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## Empowering Pre-service Biology Teachers through Sustainability Action: An Ethnobotanical Inventory Project in Cirebon

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### Abstract

Integrating Education for Sustainable Development (ESD) into teacher education requires shifting from theoretical knowledge to practical action competence. This study aims to describe how an Ethnobotanical Inventory Project empowers pre-service biology teachers to navigate the complexities of community-based conservation. Employing a qualitative case study design, the research focuses on three student working groups at UIN Siber Syekh Nurjati Cirebon who investigated distinct cultural sites: the Mundu coastal area, the Buyut Trusmi sacred site, and the Singkup agrarian village. Data were collected through field observations, semi-structured interviews, and analysis of student artifacts. The results demonstrate that the project successfully cultivated sustainability agency. Students developed interpersonal competence by negotiating access with traditional custodians (*Paraji* and *Kuncen*) and demonstrated scientific literacy by validating local knowledge with botanical taxonomy in their dissemination products (*Pocket Books*). Furthermore, the inventory highlighted a dichotomy in plant conservation: "Cultural Keystone Species" driven by ritual needs in Mundu and Trusmi (e.g., *Jasminum sambac*), versus pharmacologically validated medicinal plants in Singkup (e.g., *Curcuma xanthorrhiza*). It is concluded that incorporating local wisdom into biology learning serves as a strategic pedagogical tool to foster future teachers who are scientifically literate, culturally sensitive, and capable of leading sustainability actions.

Keywords: Ethnobotany, Local Wisdom, Pre-service Biology Teachers, Student Agency, Sustainability Action.

### INTRODUCTION

In the rapidly changing landscape of the 21st century, Higher Education Institutions (HEIs) are under increasing pressure to lead the transition towards a sustainable future. The integration of Education for Sustainable Development (ESD) into teacher education programs is not merely an option but a global imperative, aligned with the United Nations' Sustainable Development Goals (SDGs), particularly Goal 4 (Quality Education) and Goal 15 (Life on Land) (Rieckmann, 2018; UNESCO, 2020). Future educators are expected to possess not only content knowledge but also the "sustainability competencies" required to address complex environmental challenges. Consequently, teacher training programs must evolve from traditional, content-heavy curricula to more transformative, action-oriented pedagogies.

Biology education, in particular, plays a pivotal role in fostering environmental stewardship. Pre-service biology teachers stand at the forefront of this mission, as they will shape the ecological mindset of the next generation. It is essential that these candidates develop a strong sense of "agency", the capacity to act independently and make choices that support sustainability (Redman, Wiek, & Redman, 2018). However, developing this agency requires more than classroom lectures; it demands immersive experiences where students can interact directly with the biosphere and the communities that depend on it. Without this practical

engagement, biology education risks remaining abstract and disconnected from real-world conservation issues.

Despite the clear urgency, a persistent gap remains in teacher education globally and in Indonesia. Many pre-service teachers demonstrate high levels of environmental knowledge but display low levels of "action competence" (Vare et al., 2019). They understand the theory of biodiversity loss but often lack the practical skills to initiate or manage conservation projects within communities. This "knowing-doing gap" is a critical weakness in current Teacher Professional Education programs, which often prioritize pedagogical theory over community-based sustainability actions.

To bridge this gap, integrating ethnobotanical studies through Project-Based Learning (PjBL) offers a promising pedagogical solution. Ethnobotany, the study of the relationship between humans and plants, provides a natural context for connecting biological science with socio-cultural realities. By engaging in ethnobotanical research, students are forced to leave the comfort of the laboratory and engage with local wisdom holders (Herayanti, Fuaddunnazmi, & Sukroyanti, 2025; Sholahuddin, Hayati, Iriani, Saadi, & Susilowati, 2021). This approach aligns with the principles of Contextual Teaching and Learning, transforming passive students into active researchers who document and validate indigenous knowledge.

Literature on the educational value of ethnobotany has grown significantly in recent years. Internationally, studies have highlighted how ethnobotanical projects can enhance scientific literacy, critical thinking, and cultural appreciation among students. For instance, research by Zidny, Sjöström, and Eilks (2020) demonstrated that connecting science curricula with indigenous knowledge systems significantly increases student engagement and conceptual understanding. These studies confirm that "place-based education" is an effective strategy for making science relevant.

In the Indonesian context, numerous studies have documented the richness of local ethnobotanical knowledge. Research has extensively cataloged plant utilization in various regions, such as the medicinal plants of Java or the ritual flora of Bali (Mulyanto, Iskandar, Iskandar, & Wiyanti, 2024; Sujarwo, Caneva, & Zuccarello, 2020; Wijana, Mulyadiharja, & Riawan, 2020). Specifically in West Java and Cirebon, researchers have documented (Tresnawati, Saleh, & Wardani, 2020). However, the majority of these studies are purely descriptive, focusing on the *inventory of plants*, the species, their uses, and their phytochemical properties. While the botanical and anthropological aspects of ethnobotany in Indonesia are well-documented, there is a scarcity of research focusing on the *educational process* of these inventories. Few studies have examined how the act of planning and executing an ethnobotanical inventory empowers the pre-service teachers themselves. The existing literature

rarely addresses how dealing with the challenges of field research, such as building rapport with community leaders or navigating cultural taboos, contributes to the development of sustainability competencies. Thus, there is a need to shift the research focus from the *product* to the *process*.

This study is situated in Cirebon, West Java, a region uniquely characterized by the intersection of Islamic heritage, coastal culture, and agrarian traditions. Cirebon faces a dual challenge: rapid modernization that threatens biodiversity and the gradual erosion of traditional knowledge among the younger generation (Fauzan, 2025; Ningrum & Abdullah, 2025). The specific locations selected for this study, the coastal area of Mundu, the sacred site of Buyut Trusmi, and the agrarian village of Singkup, represent "living laboratories" where traditional ecological knowledge is still practiced but increasingly fragile.

To address the educational gap and the local conservation need, the Department of Biology Education at UIN Siber Syekh Nurjati Cirebon implemented the "Ethnobotanical Inventory Project." This initiative required pre-service teachers to navigate a complete cycle of sustainability action: (1) *Initiation*, where they identified local partners; (2) *Collaboration*, where they engaged with cultural custodians (e.g., *Paraji* and *Kuncen*); and (3) *Action*, where they documented and analysed botanical data. Unlike typical assignments, this project emphasized student autonomy and community service.

Theoretically, this study views "empowerment" through the lens of Action Competence in ESD. Empowerment in this context is defined as the process by which students gain the confidence, skills, and motivation to contribute to solving environmental problems (Mogensen & Schnack, 2010). By shifting the role of students from passive learners to active "knowledge preservers," this project aims to instill a sense of ownership over their local environment and culture.

Therefore, this article aims to describe how the Ethnobotanical Inventory Project fosters sustainability agency among pre-service biology teachers. It specifically seeks to answer: How does the process of inventorying local plants empower students to navigate the complexities of community-based conservation? By analysing student experiences across three distinct case studies (ritual, sacred, and medicinal plant inventories), this research provides a replicable model for teacher education programs seeking to integrate local wisdom into sustainability action.

## METHOD

This study employed a qualitative case study design to explore the development of pre-service teachers' sustainability agency through community-based actions. According to Creswell and Creswell (2023), a case study is an approach in which the researcher explores a real-life,

contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information. This design was chosen to capture the complex interaction between student learning processes and the social realities of the communities they investigated.

The research was conducted within the *Conservation Biology* course at the Department of Biology Education, UIN Siber Syekh Nurjati Cirebon. To facilitate sustainability action, the course integrated a Project-Based Learning (PjBL) model as the pedagogical framework. This model served as an intervention to shift students' role from passive learners to active agents who plan, manage, and execute ethnobotanical inventory projects in real-world settings.

The participants were selected using purposive sampling techniques based on their active involvement in the inventory projects. The study focused on three specific working groups representing different "cases" of local wisdom in Cirebon:

1. Group A (Mundu): Investigated ritual plants in the *Nujuh Bulan* tradition.
2. Group B (Trusmi): Investigated sacred plants in the *Buyut Trusmi* cultural site.
3. Group C (Singkup): Investigated medicinal plants in the agrarian village of Singkup.

These groups were selected because they successfully navigated the complete cycle of sustainability action, from community engagement to data documentation.

To ensure the validity of the findings, data were collected using triangulation methods, combining:

1. Observation: Direct observation of students' activities during the *planning* (campus) and *action* (fieldwork) phases.
2. Documents: Analysis of students' project artifacts, including inventory sheets (taxonomic data), field notes, and final reports which reflected their grasp of local knowledge.
3. Interviews: Semi-structured interviews with student representatives to probe their experiences, challenges, and the competencies developed during the interaction with local communities.

The collected data were analysed using thematic analysis. The ethnobotanical data were categorized taxonomically and functionally (medicinal, ritual, conservation), while the educational data regarding student experiences were coded to identify emerging themes related to sustainability competencies, such as agency, collaboration, and problem-solving.

## RESULTS AND DISCUSSION

### Translating Knowledge into Action: The Process of Community-Based Inquiry

The first major finding of this study is the successful translation of theoretical conservation concepts into tangible sustainability actions. Unlike traditional laboratory-based biology instruction, this project required pre-service teachers to navigate complex social-ecological systems. The analysis of student activities from the initial planning to the creation of dissemination products like the *Pocket Books (Buku Saku)* reveals three critical phases of empowerment: (1) Navigating social access, (2) Contextualizing scientific knowledge, and (3) Reciprocity through dissemination.

The "Action" component of ESD requires students to step outside the academic "ivory tower" and engage with community realities. Our data shows that all groups faced the initial challenge of gaining trust from the local custodians of knowledge (*Kuncen* and *Paraji*). In the Mundu Case, students had to approach a traditional birth attendant, to understand the *Nujuh Bulan* ritual. In the Trusmi Case, access to the sacred *Buyut* area required strict adherence to customary laws (e.g., prohibition of damaging plants). In the Singkup Case, students-built relationships with local mothers to document herbal recipes.

This phase validates the theory of "Place-Based Education" proposed by Sobel (2004), which argues that authentic learning occurs when students connect with the local community. Furthermore, the students' ability to negotiate access demonstrates the development of *interpersonal competence* as a key of sustainability competency (Rieckmann, 2018; Arjen E. J. Wals, 2011; Arjen E. J. Wals & Corcoran, 2023). By successfully engaging with these key informants, students moved beyond being passive observers to becoming "legitimate peripheral participants" in the community of practice (Lave & Wenger, 1991).

The *Pocket Books* produced by the students serve as concrete evidence of this synthesis. For instance, in the Singkup Booklet, students documented *Sereh (Cymbopogon citratus)* not only as a spice but with its specific local processing method. Similarly, the Trusmi Group demonstrated a high level of scientific literacy by validating the medicinal claims of sacred plants. In their booklet, they cross-referenced the local use of "*Bidara*" (*Ziziphus mauritiana*) and *Namnam (Cynometra cauliflora)* with pharmacological studies, confirming their antioxidant and anti-inflammatory properties. This proves that the project encouraged students to perform rigorous literature verification, effectively connecting the "myth" of the sacred site with the "logic" of modern science.

The final and most empowering, aspect of the process was the creation of educational artifacts. "*Buku Saku Tanaman Herbal*" and "*Buku Saku Tanaman Obat Desa Singkup*" demonstrate that the students' action went beyond extraction; it involved "giving back" to the community.

The Singkup Booklet is structured to be user-friendly, featuring clear photos, morphological description and practical uses. This indicates that students considered the *target audience* (the community or general public) rather than just the lecturer. The inclusion of phytochemical references in the Singkup booklet (citing antioxidant activities of *Curcuma caesia* and *Coleus atropurpureus*) shows that students performed rigorous literature verification to validate local claims. The visualization of the pocket books produced as dissemination artifacts can be seen in Figure 1, representing: (a) the Mundu Group, (b) the Singkup Group, and (c) the Trusmi Group.



Figure 1. The Visualization of the Pocket Books Produced as Dissemination Artifacts, representing: (a) the Mundu Group, (b) the Singkup Group, and (c) the Trusmi Group.

This creation of public-facing products represents the "Action" in *Action Competence* (Mogensen & Schnack, 2010). Students were not just learning *about* sustainability; they were acting *for* sustainability by documenting and preserving disappearing knowledge. In the context of Indonesian higher education, this supports the Merdeka Belajar Kampus Merdeka (MBKM)

policy, which emphasizes project-based learning that results in tangible societal contributions (Andika, Suryadi, Hidayat, Warlim, & Nurdin, 2025; Kurniawan et al., 2024). The booklets serve as a permanent archive of local wisdom that might otherwise be lost, fulfilling the students' role as agents of conservation.

### Ethnobotanical Diversity in Cirebon: Intertwining Cultural Heritage and Conservation

Beyond the pedagogical impact, the project successfully generated a comprehensive inventory of local flora, revealing a distinct pattern of plant utilization across the three study sites. The students' findings highlight that plant conservation in Cirebon is driven by two primary motivations: cultural significance (ritualistic needs) and pharmacological utility (health needs). In the *Buyut Trusmi* site, students documented how customary laws (taboos) effectively protect biodiversity. The prohibition of damaging plants in the sacred area has preserved species that serve dual purposes: spiritual and medicinal. A prime example identified in the Trusmi Pocket Book is “*Srigading*” (*Nyctanthes arbor-tristis*). While locally revered as a sacred flower planted in the *Buyut* complex, students documented its pragmatic use by the community: the dried flowers are brewed as tea to lower fever. This finding highlights a sophisticated "eco-spiritual" conservation model where plants are protected not just for their utility, but because they are embedded in the sacred landscape of the "Memayu" tradition.

In contrast to the coastal ritualistic focus, the agrarian community of Singkup demonstrated a rich knowledge of ethnomedicine. The *Pocket Book of Medicinal Plants* produced by the students serves as an inventory about 10 species used for preventive and curative care. A critical aspect of the students' work was cross-referencing local claims with scientific literature. For instance, the Singkup community uses *Coleus atropurpureus* (Jawer Kotok) to treat wounds and inflammation. In their final report, students validated this by citing the presence of flavonoids and tannins in the plant, which are scientifically proven anti-inflammatory agents (Fauzi, Sulistiyansih, Runadi, & Wicaksono, 2017; Hamidah, Moektiwardoyo, & Abdassah, 2019; Moektiwardoyo et al., 2018). For a more detailed overview, the plant species documented during the fieldwork are presented in Table 1.

Table 1. Detailed Overview of the Plant Species Documented During the Fieldwork.

No	Local Name	Scientific Name	Family	Part Used	Traditional Use/Function (Student Findings)	Location (Group)
A Ritual & Cultural Keystone						
1	Melati	<i>Jasminum sambac</i>	Oleaceae	Flower	Mandatory symbol of purity in Nujuh Bulan (7th-month pregnancy) & Memayu rituals.	Mundu & Trusmi

No	Local Name	Scientific Name	Family	Part Used	Traditional Use/Function (Student Findings)	Location (Group)
2	Kelapa Gading	<i>Cocos nucifera</i> var. <i>eburnea</i>	Arecaceae	Fruit	Carved with Wayang figures for Nujuh Bulan ritual (symbol of hope/protection).	Mundu
3	Srigading	<i>Nyctanthes arbor-tristis</i>	Oleaceae	Flower	Sacred plant in Buyut Trusmi; dried flowers brewed as tea to lower fever.	Trusmi
4	Kembang Tujuh Rupa	<i>Mixed Species</i> (Rose, Ylang, etc.)	Various	Flower	Used in Siraman (cleansing bath) rituals for spiritual purification.	Mundu
<b>B Medicinal &amp; Herbal (Ethnofarmacology)</b>						
5	Jawer Kotok	<i>Coleus atropurpureus</i>	Lamiaceae	Leaf	Crushed and applied topically to treat wounds and inflammation.	Singkup
6	Temulawak	<i>Curcuma xanthorrhiza</i>	Zingiberaceae	Rhizome	Boiled to improve appetite and maintain liver health (hepatoprotector).	Singkup/Mundu
7	Kunyit Hitam	<i>Curcuma caesia</i>	Zingiberaceae	Rhizome	Rare species used as antioxidant and treatment for internal ailments.	Singkup
8	Benalu Cengkih	<i>Dendrophthoe pentandra</i>	Loranthaceae	Whole plant	Brewed as a tea to treat cancer/tumors (parasite on Clove trees).	Singkup
9	Sereh	<i>Cymbopogon citratus</i>	Poaceae	Stalk	Boiled as herbal drink (Wedang) for warming the body; also, mosquito repellent.	Singkup/Mundu
10	Sirih	<i>Piper betle</i>	Piperaceae	Leaf	Antiseptic wash for hygiene; chewed for dental health.	Mundu
11	Kersen	<i>Muntingia calabura</i>	Muntingiaceae	Leaf	Boiled water of leaves used to lower high blood pressure.	Trusmi
12	Namnam	<i>Cynometra cauliflora</i>	Fabaceae	Fruit/Leaf	Treatment for cough; fruit is high in Vitamin C.	Trusmi
13	Binahong	<i>Anredera cordifolia</i>	Basellaceae	Leaf	Boiled or crushed for rapid wound healing and post-surgery recovery.	Singkup
14	Kenikir	<i>Cosmos caudatus</i>	Asteraceae	Leaf	Consumed fresh (Lalap) to improve appetite and reduce body odor.	Singkup
<b>C Dual Function (Spice &amp; Medicine)</b>						
15	Bawang Merah	<i>Allium cepa</i>	Amaryllidaceae	Bulb	Crushed (topical) for fever relief; antibacterial spice.	Mundu/Singkup
16	Bawang Putih	<i>Allium sativum</i>	Amaryllidaceae	Bulb	Consumed to lower cholesterol and hypertension; main kitchen spice.	Mundu
17	Daun Seledri	<i>Apium graveolens</i>	Apiaceae	Leaf	Decoction used for cleaning kidneys/diuretic; soup flavoring.	Mundu
18	Jeruk Nipis	<i>Citrus aurantiifolia</i>	Rutaceae	Fruit	Mixed with soy sauce (Kecap) to treat coughs.	Trusmi

Students also documented the specific processing methods, boiling for *Cymbopogon citratus* (Sereh) and direct consumption (*lalap*) for *Ocimum basilicum* (Kemangi). Documenting these methods is crucial, as Pieroni and Quave (2014) emphasize that the erosion of traditional knowledge often begins with the loss of "how to use" rather than the loss of the plant itself.

A cross-case analysis reveals that the majority of these plants are not harvested from the wild forest but are maintained in pekarangan (homegardens). Whether it is the *Pandan* (*Pandanus amaryllifolius*) for cooking in Singkup or the *Bunga Setaman* for rituals in Mundu, these plants are cultivated within the household compound. This finding supports the argument by Bernholt, Kehlenbeck, Gebauer, and Buerkert (2009); Galluzzi, Eyzaguirre, and Negri (2010) that homegardens serve as critical *in-situ* conservation units, particularly in areas undergoing rapid modernization like Cirebon.

## CONCLUSION

This study concludes that the implementation of an Ethnobotanical Inventory Project serves as a powerful pedagogical tool to empower pre-service biology teachers. By stepping out of the classroom and engaging with the communities of Cirebon, students successfully navigated the complex transition from passive learners to active agents of sustainability. First, in terms of student empowerment, the project cultivated essential sustainability competencies, particularly interpersonal competence and action competence. Students demonstrated the ability to negotiate social access with traditional custodians (*Kuncen* and *Paraji*) and to contextualize scientific taxonomy with indigenous knowledge. The creation of dissemination products, such as the *Pocket Books* (*Buku Saku*) for the Singkup and Mundu communities, evidences that students have internalized the responsibility to preserve and share knowledge, effectively bridging the gap between academic science and community service.

Second, regarding the ethnobotanical findings, this study successfully documented the rich but fragile bio-cultural diversity of Cirebon. The inventory highlights a distinct dichotomy in plant utilization: the coastal and cultural sites (Mundu and Trusmi) prioritize "Cultural Keystone Species" such as *Jasminum sambac* and *Cocos nucifera* for ritualistic preservation, whereas the agrarian community (Singkup) maintains a robust pharmacopoeia of medicinal plants like *Curcuma xanthorrhiza* and *Coleus atropurpureus*. These findings validate that local culture and belief systems are stronger drivers for plant conservation in Cirebon than previously assumed. Ultimately, this research suggests that integrating local wisdom into biology teacher education is not merely an academic exercise but a strategic necessity. It prepares future teachers who are not only scientifically literate but also culturally sensitive and ready to lead sustainability actions. For future implementation, it is recommended to expand the scope of the inventory to

include quantitative analysis of plant abundance, thereby providing more comprehensive data for conservation planning.

## SUGGESTIONS (IF ANY)

Based on the results and discussion regarding the "Ethnobotanical Inventory Project" and its impact on pre-service biology teachers and local conservation, this study proposes several recommendations for future research and practical implementation:

1. **Integration of Quantitative Ecological Analysis** While this study successfully provided a qualitative inventory of plant uses and cultural values, future studies should incorporate quantitative ecological methods. Researchers are encouraged to calculate the Index of Cultural Significance (ICS) and perform vegetation analysis in the studied areas. This would provide objective data on the abundance and distribution of the "Cultural Keystone Species" identified (such as *Jasminum sambac* in Mundu or *Nyctanthes arbor-tristis* in Trusmi), offering a more precise basis for conservation planning.
2. **Longitudinal Study on Student Agency** The current study captured student empowerment during the project cycle. Future research should conduct a longitudinal study to track these pre-service teachers after they enter the professional workforce. It is crucial to investigate whether the "Sustainability Agency" developed during this project translates into their actual teaching practices when they become biology teachers in schools.
3. **Laboratory Validation of Ethnomedicinal Claims** The students in the Trusmi and Singkup groups demonstrated high scientific literacy by cross-referencing local claims with literature. Future projects should take this a step further by collaborating with Chemistry or Pharmacy departments to conduct phytochemical screening on the specific plant populations found in Cirebon. This would empirically validate the local community's claims regarding plants like *Coleus atropurpureus* (Jawer Kotok) or *Cynometra cauliflora* (Namnam).
4. **Utilization of Artifacts for Ecotourism and Education** The dissemination products created by the students, specifically the *Pocket Books (Buku Saku)*, should not remain merely as academic requirements. It is recommended that these booklets be printed and distributed to the local village governments. Specifically, for the Trusmi Cultural Site, these booklets can be utilized as educational guides for Ethno-tourism, adding a layer of botanical education to the existing cultural tourism experience. This ensures that the academic "Action" creates a lasting impact on the community.

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