Journal of Academic Biology and Biology Education
Vol. 2, No. 2, December 2025, pp. 225~233
ISSN: 3062-9705, DOI: 10.37251/jouabe.v2i2.3234

Local Wisdom in the Management of Komplangan Mahoni Land: An Ethnoecological Study of the Gubugklakah Village Community

Hulya Urwati
Department of Biology, Mathematics and Science, University of Brawijaya, East Java, Indonesia

Article Info

Article history:

Received Oct 25, 2025
Revised Nov 23, 2025
Accepted Nov 29, 2025
Online First Dec 25, 2025

Keywords:

Cultivated Plants
Ethnoecology
Komlangan Mahogany Land
Local Wisdom
Sustainable Agroforestry

ABSTRACT

Purpose of the study: This study aims to identify the types of cultivated plants planted under mahogany stands in Gubugklakah Village, analyze land management techniques by the community, and examine the forms of utilization of cultivated plants as part of local ecological knowledge.

Methodology: This research employed descriptive and quantitative methods through field plotting, plant inventory, direct observation, free and semi-structured interviews, and environmental parameter measurements. The tools used included a GPS, compass, thermometer, pH meter, camera, oven, furnace, and measuring tape. Data analysis was conducted using vegetation analysis, the Importance Value Index (IVI), Use Value Index (UV), literature review, and demographic survey.

Main Findings: The research results show that there are 18 cultivated plant species and 15 wild plant species in the mahogany plantation. Land management techniques include terracing, bed construction, intercropping, seasonal planting, watering, and fertilization. Banana and corn have the highest utility value. Community utilization of cultivated plants remains limited, although land management demonstrates ecological adaptation based on local knowledge.

Novelty/Originality of this study: The novelty of this research lies in the ethnoecological analysis of cultivated plants in mahogany plantations through the integration of vegetation inventory, land management techniques, and plant utilization values. This research enriches knowledge of community adaptation strategies within local agroforestry systems and provides a scientific basis for the development of sustainable agriculture based on local wisdom.

Corresponding Author:
Hulya Urwati
Department of Biology, Mathematics and Science, University of Brawijaya, Veteran Street No. 10-11, Ketawanggede, Lowokwaru District, Malang City, East Java 65145, Indonesia
Email: hlyaaurwtiii@gmail.com

1. INTRODUCTION

Indonesia is a mega-biodiverse country with abundant natural resources, both flora and fauna. This diversity not only holds ecological value but also social, cultural, and economic value for local communities [1], [2]. In rural communities, the use of plants often develops through traditional knowledge passed down from generation to generation [3], [4]. This local knowledge shapes patterns of human interaction with the environment, unique to the conditions of each region [5], [6]. The study of this reciprocal relationship between communities and plants is the focus of ethnoecological studies.

Ethnoecology is a branch of science that studies how communities understand, utilize, and manage the environment based on their local knowledge [7], [8]. This approach is important because it can uncover long-standing natural resource management practices within a community. This knowledge is generally formed through the community's empirical experience in adapting to local environmental conditions. In the agricultural context, ethnoecology plays a role in explaining crop cultivation patterns that consider ecological and sociocultural aspects [9], [10]. Thus, ethnoecological research can provide insight into local wisdom in sustainable agricultural land management.

One interesting form of land management to study is the use of mahogany plantations. Kommplangan land is an area around residential areas or yards that is used by local communities to grow various types of crops. The presence of mahogany trees (Swietenia mahagoni (L.) Jacq.) on this land creates specific microclimate conditions that influence the types of plants that can be cultivated [11], [12]. In addition to serving as shade trees, mahogany also has ecological value in maintaining soil fertility and environmental stability. This makes the mahogany komplangan land a man-made ecosystem with unique characteristics worthy of study.

Gubugklakah Village, Poncokusumo District, Malang Regency, is one of the areas with significant potential for local wisdom-based cultivation practices. The village community is known for its close ties to the agricultural sector due to its geographical conditions that support plant cultivation [13], [14]. The use of the mahogany komplangan land by local residents demonstrates an adaptation strategy to land limitations and household economic needs. Various types of plants are cultivated to meet food needs, traditional medicines, and provide additional economic value [15], [16]. These practices reflect a developing local knowledge system in plant resource management.

Cultivating plants under mahogany stands requires different management techniques than in open fields. Light intensity, humidity, nutrient competition, and soil characteristics are key considerations in determining optimal plant growth [17], [18]. Communities typically develop specific techniques based on collective experience to adapt to the ecological conditions of the land [19], [20]. These techniques can include plant spacing, selecting shade-tolerant crops, and managing soil organic matter. These practices demonstrate the integration of traditional knowledge and ecological understanding passed down through generations [21], [22].

Several previous studies have examined ethnobotany and plant use by communities in various regions of Indonesia [23], [24]. However, studies specifically highlighting the ethnoecological aspects of cultivated plants in the mahogany plantations of Gubugklakah Village are still very limited. Most previous studies focused on the inventory of plant species or their general use, without examining land management techniques within the local socio-ecological context [25], [26]. This situation indicates a research gap regarding a comprehensive understanding of the relationship between communities, cultivated plants, and land management under mahogany stands. The novelty of this research lies in its integrated analysis linking plant inventory, land management techniques, and utilization patterns from a local ethnoecological perspective.

This research is crucial because documenting local community knowledge regarding land management is increasingly urgent amidst changes in land use and modernization of agricultural systems. If not documented, this traditional knowledge is at risk of being lost and difficult to pass on to the next generation. Furthermore, the results of this research are expected to form the basis for developing sustainable agricultural strategies that align with local ecological conditions. The information obtained can also support efforts to conserve biological resources and empower village communities. Therefore, the main objective of this research is to determine the types of plants cultivated by the community on mahogany plantation land in Gubugklakah Village, land management techniques, and the use of these cultivated plants by the local community.

2. RESEARCH METHOD

2.1. Time and Place

This research was conducted from February to June. The research activities were conducted on community-owned land located under mahogany trees owned by Perhutani in Gubugklakah Village, Poncokusumo District, Malang Regency. This location was chosen because it is an area used by the community for plant cultivation activities under the shade of mahogany trees. Meanwhile, the data processing and analysis processes were carried out during the final period of the research [27], [28]. These stages were carried out in the Plant Taxonomy and Developmental Structure Laboratory and the Animal Ecology and Diversity Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang.

2.2. Preliminary Survey

The preliminary survey phase of this research included several initial preparatory activities prior to the main research. These activities included obtaining research permits to ensure the administration and legality of the research. Furthermore, a literature review was conducted to obtain a theoretical basis relevant to the research topic [29], [30]. The researchers also examined the village's demographics to understand the characteristics of

the local community. The next phase involved determining the observation location and selecting informants appropriate to the research needs.

2.3. Research Area Study

The research area is community-owned land under the shade of mahogany stands owned by Perhutani in Gubugklakah Village, Poncokusumo District, Malang Regency. The land is used by the local community for various plant cultivation activities. The location was selected based on its characteristics, which represent the land management system under mahogany stands. These conditions make the research area valuable for studying the interaction between the community and the managed cultivation environment. An overview of the location and distribution of the research area is presented in a map of Gubugklakah Village.

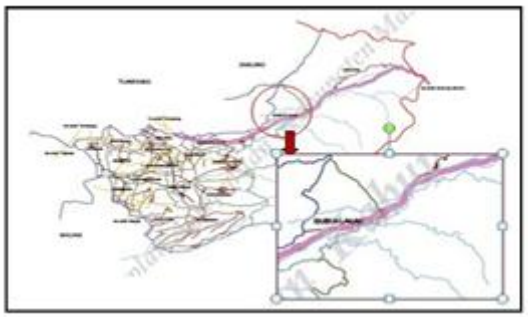

Figure 1. Map of Gubugklakah Village

2.4. Data Collection

Data collection was conducted through plotting, plant inventory, and interviews with informants. Plotting was used to obtain a picture of the vegetation in the research area through ten randomly selected observation plots. The tools used included a GPS, compass, thermometer, tape measure, camera, pH meter, oven, furnace, and writing utensils. The inventory was conducted by directly observing the plant species found in each research plot [31], [32]. All observation data was recorded and documented for identification purposes.

Interviews were conducted to obtain information on the types of plants cultivated, land management techniques, and plant use by the community. The interview methods used were both open-ended and semi-structured. The informants were randomly selected and included local residents, the head of the neighborhood association, the head of the community forestry unit, and representatives from Perhutani. In addition, measurements of soil temperature, air temperature, soil pH, water content, and soil organic matter were taken at each plot. The data obtained were then analyzed descriptively to support the ethnoecological study at the research site.

2.5. Data Analysis

Data analysis was conducted using descriptive and quantitative methods based on field observations, plant inventories, and interviews with informants [33], [34]. Descriptive analysis was used to describe the types of cultivated plants, understory vegetation, the relationship between the community and vegetation, and the land management techniques employed. Furthermore, environmental data such as soil characteristics, topography, climate, temperature, mahogany stand conditions, and community socioeconomic aspects were analyzed to support the research findings. All plants found at the research site were identified based on their local and scientific names. The results of this analysis were used to provide a comprehensive overview of the ethnoecological conditions in the research area.

Quantitative vegetation analysis was conducted to strengthen the results of the qualitative analysis by measuring density, frequency, and importance value index. These parameters were used to determine the dominance and distribution of plant species in the research area. Furthermore, the utility value of each plant species was analyzed using the Use Value method based on interviews with informants. This analysis aims to determine the level of benefit a species provides to the local community. The data obtained were then interpreted to explain the role of cultivated plants in the lives of the Gubugklakah Village community.

3. RESULTS AND DISCUSSION

3.1. Types of Cultivated Plants on the Mahoni Farm Land in Gubugklakah Village

The crops cultivated by the Gubugklakah community in the komplangan land include corn, tomatoes, ginger, chilies, ucet, carrots, peanuts, potatoes, cabbage, bentul, mbote, ganyong, shallots, leeks, lemongrass, bananas, coffee, and cassava. These crops are divided into rainy season and dry season crops. The rainy season

crops are tomatoes, carrots, cabbage, chilies, corn, and ginger. The dry season crops are ucet (green beans) and peanuts. Farmers do not plant during the dry season because irrigation in the komplangan land is mostly rainwater. Planting for the dry season is done at the end of the rainy season so that during the dry season farmers only harvest once or twice, after which farmers do not replant to avoid crop failure due to lack of watering. Land that is not being planted is then left alone until the rainy season planting season arrives.

Table 1. Types of cultivated plants in the mahogany plantation land of Gubugklakah Village

No.	Local Names	Scientific Name	Family
1.	Tomato	*Lycopersicum spesculentum L.*	Solanaceae
2.	Chili	*Capsicum sp.*	Solanaceae
3.	Carrot	*Daucus carota L.*	Apiaceae
4.	Beans	*Arachis hypogaea L.*	Fabaceae
5.	Potato	*Solanum tuberosum L.*	Solanaceae
6.	Cabbage	*Brassica oleracea L.*	Brassicaceae
7.	Bentul	*Colocasia esculenta*	Araceae
8.	Mbote	*Colocasia sp.*	Araceae
9.	Ganyong	*Canna edulis Ker Gawl.*	Cannaceae
10.	Shallot	*Allium cepa L.*	Amaryllidaceae
11.	Lemongrass	*Cymbopogon citrates (DC.) Stapf*	Poaceae
12.	Coffee	*Coffea Arabica L*	Rubiaceae
13.	Ginger	*Zingiber officinale Roscoe*	Zingiberaceae
14.	Ucet	*Phaseolus vulgaris L.*	Fabaceae
15.	Leek	*Allium fistulosum L.*	Amaryllidaceae
16.	Cassava	*Manihot utilissima Pohl*	Euphorbiaceae
17.	Corn	*Zea mays L.*	Poaceae
18.	Banana	*Musa paradisiacal L.*	Musaceae

There is no established crop rotation order, allowing farmers to grow different crops than others. This freedom stems from the fact that farmers borrow capital from middlemen. This forces farmers to sell their crops to middlemen at low prices. For example, tomatoes are purchased by middlemen from farmers for Rp 2,500/kg and then sold at the market for Rp 4,000/kg. The selling price for potatoes is Rp 7,000/kg. Cabbage is Rp 2,500/kg. Chilies are sold for Rp 7,000/kg, while carrots are sold for Rp 1,500 to Rp 5,000/kg. Fresh coffee beans are sold for Rp 4,000/kg, while dried beans are sold for Rp 12,000/kg. Farmers sell the harvest directly to collectors at prices determined by the collectors. The harvest is collected in a hut near the communal land. The huts, measuring 3x6 meters, are constructed of concrete pillars without walls and have tiled roofs. They serve not only as a place to collect harvests but also as a place for buying and selling transactions, seed preparation, storage, and shelter. These huts are helpful to farmers, most of whom live far from the communal land.

3.2. Mahogany Land Management Techniques by the Gubugklakah Village Community

The agricultural land managed by the Gubugklakah Village community is divided into two types: privately owned land and "komplangan" (soil-based land). Privately owned land is generally open, unshaded land, while "komplangan" (soil-based land) is land owned by the State Forestry Company (Perhutani) planted with mahogany trees and utilized by the community through an intercropping system. The difference between the two is evident in the boundaries: private land typically has a fence, while "komplangan" (soil-based land) does not. The use of "komplangan" (soil-based land) provides an alternative for the community to meet its agricultural needs. This system demonstrates cooperation between the community and forest management.

The generally sloping nature of "komplangan" (soil-based land) encourages farmers to employ terracing techniques, including sloping terraces and bench terraces. This technique aims to prevent erosion and reduce the risk of landslides on agricultural land. Before planting, the land is cleared of weeds and grass by hoeing or manually uprooting. Farmers then gradually create raised beds from the top of the field to the bottom. Drains are also constructed around the field to regulate drainage and maintain water availability for the plants.

Seedlings are planted in stages, starting from the bottom of the field and working their way up. The planted beds are then watered and covered with plastic to maintain soil moisture and suppress weed growth. This covering also protects the seedlings from excessive exposure to rain and sunlight. Farmers prefer land with young mahogany stands because they still provide sufficient light intensity to support plant growth [35], [36]. Conversely, land with mature mahogany tends to be less productive because the tree canopies are too dense, blocking sunlight from entering. The types of crops cultivated in komplangan land are adapted to the age and degree of canopy closure of the mahogany trees. In land with young stands, communities typically grow vegetables such as potatoes, corn, cabbage, shallots, and leeks. Meanwhile, in land with older stands, the crops generally cultivated are ginger, coffee, bananas, and cassava, which are more shade-tolerant. This choice of

crops demonstrates the community's adaptation to the ecological conditions of the land. This knowledge is acquired through generations of farming experience.

The productivity of komplangan land is generally lower than that of open land. This is due to limited light, competition for nutrients, and more difficult maintenance conditions. Nevertheless, communities continue to utilize komplangan land as a source of supplementary income. To increase crop yields, farmers use pesticides and chemical fertilizers such as ZA and NPK. These agricultural inputs are used efficiently to reduce production costs. Fertilization is carried out once or twice per growing season, depending on the type of crop being cultivated. Lower fertilization rates are often chosen to reduce costs, although this can result in reduced yields. To date, the use of organic fertilizers remains limited because people are not yet accustomed to processing crop waste into their own fertilizer. However, the use of organic fertilizers has the potential to increase soil fertility in the long term. This situation highlights the need for ongoing support regarding environmentally friendly agricultural management.

In addition to technical challenges, farmers also face various disruptions in the form of pests and plant diseases. Several diseases frequently attack cultivated plants, while pests such as planthoppers, crickets, gray monkeys, and wild boars also reduce land productivity. These pest attacks result in additional control costs for farmers. Despite these challenges, the community continues to cultivate their kompangan land. This demonstrates the community's high dependence on this land for its livelihood.

3.3. Utility Values of Cultivated Crops

Monitoring of the sustainability of the program must also be carried out continuously so that the community can continue to utilize it and it is not interrupted midway, as in the case of training in making natural fertilizer.

Table 2. Utilization of Plant Parts

Plant Parts	Number of Species	Types of Plants	Uses
Rhizome	1	Ginger	Medicines, foodstuffs
Stem	2	Corn, sticky rice tree, shrimp pond tree, and green tree	Firewood
Pseudostem	1	Candi bananas, green bananas, Cici bananas, Salah Roso bananas, Ambon bananas	Fertilizer
Tuber	7	Bentul, mbote, potatoes, canna, shallots, leeks, lemongrass, sticky rice trees, tambak udah trees, green trees, carrots, beans	Foodstuffs
Leaves	5	Corn, ucet, leek, green banana, cici banana, temple banana, wrong roso banana, ambon banana, green tree, sticky rice tree, shrimp pond tree	Animal feed, food ingredients, food packaging
Fruit	6	Corn, tomatoes, chilies, ucet, cabbage, green banana, cici banana, temple banana, Salah Roso banana, Ambon banana, green tree	Foodstuffs, traditional rituals

Table 3. Utilization of Plant Parts

Plant Parts	Number of Species	Types of Plants	Uses
Seeds	1	Coffee	Food Ingredients
Corn Husks (Husks)	1	Corn	Animal Feed
Banana Hearts	1	Candi bananas, green bananas, Cici bananas, Salah Roso bananas, Ambon bananas	Food Ingredients

The utilization rate of plant parts was also calculated. Table 2 shows that the most widely utilized plant parts are tubers and leaves. These tubers are used as food ingredients, such as in fried cassava, cassava tape, and as a kitchen spice. The leaves are used by the community as animal feed, soup mix, as a side dish, and to wrap traditional foods. The rhizomes, seeds, and corn husks (klobot) are the least utilized parts, specifically for ginger, coffee, and corn. Observations were also made of wild plants found in the komplangan area.

The results of this study indicate that the management of the mahogany plantations by the Gubugklakah Village community reflects a strong relationship between local knowledge and the community's ecological adaptability. The selection of plant species adapted to the conditions of the mahogany stands demonstrates the community's empirical understanding of light intensity, moisture, and soil fertility. Plants requiring higher light levels are planted in areas with young stands, while shade-tolerant plants are selected for areas with mature

stands. This demonstrates that the community's agricultural practices are not solely oriented toward economic returns but also consider the ecological suitability of the local environment.

The application of terracing techniques, bed-building, and intercropping systems also demonstrate the community's ability to minimize the risk of environmental damage on sloping land. These techniques serve as local adaptations to reduce erosion and maintain soil stability in sloping agricultural areas [37], [38]. These practices align with the concept of sustainable agroforestry, which emphasizes a balance between agricultural productivity and environmental conservation. Therefore, the mahogany plantation management system can be viewed as a form of local wisdom that supports the sustainability of the village community's agricultural ecosystem.

Furthermore, the presence of various types of cultivated and wild plants in the research area indicates that the Kompangan area has considerable biodiversity potential. This diverse vegetation can help maintain ecological stability, increase soil fertility, and support the survival of other organisms in the surrounding area [39], [40]. This demonstrates that traditional agricultural practices are still able to maintain ecosystem balance compared to monoculture farming systems that tend to reduce biodiversity.

The community's use of cultivated plants also demonstrates that plants have not only economic value but also social and cultural value. Several plant parts are used for food, animal feed, traditional medicine, and even for traditional rituals [23], [41]. This demonstrates that the community's relationship with plants is multidimensional and part of its local cultural identity. Knowledge of plant utilization, passed down from generation to generation, serves as a form of cultural preservation and a strategy for household food security in rural communities.

However, the utilization of most cultivated plants remains suboptimal. The low diversification of processed products prevents the economic value of plants from reaching their full potential. Farmers' dependence on middlemen also indicates that the community still faces limited access to markets and business capital [42], [43]. These conditions can impact farmers' welfare, as the selling price of their harvest tends to be determined by collectors. Therefore, assistance is needed in developing agricultural processing, product marketing, and training in sustainable agriculture to optimize the potential of komplangan land.

The impact of this research is a significant contribution to documenting local community knowledge regarding agroforestry-based land management. This research can serve as a source of information for the government, academics, and the community in designing sustainable agricultural programs that align with the local ecological and social conditions. Furthermore, the results can support environmental conservation efforts through the development of agricultural systems that maintain tree stands and plant diversity [44], [45]. Academically, this research enriches ethnoecological studies, particularly regarding the relationship between communities and agricultural systems under mahogany stands.

However, this study still has several limitations. The study was conducted in only one location, so the results cannot be generalized to other regions with different social and ecological conditions. Furthermore, this study focused more on descriptive aspects of plant types, management techniques, and utilization, thus failing to analyze in-depth economic aspects, land productivity, or long-term environmental sustainability. The limited number of informants and the relatively short research period also mean that local information remains incompletely documented. Therefore, further research is needed with a broader scope and a multidisciplinary approach to gain a more comprehensive understanding of local wisdom-based agroforestry systems.

4. CONCLUSION

Based on the research results, several conclusions can be drawn as follows. First, in the mahogany plantation area in Gubugklakah Village, 18 types of cultivated plants and 15 types of wild plants were found growing in the research area. This diversity of plant species indicates that the mahogany plantation area has the potential to be a cultivation area that supports various types of plants. This condition also reflects the ecological interaction between cultivated plants and understory vegetation in the community's agricultural system. Second, land management techniques implemented by the community include weeding, bed construction, seedling planting, bed covering, watering, and fertilization. The agricultural system used is intercropping with the application of sloping terraces and bench terraces to accommodate the sloping topography of the land. In addition, planting patterns are also adjusted to the rainy and dry seasons. These techniques demonstrate the community's local knowledge in managing land adaptively according to environmental conditions. Third, the utilization of cultivated plants by the Gubugklakah Village community is not yet fully optimal. Of the 18 types of cultivated plants found, only bananas and corn have the highest use values, namely 4.81 and 4.70, respectively. Meanwhile, other plants have lower utility value. This indicates that most cultivated plants are still underutilized and have not been developed to their full potential. Further research is recommended to examine the economic and environmental sustainability aspects of the mahogany plantation land management system to obtain a more comprehensive picture of its contribution to community welfare and environmental conservation.

ACKNOWLEDGEMENTS

The author would like to express his gratitude to all parties who have supported the implementation of this research. He also expresses his gratitude to the academic institutions who provided guidance and research facilities, the community of Gubugklakah Village who volunteered to serve as resource persons, and all those who assisted in the data collection process and the preparation of this article. Their support and contributions were invaluable to the completion of this research.

AUTHOR CONTRIBUTIONS

Conceptualization, H.U.; Methodology, H.U.; Software, H.U.; Validation, H.U.; Formal Analysis, H.U.; Investigation, H.U.; Resources, H.U.; Data Curation, H.U.; Writing – Original Draft Preparation, H.U.; Writing – Review & Editing, H.U.; Visualization, H.U.; Supervision, H.U.; Project Administration, H.U.; Funding Acquisition, H.U.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

REFERENCES

[1] U. Pascual, W. M. Adams, S. Díaz, S. Lele, G. M. Mace, and E. Turnhout, "Biodiversity and the challenge of pluralism," *Nat. Sustain.*, vol. 4, no. 7, pp. 567–572, Mar. 2021, doi: 10.1038/s41893-021-00694-7.

[2] X. Li, J. Abbas, W. Dongling, N. U. A. Baig, and R. Zhang, "From cultural tourism to social entrepreneurship: Role of social value creation for environmental sustainability," *Front. Psychol.*, vol. 13, no. July, pp. 1–16, 2022, doi: 10.3389/fpsyg.2022.925768.

[3] H. R. Perea, A. R. Piedrahita, and Ó. E. T. Alzate, "Models of environmental awareness: exploring their nature and role in environmental education – a systematic review," *Heliyon*, vol. 11, no. 13, pp. 1–24, 2025, doi: 10.1016/j.heliyon.2025.e43679.

[4] T. D. Jessen, N. C. Ban, N. X. E. M. Ŧ. O. L. T. W. Claxton, and C. T. Darimont, "Contributions of indigenous knowledge to ecological and evolutionary understanding," *Front. Ecol. Environ.*, vol. 20, no. 2, pp. 93–101, 2022, doi: 10.1002/fee.2435.

[5] M. Mbah, S. Ajaps, and P. Molthan-Hill, "A systematic review of the deployment of indigenous knowledge systems towards climate change adaptation in developing world contexts: Implications for climate change education," *Sustain.*, vol. 13, no. 9, pp. 1–24, 2021, doi: 10.3390/su13094811.

[6] M.-S. Fletcher, R. Hamilton, W. Dressler, and L. Palmer, "Indigenous knowledge and the shackles of wilderness," *Proc. Natl. Acad. Sci.*, vol. 118, no. 40, pp. 1–10, Oct. 2021, doi: 10.1073/pnas.2022218118.

[7] N. J. Turner, A. Cuerrier, and L. Joseph, "Well grounded: Indigenous Peoples' knowledge, ethnobiology and sustainability," *People Nat.*, vol. 4, no. 3, pp. 627–651, Jun. 2022, doi: 10.1002/pan3.10321.

[8] A. Sharma, S. K. Patel, and G. S. Singh, "Revitalizing Traditional Knowledge of the Himalayan Indigenous Tribes: An Ethnoecological and Ethnobotanical Approach," 2024, pp. 111–133. doi: 10.1007/978-3-031-51696-2_6.

[9] Y. Kamakaula, "Ethnoecology and climate change adaptation in agriculture," *Glob. Int. J. Innov. Res.*, vol. 2, no. 2, pp. 473–485, 2024, doi: 10.59613/global.v2i2.99.

[10] Y. Kamakaula and O. A. Fenetiruma, "Knowledge-based approaches to adaptive agriculture: An ethnoecological case study of indigenous communities in climate change adaptation," *Agro Bali*, vol. 7, no. 3, pp. 916–930, 2024, doi: 10.37637/ab.v7i3.1916.

[11] V. Kumar, T. K. Kunhamu, and A. Tiwari, "Tree nutrition and productivity changes in mahogany (Swietenia macrophylla King) based agrisilvicultural system in the humid tropics," *Agrofor. Syst.*, vol. 99, no. 3, pp. 51–61, Mar. 2025, doi: 10.1007/s10457-025-01149-0.

[12] A. N. Utomo, B. S. N. Allobua, F. S. Paramita, and I. P. Sari, "Assessment of suitability of plant communities of pole and tree standa at several main roads in sumber village, Indonesia," *Feninta Setyaning Paramita, Indah Puspita Sari Innov. J. Soc. Sci. Res.*, vol. 4, no. 6, pp. 8064–8082, 2024, doi: 10.31004/innovative.v4i6.16215.

[13] F. Sgroi, "Evaluating of the sustainability of complex rural ecosystems during the transition from agricultural villages to tourist destinations and modern agri-food systems," *J. Agric. Food Res.*, vol. 9, p. 100330, Sep. 2022, doi: 10.1016/j.jafr.2022.100330.

[14] R. Vernooy, "Does crop diversification lead to climate-related resilience? Improving the theory through insights on practice," *Agroecol. Sustain. Food Syst.*, vol. 46, no. 6, pp. 877–901, 2022, doi: 10.1080/21683565.2022.2076184.

[15] M. Fayiah, M. S. Fayiah, S. Saccoh, and M. K. Kallon, "Value of Herbal Medicine to Sustainable Development," 2024, pp. 1429–1456. doi: 10.1007/978-3-031-43199-9_32.

[16] S. R. N. S. P. Mohidin, S. Moshawih, A. Hermansyah, M. I. Asmuni, N. Shafqat, and L. C. Ming, "Cassava (manihot esculenta crantz): A systematic review for the pharmacological activities, traditional uses, nutritional values, and phytochemistry," *J. Evidence-Based Integr. Med.*, vol. 28, pp. 1–26, 2023, doi: 10.1177/2515690X231206227.

[17] Y. Arablousabet and A. Povilaitis, "Assessing the role of air nanobubble-saturated water in enhancing soil moisture, nutrient retention, and plant growth," *Sustain.*, vol. 16, no. 13, pp. 1–21, 2024, doi: 10.3390/su16135727.

[18] I. C. Vasilachi, V. Stoleru, and M. Gavrilescu, "Analysis of heavy metal impacts on cereal crop growth and

development in contaminated soils," *Agric.*, vol. 13, no. 10, pp. 1–50, 2023, doi: 10.3390/agriculture13101983.
[19] M. Galesic *et al.*, "Beyond collective intelligence: Collective adaptation," *J. R. Soc. Interface*, vol. 20, no. 200, pp. 1–19, Mar. 2023, doi: 10.1098/rsif.2022.0736.
[20] I. M. McLeod *et al.*, "Coral restoration and adaptation in Australia: The first five years," *PLoS One*, vol. 17, no. 11 November, pp. 1–22, 2022, doi: 10.1371/journal.pone.0273325.
[21] A. O. Adefila, O. Ajayi, A. S. Toromade, and N. J. Sam-Bulya, "Integrating traditional knowledge with modern agricultural practices: A sociocultural framework for sustainable development," *World J. Biol. Pharm. Heal. Sci.*, vol. 20, no. 2, pp. 025–135, 2024, doi: 10.30574/wjbphs.2024.20.2.0850.
[22] A. Kumar, S. Kumar, Komal, N. Ramchiary, and P. Singh, "Role of traditional ethnobotanical knowledge and indigenous communities in achieving sustainable development goals," *Sustain.*, vol. 13, no. 6, pp. 1–14, 2021, doi: 10.3390/su13063062.
[23] Y. Y. S. Rahayu, W. Sujarwo, A. S. D. Irsyam, A. Dwiartama, and D. Rosleine, "Exploring unconventional food plants used by local communities in a rural area of West Java, Indonesia: Ethnobotanical assessment, use trends, and potential for improved nutrition," *J. Ethnobiol. Ethnomed.*, vol. 20, no. 1, pp. 1–23, 2024, doi: 10.1186/s13002-024-00710-y.
[24] E. Elfrida, N. S. Tarigan, and A. B. Suwardi, "Ethnobotanical study of medicinal plants used by community in jambur labu village, East Aceh, Indonesia," *Biodiversitas*, vol. 22, no. 7, pp. 2893–2900, 2021, doi: 10.13057/biodiv/d220741.
[25] K. Kokou, S. Syampungani, P. W. Chirwa, and L. Makhubele, "Socio-ecological Management of Multifunctional Landscapes," in *Trees in a Sub-Saharan Multi-functional Landscape*, Cham: Springer Nature Switzerland, 2024, pp. 267–304. doi: 10.1007/978-3-031-69812-5_12.
[26] Z. E. Blesa-Marco, A. M. Agulló-Torres, F. J. Del Campo-Gomis, and J. Navarro-Pedreño, "A systematic socio-ecological impact/aptitude land planning assessment model to determine the land capacity under presence of critical endemism," *Appl. Sci.*, vol. 14, no. 24, pp. 1–21, 2024, doi: 10.3390/app142411775.
[27] A. J. Bingham, "From data management to actionable findings: A five-phase process of qualitative data analysis," *Int. J. Qual. Methods*, vol. 22, pp. 1–11, 2023, doi: 10.1177/16094069231183620.
[28] T. Nguyen, S. Hoehl, and P. Vrtiˇcka, "A guide to parent-child fNIRS hyperscanning data processing and analysis," *Sensors*, vol. 21, no. 4075, pp. 1–17, 2021, doi: 10.3390/s21124075.
[29] J. A. Luft, S. Jeong, R. Idsardi, and G. Gardner, "Literature reviews, theoretical frameworks, and conceptual frameworks: An introduction for new biology education researchers," *CBE—Life Sci. Educ.*, vol. 21, no. 3, pp. 1–10, Sep. 2022, doi: 10.1187/cbe.21-05-0134.
[30] U. E. Chigbu, S. O. Atiku, and C. C. Du Plessis, "The science of literature reviews: Searching, identifying, selecting, and synthesising," *Publications*, vol. 11, no. 1, pp. 1–16, 2023, doi: 10.3390/publications11010002.
[31] A. Cu, S. Meister, B. Lefebvre, and V. Ridde, "Assessing healthcare access using the Levesque's conceptual framework– a scoping review," 2021, *International Journal for Equity in Health*. doi: 10.1186/s12939-021-01416-3.
[32] L. Principato, G. Mattia, A. Di Leo, and C. A. Pratesi, "The household wasteful behaviour framework: A systematic review of consumer food waste," *Ind. Mark. Manag.*, vol. 93, pp. 641–649, Feb. 2021, doi: 10.1016/j.indmarman.2020.07.010.
[33] A. R. Al Firdausi and D. Suprayitno, "Application of the Economic Order Qqantity (EOQ) method in soybean Raw material inventory control at the Haji Maman Tofu factory in Matraman District, East Jakarta," *Sinergi Int. J. Logist.*, vol. 1, no. 2, pp. 73–84, 2023, doi: 10.61194/sijl.v1i2.65.
[34] B. K. Oda, E. Lulekal, B. Warkineh, Z. Asfaw, and A. Debella, "Ethnoveterinary medicinal plants and their utilization by indigenous and local communities of Dugda District, Central Rift Valley, Ethiopia," *J. Ethnobiol. Ethnomed.*, vol. 20, no. 1, pp. 1–45, 2024, doi: 10.1186/s13002-024-00665-0.
[35] N. Sharma, S. B. S. Pandey, P. V. C., K. Upadhyay, R. Chopra, and P. Bhatnagar, "Effect of growing media and light intensities on seed germination of mahogany (swietenia mahogany (L.) Jacq.) in South Eastern Region of Rajasthan, India," *J. Sci. Res. Reports*, vol. 31, no. 6, pp. 1211–1218, Jun. 2025, doi: 10.9734/jsrr/2025/v31i63210.
[36] H. U. Tanjung, H. L. Tata, and Triadiati, "The growth of mahogany seedlings (Swietenia macrophylla King.) in various planting media and shade intensity," in *IOP Conference Series: Earth and Environmental Science*, 2023, pp. 1–9. doi: 10.1088/1755-1315/1271/1/012023.
[37] S. Kumar, A. David Raj, J. G. Kalambukattu, and U. Chatterjee, "Climate change impact on land degradation and soil erosion in hilly and mountainous landscape: sustainability issues and adaptation strategies," 2022, pp. 119–155. doi: 10.1007/978-3-031-15501-7_5.
[38] D. Teku and T. Derbib, "Uncovering the drivers, impacts, and urgent solutions to soil erosion in the Ethiopian Highlands: A global perspective on local challenges," *Front. Environ. Sci.*, vol. 12, no. January, pp. 1–19, 2024, doi: 10.3389/fenvs.2024.1521611.
[39] X. Wang, Y. Chi, and S. Song, "Important soil microbiota's effects on plants and soils: a comprehensive 30-year systematic literature review," 2024. doi: 10.3389/fmicb.2024.1347745.
[40] H. Zhang, L. Dong, X. Yao, and W. Wang, "Soil fertility shifts the relative importance of saprotrophic and mycorrhizal fungi for maintaining ecosystem stability," *Glob. Chang. Biol.*, vol. 29, no. 4, pp. 1206–1216, Feb. 2023, doi: 10.1111/gcb.16540.
[41] B. Luo, Y. Tong, Y. Liu, Y. Zhang, Y. Qin, and R. Hu, "Ethnobotanical insights into the traditional food plants of the Baiku Yao community: a study of cultural significance, utilization, and conservation," *J. Ethnobiol. Ethnomed.*, vol. 20, no. 1, pp. 1–30, 2024, doi: 10.1186/s13002-024-00691-y.
[42] F. A. Ihsan, A. Syamsinar, and I. Ismail, "Farmers' economic dynamics : Challenges, dependency, and the role of middlemen in the agricultural system of serdang bedagai," in *International Conference on Islamic Economics Community Services (ICIECS)*, 2023, pp. 83–92.
[43] D. Nurjanah and H. Anggrasari, "Role of the middleman in supporting of oil palm smallholders' community performance: A case study in North Sumatra, Indonesia," *AgriHealth J. Agri-food, Nutr. Public Heal.*, vol. 4, no. 1, pp.

14–22, 2023, doi: 10.20961/agrihealth.v4i1.70619.

[44] T. B. Mihrete and F. B. Mihretu, "Crop diversification for ensuring sustainable agriculture, risk management and food security," *Glob. Challenges*, vol. 9, no. 2, pp. 1–13, Feb. 2025, doi: 10.1002/gch2.202400267.

[45] A. Sher, H. Li, A. Ullah, Y. Hamid, B. Nasir, and J. Zhang, "Importance of regenerative agriculture: climate, soil health, biodiversity and its socioecological impact," *Discov. Sustain.*, vol. 5, no. 1, pp. 1–23, 2024, doi: 10.1007/s43621-024-00662-z.