

From Forest Resources to Household Welfare: The Mediating Role of Income and the Moderating Effect of Livelihood Diversification in the Utilization of Sappanwood (*Caesalpinia sappan* L.)

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ABSTRACT

Natural resources play an important role in supporting rural livelihoods and improving household welfare in many developing countries. However, empirical evidence explaining how the utilization and economic value of local natural resources contribute to household welfare remains limited, particularly in the context of medicinal plant commodities. This study examines the role of sappanwood (*Caesalpinia sappan* L.), a locally available medicinal plant, in influencing rural household welfare through income generation and livelihood diversification. Using the sustainable livelihood framework as the theoretical foundation, this study investigates the relationships among sappanwood resource utilization, the economic value of herbal commodities, household income, livelihood diversification, and household welfare. Data were collected from rural households involved in the utilization of sappanwood resources and analyzed using Structural Equation Modeling (SEM) to examine both direct and indirect relationships among the variables. The results indicate that both sappanwood resource utilization and the economic value of herbal commodities have a significant positive effect on household income. Household income, in turn, significantly influences household welfare and mediates the relationship between natural resource utilization and welfare outcomes. Furthermore, livelihood diversification strengthens the relationship between natural resource-based economic activities and household welfare, highlighting the importance of diversified livelihood strategies in rural economies. These findings contribute to the rural development literature by providing empirical evidence on how locally available natural resources can support household welfare through income generation and diversified livelihood strategies. The study also offers practical insights for policymakers and rural development programs seeking to promote sustainable utilization of medicinal plants as a pathway for improving rural livelihoods.

Keywords: natural resource utilization; sappanwood economic value; household income; rural household welfare; sustainable livelihoods; rural economic development

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Introduction

Interest in natural resources as drivers of sustainable economic development has grown significantly in recent years, particularly in the context of rural economies in developing countries. Among these resources, medicinal and herbal plants have attracted increasing attention because they possess both

pharmacological properties and economic value. Many plant species found in tropical regions contain bioactive compounds that provide therapeutic benefits while simultaneously offering livelihood opportunities for rural communities. *Caesalpinia sappan* L., also referred to as sappanwood, is one such plant that has long been

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valued for its therapeutic qualities and traditional uses in many Asian cultures.

Brazilin, flavonoids, and other phenolic compounds that have antibacterial, anti-inflammatory, and antioxidant qualities are among the bioactive chemicals found in sappanwood. These qualities have led to the plant's widespread use in traditional medicine and herbal drinks. In recent years, scientific research has increasingly explored the pharmacological potential of these compounds, particularly in relation to the development of natural health products and plant-based pharmaceutical ingredients (Hafshah et al., 2022; Wirawati et al., 2025). In addition to its medicinal relevance, sappanwood has also gained attention as a potential source of natural dyes and environmentally friendly industrial materials.

Beyond its pharmacological significance, sappanwood also presents promising economic opportunities for rural communities. The plant can be utilized across several sectors, including the herbal beverage industry, cosmetics, pharmaceuticals, and textile production. Extracts from sappanwood are commonly used as natural coloring agents in traditional drinks, while its antioxidant compounds have potential applications in cosmetic and pharmaceutical products. Furthermore, its use as a natural dye in textile and handicraft industries reflects the growing demand for environmentally sustainable materials. These diverse applications suggest that sappanwood possesses considerable commercial potential when managed and developed effectively within local economic systems.

In rural areas, the cultivation and utilization of herbal commodities such as sappanwood may play an important role in supporting household livelihoods. The plant is relatively adaptable to various environmental conditions and can be cultivated without requiring advanced agricultural technology. As a result, it can be integrated into small-scale farming systems, including agroforestry practices or intercropping arrangements. Such characteristics make sappanwood a potentially accessible economic resource for rural households with limited land ownership and financial capital.

Despite its promising economic potential, much of the existing research on sappanwood has primarily focused on its chemical composition, pharmacological properties, and medicinal applications. While studies examining its bioactive compounds have expanded considerably, relatively little attention has been devoted to the socio-economic dimensions of sappanwood utilization, particularly its contribution to rural household welfare. Consequently, the role of this herbal commodity within local

livelihood systems remains insufficiently examined in the current literature.

More importantly, previous studies rarely investigate how the economic utilization of herbal plants interacts with household livelihood strategies to influence welfare outcomes. Research on medicinal plants often concentrates on biological or pharmacological aspects, while the broader development implications of these resources, such as their role in income generation, livelihood diversification, and household welfare, receive comparatively limited attention. Moreover, existing studies seldom integrate theoretical perspectives from rural development frameworks, such as the sustainable livelihood approach, the capability approach, and livelihood diversification theory, to explain how natural resource utilization contributes to improvements in household well-being. This limitation highlights a significant research gap concerning the socio-economic role of medicinal plants within rural livelihood systems.

Understanding these dynamics is particularly important because rural households typically rely on multiple economic activities to sustain their livelihoods. Agricultural production, natural resource utilization, and non-farm employment often coexist as complementary income sources. The interaction among these livelihood strategies may substantially influence household economic resilience and welfare. Therefore, examining the contribution of locally available natural resources within a broader livelihood framework can provide valuable insights into sustainable rural development strategies.

Addressing this gap, the present study investigates the economic utilization of sappanwood within rural household economies. Specifically, the research analyzes how the utilization of sappanwood roots and wood contributes to household income generation and how these economic activities affect family welfare. In addition, the study examines the moderating role of livelihood diversification in shaping the relationship between natural resource utilization and household welfare outcomes. By integrating perspectives from the sustainable livelihood framework and rural development theory, this research seeks to provide a more comprehensive understanding of how local biological resources can support rural livelihoods.

This research was conducted in Mangunan Village, located in Jombang Regency, East Java, Indonesia. The area possesses considerable potential for herbal plant resources, including sappanwood. Some members of the local community utilize sappanwood, particularly its roots and wood, as raw materials for

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traditional herbal beverages and as commodities traded in local markets. These practices represent forms of locally embedded knowledge and resource utilization that have developed within the socio-economic life of rural communities.

Using a field-based research approach, this study analyzes the economic contribution of sappanwood utilization to household welfare in Mangunan Village. The specific objectives of the research are: (1) to identify patterns of sappanwood utilization among local communities, (2) to evaluate the contribution of sappanwood roots and wood to household income, and (3) to assess the implications of these economic activities for family welfare from a rural development perspective.

The findings of this study contribute to the literature on rural economics and natural resource-based livelihoods in two important ways. First, the research provides empirical evidence on the socio-economic role of a medicinal plant commodity within rural livelihood systems, an area that has received relatively limited scholarly attention. Second, the study offers an integrated analytical perspective by linking natural resource utilization, household income, livelihood diversification, and welfare outcomes within a single conceptual framework. These insights also provide practical implications for policymakers and rural development programs seeking to promote sustainable and community-based utilization of local biological resources to strengthen rural economic resilience.

Literature Review and Theoretical Framework *Local Natural Resource Utilization in Rural Economies*

Natural resources play a central role in sustaining rural economic systems, particularly in developing countries where many households depend directly on environmental assets for their livelihoods. Forests, agricultural land, and biodiversity provide not only ecological functions but also important economic opportunities that enable communities to maintain their daily subsistence and generate income.

In many rural areas, communities utilize a variety of locally available natural resources through activities such as harvesting, cultivation, and small-scale processing. These practices often involve the use of forest products, medicinal plants, timber resources, and other non-timber forest products that can be transformed into marketable commodities. Through such activities, natural resources become an integral component of rural livelihood strategies.

The economic role of environmental resources in rural livelihoods is widely discussed within the **Sustainable Livelihood Framework (SLF)**. This framework explains that household livelihoods are shaped by the ability of individuals or families to access and mobilize different forms of capital, including natural capital, human capital, social capital, financial capital, and physical capital. Among these forms of capital, natural resources frequently serve as the foundational asset that enables households to undertake productive economic activities.

Previous empirical studies indicate that environmental resources can contribute significantly to rural household income. In several developing regions, forest products and other natural resource-based activities constitute an important share of household earnings. Such findings demonstrate that natural resources are not merely supplementary sources of income but may function as core components of rural economic systems.

Moreover, the effective management and utilization of natural resources can contribute to broader rural development outcomes. By transforming environmental assets into economic opportunities, rural communities can enhance their livelihood security and improve their overall welfare. Consequently, understanding the role of natural resources in rural livelihood systems is essential for developing strategies aimed at sustainable economic development in rural areas.

Economic Value of Herbal Commodities in Local Economies

Herbal and medicinal plants have increasingly attracted attention as valuable natural resources with both ecological and economic significance. In many regions, these plants are not only utilized for traditional health practices but also serve as raw materials for various industries, including pharmaceuticals, food and beverages, cosmetics, and natural dye production. The growing global interest in plant-based products has further strengthened the economic relevance of herbal commodities.

Medicinal plants contain diverse bioactive compounds that provide therapeutic benefits. These compounds, which include phenolic substances, flavonoids, and other phytochemicals are widely recognized for their pharmacological properties such as antioxidant, antimicrobial, and anti-inflammatory effects. Because of these characteristics, medicinal plants have been extensively studied and developed as

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ingredients for herbal medicine, functional foods, and natural health products.

One plant that has received considerable attention in both traditional and scientific contexts is *Caesalpinia sappan* L., commonly referred to as sappanwood. This plant species is found throughout Asia's tropical regions and has long been utilized in traditional medicine. Sappanwood contains a number of essential chemicals, including brazilin and related phenolic components, which contribute to its antioxidant and antibacterial properties.

In addition to its medicinal applications, sappanwood also possesses economic value in several industrial sectors. Extracts derived from this plant are commonly used as natural coloring agents in traditional herbal beverages, while its pigment compounds have also been applied in textile dyeing processes. The increasing demand for environmentally friendly and natural ingredients has further expanded the potential market for products derived from sappanwood.

From an economic perspective, the cultivation and utilization of herbal plants can provide alternative income opportunities for rural communities. Many medicinal plant species can be cultivated using relatively simple agricultural techniques and can be integrated into existing farming systems, such as agroforestry or mixed cropping practices. This flexibility allows rural households to diversify their economic activities without requiring significant additional capital or technological investment.

As global markets increasingly favor natural and sustainable products, herbal plant commodities are gaining greater commercial value. This trend creates opportunities for rural communities to develop small-scale enterprises based on the processing and marketing of medicinal plants. Consequently, the economic utilization of herbal resources has the potential to contribute to rural income generation and local economic development.

Household Income as a Determinant of Welfare

Household income is widely recognized as a fundamental determinant of family welfare. In development economics, income represents the financial capacity of households to fulfill basic needs such as food, housing, education, and healthcare. Higher income levels generally allow households to improve their living standards and access better social and economic opportunities.

Income also reflects the productivity of household economic activities. In rural areas, household earnings are typically generated from a combination of

agricultural production, natural resource utilization, and small-scale economic enterprises. These income-generating activities enable families to sustain their daily livelihoods while also supporting long-term economic stability.

From a welfare perspective, income plays a crucial role in determining the ability of households to invest in human capital and social well-being. Families with higher income levels are more capable of allocating resources for education, nutrition, and health services, which in turn contribute to improved quality of life. Consequently, household income is often used as an important indicator in assessing welfare outcomes in rural communities.

In addition, stable income sources can reduce economic vulnerability and improve household resilience to unexpected shocks. When families possess reliable earnings, they are better positioned to manage financial risks and maintain their standard of living during periods of economic uncertainty. Therefore, increasing household income is frequently considered a key pathway toward enhancing welfare in rural areas.

Livelihood Diversification as a Strategy for Economic Resilience

Livelihood diversification refers to the process through which households engage in multiple economic activities in order to sustain and improve their livelihoods. In rural areas, diversification is commonly adopted as a strategy to reduce dependence on a single source of income and to manage economic risks associated with environmental and market fluctuations.

Rural households often combine various activities such as farming, resource harvesting, trading, and wage employment. By developing multiple income streams, households can strengthen their economic stability and minimize the impact of shocks affecting specific sectors. Diversification therefore becomes an important adaptive strategy in rural livelihood systems.

Beyond economic stability, livelihood diversification also contributes to greater flexibility in responding to changing socio-economic conditions. Households that possess diverse livelihood options are generally better equipped to adapt to shifting market opportunities and environmental constraints. This adaptability enhances their capacity to maintain sustainable livelihoods over time.

Furthermore, diversification can support the optimal utilization of locally available resources. By integrating different economic activities, rural households are able to transform environmental assets, labor, and local knowledge into productive

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opportunities. As a result, diversified livelihood strategies can improve both household income and overall welfare.

Conceptual Relationships among Variables

The conceptual framework of this study explains the relationships among natural resource utilization, household income, livelihood diversification, and family welfare. Natural resource utilization represents the extent to which local communities are able to transform environmental assets into economic activities that generate income.

The economic value derived from local natural resources, particularly herbal commodities, can create opportunities for households to increase their earnings. When these resources are processed, marketed, or integrated into local economic activities, they may contribute directly to the generation of household income.

Household income is expected to play an important role in influencing family welfare. Higher income levels provide households with greater financial capacity to meet their basic needs and improve their living standards. Therefore, income is assumed to be positively associated with welfare outcomes.

In addition, livelihood diversification may strengthen the relationship between economic activities and welfare. Households that develop multiple income sources tend to have greater economic resilience and a stronger ability to cope with uncertainty. As a result, diversification strategies can enhance the contribution of income-generating activities to overall welfare.

Taken together, these relationships suggest that the effective utilization of natural resources, supported by diversified livelihood strategies, can contribute to improved household income and ultimately lead to better welfare conditions for rural families. The following is a conceptual illustration of the study and the relationships between the research variables.

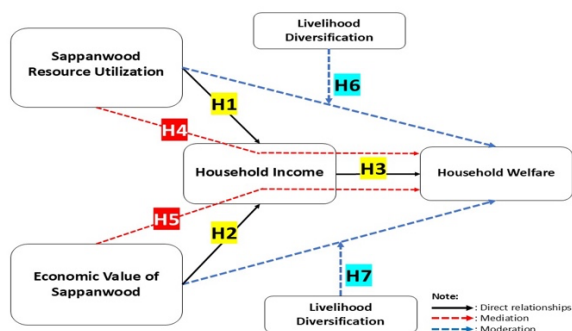


Figure 1. Conceptual Framework of the Research

Research Gap and Research Contribution

Although numerous studies have explored the relationship between natural resource utilization and rural livelihoods, several gaps remain in the existing literature. Many previous studies primarily focus on agricultural production or large-scale resource management, while relatively limited attention has been given to the economic potential of local herbal commodities as a source of household income.

In addition, earlier research often examines income generation or livelihood diversification as separate factors influencing rural welfare. However, fewer studies investigate how these variables interact within an integrated framework that connects natural resource utilization, household income, diversification strategies, and family welfare.

Another limitation of prior research is the insufficient empirical evidence regarding how locally available natural resources can be transformed into sustainable economic opportunities at the household level. Understanding this process is important for identifying strategies that support inclusive rural development and community-based resource management.

This study seeks to address these gaps by examining the relationships among natural resource utilization, household income, livelihood diversification, and family welfare within a single analytical framework. By focusing on the economic potential of local herbal commodities, this research provides empirical insights into how environmental resources can contribute to rural household welfare.

The study's findings are intended to contribute to the literature on rural development and livelihood strategies by providing a more comprehensive view of the function of natural resources in increasing household welfare.

Hypothesis Development

Rural development literature increasingly highlights the importance of natural resource utilization as a key factor influencing household economic resilience and welfare. In many developing regions, rural livelihoods remain closely linked to the availability and use of local natural resources. When these resources are utilized sustainably, they can generate economic opportunities for households while also supporting broader community stability. Within this context, the **sustainable livelihood framework** is frequently used to explain how households combine different assets and strategies to sustain and improve their livelihoods. According to this framework, households mobilize available resources—including natural assets, human

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capabilities, and economic opportunities—to generate income that ultimately contributes to improved welfare. In rural environments, resources such as non-timber forest products, medicinal plants, and agroforestry commodities often function as important livelihood assets that allow households to diversify income sources and strengthen economic security.

One example of such a resource is **sappanwood (*Caesalpinia sappan* L.)**, a tropical plant widely recognized for its use in traditional medicine, herbal beverages, and natural dyes. In addition to its pharmacological characteristics, sappanwood has recently gained increasing economic attention due to the growing global demand for natural and plant-based products. Previous studies have emphasized that medicinal plants and other non-timber forest products can provide valuable sources of income for rural communities. These resources typically require relatively modest capital investment and can be incorporated into existing agroforestry systems or small-scale agricultural practices. Consequently, the utilization of medicinal plants and other natural resources may offer additional livelihood opportunities that contribute to household economic resilience and poverty reduction. The economic benefits derived from these resources therefore have the potential to influence both rural household income and welfare outcomes.

Within the sustainable livelihood framework, the utilization of natural resources can be understood as a livelihood strategy through which households transform available assets into economic returns. When rural households actively participate in the harvesting, processing, or marketing of local resources, these activities can generate additional income streams. Empirical research shows that non-timber forest products and similar environmental resources frequently play an important role in supporting rural household economies. Studies on forest-based livelihoods indicate that income derived from natural resource utilization can significantly contribute to household earnings and enhance economic stability in rural areas. Likewise, research on agroforestry systems demonstrates that integrating forest-based commodities into household economic activities can strengthen livelihood resilience and reduce vulnerability to economic shocks.

In the context of this study, the utilization of sappanwood as a locally available natural resource may provide rural households with opportunities to generate income through activities such as collecting, processing, and marketing wood-based or extract-based products. As household participation in these activities

increases, the potential for income generation may also rise. This relationship reflects the broader economic principle that productive use of natural resources can enhance the financial capacity of households. Therefore, greater utilization of sappanwood resources is expected to positively influence the income level of rural households. Based on this reasoning, the following hypothesis is proposed **H1: Sappanwood resource utilization positively affects household income.**

In addition to the level of resource utilization, the economic value associated with a resource represents another important factor that may influence household income. Economic value refers to the monetary benefits that can be generated through the production, processing, and commercialization of a particular commodity. In rural economies, the market value of natural resource-based products often determines the extent to which these commodities contribute to household earnings. When the economic value of a product increases, households involved in its production or trade are more likely to receive greater financial returns. This situation is particularly evident in the market for medicinal plants and herbal products, where increasing consumer demand for natural health products has significantly expanded market opportunities.

Recent studies on rural economic systems demonstrate that the economic value of non-timber forest products and agroforestry commodities can play a significant role in improving household income. Research indicates that the commercialization of forest products and medicinal plants may create new economic opportunities for rural communities, especially when these commodities experience strong market demand. For example, studies on forest-based products highlight that the economic value of such resources can directly contribute to rural household income while also supporting sustainable forest management practices (Utami et al., 2026). Similarly, research on traditional medicinal plant utilization shows that local communities often obtain measurable economic benefits from the commercialization of plant-based resources, which strengthen household economies and support livelihood sustainability (Rujehan et al., 2024).

In the case of sappanwood, its growing use in herbal medicine, natural food coloring, and pharmaceutical products has increased its market potential. When the economic value of sappanwood rises, rural households involved in its production, processing, or trade may experience higher income levels. Therefore, the economic value of sappanwood is

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expected to have a positive impact on household income. Based on this argument, the following hypothesis is proposed **H2: The economic value of sappanwood positively affects household income.**

Household income is widely regarded as a crucial determinant of welfare in development economics. The **capability approach**, introduced by **Amartya Sen**, emphasizes that income plays an important role in expanding individuals' capabilities and enhancing their ability to achieve well-being. Although welfare is multidimensional—encompassing aspects such as health, education, and social participation—income remains a key resource that enables households to obtain essential goods and services. Higher income levels allow families to invest in better nutrition, healthcare, housing, and education, all of which contribute to improved living standards.

In rural areas, the link between income and welfare is particularly important because many households face economic vulnerability resulting from fluctuating agricultural production, unstable markets, and limited employment opportunities. Increasing household income therefore becomes an important pathway through which rural families can improve their quality of life and reduce poverty. Empirical evidence consistently shows that households with higher income levels tend to achieve better welfare outcomes, including improved food security, greater access to education, and enhanced economic well-being. Based on this reasoning, the following hypothesis is proposed **H3: Household income positively affects household welfare.**

Beyond its direct influence on welfare, household income may also function as a mechanism through which natural resource utilization affects household well-being. Within the sustainable livelihood framework, natural resources are often viewed as productive assets that generate economic returns, which subsequently contribute to improved welfare outcomes. In this sense, income acts as an intermediary variable linking resource utilization with welfare improvement.

The utilization of sappanwood resources may increase household income through activities such as harvesting, processing, and selling sappanwood products. The income obtained from these activities can then support household consumption, investment, and financial security. Consequently, the positive effect of sappanwood resource utilization on household welfare may occur indirectly through increased household income. Based on this theoretical perspective, the following hypothesis is proposed **H4: Household income mediates the relationship between**

sappanwood resource utilization and household welfare.

Similarly, the economic value of sappanwood may influence household welfare through its impact on household income. When the market value of a resource increases, households engaged in its production or commercialization are likely to receive higher financial returns. These additional earnings can then be used to improve various aspects of household well-being, such as health, education, and overall living conditions. In this context, income serves as a transmission mechanism through which the economic value of natural resources affects household welfare.

Evidence from rural livelihood studies shows that the commercialization of natural resources often improves household welfare primarily through increased income generation. Therefore, it is reasonable to expect that the economic value of sappanwood will influence household welfare indirectly through household income. Based on this reasoning, the following hypothesis is proposed **H5: Household income mediates the relationship between the economic value of sappanwood and household welfare.**

Another important concept in rural livelihood studies is **livelihood diversification**. Rural households rarely rely on a single source of income; instead, they usually integrate several economic activities to ensure economic stability and avoid risk. Livelihood diversification is the process by which households engage in diverse livelihood activities, such as agriculture, non-farm jobs, and natural resource exploitation, in order to diversify their income sources. Such strategies are commonly adopted as responses to economic uncertainty, environmental risks, and market fluctuations.

Recent empirical studies highlight that livelihood diversification plays a significant role in shaping rural household economic outcomes. Households with diversified livelihood strategies often demonstrate greater economic resilience because they are less vulnerable to disruptions affecting a single income source. Diversification can help stabilize income and improve welfare by distributing economic risk across multiple activities (Wang et al., 2024). Furthermore, research on rural livelihood systems indicates that diversification strategies significantly influence household welfare and economic performance in developing countries (Anyachukwudinarum et al., 2024).

However, diversification may also affect the extent to which natural resource utilization influences

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household welfare. For households with highly diversified livelihoods, the contribution of a single resource, such as sappanwood, may represent only a limited portion of total household income. In contrast, households with less diversified livelihoods may rely more heavily on specific resources, making their welfare more sensitive to changes in resource utilization. As a result, livelihood diversification has the potential to regulate the link between sappanwood resource usage and household wellbeing. Based on this rationale, the following hypothesis is proposed **H6: Livelihood diversification modifies the link between sappanwood resource usage and household welfare.**

Finally, livelihood diversification may also influence the relationship between the economic value of sappanwood and household welfare. When households depend heavily on a single resource for income, fluctuations in the economic value of that resource can significantly affect household welfare. Conversely, households with diversified income sources may be less vulnerable to changes in the value of any single commodity. As a result, the welfare impact of the economic value of sappanwood may vary depending on the degree of livelihood diversification within the household.

Diversification is generally recognized in rural development studies as a method for reducing economic vulnerability and strengthening livelihood resilience. Households with diversified income sources are better able to withstand economic shocks and sustain stable welfare conditions because their income is spread across numerous activities. As a result, the impact of sappanwood's economic worth on household wellbeing may vary according to the level of livelihood diversification. Based on this rationale, we offer the following hypothesis **H7: Livelihood diversification moderates the relationship between sappanwood's economic value and household welfare.**

Methodology

Research Design

This study uses a quantitative explanatory research approach to investigate the links between natural resource consumption, economic value of herbal commodities, household income, livelihood diversification, and household welfare in rural areas. The explanatory research approach is employed in this study because it tries to explore causal links between variables using theoretical frameworks and previously stated hypotheses.

A **cross-sectional survey method** was applied to collect primary data from rural households involved

in the utilization and economic activities related to local natural resources, particularly the utilization of herbal plants such as sappanwood. The quantitative approach allows the study to statistically examine the structural relationships among the research variables and to test the proposed hypotheses.

Research Location

The research was conducted in Mangunan Village, Kabuh District, Jombang Regency, East Java, Indonesia. Administratively, Mangunan Village is one of the rural villages within Kabuh District, which consists of approximately sixteen villages characterized by agrarian economic structures and rural livelihood systems. The village is located in the northern part of Jombang Regency, an area that forms part of the Kendeng Mountain range. Geographically, this region is characterized by structural hills with slopes ranging from moderate to relatively steep, shaped by long-term geological and erosion processes. The landscape is largely dominated by hilly terrain, dryland agricultural areas, and patches of forest vegetation that contribute to the ecological diversity of the region.

The northern region of Jombang, including Kabuh District, also contains extensive forest areas managed by the state forestry company (Perhutani). These forest ecosystems are dominated by tropical vegetation, particularly teak forests and other tropical plant species that support various forms of local resource utilization by surrounding communities. The presence of forest landscapes in the area creates a rural environment where local communities maintain close interactions with natural ecosystems through activities such as farming, collecting forest products, and utilizing various plant resources for household and economic purposes. Mangunan Village itself is located near areas that historically consisted of teak forest landscapes and diverse tropical vegetation, some of which have gradually been converted into agricultural land and village facilities while still retaining elements of the surrounding forest ecosystem.

Such ecological conditions provide favorable environments for the growth of various tropical and medicinal plants traditionally utilized by local communities. Among these plants, sappanwood (*Caesalpinia sappan* L.) has been recognized as a valuable herbal resource due to its medicinal properties and economic potential as a raw material for herbal beverages and traditional medicine. The availability of tropical vegetation and forest-related ecosystems therefore creates opportunities for rural households to utilize herbal plants as part of their livelihood strategies.

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Based on these conditions, Mangunan Village was selected as the research location because it represents a typical rural community located near forest ecosystems where natural resource utilization plays an important role in household livelihoods. Furthermore, the geographical conditions and socio-economic characteristics of the village provide a relevant empirical setting for examining how the utilization and economic value of local natural resources contribute to household income and rural household welfare.

Population and Sample

The population of this study consists of **all households in Mangunan Village that are involved in natural resource-based economic activities**, particularly those related to agricultural products and herbal plant utilization. Because it is difficult to identify all households directly involved in herbal commodity activities, the study uses **purposive sampling** to select respondents who meet specific criteria. The criteria for selecting respondents include:

1. Households residing in Mangunan Village.
2. Housewives or household heads engaged in agricultural or natural resource-based economic activities.
3. Households that have experience in utilizing or processing local natural resources for economic purposes.

To ensure adequate representation and statistical reliability, the sample size was determined using the **minimum sample requirement for structural equation modeling (SEM)**. According to Hair et al. (2021), SEM-based research typically requires a minimum sample size ranging from **100 to 200 respondents** depending on model complexity. Based on these considerations, this study targeted **approximately 120–150 household respondents**, which is considered sufficient to perform statistical analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM).

Data Collection Method

This study employs **primary data collection through structured questionnaires** distributed to selected household respondents in Mangunan Village. The questionnaire was designed based on theoretical constructs derived from previous literature on rural livelihoods, natural resource economics, and household welfare.

The data collection process was conducted through **direct field surveys**, where respondents were

asked to provide information regarding their household economic activities, utilization of natural resources, income sources, and perceived welfare conditions. In addition to primary data, **secondary data** were also collected from various sources, including government reports, village administrative records, and previous academic studies related to rural economic development and natural resource utilization. These secondary data were used to support contextual analysis and to provide a broader understanding of the socio-economic conditions of the research location.

Variable Measurement

The variables in this study were operationalized using indicators derived from relevant literature. Each characteristic was measured on a Likert scale of 1 to 5, with respondents asked to rate their level of agreement with statements linked to each indicator.

The key variables in this study include: **Natural Resource Utilization**, this variable refers to the extent to which households utilize locally available natural resources for economic purposes. Indicators include: harvesting intensity, production volume, processing activities, and utilization of different parts of the plant.

Economic Value of Sappanwood, this variable reflects the economic potential of the herbal commodity as perceived by rural households. Indicators include: market price level, demand stability, income contribution, and market accessibility. **Household Income**, represents the total earnings obtained by the household from various economic activities. Indicators include: income from natural resource utilization, agricultural income, non-farm income, and total monthly household income.

Livelihood Diversification, this variable measures the extent to which households rely on multiple income sources. Indicators include: number of income-generating activities, involvement in non-farm employment, and participation in small-scale businesses. Finally for **Household Welfare**, reflects the living conditions and socio-economic well-being of households. Indicators include: household consumption level, education expenditure, access to healthcare, and housing conditions.

Data Analysis Technique

The data were analyzed using **Partial Least Squares Structural Equation Modeling (PLS-SEM)** with the help of **SmartPLS software**. PLS-SEM was chosen because it is appropriate for investigating complex

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associations between latent variables and may be used with small sample numbers.

The data analysis technique was divided into two stages: measurement model evaluation and structural model evaluation. **The first stage** entailed examining the measurement model to determine the validity and reliability of the constructs. The evaluation included: **Convergent validity** was examined using factor loadings and Average Variance Extracted (AVE), while **composite reliability** was used to test internal consistency. **Discriminant validity** was assessed using the Fornell-Larcker criterion and cross-loading analyses.

The second stage, Structural Model Evaluation, entailed testing the provided hypotheses using the structural model. The structural model analysis comprised the following: **Path coefficient estimation** measures the strength of correlations between variables, whereas **coefficient of determination (R²)** evaluates the model's explanatory ability. **Bootstrapping analysis** is used to assess the statistical significance of the postulated associations.

Through this analytical approach, the study aims to provide empirical evidence on how natural resource utilization and economic value contribute to household welfare in rural communities, both directly and indirectly through household income.

Results

Respondent Characteristics

This study involved **135 household respondents** residing in Mangunan Village, Kabuh District, Jombang Regency, East Java. The respondents consisted primarily of household heads or family members actively involved in agricultural activities and natural resource-based livelihoods, including the utilization of local plant resources. The following is a table showing the Respondent Characteristics of the areas that were the objects of research.

Table 1. Demographic Characteristics of Respondents (n = 135)

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Male	97	71.9
	Female	38	28.1
Age	20–34 years	20	14.8
	35–55 years	82	60.7
	>55 years	33	24.5

Characteristics	Category	Frequency (n)	Percentage (%)
Education Level	Primary School	27	20.0
	Junior High School	65	48.1
	Senior High School	43	31.9
Main Occupation	Farmer	86	63.7
	Small-scale trader	24	17.8
	Agricultural laborer	14	10.4
	Others informal sector	11	8.1
Livelihood Diversification	Single income source	58	43.0
	Multiple income sources	77	57.0

Source: Processed by the author (2026)

Based on the demographic profile, the majority of respondents were **male household heads (72%)**, while **28% were female respondents**, mostly spouses who were also involved in household economic activities. In terms of the age distribution, the majority of respondents were **between the ages of 35 and 55**, accounting for around **61% of the sample**, followed by respondents aged above 55 years (24%) and those aged between 20 and 34 years (15%). This age distribution indicates that the respondents generally possess sufficient experience in managing household economic activities and utilizing local natural resources.

Regarding educational background, most respondents had completed **secondary education**, with approximately **48% holding junior high school qualifications, 32% senior high school**, and **20% primary school education**. Although the level of formal education is relatively moderate, many respondents reported having extensive practical knowledge regarding agricultural practices and the utilization of herbal plants obtained through intergenerational knowledge transfer within the community.

In terms of occupational structure, the majority of respondents reported **farming as their primary**

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occupation, representing approximately **64% of the sample**. The remaining respondents were engaged in **small-scale trading (18%)**, **agricultural labor (10%)**, and **other informal sector activities (8%)**. These findings confirm that Mangunan Village is characterized by a predominantly agrarian livelihood structure where households rely on agriculture and natural resource utilization as their main sources of income.

Furthermore, regarding livelihood diversification, approximately **57% of households reported having more than one source of income**, including agricultural activities, small-scale trading, and wage labor. This indicates that rural households in the study area often adopt diversified livelihood strategies to maintain income stability and reduce economic vulnerability.

Descriptive Statistics

Descriptive statistical analysis was conducted to examine the general patterns of responses related to the main research variables, namely natural resource utilization, economic value of sappanwood, household income, livelihood diversification, and household welfare. The following is a table showing the Descriptive Statistics of the research variables.

Table 2. Descriptive Statistics of Research Variables

Variable	Number of Items	Mean	Standard Deviation	Minimum	Maximum
Natural Resource Utilization (NRU)	4	3.87	0.68	2.10	4.85
Economic Value of Sappanwood (EVS)	4	3.74	0.71	2.00	4.80
Household Income (HI)	4	3.69	0.73	1.95	4.70
Livelihood Diversification (LD)	3	3.55	0.76	1.80	4.60
Household Welfare (HW)	5	3.81	0.66	2.10	4.90

Source: Processed by the author (2026)

Table 2 presents the descriptive statistics of the main research variables used in this study, including the number of measurement items for each construct. Natural Resource Utilization (NRU) was measured using four indicators reflecting household activities related to harvesting, processing, and utilizing local natural resources. Similarly, the Economic Value of Sappanwood (EVS) construct was operationalized using four indicators capturing respondents' perceptions of the market value, demand stability, and income contribution of sappanwood. Household Income (HI) was also measured through four items that assess the level and stability of income generated from economic activities, including those related to natural resource utilization. Livelihood Diversification (LD) was measured using three indicators reflecting the extent to which households engage in multiple income-generating activities beyond a single primary occupation. Finally, Household Welfare (HW) was measured using five indicators capturing key aspects of household living conditions, including consumption capacity, access to education, housing conditions, and overall economic well-being. The variation in the number of items across constructs reflects the conceptual complexity of each variable while ensuring adequate representation of the underlying theoretical dimensions.

The findings show that the **average value of natural resource consumption is rather high**, implying that households actively employ locally available plant resources for economic objectives. Respondents reported engaging in various activities such as harvesting plant materials, processing herbal products, and selling these products in local markets.

Similarly, the perceived **economic value of sappanwood was moderately high**, indicating that respondents recognize the potential economic benefits associated with the plant. Many respondents reported that sappanwood is commonly used as a traditional herbal beverage ingredient and possesses stable demand within local markets.

Regarding household income, the results show that income levels vary across households depending on the scale of agricultural activities and the extent of involvement in natural resource-based economic activities. Households that reported higher levels of natural resource utilization and market participation tended to have relatively higher income levels.

Meanwhile, the **livelihood diversification variable shows moderate variation**, suggesting that while some households rely primarily on agricultural income, others engage in multiple economic activities,

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including small-scale trade and seasonal labor. Finally, the descriptive statistics also reveal that **household welfare indicators show moderate to relatively positive conditions**, particularly in terms of basic consumption levels, access to education, and housing conditions.

Measurement Model Evaluation

The measurement model evaluation was carried out to determine the **validity and reliability of the constructs** employed in this study. This evaluation comprised tests for convergent validity, composite reliability, and discriminant validity. The following is a table showing the Measurement Model Evaluation of the research variables.

Table 3. Measurement Model Evaluation

Construct	Indicator	Outer Loading	Cronbach's Alpha	Composite Reliability	AVE
Natural Resource Utilization	NRU1	0.81	0.84	0.89	0.66
	NRU2	0.83			
	NRU3	0.79			
	NRU4	0.82			
Economic Value of Sappanwood	EVS1	0.80	0.85	0.90	0.68
	EVS2	0.84			
	EVS3	0.82			
	EVS4	0.83			
Household Income	HI1	0.78	0.83	0.88	0.64
	HI2	0.82			
	HI3	0.81			
	HI4	0.79			
Livelihood Diversification	LD1	0.80	0.79	0.87	0.69
	LD2	0.84			
	LD3	0.83			
Household Welfare	HW1	0.82	0.87	0.91	0.67
	HW2	0.84			
	HW3	0.80			
	HW4	0.83			
	HW5	0.79			

Source: Processed by the author (2026)

Table 3, which shows the evaluation of the measurement model, shows that all constructs meet the recommended validity and reliability thresholds. All indicator loadings exceed the recommended value of

0.70, indicating strong indicator reliability. Furthermore, the Average Variance Extracted (AVE) values for all constructs are above 0.50, confirming convergent validity. The composite reliability value also exceeds 0.70, indicating satisfactory internal consistency among the measurement items.

Convergent validity was assessed by examining the **factor loadings and Average Variance Extracted (AVE)** values of each construct. The results indicate that all indicator loadings exceeded the recommended threshold value of **0.70**, indicating that the indicators adequately represent their respective constructs.

Furthermore, the AVE values for all constructs exceeded the minimum threshold of **0.50**, implying that each construct explains more than half of the variance in its indicators. These results confirm that the constructs used in the study demonstrate satisfactory convergent validity.

Construct reliability was evaluated using **Composite Reliability (CR)** and **Cronbach's Alpha** values. The results show that all constructs achieved composite reliability values above **0.70**, indicating satisfactory internal consistency among the measurement indicators. These findings confirm that the measurement instruments used in this study are reliable and suitable for further structural model analysis.

Discriminant validity was assessed using the Fornell–Larcker criterion, which compares the square root of the AVE value with the correlation between constructs. If the results show that the square root of the AVE for each construct is greater than its correlation with other constructs, it indicates that each construct is empirically distinct from the others. The measurement model in this study must meet the required validity and reliability criteria so that the analysis can proceed to the structural model evaluation. The table below displays Discriminant Validity using the Fornell-Larcker Criteria.

Table 4. Discriminant Validity (Fornell–Larcker Criterion)

Construct	NRU	EVS	HI	LD	HW
Natural Resource Utilization (NRU)	0.81				
Economic Value of Sappanwood (EVS)	0.46	0.82			
Household Income (HI)	0.52	0.49	0.80		
Livelihood Diversification (LD)	0.37	0.41	0.45	0.83	

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Construct	NRU	EVS	HI	LD	HW
Household Welfare (HW)	0.48	0.44	0.57	0.39	0.82

Source: Processed by the author (2026)

Table 4 presents the discriminant validity assessment using the Fornell–Larcker criterion. The results show that the square root of the Average Variance Extracted (AVE) for each construct is greater than its correlation with other constructs in the model. This indicates that each latent variable is empirically distinct from the others and confirms that the measurement model meets the requirements for discriminant validity, allowing the analysis to proceed to the structural model evaluation stage.

Structural Model Evaluation

After confirming the adequacy of the measurement model, the next step involved evaluating the **structural model** to examine the relationships between the latent variables. The **coefficient of determination (R²)** was used to assess the explanatory power of the structural model. The following table shows the coefficient of determination (R²) in this study.

Table 5. Coefficient of Determination (R²)

Endogenous Variable	R ²	Interpretation
Household Income	0.47	Moderate
Household Welfare	0.52	Moderate

Source: Processed by the author (2026)

The results indicate that the R² value for **household income** is **0.47**, suggesting that natural resource utilization and economic value of sappanwood explain approximately **47% of the variance in household income**. Meanwhile, the R² value for **household welfare** is **0.52**, indicating that natural resource utilization, economic value, household income, and livelihood diversification collectively explain **52% of the variance in household welfare**.

These results suggest that the model demonstrates a **moderate level of explanatory power**, indicating that the selected variables play an important role in explaining household welfare in the study area.

While other things related to **the effect size (f²)** analysis indicates that natural resource utilization has a **moderate effect** on household income, while the economic value of sappanwood demonstrates a **small to moderate effect** on income levels. Household income, in turn, shows a **moderate effect** on household welfare. The results of the study, which show the effect size (f²), are shown in the following table.

Table 6. Effect Size (f²)

Relationship	f ²	Effect Size
NRU → Household Income	0.21	Medium
EVS → Household Income	0.14	Small–Medium
Household Income → Household Welfare	0.26	Medium

Source: Processed by the author (2026)

Effect size analysis shows that natural resource utilization has a moderate effect on household income (f² = 0.21), while the economic value of sappanwood has a small to moderate effect (f² = 0.14). Household income demonstrates a moderate effect on household welfare (f² = 0.26).

Hypothesis Testing

The hypotheses were tested using the **bootstrapping procedure** in PLS-SEM to evaluate the statistical significance of the relationships between variables. The results indicate that **natural resource utilization has a significant positive effect on household income**, supporting Hypothesis 1. This finding suggests that households that actively utilize local plant resources, including herbal plants such as sappanwood, are able to generate higher levels of income. Similarly, the results show that the **economic value of sappanwood positively influences household income**, supporting Hypothesis 2. This finding indicates that the perceived market value and demand for sappanwood contribute to increased household earnings.

Furthermore, the analysis shows that **natural resource utilization has a positive and significant effect on household welfare**, supporting Hypothesis 3. This suggests that the direct benefits derived from resource utilization contribute to improvements in household living conditions. The results also indicate that the **economic value of sappanwood positively affects household welfare**, supporting Hypothesis 4. This finding highlights the importance of market opportunities for herbal commodities in enhancing rural household welfare.

In addition, the analysis confirms that **household income has a strong positive effect on household welfare**, supporting Hypothesis 5. This result is consistent with development economics literature, which emphasizes the central role of income in improving household living standards.

Finally, mediation analysis shows that household income mediates the association between natural resource consumption and household welfare, as

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well as the relationship between sappanwood's economic value and household welfare. These findings support Hypotheses 6 and 7, indicating that income serves as an important mechanism through which natural resource-based economic activities contribute to household welfare. The following is a table showing the results of the hypothesis testing.

Table 7. Structural Model and Hypothesis Testing

Hypothesis	Relationship	Path Coefficient	t-value	p-value	Result
H1	Natural Resource Utilization → Household Income	0.41	5.21	0.000	Supported
H2	Economic Value of Sappanwood → Household Income	0.33	4.18	0.000	Supported
H3	Household Income → Household Welfare	0.46	6.02	0.000	Supported
H4	Natural Resource Utilization → Household Welfare	0.19	2.41	0.016	Supported
H5	Economic Value of Sappanwood → Household Welfare	0.22	2.78	0.006	Supported
H6	NRU → HI → HW (Mediation)	0.19	3.14	0.002	Supported
H7	EVS → HI → HW (Mediation)	0.15	2.87	0.004	Supported

Source: Processed by the author (2026)

The structural model analysis indicates that natural resource utilization and the economic value of sappanwood significantly influence household income. Furthermore, household income has a strong positive effect on household welfare. Mediation research also shows that household income plays a role in mediating the links between natural resource consumption, sappanwood economic value, and household welfare.

Discussion

Natural Resource Utilization and Household Income

The results of this study indicate that natural resource utilization has a positive and significant effect on household income. This finding highlights the important role of locally available natural resources in supporting rural household livelihoods. In many rural communities, natural resources function not only as ecological assets but also as economic capital that enables households to generate income through harvesting, processing, and trading activities.

These findings are consistent with previous studies that emphasize the importance of natural resource-based livelihoods in rural economies. For instance, research on non-timber forest products (NTFPs) shows that forest resources contribute significantly to household income in many developing countries. In Indonesia and other tropical regions, the utilization of NTFPs such as medicinal plants, resins, and forest products often provides supplementary income that helps rural households maintain economic stability. A study conducted by Utami et al. (2026) shows that commercialization of forest-based products can significantly increase household income and create alternative livelihood opportunities for communities living near forest areas.

In addition, natural resource utilization is closely linked to the concept of **natural capital** within the Sustainable Livelihood Framework. Natural capital represents one of the key livelihood assets that households use to sustain their economic activities. When households have access to natural resources such as forests, land, and plant biodiversity, they are able to transform these assets into income-generating activities through harvesting, processing, and marketing of products. Empirical studies on sustainable livelihoods show that natural resource capital plays an important role in shaping livelihood strategies and improving the welfare of rural households, as conveyed in the research of Astaman, et al. (2024).

The findings of this study also highlight the importance of local ecological environments in supporting rural livelihoods. In the case of Mangunan

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Village, the surrounding forest landscapes and tropical vegetation provide favorable ecological conditions for the growth of various medicinal plants, including sappanwood. These natural resources create economic opportunities for rural households by enabling them to engage in the collection and utilization of herbal plants for both household consumption and market activities.

From a broader perspective, this result reinforces the argument that rural development strategies should recognize the economic value of biodiversity and local ecosystems. Sustainable management of natural resources not only preserves ecological integrity but also supports rural economic resilience by providing income-generating opportunities for local communities.

Economic Value of Sappanwood and Household Income

The study also found that the economic value of sappanwood has a significant positive influence on household income. This finding indicates that the market value and demand for herbal commodities can play a crucial role in shaping rural economic activities.

The economic value of natural resource-based commodities is determined by several factors, including market demand, price stability, and the ability of households to access distribution networks. In rural areas, the commercialization of plant-based products often creates opportunities for households to diversify their sources of income and reduce dependence on traditional agricultural activities.

Empirical studies on NTFPs demonstrate that many rural households rely on forest products as an important source of income. In several regions of Southeast Asia, the trade of medicinal plants and forest-based products has become a significant component of local rural economies. The economic valuation of these products shows that they can generate substantial income for rural households, particularly when supported by stable market demand and effective value chains. (Azuela & Onsay, 2025)

In this study, sappanwood represents a valuable herbal commodity with growing market potential. Traditionally used as a natural dye and medicinal ingredient, sappanwood has increasingly been utilized in herbal beverages and traditional medicine products. This increasing demand enhances the economic value of the plant and creates opportunities for rural households to generate income through harvesting and selling the product.

Furthermore, the economic value of herbal plants is closely linked to the broader trend of growing

demand for natural and traditional health products. As consumers increasingly seek plant-based remedies and herbal beverages, the market potential for medicinal plants continues to expand. This trend creates new economic opportunities for rural communities that possess access to biodiversity-rich environments.

Therefore, the findings of this study suggest that promoting the commercialization of herbal plants such as sappanwood could become an effective strategy for enhancing rural household income while simultaneously supporting the conservation of local biodiversity.

Household Income and Rural Welfare

The results of the structural model study show that household income has a significant beneficial impact on household welfare. This finding confirms the central role of income as a key determinant of living standards and economic well-being.

In development economics, household income is widely recognized as one of the primary indicators of welfare. Higher income enables households to access essential goods and services such as food, education, healthcare, and housing. In rural areas, increased income also allows households to invest in productive assets, improve agricultural productivity, and enhance long-term livelihood stability.

Empirical research consistently demonstrates that increases in household income contribute to improvements in rural welfare outcomes. For example, a study on rural poverty and welfare conducted by Purwandaya & Agustin (2024) showed that higher income levels were associated with increased consumption capacity and better living conditions among rural households.

Moreover, income growth plays an important role in reducing vulnerability to economic shocks. Rural households often face risks related to climate variability, market fluctuations, and limited access to financial services. In such contexts, higher and more stable income can enhance household resilience by enabling families to build savings, diversify livelihood strategies, and cope with unexpected economic disruptions.

The findings of this study therefore reinforce the view that policies aimed at increasing rural household income are essential for improving rural welfare. By promoting income-generating activities based on local resources, rural development programs can simultaneously enhance economic well-being and strengthen community resilience.

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The Mediating Role of Household Income

One of the key contributions of this study lies in identifying the mediating role of household income in the relationship between natural resource utilization, economic value of sappanwood, and household welfare. The results show that household income partially mediates these relationships, indicating that natural resource utilization contributes to welfare improvements primarily through its effect on income generation.

This finding is consistent with the theoretical logic of the **Sustainable Livelihood Framework**, which emphasizes that livelihood assets influence welfare outcomes through economic activities and income generation mechanisms. In this framework, natural capital provides opportunities for households to engage in productive activities, which subsequently generate income and improve welfare.

Empirical evidence also supports this mediation mechanism. Studies on rural livelihood strategies demonstrate that access to natural resources and diversification of income sources significantly influence household income, which in turn affects welfare outcomes. For example, research on rural livelihood diversification conducted by Mishra et al. (2024) shows that households that adopt multiple income-generating strategies tend to achieve higher income levels and better living conditions. Therefore, the mediating role of income highlights the importance of strengthening rural economic systems that enable households to convert natural resource assets into sustainable income streams.

Theoretical Implications

This study provides several important theoretical contributions to the literature on rural development, natural resource economics, and sustainable livelihoods. First, the study contributes to the **Sustainable Livelihood Framework** by empirically demonstrating the role of natural resource utilization as a key determinant of household income and welfare. While previous studies have emphasized the importance of livelihood assets, this study provides empirical evidence on how specific natural resource-based activities, such as the utilization of herbal plants, influence economic outcomes at the household level.

Second, the findings extend the literature on **non-timber forest products (NTFPs)** by highlighting the economic significance of herbal plants such as sappanwood in rural livelihood systems. Many studies have examined the economic contribution of NTFPs in

general, but relatively few studies focus on specific medicinal plants as drivers of rural income and welfare.

Third, the study contributes to the literature on **rural economic diversification** by demonstrating that natural resource-based activities can serve as an important complementary income source for rural households. In many rural areas, dependence on a single livelihood activity increases vulnerability to economic shocks. By engaging in natural resource utilization and herbal plant commercialization, households can diversify their income sources and improve economic stability.

Finally, the study also contributes to the emerging literature on **nature-based rural development**, which emphasizes the integration of biodiversity conservation and economic development. The results show that sustainable utilization of local natural resources can simultaneously support rural livelihoods and promote environmental sustainability.

Policy Implications for Rural Economic Development

The findings of this study have several important implications for rural development policy, particularly in regions with high biodiversity and abundant natural resources. First, rural development policies should recognize the economic potential of **local herbal plants and non-timber forest products**. Governments and development agencies can support rural communities by promoting sustainable harvesting practices, improving processing techniques, and facilitating market access for herbal products.

Second, policies should focus on strengthening **value chains for herbal commodities**. Many rural communities struggle to reach stable markets and earn fair prices for their products. Establishing cooperative marketing systems, improving transportation infrastructure, and supporting small-scale processing industries can enhance the economic value of herbal products and increase household income.

Third, rural development programs should promote **capacity building and entrepreneurship** among rural communities. Training programs on product processing, packaging, and marketing can help households transform raw natural resources into higher-value products, thereby increasing their income potential.

Fourth, policies should encourage **sustainable natural resource management** to ensure that the utilization of forest resources does not lead to environmental degradation. Community-based forest management systems can help balance economic benefits with ecological sustainability, ensuring that

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natural resources continue to support rural livelihoods in the long term.

Finally, integrating natural resource utilization into broader **rural development strategies** can contribute to poverty reduction and economic resilience. By promoting nature-based economic activities, policymakers can create sustainable livelihood opportunities while preserving ecological systems that support rural communities.

Conclusion

This study aims to examine the relationship between natural resource utilization, the economic value of sappanwood, household income, and rural household welfare in Mangunan Village, Kabuh District, Jombang Regency, East Java, Indonesia. The study uses a structural equation modeling approach based on Partial Least Squares (PLS-SEM) to give empirical data on how natural resource-related economic activities affect rural household livelihoods.

The findings reveal that natural resource utilization plays a significant role in increasing household income. Rural households that actively utilize local natural resources, including herbal plants such as sappanwood, are able to generate additional income through harvesting, processing, and selling these products. This confirms the importance of natural capital as a critical livelihood asset within rural economic systems. Access to natural resources enables households to develop productive economic activities that support income generation and livelihood sustainability.

The results also demonstrate that the economic value of sappanwood has a positive effect on household income. As a medicinal plant with growing market demand, sappanwood represents an economically valuable commodity that can contribute to rural economic development. When local communities are able to capture the economic value of such natural resources, these resources become important drivers of rural household income and economic resilience.

Furthermore, the study finds that household income significantly influences household welfare. Higher income levels allow rural households to improve their living standards by increasing consumption capacity, accessing education and health services, and investing in productive assets. This finding reinforces the widely accepted view in development economics that income growth remains one of the most important pathways for improving household welfare.

Another important finding of this study is the mediating role of household income in the relationship

between natural resource utilization, economic value of sappanwood, and household welfare. The results indicate that natural resource utilization contributes to welfare improvements primarily through income generation. In other words, natural resources improve welfare not only through direct consumption but also by enabling households to participate in market-based economic activities.

Overall, the study demonstrates that natural resource utilization and the economic value of herbal commodities can play an important role in supporting rural livelihoods. When managed sustainably and supported by appropriate economic institutions, local natural resources can become key drivers of rural economic development and household welfare.

Policy Recommendations

The findings of this study provide several important insights for policymakers, particularly in the context of rural development and natural resource management. First, rural development policies should recognize the economic potential of local natural resources, especially herbal plants and other non-timber forest products. Governments and local development agencies should support the sustainable utilization of these resources by promoting community-based resource management practices. Such initiatives can help ensure that natural resources continue to provide economic benefits while maintaining ecological sustainability.

Second, strengthening the value chain of herbal commodities is essential to increase the economic benefits received by rural communities. Many rural households currently participate only at the lowest levels of the value chain, primarily as raw material suppliers. By improving access to processing technology, packaging facilities, and marketing networks, rural communities can produce higher-value products that generate greater income.

Third, capacity-building programs should be developed to enhance rural entrepreneurship related to natural resource-based products. Training in product processing, business management, and marketing strategies can help rural households transform natural resource products into marketable commodities. Such programs can also encourage innovation in the development of herbal products, including beverages, health supplements, and traditional medicines.

Fourth, improving market access is crucial for enhancing the economic value of rural natural resources. Government support in developing local cooperatives, facilitating partnerships with private

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sector actors, and expanding access to regional markets can significantly increase the profitability of herbal products such as sappanwood.

Fifth, sustainable natural resource governance should be integrated into broader rural development strategies. Policymakers should encourage the implementation of community-based forest management and biodiversity conservation programs. By aligning economic incentives with environmental sustainability, rural communities can continue to benefit from natural resources without compromising ecological integrity.

Finally, integrating nature-based economic activities into rural development planning can contribute to broader goals such as poverty reduction, rural employment generation, and regional economic growth. By promoting the sustainable commercialization of local natural resources, governments can create inclusive development pathways that support both economic and environmental objectives.

Limitations and Future Research

Despite providing important insights into the relationship between natural resource utilization, economic value of herbal commodities, and rural household welfare, this study has several limitations that should be acknowledged. First, the study focuses on a single rural location, namely Mangunan Village in Kabuh District, Jombang Regency. Although the village provides a relevant context for examining natural resource-based livelihoods, the findings may not fully represent rural communities in other regions with different ecological, economic, and social conditions. Future research could expand the geographical scope by conducting comparative studies across multiple rural regions to obtain a more comprehensive understanding of natural resource-based rural economies.

Second, the study primarily relies on cross-sectional survey data, which limits the ability to capture dynamic changes in household income and welfare over time. Rural economic conditions often fluctuate due to factors such as market price changes, climate variability, and policy shifts. Longitudinal studies could provide deeper insights into how natural resource utilization and herbal commodity markets influence household welfare in the long run.

Third, the measurement of economic value in this study focuses primarily on household perceptions and income contributions associated with sappanwood. Future studies could incorporate more detailed economic valuation methods, such as market price

analysis, value chain assessment, and cost-benefit analysis, to obtain a more precise understanding of the economic potential of herbal commodities.

Fourth, the study does not extensively explore institutional factors such as market access, government support programs, or local cooperative structures that may influence the commercialization of natural resource products. Future research could examine how institutional arrangements and governance systems shape rural economic opportunities related to natural resource utilization.

Finally, further research could explore the integration of natural resource-based livelihoods with broader sustainability frameworks, including climate resilience, biodiversity conservation, and green rural development strategies. Understanding these relationships will become increasingly important as policymakers seek to balance economic development with environmental sustainability.

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