Utilization
Sembiring et al., 2024	Discovery Learning	Flora and fauna of Riau (nibung trees and selais fish)	Learning resources Flora and fauna mascots Student worksheets Enhancing environmental engagement and awareness, thinking skills, motivation, and learning outcomes
Prasetyo et al., 2023		Flora of the Arecaceae family in Way Kambas National Park	
Nurfatihah et al., 2018		Ecosystem components in SMA Negeri 5 Sinjai	
Supriyanto et al., 2018	Outdoor Learning	Butterflies at the Curug Cilember Nature Tourism Breeding Center	Learning resources Instilling a love of conservation, enhancing critical thinking, conceptual understanding, interest, motivation, and learning outcomes
Garnasih, 2018		Flora and fauna in MAS Ar-Rosyidiyah Cibiru, Bandung	
Yusrina et al., 2019		Flora in the Situ Pondok Jagung Green Open Space, South Tangerang	
Irwandi & Fajeriadi, 2019		Fauna in the coastal area, South Kalimantan	
Thaariq et al., 2020		Flora in the school garden of SMA Negeri 3 Kuala, Nagan Raya Regency	
Febrianti et al., 2019	Guided Inquiry	Flora and fauna in SMA Negeri 4 Palembang	Learning resources Improving learning outcomes and science process skills
Siregar et al., 2025		Ecosystem components in MAS Darul Ulum Sipaho	
Nurafdaliah et al., 2024		Flora and fauna in SMA Negeri 5 Sinjai	
Lubis & Nababan, 2025	Project-Based Learning (PjBL)	Components of the Lake Toba ecosystem	Learning resources Learning modules Strengthening local values, fostering environmental awareness, honing cooperation skills, data collection, and technology application
Ihsan et al., 2024		Flora in SMA Muhammadiyah 1 Palangka Raya, Central Kalimantan	
Subrata et al., 2023	Problem-Based Learning (PBL)	Ecosystem components in SMA Negeri 2 Denpasar	Learning resources Student worksheets Encourages higher-order thinking skills and improves conceptual mastery, motivation, and learning outcomes
Pana, 2020		Flora and fauna in Lake Tambing, Lore Lindu National Park	
Mantek et al., 2019		Ecosystem components in SMA Negeri 1 Arso and SMA Negeri 2 Skanto	

Source	Learning Model	Biodiversity	Utilization
Hadi, 2017		Flora and fauna in Sawang District, Aceh	
Setiawati & Budiningsih, 2018	Cooperative Learning	Flora in the Taman Ayun Bali Temple Tourism Area	Learning resources Increasing interest in learning
Apridayani et al., 2022	Jelajah Alam Sekitar (JAS)	Ecosystem components of the Cukuh Balak Mangrove Forest	Learning resources Improving learning outcomes
Awal & Sutriana, 2017	VAK (Visual, Auditory, Kinesthetic)	Ecosystem components in SMA Negeri 13 Pekanbaru	Learning resources Improving conceptual mastery

Based on Table 2, it can be seen that the utilization of biodiversity in biology learning activities as a learning resource with various innovative learning models has been widely implemented. The most frequently used learning models are Outdoor Learning and Problem-Based Learning (PBL). Both learning models emphasize the active involvement of students in exploratory activities in the environment to improve science process skills, conceptual understanding, higher-order thinking skills, motivation, and learning outcomes (Hadi, 2017; Siregar et al., 2025; Subrata et al., 2023; Thaariq et al., 2020). In addition, the Project-Based Learning, Discovery Learning, and Guided Inquiry models have also been proven effective in enhancing collaboration and data collection skills for problem-solving, while simultaneously promoting environmental awareness and improving learning outcomes (Ihsan et al., 2024; Lubis & Nababan, 2025; Nurafdaliah et al., 2024; Prasetyo et al., 2023; Sembiring et al., 2024). Less commonly used learning models, such as cooperative learning, Exploring the Surrounding Environment (JAS), and VAK (Visual, Auditory, Kinesthetic), have also been shown to enhance concept mastery, increase motivation, and improve overall learning outcomes (Apridayani et al., 2022; Awal & Sutriana, 2017; Setiawati & Budiningsih, 2018).

Based on Table 2, it can also be seen that the biodiversity utilized consists of biological diversity, flora and fauna, and ecosystem components located predominantly in the school's surroundings because they are easily accessible and do not require large costs (Supriyanto et al., 2018). In addition, several studies also utilize locations such as natural ecosystems, such as lakes, mangrove forests, national parks, and coastal areas, as well as green open spaces that can provide contextual learning experiences, support conceptual understanding, encourage higher-order thinking skills, and increase environmental awareness (Apridayani et al., 2022; Hadi, 2017; Irwandi & Fajeriadi, 2019; Lubis & Nababan, 2025; Pana, 2020; Sembiring et al., 2024). Overall, the results of the literature review indicate that biodiversity has great potential to be utilized in teaching biodiversity material as a learning resource through various innovative learning models that have been proven to increase motivation and learning outcomes, scientific process skills, critical thinking skills, conceptual understanding, and foster an attitude of caring for the environment.

Based on Gresik biodiversity data, data on high school profiles in Gresik, and combined with data from a literature review, several recommendations for utilizing Gresik's biodiversity in teaching biodiversity as a learning resource can be presented in Table 3.

Table 3. Recommendations for learning models using Gresik's biodiversity as a source of learning material on teaching biodiversity

Learning Model	Learning Objectives	Examples of Implementation in Learning Activities
Outdoor Learning	Students are able to identify levels of biodiversity through direct observation.	The teacher guided students to identify the level of diversity of Bivalve (shellfish) directly on Delegan Beach, Panceng District.
Discovery Learning	Students are able to apply classification principles based on morphological characteristics through direct observation.	The teacher guided students to find types of grasshoppers (Order Orthoptera) in the fields of Morowudi Village, Cerme District, and classify them based on morphological characteristics.
Guided Inquiry	Students are able to analyze factors threatening biodiversity conservation through direct observation.	Teachers guided students to analyze the factors threatening the sustainability of Pisces (fish) in the Putat Lor Village River, Menganti District.
Project-Based Learning (PjBL)	Students are able to design biodiversity conservation projects based on direct observation.	Teachers invited students to study the diversity of Crustacea (crabs) in the Karangkering Beach Mangrove ecosystem, Kebomas District, and design projects related to conservation efforts.

The above recommendations can be adjusted by teachers regarding the objects and locations of learning. Gresik's biodiversity as a learning resource for teaching biodiversity can be utilized using learning models such as Outdoor Learning, Discovery Learning, Guided Inquiry, and Project-Based Learning. The Outdoor Learning model is recommended because it emphasizes learning experiences outside the classroom that enable students to interact directly with the environment, thereby reinforcing concepts and providing joyful learning (Thaariq et al., 2020). Furthermore, the Discovery Learning model is also recommended because it encourages students to ask questions, explore, and find answers independently so they can develop a deeper understanding and relevance of biodiversity in everyday life (Sembiring et al., 2024). Furthermore, the Guided Inquiry learning model is recommended because it includes various methods that integrate various scientific skills so that students are directly involved in the investigation process and obtain information, which will have an impact on improving students' critical thinking (Ningsih et al., 2025; Siregar et al., 2025). The Project-Based Learning model is recommended because it emphasizes student involvement in the design, implementation, and completion of projects so students can understand how their knowledge can be applied in real-world situations (Ihsan et al., 2024).

The recommended learning model has also been adapted to the learning outcomes for biodiversity material in phase E of grade 10 high school in the latest curriculum, which emphasizes that students can apply classification principles through direct learning in the environment and can make efforts to preserve biodiversity through project-based learning (Widodo et al., 2025). The use of Gresik's biodiversity as a learning resource using the recommended learning model is also part of the application of deep learning, which consists of three main pillars, including mindful, meaningful, and joyful learning (Manalu et al., 2025). It is mindful because students are actively engaged both in the learning process and in solving real-world problems; meaningful because learning occurs contextually, directly connected to the students' surrounding environmental conditions; and joyful because outdoor learning creates a fresh and enjoyable atmosphere.

The Sustainable Development Goals (SDGs) are a set of sustainable programs launched by the United Nations covering 17 goals and 169 targets to be achieved by 2030

(Wiranti & Nugraheni, 2024). The use of Gresik's biodiversity as a learning resource in teaching biodiversity is in line with the achievement of SDGs goals 14 and 15, namely to conserve marine and terrestrial ecosystems. The use of biodiversity in learning through observation and project activities is effective in imparting sustainability values related to biodiversity, and is aimed at providing students with knowledge, insight, skills, and problem-solving competencies related to important cases and issues concerning biodiversity (Faizah et al., 2025; Santoso et al., 2024). As a result, awareness will arise in the management of natural resources, especially in marine and terrestrial ecosystems, which are key to achieving sustainable development and global welfare.

CONCLUSION

This study showed that Gresik's biodiversity holds great potential for use as a contextual learning resource in teaching biodiversity. The uniqueness of this study lies in the integration of the results of the Gresik biodiversity inventory, the practices of high school biology teachers, and a literature review, thereby providing a comprehensive overview of the opportunities for utilizing Gresik's biodiversity in education. The results of data triangulation indicate that Gresik's biodiversity, comprising 225 animal species across 7 groups of invertebrates and 2 groups of vertebrates distributed across 10 distinct ecosystems can be integrated into the Outdoor Learning model, Discovery Learning, Guided Inquiry, and Project-Based Learning to support the implementation of the Merdeka Curriculum, the principles of Deep Learning, and students' awareness of sustainable conservation. Scientifically, this study contributes to providing a structured database of Gresik's biodiversity that has the potential to serve as a reference for developing learning resources based on local potential. The research findings also offer practical implications for teachers in developing learning experiences that are more relevant to the surrounding environment while supporting the achievement of SDG 14 (Life Below Water) and SDG 15 (Life on Land). Further research is recommended to develop and test the effectiveness of Gresik biodiversity-based teaching materials, learning media, and learning tools in improving student learning outcomes, environmental literacy, and sustainability competencies.

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