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Empowering Local Communities through Biodiversity Conservation, Ecosystem-Based Ecotourism, and Natural Capital Accounting for Sustainable Development in Buluh Cina, Riau, Indonesia

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ABSTRACT

Biodiversity conservation and sustainable natural resource management are essential for supporting environmental sustainability and inclusive community development. This community service initiative aims to empower local communities in Buluh Cina, Kampar Regency, Riau Province, Indonesia, by integrating biodiversity conservation, ecosystem-based ecotourism, and natural capital accounting. The program focuses on strengthening community awareness of local natural assets, explaining the ecological functions of forest and freshwater ecosystems, introducing natural capital accounting and carbon sequestration concepts, and identifying opportunities for conservation-oriented ecotourism. A participatory community empowerment approach is proposed, comprising preliminary natural asset identification, biodiversity conservation education, introductory natural capital accounting and carbon literacy, ecotourism planning, and program evaluation. The initiative emphasizes the importance of recognizing the ecological, social, and potential economic contributions of local flora, fauna, forests, lakes, wetlands, and riverine habitats. It also highlights the role of natural capital accounting in organizing information about ecosystem assets and services to support more informed community-level decision-making. The expected contribution is to strengthen environmental literacy, encourage community participation in conservation, and provide a foundation for sustainable ecotourism planning and future ecosystem service assessments. However, verified biodiversity inventories, quantitative carbon assessments, and economic valuations require additional field data and systematic measurement. This integrated approach offers a framework for connecting biodiversity conservation with community empowerment and sustainable development in Buluh Cina.

Keywords: Biodiversity Conservation; Community Empowerment; Ecosystem-Based Ecotourism; Natural Capital Accounting; Ecosystem Services; Sustainable Development; Buluh Cina

Fields: Community Development; Ecotourism Management; Natural Resource Management; Environmental Economics; Natural Capital Accounting

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INTRODUCTION

Biodiversity conservation and sustainable natural resource management have become increasingly important in addressing environmental degradation, climate change, and the challenges of achieving inclusive economic development (Lu & Wang, 2023). Forests, freshwater ecosystems, and other natural habitats provide essential ecological services, including carbon sequestration, water regulation, soil protection, and the maintenance of biodiversity. However, the ecological value of these resources is not always adequately recognized

in local development planning and community economic activities. Consequently, strengthening community awareness and participation in natural resource conservation is essential to ensure that environmental protection generates long-term ecological and socioeconomic benefits.

Buluh Cina, located in Kampar Regency, Riau Province, Indonesia, represents an important landscape for integrating biodiversity conservation with community-based sustainable development. The area is characterized by lowland tropical forests, freshwater wetlands, natural lakes, and riverine habitats that support diverse flora and fauna. The ***Taman Wisata Alam*** (Nature Tourism Park) Buluh Cina provides an important foundation for environmental conservation and nature-based tourism. These ecosystems potentially contribute to carbon storage and sequestration, freshwater ecosystem regulation, wildlife habitat provision, and the maintenance of ecological balance (Nyoto et al., 2023). Nevertheless, translating these ecological functions into locally understood and measurable values remains an important challenge, particularly in connecting conservation initiatives with community livelihoods and local development priorities.

Community-based ecotourism offers an opportunity to address this challenge by linking environmental protection with economic opportunities for local residents (Kunjuraman et al., 2022). Through the development of nature-based tourism activities, local communities can participate in environmental education, biodiversity interpretation, guided nature experiences, and the promotion of locally distinctive ecological and cultural assets. However, ecotourism development must be supported by adequate ecological knowledge, community capacity, and responsible management practices. Without these foundations, tourism activities may fail to generate meaningful conservation outcomes or may place additional pressure on sensitive ecosystems. Therefore, empowering local communities to understand, protect, and sustainably utilize their natural surroundings is a critical step toward developing ecotourism that delivers both environmental and socioeconomic benefits.

An important complementary approach is natural capital accounting (NCA), which provides a systematic framework for organizing information about natural resources and the contributions of ecosystems to human well-being and economic activities (Turner et al., 2019). Unlike conventional economic assessments that primarily emphasize financial and physical assets, natural capital accounting recognizes the importance of ecosystems and the services they provide. In the context of Buluh Cina, this approach can help communities and local stakeholders understand the significance of forest cover, freshwater ecosystems, biodiversity, and ecosystem services in supporting sustainable development. Carbon storage and sequestration are particularly relevant because forest ecosystems absorb and store atmospheric carbon dioxide, contributing to climate change mitigation. Introducing the basic principles of natural capital accounting can therefore strengthen environmental literacy and encourage more informed decisions regarding conservation priorities, ecotourism development, and the sustainable use of local natural resources.

Despite the potential of these approaches, integrating biodiversity conservation, ecosystem-based ecotourism, and natural capital accounting into community-level initiatives requires practical knowledge and active participation from local stakeholders (Samal & Dash, 2023). Communities need accessible information about local biodiversity, the ecological functions of forests and freshwater habitats, and the relationship between environmental quality and sustainable livelihoods. They also need appropriate methods to identify local natural assets, document ecosystem conditions, and recognize the potential environmental benefits of conservation activities. Community empowerment is therefore not limited to transferring environmental knowledge; it also involves building the capacity of residents to participate in resource identification, conservation planning, ecotourism initiatives, and the preliminary assessment of ecosystem services.

In response to these needs, this community service program aims to empower local communities in Buluh Cina, Riau, Indonesia, through an integrated approach to biodiversity conservation, ecosystem-based ecotourism, and natural capital accounting. The program focuses on increasing community awareness of local ecological assets, strengthening understanding of the relationship between biodiversity and ecosystem services, introducing the concepts of carbon storage and sequestration, and encouraging community participation in sustainable ecotourism development. It also seeks to introduce practical approaches for documenting natural assets and recognizing their ecological and socioeconomic significance as a foundation for future natural capital accounting initiatives.

The expected contribution of this program is to strengthen the capacity of local communities to recognize the value of their natural environment and incorporate ecological considerations into local development initiatives (Renaldo et al., 2025). By connecting biodiversity conservation with ecotourism opportunities and natural capital accounting, the program offers an integrated framework for promoting environmental stewardship, supporting sustainable livelihoods, and improving the recognition of ecosystem services in community-level decision-making. Ultimately, this initiative is expected to contribute to a more participatory and environmentally responsible development pathway for Buluh Cina, while providing a foundation for future collaborative efforts in biodiversity monitoring, ecosystem service assessment, and sustainable natural resource management.

LITERATURE REVIEW

2.1. Biodiversity Conservation and Ecosystem Services

Biodiversity is a fundamental component of ecosystem stability and resilience, supporting ecological processes that sustain human well-being (Smith, 1996). Forests, wetlands, rivers, and freshwater lakes provide multiple ecosystem services, including habitat provision, water regulation, soil protection, climate regulation, and recreational opportunities. These services demonstrate that biodiversity conservation should not be viewed solely as the protection of individual species but also as the maintenance of ecological functions and the benefits that ecosystems provide to society.

The relationship between biodiversity and ecosystem functioning is particularly important in landscapes containing interconnected terrestrial and freshwater habitats. Changes in vegetation composition, habitat quality, and species abundance can influence ecosystem processes and the availability of ecosystem services. Recent synthesis research has further demonstrated that biodiversity contributes to the maintenance of ecosystem functions and services, although the strength of these relationships varies across ecological contexts (Moffett et al., 2026). Accordingly, conservation initiatives should consider the ecological characteristics of individual habitats and the interactions among them.

In Buluh Cina, Kampar Regency, Riau Province, the coexistence of lowland tropical forest, freshwater wetlands, natural lakes, and riverine environments provides an important basis for community-based biodiversity conservation. These habitats potentially support diverse plant and animal communities while contributing to hydrological regulation, carbon storage, and environmental quality. Nevertheless, the effective protection of these ecological assets requires more than the designation of conservation areas. Community understanding, participation, and the ability to recognize the ecological significance of local natural resources are also essential.

Community-based conservation can strengthen the relationship between environmental protection and local development by involving residents in environmental education, biodiversity documentation, habitat monitoring, and sustainable resource management. Such participation can help communities recognize the long-term benefits of maintaining ecosystem integrity. In a community service context, biodiversity conservation education therefore provides a practical foundation for strengthening environmental awareness and encouraging responsible interaction with local ecosystems.

2.2. Community Empowerment and Ecosystem-Based Ecotourism

Ecotourism is commonly understood as a form of nature-based tourism that emphasizes environmental conservation, interpretation of natural and cultural heritage, and benefits for local communities (Samal & Dash, 2023). When appropriately planned, ecotourism can create economic opportunities while encouraging the protection of ecosystems and biodiversity. However, the relationship between tourism and conservation is not automatically positive. Tourism activities may generate environmental pressures or unequal economic benefits when community participation, visitor management, and conservation safeguards are insufficient.

(Stronza et al., 2019), in their review of three decades of ecotourism research, emphasized the need to evaluate ecological and social outcomes together rather than assuming that tourism development necessarily produces conservation benefits. Their analysis highlights the importance of examining how tourism affects biodiversity, livelihoods, local governance, and community participation. This perspective suggests that ecotourism initiatives should be designed around explicit conservation objectives and measurable community benefits.

Community empowerment is therefore a central component of ecosystem-based ecotourism. Local residents need opportunities to participate in identifying tourism assets, planning activities, interpreting ecological features, developing local products, and making decisions about destination management. Training in environmental interpretation can help community members communicate the importance of forests, freshwater habitats, native plants, and wildlife to visitors. Participatory planning can also help ensure that tourism development reflects local priorities and respects the ecological carrying capacity of sensitive habitats.

Evidence from community-based tourism research in Indonesia similarly highlights the importance of participation, collaboration, local knowledge, and equitable benefit distribution in sustainable tourism development (Muda, 2025). These principles are relevant to Buluh Cina, where the natural landscape can provide a foundation for environmental education and nature-based tourism. Potential activities include guided nature walks, biodiversity interpretation, freshwater ecosystem education, and community-led conservation campaigns.

Nevertheless, ecosystem-based ecotourism should not be evaluated solely through visitor numbers or tourism revenue. Its broader contribution should also be assessed in terms of environmental awareness,

community involvement, habitat protection, and the sustainability of local livelihoods. Integrating ecological considerations into tourism planning can help communities understand that natural ecosystems are not merely tourism attractions but valuable assets that require long-term stewardship.

2.3. Natural Capital Accounting and Ecosystem Valuation

Natural capital refers to the stock of renewable and non-renewable natural resources, including plants, animals, water, soil, and ecosystems, that generate benefits for people and the economy. Natural capital accounting (NCA) provides a systematic approach to organizing information about these natural assets, their condition, and the benefits they generate. It seeks to make the contributions of nature more visible in economic analysis, planning, and decision-making.

The United Nations System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA) provides an internationally recognized framework for organizing information about ecosystem extent, ecosystem condition, ecosystem services, and changes in ecosystem assets. Adopted by the United Nations Statistical Commission in March 2021, the framework links ecological information with economic and social activities through spatially explicit ecosystem accounts (Edens et al., 2022). The framework is relevant to forests, wetlands, freshwater systems, and other ecosystems because it provides a structured basis for documenting their extent, condition, and contributions to human well-being.

Natural capital accounting can help address a limitation in conventional development planning: the ecological contributions of natural environments may remain insufficiently represented in decisions that prioritize immediate financial returns. For example, a forest may provide habitat, store carbon, regulate water flows, and support recreational activities, even when these benefits are not directly reflected in market transactions. By organizing information about these ecosystem services, natural capital accounting can support a more comprehensive understanding of the relationship between environmental conservation and local economic development.

For Buluh Cina, an introductory natural capital accounting approach could begin with identifying major ecosystem assets, describing their ecological characteristics, and documenting the services they potentially provide. These assets may include forest vegetation, freshwater lakes, wetlands, riverine habitats, and associated biodiversity. Community members could participate in preparing preliminary natural asset inventories, mapping important ecological locations, and identifying ecosystem services relevant to local livelihoods and ecotourism.

Such activities should be understood as preliminary community-level natural capital documentation rather than a complete ecosystem accounting system. A comprehensive account would require systematic spatial data, ecological condition indicators, appropriate ecosystem service measurement, and, where relevant, monetary valuation. Nevertheless, introducing these concepts through community service activities can improve environmental literacy and establish a foundation for more rigorous assessments in the future.

2.4. Carbon Sequestration and the Climate Regulation Services of Forest Ecosystems

Carbon sequestration is the process through which atmospheric carbon dioxide is captured and stored in biological or geological systems (Lal, 2013). Forest ecosystems contribute to climate regulation by accumulating carbon in aboveground biomass, belowground biomass, dead organic matter, and soils. The amount of carbon stored depends on factors such as vegetation composition, tree size, stand structure, soil characteristics, environmental conditions, and land-use history.

The Intergovernmental Panel on Climate Change (IPCC) provides methodological guidance for estimating greenhouse gas emissions and removals associated with land use, land-use change, and forestry. The IPCC guidelines identify relevant carbon pools and describe approaches for estimating changes in carbon stocks using forest inventory data, biomass estimates, and other appropriate information (IPCC, 2006; IPCC, 2019). These methods provide a scientific basis for understanding how forest condition and land-use change influence carbon storage and climate mitigation.

In the context of Buluh Cina, forest conservation provides an opportunity to introduce communities to the relationship between vegetation, carbon storage, and climate change mitigation. The protection of existing forest cover can help maintain carbon stocks, while the conservation and restoration of suitable habitats may support additional carbon uptake over time. However, carbon storage and carbon sequestration represent different measures: carbon storage refers to the amount of carbon held within an ecosystem at a particular time, whereas sequestration concerns the removal of carbon from the atmosphere over a period. This distinction is important when communicating the climate benefits of forest conservation.

Carbon-related information can also contribute to natural capital accounting by documenting ecosystem assets and their climate regulation services. Depending on the available data, community-level activities may

introduce forest carbon concepts, identify vegetation characteristics relevant to carbon storage, and explain how repeated measurements can support estimates of changes in carbon stocks. More advanced assessments would require appropriate sampling designs, field measurements, allometric equations, and transparent estimation procedures.

It is important, however, to distinguish environmental education from carbon quantification. A community service program that introduces carbon sequestration concepts should not claim a specific quantity of carbon captured or a monetary value for carbon services unless these estimates are supported by suitable data and methods. For Buluh Cina, carbon sequestration can initially serve as an educational and planning component that helps connect biodiversity conservation with the broader concept of natural capital.

2.5. Integrating Biodiversity Conservation, Ecotourism, and Natural Capital Accounting

Biodiversity conservation, ecosystem-based ecotourism, and natural capital accounting are complementary approaches to sustainable natural resource management (Badura et al., 2024). Biodiversity conservation focuses on maintaining ecological integrity and species diversity; ecotourism connects natural assets with environmental education and potential livelihood opportunities; and natural capital accounting provides a structured approach to documenting ecosystem assets and the services they generate.

Integrating these approaches can create a framework in which communities recognize the ecological, social, and economic significance of their surrounding environment. Biodiversity inventories and ecosystem mapping can identify natural assets, while environmental interpretation can translate ecological information into learning opportunities for residents and visitors. Natural capital accounting concepts can then help organize this information to support conservation planning and discussions about the long-term value of ecosystem services.

The integration is particularly relevant to community-based initiatives because environmental information becomes more useful when local stakeholders can understand and apply it. Community participation in identifying ecosystem assets can strengthen local ownership of conservation activities, while environmental education can improve awareness of the relationship between ecosystem condition and sustainable livelihoods. At the same time, ecotourism development can provide opportunities to communicate conservation messages and encourage responsible visitor behavior.

However, successful integration requires coordination among communities, local authorities, conservation managers, tourism stakeholders, and educational institutions. It also requires realistic objectives and indicators that distinguish immediate program outputs from longer-term environmental outcomes. For example, increased knowledge of natural capital accounting can be assessed through participant evaluations, while actual improvements in forest condition, biodiversity, or carbon stocks require separate ecological monitoring.

For Buluh Cina, an integrated community empowerment approach could begin with participatory identification of local ecosystems, environmental education on biodiversity and ecosystem services, introductory training in natural capital accounting, and discussions about conservation-oriented ecotourism opportunities. These activities would establish a foundation for future initiatives involving more detailed biodiversity monitoring, ecosystem service assessment, and sustainable tourism management.

2.6. Conceptual Framework and Research Gap

The literature establishes the importance of biodiversity conservation, community participation in ecotourism, natural capital accounting, and forest-based carbon storage. Nevertheless, these concepts are often addressed through separate analytical and practical approaches. Ecotourism research has highlighted the need to evaluate ecological and socioeconomic outcomes together, while natural capital accounting provides a structured framework for connecting ecosystem information with human activities and economic decision-making (Stronza et al., 2019).

At the community level, an important practical challenge is translating these broader concepts into accessible learning activities that help residents identify local natural assets, understand their ecological functions, and recognize their relevance to sustainable development. In Buluh Cina, the combination of forest, wetland, lake, and riverine habitats provides a useful context for connecting biodiversity education with ecosystem services and conservation-oriented tourism.

The present community service initiative addresses this practical need by integrating biodiversity conservation awareness, ecosystem-based ecotourism education, and introductory natural capital accounting into a community empowerment framework. Rather than claiming to establish a comprehensive ecosystem account or quantify carbon sequestration without field measurements, the initiative emphasizes building community capacity to recognize natural assets, understand carbon-related ecosystem services, and participate in environmentally responsible local development.

The conceptual relationship underlying the program can be summarized as follows:

Biodiversity and Ecosystem Identification → Environmental Awareness and Community Capacity Building → Natural Capital and Carbon Literacy → Conservation-Oriented Ecotourism Planning → Sustainable Community Development.

This framework positions community empowerment as the mechanism connecting ecological knowledge with practical conservation and development initiatives. Its immediate outcomes may include improved participant knowledge, greater awareness of ecosystem services, and the identification of potential nature-based tourism opportunities. Longer-term benefits, such as improved ecosystem condition, sustainable livelihood development, and measurable changes in carbon stocks, would require continued implementation, appropriate monitoring, and further assessment.

METHODOLOGY

3.1. Location and Approach

This community service program was designed for implementation in Buluh Cina, Kampar Regency, Riau Province, Indonesia. The area was selected because of its forest ecosystems, freshwater habitats, natural lakes, and biodiversity, which provide opportunities for integrating environmental conservation with sustainable community development. The program focuses on strengthening community capacity to recognize local natural assets, understand ecosystem services, and identify opportunities for conservation-oriented ecotourism.

A participatory community empowerment approach was adopted, combining environmental education, community engagement, introductory natural capital accounting, and ecosystem-based ecotourism planning (Maifizar et al., 2026). This approach positions community members as active participants in identifying environmental challenges, documenting local natural assets, and developing practical ideas for sustainable resource management.

The methodology was organized into five interconnected stages: (1) preliminary assessment and stakeholder engagement, (2) biodiversity and ecosystem awareness, (3) natural capital accounting and carbon literacy, (4) ecosystem-based ecotourism development, and (5) program evaluation and follow-up planning.

3.2. Participants and Stakeholder Engagement

The target participants comprised community members and relevant local stakeholders in Buluh Cina. Depending on local availability and program arrangements, participants could include village representatives, community groups, tourism operators, environmental volunteers, youth organizations, and other residents interested in conservation and sustainable livelihoods.

Participants were engaged through coordination with local representatives and community organizations. The initial engagement process aimed to identify local environmental priorities, existing knowledge of biodiversity and ecosystem services, potential barriers to conservation participation, and community expectations regarding ecotourism development.

A purposive recruitment approach was proposed to involve participants with relevant local knowledge or an interest in environmental management. Participation was voluntary, and the objectives and procedures of the program were explained before data collection. Any personal information collected during the evaluation was handled confidentially.

The number and characteristics of participants should be reported based on actual attendance records, including the total number of participants, relevant stakeholder groups, and, where appropriate, basic demographic characteristics.

3.3. Implementation Stages

Stage 1: Preliminary Assessment and Identification of Local Natural Assets

The first stage involved a preliminary assessment of local environmental conditions and community needs (Renaldo et al., 2026). Information was gathered through discussions with community representatives, observation of accessible locations, and a review of relevant secondary sources concerning the ecology and natural resource characteristics of Buluh Cina.

The assessment focused on identifying major ecosystem categories, including forest vegetation, freshwater wetlands, lakes, and riverine habitats. It also explored community perceptions of local biodiversity,

existing conservation practices, potential ecotourism attractions, and opportunities for community involvement in environmental management.

Where feasible, a participatory mapping exercise was conducted to identify natural assets and locations considered important by local residents. The resulting inventory was intended to provide a preliminary basis for environmental education and future natural capital accounting activities.

This stage was not intended to replace a formal biodiversity survey. Species identification and ecological condition assessments requiring specialist expertise were to be undertaken using appropriate field methods and taxonomic verification.

Stage 2: Biodiversity Conservation and Environmental Awareness

The second stage focused on improving participants' understanding of biodiversity and ecosystem conservation. Educational activities addressed the ecological functions of forests and freshwater habitats, the importance of native flora and fauna, the relationship between habitat quality and biodiversity, and the consequences of environmental degradation.

Learning activities could include presentations, facilitated discussions, visual educational materials, and participatory identification of local ecosystem components. Participants were encouraged to connect general ecological concepts with their observations and knowledge of the Buluh Cina landscape.

The educational component also emphasized community responsibility in maintaining ecosystem integrity. Relevant topics included responsible behavior in natural areas, protection of wildlife habitats, avoidance of ecosystem disturbance, and the importance of community participation in conservation initiatives.

Learning outcomes were assessed through structured questions or questionnaires administered before and after the educational activities, where feasible. The assessment focused on participants' knowledge of biodiversity, ecosystem services, conservation practices, and the relationship between environmental quality and sustainable livelihoods.

Stage 3: Introduction to Natural Capital Accounting and Carbon Sequestration

The third stage introduced the principles of natural capital accounting, emphasizing the identification of natural assets and the ecosystem services they provide. The educational materials drew on the conceptual framework of the System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA), which provides internationally recognized guidance for organizing information on ecosystem extent, condition, services, and assets.

Participants were introduced to the distinction between natural assets and the ecosystem services generated by those assets. For example, forest vegetation represents an ecosystem asset, while carbon storage, climate regulation, and habitat provision represent ecological functions or services associated with that asset.

A preliminary natural asset inventory was developed as an educational exercise. The inventory could include the following components:

1. **Natural asset identification:** Forests, wetlands, lakes, riverine habitats, and associated vegetation.
2. **Ecological characteristics:** General habitat descriptions, vegetation characteristics, and observed environmental conditions.
3. **Ecosystem services:** Potential contributions to biodiversity conservation, carbon storage, water regulation, and nature-based recreation.
4. **Community relevance:** Relationships between natural assets, local livelihoods, environmental quality, and ecotourism opportunities.
5. **Information requirements:** Identification of additional data needed for future ecosystem assessment and natural capital accounting.

Carbon sequestration was introduced as an example of a climate regulation service associated with forest ecosystems. Participants learned the difference between carbon stocks and changes in carbon stocks over time, as well as the importance of forest vegetation, tree dimensions, biomass, and soil characteristics in carbon assessments.

The program emphasized that carbon storage and sequestration cannot be reliably quantified through general observation alone. A quantitative assessment would require an appropriate sampling design, field measurements, suitable biomass estimation methods, and transparent calculations based on recognized guidance, such as the Intergovernmental Panel on Climate Change (IPCC) guidelines.

Accordingly, unless supported by actual field measurements, the outputs of this stage were limited to environmental education, preliminary natural asset documentation, and identification of data requirements for future carbon assessment. No numerical carbon sequestration estimates were assumed.

Stage 4: Ecosystem-Based Ecotourism and Community Action Planning

The fourth stage connected biodiversity conservation and natural capital concepts with potential community-based ecotourism initiatives. Participants discussed how local ecosystems could support educational and recreational activities while maintaining environmental integrity.

Potential activities included guided nature interpretation, biodiversity education, freshwater ecosystem awareness, and community-led environmental campaigns. These activities were considered preliminary opportunities rather than established tourism products unless their implementation had been confirmed.

Participants were encouraged to identify potential tourism assets, relevant ecological safeguards, possible community roles, and opportunities for local economic participation. Discussion topics included responsible visitor behavior, protection of sensitive habitats, community participation in tourism planning, and the importance of ensuring that tourism activities do not compromise conservation objectives.

A participatory planning exercise was used to develop preliminary recommendations for sustainable ecotourism. Where feasible, these recommendations were organized into a community action plan specifying proposed activities, responsible stakeholders, resource requirements, and potential monitoring indicators.

The natural capital accounting perspective was incorporated by encouraging participants to consider the ecological significance of natural assets alongside their potential recreational and economic contributions. The objective was to promote an understanding that the long-term value of ecotourism depends on maintaining the quality and integrity of the ecosystems on which it relies.

Stage 5: Program Evaluation and Follow-Up Planning

The final stage evaluated the implementation process and identified opportunities for continued community engagement. Evaluation focused on participation, knowledge acquisition, perceived relevance, and the development of practical recommendations for conservation and sustainable ecotourism.

The evaluation used attendance records, participant feedback, educational assessments, and documentation of program outputs. Where pre- and post-activity questionnaires were available, the results were compared to examine changes in participants' knowledge of biodiversity, ecosystem services, natural capital accounting, and carbon sequestration.

The program also documented tangible outputs, such as educational materials, preliminary natural asset inventories, participatory maps, and community action plans, where these were actually produced.

Follow-up discussions were used to identify potential next steps, including continued environmental education, participatory biodiversity documentation, improved ecosystem monitoring, and collaboration with relevant conservation or local government institutions.

3.4. Data Collection Instruments

Data collection was organized around the program's educational, ecological, and community empowerment objectives. The instruments and sources of information included:

Table 1. Data Collection Instruments

Instrument or source	Information collected	Purpose
Preliminary assessment questionnaire	Existing knowledge and environmental concerns	Identify community learning needs
Participant attendance records	Number and characteristics of participants	Document program reach
Pre- and post-activity questionnaires	Knowledge of biodiversity, ecosystem services, natural capital, and carbon sequestration	Assess changes in knowledge
Observation checklist	Implementation of educational and participatory activities	Document program delivery

Instrument or source	Information collected	Purpose
Participatory mapping	Community-identified natural assets and potential ecotourism locations	Support preliminary asset identification
Facilitated group discussions	Community priorities, perceived opportunities, and conservation concerns	Inform community action planning
Program documentation	Educational materials, inventories, maps, and action plans	Verify program outputs

The final manuscript should identify the instruments actually used and distinguish between information collected through community participation and ecological data obtained through field measurements or secondary sources.

3.5. Data Analysis

Quantitative data from participant questionnaires were analyzed using descriptive statistics. Frequencies and percentages were used to summarize participant characteristics, attendance, and responses to knowledge assessment questions.

Where identical knowledge assessments were administered before and after the program, the percentage of correct responses was calculated for each assessment:

$$P = C / N \times 100\%$$

where:

- P = percentage of correct responses;
- C = number of correct responses;
- N = total number of responses assessed.

The change in the percentage of correct responses was calculated as:

$$\Delta P = P_{post} - P_{pre}$$

where P_{post} and P_{pre} represent the percentages of correct responses after and before the educational activities, respectively.

The results were used to describe changes in participants' knowledge. If individual participant scores were available and the sample size and data structure were appropriate, a paired statistical test could additionally be used to assess whether the observed changes were statistically significant.

Qualitative information from group discussions, observations, and participant feedback was analyzed thematically. The analysis focused on recurring themes concerning biodiversity awareness, perceptions of ecosystem services, community participation, perceived ecotourism opportunities, and barriers to sustainable natural resource management.

Program outputs were assessed descriptively against the activities planned and completed. Where preliminary natural asset inventories or participatory maps were produced, they were reviewed for completeness and relevance to the program's objectives.

No ecological impact or carbon sequestration effect was inferred solely from improvements in participant knowledge or the completion of educational activities. Such outcomes would require separate ecological measurements and an appropriate assessment design.

3.6. Indicators of Program Achievement

The program's achievement was assessed using indicators corresponding to its main objectives.

Table 2. Indicators of Program Achievement

Dimension	Indicator	Method of assessment
Community participation	Number of participants attending the activities	Attendance records

Dimension	Indicator	Method of assessment
Biodiversity awareness	Knowledge of local biodiversity and conservation principles	Questionnaires
Ecosystem services literacy	Understanding of ecosystem functions and benefits	Knowledge assessment
Natural capital accounting literacy	Ability to identify natural assets and associated ecosystem services	Questionnaire or practical exercise
Carbon literacy	Understanding of carbon stocks and sequestration	Knowledge assessment
Ecotourism planning	Identification of potential nature-based tourism opportunities and safeguards	Group discussion and planning outputs
Community empowerment	Participation in developing conservation recommendations	Observation and documentation
Program outputs	Completion of educational materials, inventories, maps, or action plans	Document review

The indicators were intended to distinguish immediate educational outcomes from longer-term environmental and socioeconomic impacts. Actual targets and achievement levels should be reported using the program's records rather than assumed values.

3.7. Ethical and Environmental Considerations

The program was designed to respect voluntary community participation, local knowledge, and environmental protection principles. Participants were informed about the objectives of the activities and the intended use of information collected for program evaluation and scientific publication.

Personal information was to be treated confidentially, and any identifiable information included in reporting required appropriate permission. Community knowledge was documented respectfully, with consideration for local preferences concerning the disclosure of sensitive information.

Any field activities within protected or managed conservation areas were subject to applicable access requirements, management rules, and relevant permissions. Wildlife disturbance, habitat damage, and the collection of plants or animals without appropriate authorization were avoided.

The program also recognized the distinction between community education and formal ecological assessment. Any subsequent biodiversity inventory, forest carbon assessment, or ecosystem service valuation would require suitable scientific methods, relevant expertise, and compliance with applicable environmental requirements.

RESULTS AND DISCUSSION

4.1. Identification of Local Natural Assets and Biodiversity Conservation Potential

Buluh Cina, located in Kampar Regency, Riau Province, Indonesia, offers an important setting for integrating biodiversity conservation with community-based sustainable development. Its landscape encompasses forest vegetation, freshwater habitats, natural lakes, and riverine ecosystems that potentially support diverse biological communities and provide important ecosystem services. These natural assets form the ecological foundation for environmental education, conservation initiatives, and the development of nature-based tourism.

The preliminary identification of local natural assets provides a starting point for helping communities understand the relationship between ecological integrity and sustainable development (Bai et al., 2025). Forest ecosystems can support wildlife habitats, maintain vegetation diversity, store carbon, and contribute to hydrological regulation. Meanwhile, freshwater ecosystems provide habitats for aquatic organisms and create opportunities for environmental interpretation and responsible recreational activities.

From a community empowerment perspective, documenting these assets can help translate general conservation principles into a locally relevant understanding of environmental resources. Participatory

identification activities can encourage residents to recognize the ecological functions of forests, wetlands, lakes, and rivers rather than viewing them exclusively as physical landscapes or potential tourism attractions.

This approach is consistent with the broader understanding of biodiversity as a contributor to ecosystem functioning and human well-being. Biodiversity conservation therefore requires attention not only to individual species but also to habitat quality, ecological processes, and the interactions among different ecosystem components.

However, preliminary identification of natural assets should not be interpreted as a comprehensive biodiversity inventory. Confirming species composition, conservation status, and ecological condition requires systematic field observations and appropriate identification methods. Accordingly, the principal contribution of this stage is to establish a foundation for community awareness, preliminary environmental documentation, and future participatory conservation initiatives.

4.2. Flora, Fauna, and Their Ecological and Economic Values

The biodiversity of Buluh Cina represents an important component of its natural capital, providing ecological functions and potential socioeconomic benefits for local communities. The area's forest vegetation, freshwater ecosystems, and associated wildlife contribute to habitat maintenance, nutrient cycling, carbon storage, and other ecosystem services (Danley & Widmark, 2016). Understanding the ecological and economic significance of local flora and fauna can help communities recognize the importance of biodiversity conservation while identifying opportunities for sustainable livelihoods and ecosystem-based ecotourism.

Flora and Their Economic Potential

The forest landscape of Buluh Cina includes vegetation associated with tropical lowland forests and freshwater environments. Trees such as rengas, meranti, keruing, mahang, and other native forest species have ecological importance in maintaining forest structure, providing wildlife habitats, and contributing to carbon storage. Other plant groups, including rattan, ferns, and epiphytic plants such as forest orchids, contribute to vegetation diversity and the structural complexity of forest ecosystems.

From an economic perspective, forest plants provide different types of potential value (Indratna et al., 2023). Timber-producing species may have commercial value where harvesting is legally permitted, while non-timber forest products, including rattan and selected plant materials, may offer opportunities for sustainable livelihood development. Fruit-producing plants, where locally present and appropriately identified, may also support traditional food practices, local product development, and nature-based tourism experiences.

However, the economic potential of these plants should not be assessed solely through their market prices. Native vegetation contributes to ecosystem services that support long-term environmental quality. Forest trees accumulate biomass and store carbon, vegetation helps maintain soil structure, and plant communities provide food and shelter for wildlife. These ecological functions can generate indirect benefits for communities by supporting ecosystem stability and maintaining the environmental conditions required for sustainable tourism and other nature-dependent activities.

The potential value of flora can therefore be considered through three complementary dimensions: direct use value, ecosystem service value, and conservation value. Direct use value refers to products that may be sustainably harvested or utilized where permitted. Ecosystem service value includes carbon storage, habitat provision, and contributions to hydrological processes. Conservation value reflects the importance of maintaining native species and ecological relationships for future generations.

For community empowerment, an important opportunity is to introduce residents to the distinction between commercially usable plants and species whose primary importance lies in maintaining ecological integrity. This distinction is particularly relevant in conservation areas, where harvesting restrictions and habitat protection requirements must be respected. Potential livelihood initiatives should prioritize permitted, sustainable activities, such as environmental interpretation, nature photography, educational materials, and locally developed products sourced from appropriate and legally obtained materials.

Fauna and Their Ecological and Economic Significance

The forest and freshwater habitats of Buluh Cina provide potential habitat for diverse wildlife, including primates, terrestrial mammals, birds, fish, amphibians, reptiles, and invertebrates. Species reported in descriptions of the wider area include siamang, monkeys, deer, and various forest birds. The presence and current distribution of individual species should nevertheless be confirmed through reliable local records or systematic field surveys before they are presented as verified findings of the community service program.

Wildlife contributes to ecosystem functioning through several ecological processes (Loeb et al., 1998). Primates and fruit-eating birds may contribute to seed dispersal, supporting forest regeneration. Insectivorous birds and other predators can influence prey populations, while insects and other invertebrates contribute to pollination, decomposition, and nutrient cycling. Aquatic organisms also contribute to freshwater food webs and help maintain ecological relationships within lakes and rivers.

The economic significance of fauna is often associated with indirect ecosystem services and nature-based tourism rather than direct extraction. Wildlife observation, birdwatching, nature interpretation, and biodiversity education may create opportunities for local guiding services and community-based ecotourism. These activities can generate economic benefits while encouraging residents and visitors to appreciate the importance of wildlife conservation.

Nevertheless, wildlife-related tourism must be designed to avoid disturbing animals or degrading their habitats. Activities should follow applicable conservation regulations and management requirements, particularly where protected species or sensitive habitats are involved. Hunting, capture, trade, and other forms of direct exploitation should not be promoted as community livelihood strategies for protected wildlife.

The ecological value of fauna also illustrates why natural capital cannot be assessed exclusively through the market price of individual organisms. Wildlife contributes to ecosystem processes that may be difficult to value through conventional economic transactions. Maintaining viable habitats and ecological interactions can therefore generate substantial societal benefits even when individual species have no appropriate direct commercial use.

Integrating Biodiversity Values into Natural Capital Accounting

The ecological and economic contributions of flora and fauna provide a basis for introducing natural capital accounting at the community level. Within this framework, forest vegetation and wildlife habitats can be identified as components of natural assets, while the services they support can be documented as contributions to environmental quality and human well-being.

For example, forest vegetation may contribute to carbon storage and habitat provision, while wildlife supports biodiversity, ecological interactions, and opportunities for nature-based recreation (Ghaedi et al., 2026). These relationships can be documented through a preliminary natural asset inventory that identifies ecosystem types, relevant species or species groups, associated ecological functions, and potential community benefits.

Table 3. Flora, Fauna, and Their Potential Ecological and Economic Contributions in Buluh Cina

Biodiversity component	Ecological contribution	Potential economic or social value	Considerations for sustainable management
Native forest trees, including locally verified meranti and keruing species	Forest structure, biomass accumulation, carbon storage, and wildlife habitat	Ecosystem services, permitted forest products, and environmental education	Follow conservation regulations and sustainable forest management requirements
Rengas and other native trees associated with wet or riverine habitats	Habitat provision and contribution to forest structure	Environmental interpretation and biodiversity education	Avoid inappropriate harvesting; rengas sap may cause skin irritation
Rattan	Vegetation diversity and habitat complexity	Potential non-timber forest products where harvesting is permitted	Verify species and ensure harvesting does not damage protected habitats
Native fruit-producing plants	Food resources for wildlife and potential support for forest regeneration	Locally appropriate food products and ecotourism interpretation	Confirm species identity, availability, and sustainable sourcing
Ferns and forest orchids	Vegetation diversity and habitat complexity	Botanical education, nature interpretation, and photography	Avoid collecting wild plants without appropriate authorization

Biodiversity component	Ecological contribution	Potential economic or social value	Considerations for sustainable management
Primates, including siamang where locally confirmed	Seed dispersal and forest ecological interactions	Wildlife observation and conservation education	Protect habitats and avoid disturbance
Deer and other terrestrial mammals where locally confirmed	Herbivory, nutrient cycling, and food-web interactions	Wildlife interpretation and nature-based tourism	Confirm local occurrence and comply with wildlife protection requirements
Forest birds, including fruit-eating species	Seed dispersal, insect population regulation, and food-web interactions	Birdwatching and environmental education	Protect nesting habitats and avoid disturbance
Freshwater fish and other aquatic organisms	Aquatic food webs and freshwater ecosystem functioning	Potential sustainable fisheries where legally and ecologically appropriate; aquatic biodiversity education	Identify species, assess ecological conditions, and follow fisheries regulations
Insects and other invertebrates	Pollination, decomposition, and nutrient cycling	Environmental education and potential support for nature-based tourism	Maintain habitat quality and avoid unnecessary disturbance

Source: Authors' synthesis of potential ecological functions and economic uses. The table is a preliminary analytical framework, not a verified inventory of species or a quantified economic valuation of Buluh Cina's biodiversity.

The framework demonstrates that the economic significance of biodiversity extends beyond products that can be sold in markets. Ecosystem services, conservation benefits, and opportunities for environmental education should also be considered when evaluating the contributions of natural assets to local development.

For Buluh Cina, community-based biodiversity documentation could provide an initial foundation for identifying locally relevant natural assets and their associated ecosystem services. Such documentation could subsequently support more detailed ecological assessments, ecotourism planning, and natural capital accounting initiatives. However, the monetary valuation of these benefits would require additional evidence, including verified species information, ecosystem condition data, appropriate valuation methods, and clear definitions of the benefits being assessed.

Ultimately, recognizing the ecological and economic contributions of flora and fauna can strengthen the connection between biodiversity conservation and community empowerment. By understanding both the direct and indirect benefits of natural assets, local communities can identify development opportunities that support livelihoods without undermining the ecological integrity of Buluh Cina.

4.3. Community Empowerment through Biodiversity Conservation Education

Environmental education is an important mechanism for strengthening community participation in natural resource management. By introducing the ecological functions of local forests and freshwater habitats, community service activities can help residents understand why biodiversity conservation matters for environmental quality, sustainable livelihoods, and the long-term availability of natural resources.

In Buluh Cina, biodiversity conservation education can focus on the relationships between vegetation, wildlife habitats, freshwater ecosystems, and ecosystem services. Such an approach allows participants to connect ecological concepts with their surroundings and consider how everyday activities may influence environmental conditions.

The educational process can also encourage communities to identify practical conservation actions, including responsible waste management, protection of sensitive habitats, avoidance of wildlife disturbance, and participation in environmental monitoring (Fajri et al., 2025). These activities can strengthen the connection between environmental knowledge and individual or collective responsibility.

The effectiveness of community education should nevertheless be evaluated using evidence rather than assumed from participation alone. Where pre- and post-activity assessments are available, changes in the percentage of correct responses can provide an initial indication of knowledge acquisition. Participant feedback

and group discussions can complement these results by identifying concepts that were well understood and topics requiring additional explanation.

Community empowerment should also be understood as a continuing process rather than a one-time educational outcome. Sustained participation requires opportunities for residents to apply their knowledge through community initiatives, collaboration with local stakeholders, and continued access to relevant environmental information.

4.4. Ecosystem-Based Ecotourism as an Opportunity for Sustainable Livelihoods

The ecological characteristics of Buluh Cina provide a potential foundation for ecosystem-based ecotourism. Forest landscapes, freshwater lakes, riverine habitats, and local biodiversity can support educational and recreational experiences that emphasize environmental interpretation and responsible interaction with nature.

Community participation is particularly important because local residents possess knowledge of the landscape, its cultural significance, and the ways natural resources are used in everyday life (Li et al., 2020). Incorporating this knowledge into tourism planning may help develop locally relevant experiences while strengthening community involvement in environmental stewardship.

Potential ecotourism activities include guided nature walks, interpretation of local vegetation, freshwater ecosystem education, biodiversity observation, and community-led conservation campaigns. These activities should be developed according to the ecological characteristics of each location and the applicable conservation management requirements.

An important consideration is that ecotourism should not be treated as automatically sustainable. Increased visitor activity may generate waste, disturb wildlife, damage vegetation, or place pressure on sensitive habitats if it is not appropriately managed. Tourism development should therefore incorporate environmental safeguards, visitor management, community participation, and monitoring of potential ecological impacts.

The integration of biodiversity conservation with ecotourism can also broaden the way communities understand the economic value of their environment. Rather than focusing exclusively on extracting natural resources, residents can explore opportunities to generate benefits through environmental education, local guiding services, and other activities that depend on maintaining ecosystem quality.

From this perspective, ecotourism represents a possible pathway for connecting conservation objectives with local livelihood opportunities. However, claims concerning increased income, employment creation, or tourism growth should only be made when supported by actual program results or subsequent monitoring.

4.5. Introducing Natural Capital Accounting at the Community Level

Natural capital accounting provides a framework for organizing information about natural assets and the ecosystem services they generate. In the context of Buluh Cina, introducing this concept can help communities recognize that forests, freshwater habitats, and biodiversity contribute to environmental quality and human well-being in ways that are not always reflected in conventional financial assessments.

The System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA) provides an internationally recognized framework for organizing information on ecosystem extent, condition, services, and assets (Edens et al., 2022). Although a complete ecosystem accounting system requires systematic data and appropriate analytical methods, its underlying concepts can be introduced through accessible community-level learning activities.

For example, participants can identify local ecosystem categories, describe their ecological characteristics, and discuss the services associated with each asset. Forests may be associated with carbon storage, wildlife habitat, and climate regulation, while lakes and rivers may provide freshwater habitat, recreational opportunities, and other locally relevant ecosystem services.

A preliminary natural asset inventory can organize this information into a practical format.

Table 4. Preliminary natural asset inventory framework for Buluh Cina

Natural asset	Relevant ecological characteristics	Potential ecosystem services	Information required for further assessment
Forest ecosystems	Vegetation structure, tree composition, and habitat condition	Carbon storage, habitat provision, and climate regulation	Forest area, tree inventory, biomass estimates, and condition indicators

Natural asset	Relevant ecological characteristics	Potential ecosystem services	Information required for further assessment
Freshwater wetlands	Hydrological characteristics and vegetation composition	Habitat provision, water regulation, and carbon storage where applicable	Wetland extent, seasonal water conditions, vegetation, and soil data
Natural lakes	Water quality, aquatic habitats, and surrounding vegetation	Aquatic biodiversity, recreation, and other locally relevant services	Water quality, habitat condition, and ecosystem service indicators
Riverine ecosystems	Flow conditions, riparian vegetation, and aquatic habitats	Aquatic habitat provision, water-related services, and recreation	Hydrological observations, water quality, and riparian condition
Biodiversity resources	Species composition and habitat associations	Ecological functioning, wildlife observation, and environmental education	Verified species records, abundance estimates where appropriate, and habitat data

Source: Authors' conceptual framework, informed by the SEEA EA framework (United Nations et al., 2021). The table presents a preliminary framework, not measured ecosystem accounts for Buluh Cina.

The inventory illustrates how natural capital accounting concepts can be translated into a community learning tool. It also identifies information gaps that must be addressed before more comprehensive ecological or economic assessments can be undertaken.

Importantly, ecosystem services should not automatically be assigned monetary values. Valuation requires an appropriate method, a clearly defined service, reliable data, and consideration of the relevant beneficiaries and accounting boundaries. For community service purposes, the initial priority may be to improve recognition and documentation of natural assets before proceeding to more advanced quantitative or monetary assessments.

4.6. Carbon Sequestration and Climate Change Awareness

Carbon sequestration provides an important link between biodiversity conservation and natural capital accounting. Forest ecosystems store carbon in living vegetation, roots, dead organic matter, and soils. Maintaining forest integrity can help preserve existing carbon stocks, while changes in ecosystem conditions may affect carbon storage and the rate at which atmospheric carbon dioxide is removed over time.

Introducing these concepts to local communities can broaden the understanding of forests beyond their visible biological characteristics (Chazdon et al., 2016). Forests can be understood simultaneously as habitats for biodiversity, components of the local landscape, potential ecotourism assets, and natural systems that contribute to climate regulation.

In Buluh Cina, carbon-related environmental education can explain the distinction between carbon stocks and carbon sequestration. Carbon stocks refer to the quantity of carbon held in an ecosystem at a particular time, whereas sequestration concerns the accumulation of carbon over a period. This distinction is important because the presence of trees alone does not establish the amount of carbon stored or the rate at which additional carbon is being captured.

A quantitative carbon assessment would require an appropriate sampling design, field measurements of vegetation characteristics, suitable biomass estimation methods, and conversion factors consistent with recognized guidance, such as the IPCC Guidelines for National Greenhouse Gas Inventories. Soil carbon assessment may also be relevant, depending on the ecosystem and the scope of the investigation.

For this reason, carbon sequestration is most appropriately positioned as an educational and planning component when the community service program does not include direct carbon measurements. Participants can learn which ecosystem characteristics are relevant to carbon assessment and why long-term monitoring is necessary to evaluate changes in carbon stocks.

This distinction also strengthens the natural capital accounting component of the program. Instead of presenting unverified carbon values, the initiative can identify the data needed to assess climate regulation services more rigorously in future research. Such an approach supports scientific transparency while demonstrating the potential contribution of conservation-oriented community development to climate awareness.

4.7. Integrating Biodiversity Conservation, Ecotourism, and Natural Capital Accounting

The principal conceptual contribution of the proposed program is the integration of biodiversity conservation, ecosystem-based ecotourism, and natural capital accounting within a community empowerment framework.

These approaches serve complementary purposes. Biodiversity conservation emphasizes the protection of species and habitats (Schneiders et al., 2012). Ecosystem-based ecotourism connects ecological resources with environmental education and potential livelihood opportunities. Natural capital accounting provides a structured way to document ecosystem assets and understand the services they generate.

Integrating these perspectives can help communities consider both the ecological importance and the development potential of local natural resources. For example, a forest may provide wildlife habitat and carbon storage while also offering opportunities for environmental interpretation. A freshwater lake may support aquatic biodiversity and provide a setting for educational activities, provided that tourism is managed in ways that protect water quality and habitat integrity.

Natural capital accounting strengthens this integration by encouraging the systematic identification of natural assets and their associated ecosystem services. The resulting information can inform discussions about conservation priorities, ecotourism planning, and the long-term implications of alternative resource management decisions.

Nevertheless, the relationship between conservation and economic development requires careful management. Potential tourism benefits should not override ecological safeguards, and ecosystem service assessments should not be reduced to monetary calculations alone. Cultural values, local knowledge, biodiversity protection, and the distribution of benefits among community members should also be considered.

The integrated approach therefore provides a practical framework for linking environmental knowledge with community decision-making. Its immediate outputs may include improved understanding of ecosystem services, preliminary natural asset documentation, and recommendations for conservation-oriented ecotourism. More substantial outcomes, such as improved ecosystem condition, increased household income, or measurable carbon sequestration, would require continued implementation and appropriate longitudinal assessment.

CONCLUSION

Conclusion

This community service initiative highlights the importance of integrating biodiversity conservation, ecosystem-based ecotourism, and natural capital accounting to support sustainable community development in Buluh Cina, Riau, Indonesia. The area's forest ecosystems, freshwater lakes, riverine environments, and associated flora and fauna represent valuable natural assets that provide ecological, social, educational, and potential economic benefits. Protecting these resources is essential not only for maintaining ecosystem functions but also for creating opportunities for sustainable local livelihoods.

Community empowerment plays a central role in connecting environmental conservation with local development. Through environmental education, biodiversity awareness, and the introduction of natural capital accounting principles, community members can develop a better understanding of the relationships between natural resources, ecosystem services, and human well-being. Ecosystem-based ecotourism may provide an additional pathway for translating this understanding into responsible tourism activities, environmental interpretation, and locally managed economic opportunities.

Natural capital accounting offers a useful conceptual framework for identifying and documenting the value of local ecosystems beyond their immediate market value. Although this initiative provides a foundation for integrating ecological and economic perspectives into community development, comprehensive biodiversity inventories, ecosystem service assessments, carbon measurements, and economic valuation are still required to establish measurable outcomes. Overall, the integration of conservation, community participation, and ecosystem-based economic activities offers a promising approach to supporting sustainable development in Buluh Cina.

Implications

The initiative has several implications for environmental management, community empowerment, local economic development, and future research. First, biodiversity conservation should be integrated into community development planning. Local flora and fauna should be understood not merely as biological resources but as components of interconnected ecosystems that support habitat quality, nutrient cycling, pollination, seed dispersal,

water-related ecological functions, and other ecosystem services. Community awareness of these functions can encourage greater participation in protecting local natural assets.

Second, ecosystem-based ecotourism can strengthen the relationship between conservation and local livelihoods. Activities such as guided nature walks, birdwatching, biodiversity interpretation, environmental education, and community-based tourism services may create economic opportunities while encouraging responsible environmental behavior. However, tourism development should be based on ecological carrying capacity, local community participation, applicable conservation regulations, and appropriate benefit-sharing arrangements.

Third, natural capital accounting can support more informed local decision-making. A systematic inventory of ecosystems, biodiversity, ecosystem services, and potential environmental pressures can help communities and local stakeholders identify which natural assets require priority protection. Over time, these data may contribute to local development plans, conservation programs, and assessments of the relationship between environmental quality and community welfare.

Fourth, collaboration among communities, government institutions, universities, tourism managers, and local businesses is essential. Such collaboration can provide technical assistance, strengthen community capacity, support biodiversity monitoring, and facilitate the development of environmentally responsible tourism products. The implications of this initiative therefore extend beyond environmental awareness to the development of a collaborative framework for managing natural resources sustainably.

Limitations

Several limitations should be considered when interpreting the outcomes and implications of this community service initiative. First, the comprehensiveness of the biodiversity assessment depends on the availability of field observations, ecological records, and verified species identification. References to particular plant and animal groups should therefore be confirmed through field surveys or reliable local biodiversity records before being presented as documented occurrences in Buluh Cina.

Second, natural capital accounting requires systematic ecological and economic information. Without detailed ecosystem mapping, measurements of ecosystem condition, assessments of ecosystem services, and appropriate valuation methods, the economic value of local biodiversity and ecosystem services cannot be quantified reliably. Potential economic uses discussed in this article should consequently be interpreted as opportunities for further assessment rather than evidence of realized financial benefits.

Third, carbon sequestration and carbon storage cannot be established solely through environmental awareness activities or general descriptions of forest ecosystems. Reliable estimates require appropriate field measurements, validated secondary data, or scientifically accepted estimation methods, including clearly defined boundaries and assumptions. Accordingly, the present discussion should not be interpreted as a quantitative assessment of carbon stocks or sequestration rates.

Fourth, the extent of community empowerment and changes in environmental knowledge must be evaluated using evidence from actual program implementation. Where available, attendance records, pre- and post-activity assessments, participant feedback, documentation of community outputs, and follow-up observations can strengthen the evaluation. Without these data, conclusions regarding improvements in knowledge, behavior, income, or environmental conditions should remain cautious.

Finally, the long-term sustainability of community-based conservation and ecotourism depends on continued participation, institutional support, financial feasibility, and effective local management. A single community service activity may provide an initial foundation, but it cannot independently demonstrate long-term ecological recovery or sustained improvements in community welfare.

Recommendations

Based on the discussion, several recommendations are proposed.

1. **Develop a verified biodiversity inventory.** Future activities should document locally occurring plant and animal species, their habitats, ecological functions, conservation status, and potential threats. Species identification should be supported by qualified experts, reliable scientific references, or appropriate field documentation.
2. **Strengthen community environmental education.** Educational programs should address biodiversity conservation, ecosystem services, responsible resource use, waste management, water protection, and the relationship between environmental quality and local livelihoods. Training materials should be adapted to local knowledge, community needs, and the characteristics of Buluh Cina's ecosystems.

3. **Establish a community-based natural asset database.** Local stakeholders should document forest areas, lakes, riverine habitats, biodiversity resources, ecosystem services, existing tourism activities, and relevant environmental pressures. The database should be updated periodically and used to support local planning and conservation priorities.
4. **Design ecotourism activities around ecological sustainability.** Potential products may include guided nature interpretation, birdwatching, biodiversity education, cultural experiences, and locally produced goods derived from legally and sustainably managed resources. Tourism activities should comply with applicable conservation regulations and avoid disturbing wildlife or degrading sensitive habitats.
5. **Introduce practical natural capital accounting.** Communities and local institutions should begin with a basic ecosystem asset inventory before progressing to ecosystem condition assessments, physical measurements of ecosystem services, and monetary valuation where reliable data and appropriate methods are available. Carbon accounting should be undertaken only when sufficient data and technical expertise are available.
6. **Build partnerships for conservation and local economic development.** Collaboration with local government, universities, conservation organizations, tourism operators, and community groups should be encouraged to provide technical support, facilitate training, and develop feasible conservation-oriented economic initiatives.
7. **Implement evidence-based program evaluation.** Future community service activities should establish measurable indicators, such as participant attendance, changes in environmental knowledge, the number of verified species recorded, the number of community-led conservation activities, and the development of ecotourism plans. Economic and ecological indicators should be assessed only when appropriate baseline and follow-up data are available.

Future Community Service

Future community service programs in Buluh Cina should build on the integration of biodiversity conservation, ecosystem-based ecotourism, and natural capital accounting through a more systematic, participatory, and measurable approach. Rather than treating these themes as separate activities, subsequent programs should connect environmental education with practical conservation actions, community enterprise development, and the collection of ecological and socioeconomic data.

The first priority is to conduct a participatory biodiversity and natural asset assessment involving community representatives, local environmental stakeholders, and academic partners. This activity should produce a preliminary map and inventory of important ecosystems, locally verified flora and fauna, ecosystem services, environmental pressures, and areas with potential for conservation education. Community knowledge can contribute to this process, while species records and ecological claims should be checked against appropriate scientific evidence.

The second priority is to strengthen community capacity through training in biodiversity monitoring, environmental interpretation, sustainable tourism management, and basic natural capital accounting. Participants could be trained to document environmental observations, maintain simple monitoring records, interpret ecosystem functions, and communicate conservation messages to visitors. These activities would help establish a foundation for community participation in long-term environmental stewardship.

The third priority is to develop and pilot community-based ecotourism activities that reflect the ecological and cultural characteristics of Buluh Cina. Potential initiatives include guided nature trails, birdwatching, local biodiversity interpretation, environmental learning activities, and community-based tourism services. Their implementation should be preceded by stakeholder consultation, an assessment of environmental suitability, compliance with relevant regulations, and consideration of the distribution of economic benefits among community members.

The fourth priority is to develop a practical natural capital accounting framework at the local level. Initial activities may focus on identifying ecosystem assets and recording their condition and physical contributions, such as habitat provision and other locally relevant ecosystem services. Where appropriate data are available, subsequent programs may assess forest carbon stocks, carbon sequestration potential, water-related ecosystem services, and the economic contribution of sustainable tourism. Any valuation should use transparent methods, clearly defined boundaries, and documented assumptions.

Finally, future programs should incorporate longitudinal monitoring to assess whether training and community participation lead to sustained improvements in environmental knowledge, conservation practices, institutional collaboration, and locally managed economic opportunities. Baseline data should be collected before

implementation and compared with follow-up observations using clearly defined indicators. This approach would strengthen accountability, provide evidence for program improvement, and support the development of replicable community service models for other rural areas with comparable natural assets.

Through these progressive activities, Buluh Cina could serve as a learning context for connecting biodiversity conservation, responsible tourism, and natural capital accounting with participatory local development. The long-term objective should be to strengthen community capacity to protect natural ecosystems while identifying economic opportunities that are compatible with ecological sustainability and local priorities.

REFERENCES

Badura, T., Turner, K. R., & Ferrini, S. (2024). Natural Capital Accounting and Biodiversity Conservation. In *Encyclopedia of Biodiversity* (pp. 741–751). Elsevier. https://doi.org/10.1016/B978-0-12-822562-2.00046-3

Bai, L., Chen, Y., Cui, Y., Feng, C., Wu, C., Ma, B., Zhao, W., Duan, C., & Wang, W. (2025). Evaluating the Sustainable Development Level of Local Communities Within Hunan Nanshan National Park, China. *Land*, *14*(9), 1749. https://doi.org/10.3390/land14091749

Chazdon, R. L., Brancalion, P. H. S., Laestadius, L., Bennett-Curry, A., Buckingham, K., Kumar, C., Moll-Rocek, J., Vieira, I. C. G., & Wilson, S. J. (2016). When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration. *Ambio*, *45*(5), 538–550. https://doi.org/10.1007/s13280-016-0772-y

Danley, B., & Widmark, C. (2016). Evaluating conceptual definitions of ecosystem services and their implications. *Ecological Economics*, *126*, 132–138. https://doi.org/10.1016/J.ECOLECON.2016.04.003

Edens, B., Maes, J., Hein, L., Obst, C., Siikamaki, J., Schenau, S., Javorsek, M., Chow, J., Chan, J. Y., Steurer, A., & Alfieri, A. (2022). Establishing the SEEA Ecosystem Accounting as a global standard. *Ecosystem Services*, *54*, 101413. https://doi.org/10.1016/J.ECOSER.2022.101413

Fajri, S. R., Citrawathi, D. M., Adnyana, P. B., Arnyana, I. B. P., Sarnita, F., Fajri, N., & Fitriani, H. (2025). The strategic role of conservation education in efforts to improve biodiversity literacy: a systematic review. *Journal of Turkish Science Education*, *22*(2), 374–392. https://doi.org/10.36681/tused.2025.019

Ghaedi, Z., Santos, C., & Monteiro, C. (2026). Nature-Based solutions, climate change, and biodiversity: A systematic review of opportunities and risks. *Nature-Based Solutions*, *9*, 100302. https://doi.org/10.1016/J.NBSJ.2026.100302

Indratna, A. D., Putri, A. P. I. K. S., Azzahra, E. O., Oktavia, M. S., Widodo, T., Agustina, A., & Pertiwi, Y. A. B. (2023). Potential economic value of non-wood forest products in agroforestry system at Gempolan Village, Kerjo District, Karanganyar Regency: an economic perspective. *IOP Conference Series: Earth and Environmental Science*, *1220*(1), 012014. https://doi.org/10.1088/1755-1315/1220/1/012014

Kunjuraman, V., Hussin, R., & Aziz, R. C. (2022). Community-based ecotourism as a social transformation tool for rural community: A victory or a quagmire? *Journal of Outdoor Recreation and Tourism*, *39*, 100524. https://doi.org/10.1016/J.JORT.2022.100524

Lal, R. (2013). Carbon Sequestration, Terrestrial. *Reference Module in Earth Systems and Environmental Sciences*. https://doi.org/10.1016/B978-0-12-409548-9.01211-2

Li, J., Krishnamurthy, S., Pereira Roders, A., & van Wesemael, P. (2020). Community participation in cultural heritage management: A systematic literature review comparing Chinese and international practices. *Cities*, *96*, 102476. https://doi.org/10.1016/J.CITIES.2019.102476

Loeb, S. C., Lennartz, M. R., & Szaro, R. C. (1998). The role of fish, wildlife and plant research in ecosystem management. *Landscape and Urban Planning*, *40*(1–3), 131–139. https://doi.org/10.1016/S0169-2046(97)00105-9

Lu, C., & Wang, K. (2023). Natural resource conservation outpaces and climate change: Roles of reforestation, mineral extraction, and natural resources depletion. *Resources Policy*, *86*, 104159. https://doi.org/10.1016/J.RESOURPOL.2023.104159

Maifizar, A., Natasya, S., & Angriani, D. (2026). Empowering Coastal Communities Through Ecotourism Development. *Jurnal Masyarakat Maritim*, *9*(2). https://doi.org/10.31629/ct2gpk93

Moffett, E. R., Gayford, J. H., Chen, L., Morris, O. F., Shi, Y., Somekh, L., Stasik, N., Purvis, A., Woodward, G., & Pearse, W. D. (2026). Biodiversity safeguards ecosystem services and functions worldwide. *Nature Ecology & Evolution*. https://doi.org/10.1038/s41559-026-03200-4

Muda, F. (2025). Community participation in Indonesian sustainable tourism: A systematic review of models, impacts, and gaps. *Priviet Social Sciences Journal*, *5*(8), 125–139. https://doi.org/10.55942/pssj.v5i8.462

Nyoto, Renaldo, N., & Effendi, I. (2023). SWOT Analysis of Economic Impact Development of Potential Kuantan Singingi Pacu Jalur Tourism Development. *The Seybold Report*, *18*(02), 1342–1349. https://doi.org/10.17605/OSF.IO/T58CF

Renaldo, N., Fransisca, L., Junaedi, A. T., Augustine, Y., Suhardjo, S., & Andi, A. (2025). *Value Creation in Digital Accounting*. www.penerbitlitnus.co.id

Renaldo, N., Tavip Junaedi, A., Br Hutahuruk, M., Josephus Swanto Tjahjana, D., Fransisca, L., Purnama, I., Pringgo Prayetno, M., Dwi Prihastomo, A., Andi, A., & Yulia Putri, N. (2026). Workshop on Smart PLS to Enhance Quantitative Data Analysis Literacy at ICMA 2025. *Seroja Journal of Empowerment and Community Service*, *2*(1), 16–23. https://doi.org/10.61230/seroja.v2i1.147

Samal, R., & Dash, M. (2023). Ecotourism, biodiversity conservation and livelihoods: Understanding the convergence and divergence. *International Journal of Geoheritage and Parks*, *11*(1), 1–20. https://doi.org/10.1016/J.IJGEOP.2022.11.001

Schneiders, A., Van Daele, T., Van Landuyt, W., & Van Reeth, W. (2012). Biodiversity and ecosystem services: Complementary approaches for ecosystem management? *Ecological Indicators*, *21*, 123–133. https://doi.org/10.1016/J.ECOLIND.2011.06.021

Smith, F. (1996). Biological diversity, ecosystem stability and economic development. *Ecological Economics*, *16*(3), 191–203. https://doi.org/10.1016/0921-8009(95)00096-8

Stronza, A. L., Hunt, C. A., & Fitzgerald, L. A. (2019). Ecotourism for Conservation? *Annual Review of Environment and Resources*, *44*(1), 229–253. https://doi.org/10.1146/annurev-environ-101718-033046

Turner, K., Badura, T., & Ferrini, S. (2019). Natural capital accounting perspectives: a pragmatic way forward. *Ecosystem Health and Sustainability*, *5*(1), 237–241. https://doi.org/10.1080/20964129.2019.1682470