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Typology of Forest Users in West Usambara Tanzania and Implication to Forest Management

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Abstract: The West Usambara landscape is a complex ecosystem in Tanzania known for its rich biodiversity and livelihood support within and beyond its scope. The community dependency on this forest places pressure on its resources, so this forest requires better management strategies. Previous studies on forest conservation ignored details on the heterogeneity of forest users around the forest fringes. Part of the challenge is to understand the characteristics, behavior, and variability of forest users to plan and inform management decisions. This study is an attempt to assess typologies of forest users, their perceptions, and their motivations for understanding better forest management and utilization. The data were collected from 159 randomly sampled households located in four villages bordering the forests, supplemented with focus group discussions and key informant interviews. A factor analysis identified three management and two utilization dimensions, while cluster analysis identified three typologies: high (HFIS), medium (MFIS), and low (LFIS) forest users. The typologies varied in their socioeconomic characteristics, management, and utilization index. The management and utilization index varied from low for HFIS and MFIS to medium for LFIS, indicating a possible difference in resource utilization as well as incentives for management efforts. A multinomial logit indicated further that age, training, and livestock ownership limited upward trends in forest utilization. These findings indicate that, to improve forest management in West Usambara, different management prescriptions are required to respond to the characteristics and variability of forest users (along typologies). Moreover, forest-linked income-generating activities should be encouraged to improve forest income and motivate villagers' engagement in the forest activities.

Keywords: community; typology; west usambara; forest management; forest income

Citation: Luswaga, H.; Nuppenau, E.-A. Typology of Forest Users in West Usambara Tanzania and Implication to Forest Management. *Forests* **2021**, *12*, 24. https://doi.org/10.3390/f12010024

Received: 6 November 2020
Accepted: 24 December 2020
Published: 28 December 2020

1. Introduction

Mountainous areas, especially those with high landscape variability, support the livelihood strategies of many communities worldwide. The management of mountain ecosystems for their resources deserves special consideration because of the high levels of poverty and food insecurity in mountain areas compared to lowland areas [1]. Due to their importance, mountain forests are given special consideration in Agenda 2030 of the Sustainable Development Goals (SDGs), in which target 15.4 of SDG 15 (Life on Land) places special emphasis on the benefits of mountain ecosystem conservation [2].

In countries with mountain landscapes, there is a linkage between and dependency of community members on the mountainous ecosystems. The pressure on mountains creates conservation problems requiring policies informed by comprehensive research. Understanding the linkage between nature and community around these mountains is paramount to formulate and implement decisive policies [3] that can improve the conservation and management of the mountain landscapes.

On a continental basis (compared to the Latin America Andes, Asia Himalaya, or European Alps), the mountains in East Africa are reported to have a relatively larger contribution

to the community welfare within and beyond their boundaries [3]. Specifically, Tanzania is known for its variability and rich landscapes, spanning mountains, coastal, and semi-arid areas to Miombo woodland ecosystems supporting many people. West Usambara is among the mountain areas rich in endemic biodiversity, supporting many communities [4] as an extension of the Eastern arc mountains, starting from the Taita Hills in Kenya and extending towards Tanzania [5]. Communities have settled in these mountains for many decades, and the patterns of the related livelihood strategies have followed an interesting trajectory in the pre- and post-colonial periods. One permanent feature is agriculture as the main economic activity, both within and bordering the forest, although there has also been a shift in cropping patterns [6].

An interesting aspect in West Usambara is the relationship between forest fringe communities and the forest landscapes that provide goods and services. The communities, despite being poor, still obtain direct benefits such as energy materials, food (in terms of fruits and vegetables), medicinal plants, water sources, and other indirect and more global benefits, including carbon sinks, air purification, and nutrient cycling. The forest is also important for small animals and insects that offer pollination services [5,7]. Therefore, the interaction of forest ecosystems and the community in the West Usambara Mountains (WUMs) is important for resource extraction and the people's contributions to the management of the forests.

In terms of forest management, large areas in the WUMs are under a certain form of conservation, whether via central or local government collaboration with communities or under complete communal management [8]. Collaboration between the government and the communities is famously known as Joint Forest Management (JFM), while complete community ownership and management are known as Community-Based Forest Management (CBFM) [9]. While the institutional arrangements have a positive conservation role, they may present limitations to communities in terms of resource access, at least in the short term. To overcome this negative situation for the communities, some authors have advised introducing income-generating activities that have a direct link to the forest [10,11].

Individual household dependency on the forest is based on resource endowments that determine particular livelihood strategies and approaches, institutions mediating access to these resources, and the forest products' roles in the household. From a wider perspective, three main roles of the forest and the communities are recognized, including supplementing consumption, supporting vulnerable individuals facing livelihood issues, and harvesting timber in large and profitable quantities, therefore, helping communities out of poverty (stepping stone) [12]. The most likely role of the forest in the WUMs is a supplementary role due to the conservation institutions in place limiting resource extraction.

Specific livelihood strategies and their impacts on the forest are important for linking conservation and the resource welfare of the communities. Because it is not practical to deal with individual household interests, it becomes necessary to group or classify community members in some way [13]. Therefore, understanding the community in terms of the typology of forest use strategies provides a good policy input to identify farmer groups likely to respond to particular extension prescriptions [14].

However, studies characterizing forest resource utilization typologies under farming communities in rural areas have not been conducted in Tanzania, thus limiting our understanding of farmers' specific forest uses, conservation initiatives, and possible policy interventions. These linkages are important, as farming and forest extraction are inseparable in many parts of rural communities in developing economies [15].

In West Usambara, similar to many rural communities in Tanzania, farming is the main livelihood strategy, although the forest contributes non-timber forest products. Understanding the linkage between forest and agricultural activities is thus important. For example, some farmers engage in horticultural crops that depend on water flow from forest sources in the mountains [16], which means that the conservation of the forest should maintain a continuous flow. In addition, some tree crops are planted that create a fringe for the natural forests, and farmers are aware of the benefits of agroforestry [17].

Usually, a livelihood strategy describes the household assets used to perform activities that not only generate income but serve various other sociocultural functions while defining the household's primary occupation [18]. The set of internal and external variables (elaborated in Table 1, Section 2.4.3) that classify a particular household's command of its resources into a certain strategy enable us to group these variables as a typology. Grouping the households into certain typologies will further facilitate our understanding of their resource endowments, the employment of these resources in the forest for households' benefits, and, eventually, efforts for protection. The conservation and protection of the forest also means that effort is required from communities, entailing costs to households. Importantly, maintaining a balance between the sustainable use of the forests and supporting farming activities is of paramount importance for choices in counselling. Therefore, a thorough assessment of these typologies is needed so that informed decisions can be made to improve management conditions.

Moreover, agriculture and forest policies need to inform each other based on an understanding of the various characteristics of farming communities who are engaged in resource use and ultimately conserve or destroy forests. In many parts of Africa, communities extend their agricultural activities to the forest frontiers, indicating a close linkage between agriculture and forest management. There is also a tendency to develop agriculture and forest policies in isolation, sometimes confusing farmers [16]. To fill the relevant knowledge gaps and streamline the extension of forest management information to the communities, this study aimed to assess the typology of forest users in West Usambara. Specifically, the objectives of this study were (i) to identify the variations of the socioeconomic characteristics and forest benefits between typologies; (ii) to assess the community perception of forest management and utilization; and (iii) to evaluate factors influencing the forest dependency between typologies. Our hypothesis is that proximity to agriculture has a negative impact on willingness to participate in forest management activities. This study, specifically, asks the following questions: (i) How do forest livelihood typologies differ in their socioeconomic characteristics and benefits from the forest? (ii) Is there a difference in perception in the utilization and management of the forest based on these typologies? (iii) Which factors determine the typologies' dependency on the forest? The study's findings are important to provide insight into the patterns of forest dependency in WUMs and advise on better forest management and utilization strategies consistent with Tanzanian forest policy and global goals.

2. Materials and Methods

The section describes the study location, data collection method, theoretical perspective, and data analysis procedures followed by the study.

2.1. Description of Study Site

This study took place in the West Usambara Mountains (WUMs) located in the Lushoto district, covering about 80% (4500 km^2) of the Tanga region, with an elevation of approximately 2250 m above sea level [5]. A large part of the WUMs is covered with biodiverse types of forest ranges supporting the livelihoods of a large population [4].

The WUMs are a part of the Eastern Arc Mountains, extending from the Taita Hills in Kenya to the Udzungwa Mountains in Tanzania, withstanding large population pressure [19]. The population brings many challenges to WUMs like many other developing economies with livestock, encroachment for agriculture, and settlement being common [8]. The pressure on the forest is, therefore, large, and conservation efforts have been a priority, with many projects and devolution strategies involving communities [20]. These conservation initiatives are linked with national conservation policies [21] and the global sustainable development goal 4, which specifically advocates for mountain area conservation to offer ecosystem services for the communities in the WUMs and beyond by 2030 [22].

The WUMs are a bimodal rain area experiencing short rains (*Vuli*) between October and December and long rains (*Masika*) between October and December, averaging 600–1200 mm

annually [5,17]. The rainfall supports food crops (e.g., maize, beans, and Irish potatoes), with livestock and some other off-farm activities being the main economic activities for the population [23]. The WUMs are inhabited by three main tribes, the Mbugu (5%), Pare (14%), and Sambaa (78%), and a few minor tribes [24]. There are, however, intermarriages between the tribes in the WUMs due to many years of interactions causing a significant overlap of culture [25].

The specific study location included four villages (Figure 1), Viti, Kibaoni, Goka, and Sunga, surrounding the WUM ranges. These villages are located about a 90 min car drive from Lushoto town. The data collected were both primary and secondary types and used a multi-stage sampling approach. The study philosophy employed a cross-sectional design, where the actual data collection was done between July and September 2016 with additional brief re-captures in December 2017. All local ethical and administrative procedures were followed, and official permission for the research was provided.

The study villages border the Shagayu and Chambogo mountainous forests. The Sunga and Goka villages surround the Shagayu Forest reserve, covering 7830 hectares [26]. The Sunga households are located near the main road, while Goka is located in the interior and is, therefore, closer to the forest. On the other hand, Viti and Kibaoni border the Chambogo Forest reserve, covering approximately 605 hectares [27]. The Joint Forest Management (JFM) under the Shagayu forest reserve was established in 2002 [26], while the community forest (CBFM) around the Chambogo Village Forest Reserve was established in 1998 [27].

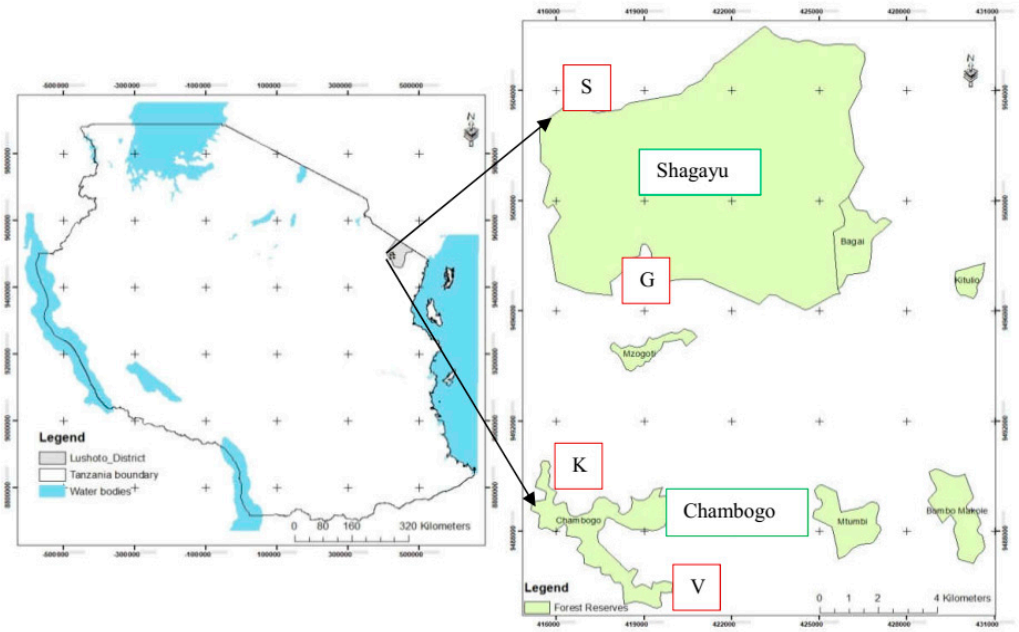

Figure 1. Map covering the four study villages around the Shagayu (Sunga and Goka) and Chambogo (Kibaoni and Viti) forests. Adopted from [28].

2.2. Data Collection

A purposeful sampling approach was followed to choose the villages, followed by random sampling of the households within the villages. In total, 159 households were involved, including 79 from Goka and Sunga and the remaining 80 from Kibaoni and Viti. This study obtained its sample-size based on Suleiman et al. [29]. The decision to choose a similar number of households in the villages was based on the small variations in the number of households in the villages and resource availability.

The village register was the sampling frame from which the households were selected based on their location relative to the forest, their accessibility, and differences in institutional regimes managing the forest.

The household was the unit of analysis chosen because variations in the utilization of the forest are easily captured at the household level. "Household" in this study is defined as a "residential unit in which members live under the same roof and organize production and consumption activities by pooling their resources together" [30]. It is argued that the policies and programs for the forest affect communities at the household level [31].

The data collected through the household survey inquired about the participation indicators, socioeconomic aspects, and households' livelihood strategies, specifically their income sources. Interview schedules, field observations, key informant interviews (KIIs), and focus group discussions (FGDs) were used for data collection. The FGDs involved some community members and village natural resource committee members. The key informants were older people at the weekly market who explained about the availability, sales, and uses of medicinal and other products from the forest. Rejection was not encountered, likely because of the good rapport between the data collection assistants and the community members, as the assistants came from a forest research institute based in Lushoto. One questionnaire was disqualified because we later observed incoherence in the response. The data collected were checked for inconsistencies and minor errors and refined, and the needed information was extracted using the Excel and Stata software. Further, the FGDs were refined and elaborated based on the Excel approach by Ose [32].

2.3. Theoretical Perspective

A number of theories have been applied in a variety of contexts as a foundation for the development and understanding of farming or resource use typologies. The aim of this study, however, is not to revise all the theories; nevertheless, it is important to highlight the relevance of these theories. The first two theories are related to farming, known as the farming style and farming context theories. The farming style theory relates to sociocultural aspects and farmers' decisions to arrange and develop their farming patterns relative to their culture, usually perfected through experience [33]. The farming context, on the other hand, considers the differences in the practices of similar farms resulting from socioeconomic, biophysical, or individual factors [34]. The third theory of market structure takes advantage of the intensity of production, use, and market aspect of the produce to develop an understanding of the farming typology. This approach can eventually describe the farmers and farming patterns, informing a particular typology [35]. The last theory under consideration, sustainable livelihood, considers the different approaches taken by households to earn a living [34]. This method has been used in many community development contexts in rural areas [36]. A rural community, depending on its assets, can employ more than one livelihood strategy—in most cases, combining farming with other strategies. This study follows the sustainable livelihood framework (SLF) (Figure 2) as a fundamental approach due to its applicability in rural areas like Tanzania, thereby linking the agriculture and forestry strategies [37]. A more elaborate description of the theories mentioned can be found in [34,38].

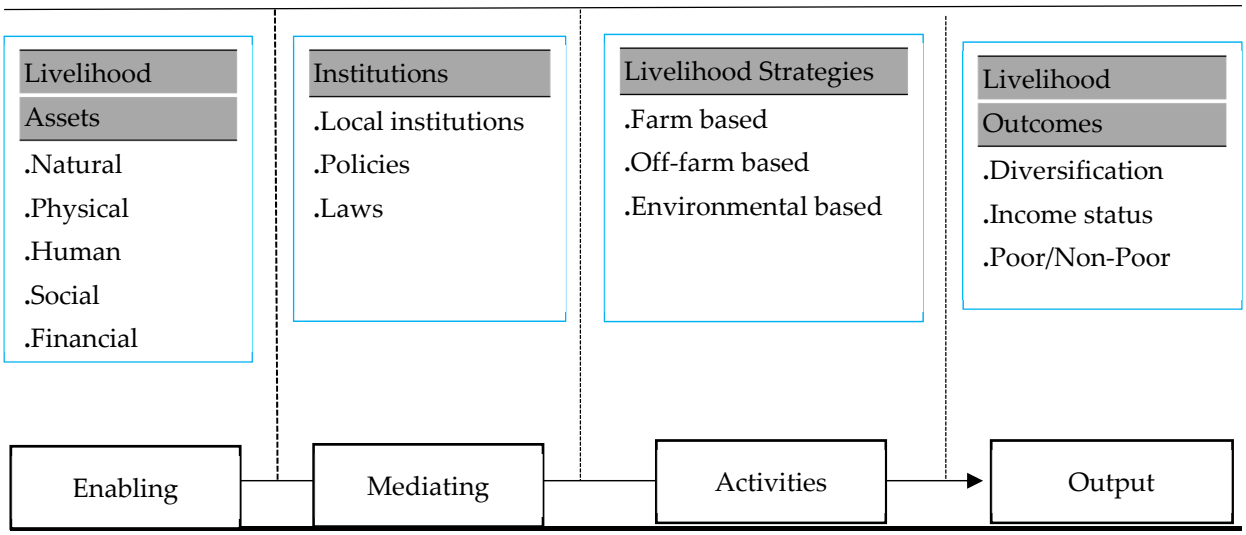

Figure 2. Adopted Sustainable Livelihood Framework used for conceptualizing the study [34,39].

In SLF, the livelihoods assets, mediated by institutional environments, enable a combination of activities that can identify the livelihood strategies. Eventually, this combination will produce a particular livelihood outcome, with or without the ability to access or diversify, thus placing the household in a certain level of income and categorizing it as poor or not. In the context of WUMs, most households are poor and have fewer assets than others, especially those operating with small land sizes, making forests important as a supplemental resource. The forest conservation policies in place may further limit the communities' forest accessibility. Therefore, villagers have to focus more on farming, small-scale business, or remittances from relatives. The forest use typologies, as the output of our study, are influenced by assets as enablers and institutions as mediators, thereby shaping the households' economic activities and interactions with the forest.

2.4. Data Analysis

2.4.1. Income for Typology Construction

A typological approach has been used in various fields of concern—for example, in agriculture, to profile farmers for improving policy decisions [40], scaling for agricultural inputs (e.g., in Rwanda) [41], understanding the adoption of innovation and technology [42], farms' resource use efficiency [43], farms' economic characterization [44], and capturing the diversity of farming systems [45], among others. In other studies, typologies have been used to understand the patterns and efforts related to collaboration in environmental issues [46], thus proposing socioecological system benefit-sharing mechanisms in developing economies [47].

In forestry, as one of the natural resource use sectors that needs a reference to differentiate its management, typologies have been used for guiding extension based on tree growth assessments [14]. Moreover, typologies have been used for the analysis of private small-scale forest owners [48]; categorizing forest conservation [49]; and management in communal forests and profiling the socioeconomic factors influencing small scale forest development [34]. Due to importance in the utilization of the information resulting from typologies for management, our construction of types and clusters of prevalent users follows a process that classifies, describes, compares, and interprets or explains a set of elements based on elaborated criteria that reduce or simplify the numbers of elements into a few elementary units [45]. Working with simplified units enables us to view a problem or challenge from different angles and intervene via relevant prescriptions.

Cluster analysis has been employed as the dominant approach in grouping livelihood strategies [25]. As a statistical technique, cluster analysis pairs a number of cases based on their similarities [50]. The asset endowments in a household facilitate the par-

ticular strategies followed by that household. Therefore, it is imperative to consider the assets when developing the clustering procedure. The socioeconomic activities are also important determinants of livelihood strategies [18] and forest dependency among rural communities [12].

There is no general rule used to select the variables for inclusion in typology identification [13]. However, the study core problem was to investigate the forest dependency of farm typologies. The variables chosen, therefore, were those that seemed relevant to investigate this linkage.

The typology construction followed two stages. Firstly, the annual total income of the households was determined using the four income sources. The annual income for the households was determined from the off-farm (remittances and business), farm (agriculture and livestock), and environmental income (forest), as depicted in the framework (Figure 2).

The sum of the income (Equation (1)) sources contributing to the total income of the household [51] is given by

$$AN_{TI} = \sum_{t=1}^{n} X_i = \sum (F + A + L + O) \quad (1)$$

where AN_{TI} is the annual total household income, X_i defines the components of the household's total income, F is forest income, A is agriculture income, L is livestock income, and O is off-farm income.

The forest income originates from all the products that come from the forest, including non-timber forest products, whether for subsistence or cash. For the products not sold in the market, the prices of close substitutes were used for the valuation [31]. Further, for agriculture and livestock, the income constituted subsistence and cash income. Off-farm income originated mostly from the remittances from family members residing in other regions. The relevant costs in each income category were subtracted to obtain the net income. For example, the cost for agricultural labor from outside the household, agricultural inputs, and livestock feed were all considered.

Secondly, agglomerative hierarchical cluster analysis (Ward's criterion) [52] was employed based on a combination of household socioeconomic analysis and the four income sources. The hierarchical cluster analysis was preferred because it is the dominant approach used in the process of typology construction [53]. The number of clusters to include was determined based on dendrogram subjective inspection [13].

The livelihood activity choice was based on the share of forest income to total income. Therefore, the contribution of forest income (share) to the total income for each typology is given by Equation (2):

$$\frac{Forest\ Income}{Total\ income} = forest\ share\ of\ the\ total\ income \quad (2)$$

2.4.2. Perception of Benefits, Management, and Sustainable Utilization of Forest

The villagers in West Usambara relate to the forest through various benefits and services. Linked with the benefits, villagers take part in forest management activities arranged through participatory forest management, with some variations between JFM and CBFM. Therefore, beyond the tangible benefits captured in income accounting (Equation (1)), a factor analysis was employed to study the variety of statement items capturing the perception dimensions for the management (effort) and utilization (benefits) of the forest. The perception dimensions were focused on the economic, ecological, cultural, and institutional aspects of the forest. The self-perception statements [40] were deliberated based on Tanzanian forest policy [21] and studies related to the perception of forest management, benefits, and utilization [54–56]. A past study showed that self-perception statements can be employed to understand typologies' positions in different aspects of resources, such as conservation, management, and innovation taking [40]. The factor analysis is aimed at

dimensional reduction [57] and establishing a pattern to summarize the factor scores to explain the community perceptions and variations among typologies.

This study employed 5-point Likert-type classification (from 1 = Strongly Disagree/Very Low to 5 = Strongly Agree/Very High) to capture the households' positions on forest use and management [58–60]. The factor analysis reduced the number of items from the survey to retain only those with relevant variables (items with factor loading >0.5) for further factor score scaling [57] (Equation (3)). The study preferred factor score scaling over the use of factor scores to avoid the inclusion of factor scores with item loading below 0.3 in the calculations [61]. Proper care was taken to name the factor scores through a combination of loaded variables. The naming followed the wisdom that "it is best that the interpretation remains simple but at the same time suggestive as to what dimension that factor represents" [57]. The factor scores summarized from the factor analysis were elaborated into factor score scaling, which was then compared between typologies to identify the perception variation.

The average scores for the benefit and management perceptions of each summarized factor are given by

$$Factor\ Score = \frac{1}{N} \sum Likert\ response\ for\ each\ loaded\ item \quad (3)$$

where N is the number of items loaded by factor analysis.

This study further gauged the perception of forest management and utilization between typologies through the construction of an index dubbed the "management and utilization index" (MUI) (Equation (4)). The present study uses this index to illustrate complex issues as simple and single metrics [62] and compare the households [63]. The community's perception of benefits realized from the forest and its role in conservation, although complex, can be understood with the use of an index. The MUI offers a snapshot indicator of the perceived relationships between typologies based on the perceived benefits and efforts (costs) related to the utilization and management of the forest. The formulation of the MUI based on the aggregated normalized weight of the principal component factors of forest management and utilization can be summarized from Equation (3). The MUI ranged from 0 to 1, with values closer to 1 indicating a strong perception. The score gradations adopted were very low (0–0.20), low (0.21–0.40), medium (0.41–0.60), high (0.61–0.80), and very high (0.81–1.00).

$$MUI = \sum W_n * PCF_n \quad (4)$$

where W_n is the weight in percentage corresponding to the variance explained in the factor analysis, and PCF_n is the respective principal component factor related to W_n.

The findings of perception describe the community beliefs related to forest management and utilization, as supported by a theory of reasoned action based on the causality between beliefs and behaviors [64].

2.4.3. Factors Influencing Typology Forest Dependency

Livelihood strategies are influenced by asset characteristics as enabling or limiting conditions mediated by various institutional contexts [18], similar to the communities in West Usambara. Table 1 indicates the factors and influencing relationships between the households and the forest livelihood strategies determined from the literature and the situation in West Usambara. These factors describe the households' capabilities and the influence of forest uses [59,60]. These characteristics were entered into multinomial logit regression to determine the explanatory variables for a household to be included under a particular typology of forest income share relative to the base category [65,66].

Table 1. Hypothesized determinants of livelihood strategies and forest relationship.

Explanatory Variable	Definition	Relationship with Forest Dependence
Land size	Size of land used for agriculture (acre)	The increase in area used for farming may negatively influence forest dependency, as it may be linked to food sufficiency [67].
Livestock ownership	Total livestock measured in livestock units (TLU)	The households with livestock may have high dependency on the forest if they depend on the forest for pasture, but many households in West Usambara grow their own folder on their farm hedges [68].
Gender of household head	Gender of decision-maker of household (female = 1, male = 0)	The forest is important for female headed households to meet family needs, therefore, may depend more in the forest [68,69].
Age	Number of years of age of the household decision-maker	The knowledge and use of the forest increases (+) with age but declines at a certain level [70].
Household labor (AEU)	Standardized labor composition of the household	Labor composition determines the household employability for farming and forest activities and may positively increase the household dependency on the forest [71,72].
Education	Number of years of education of the decision-maker	In West Usambara, most villagers are poorly educated, with the majority only receiving primary education. Normally, forest dependency is negatively influenced by years of education (−), as educated people may engage in other income activities [60,73].
Training	Whether the decision-maker attended agriculture or natural resource training (Yes = 1, No = 0)	Training in agriculture may increase productivity, and natural resource training may improve the perception of forest importance and may reduce forest dependency [74].
Access to remittances	Whether a household has access to an external income source (Yes = 1, No = 0)	Access to external sources of income may reduce the household income burden and reduce forest dependency, similar to having access to credit sources [74,75].
The location of household	Location of household relative to the institutional regime (JMF = 1, CBFM = 0)	In West Usambara, households located around the JFM forest may have the advantage of better forest access and, therefore, high forest dependency [76].
Forest distance	Household distance to the forest (min)	Generally, the distance from a household to a forest will influence forest dependency negatively due to fewer direct forest benefits [68].
Market access	Distance from the household to the market center (min)	An increase in distance from a household to the market may influence the forest negatively due to less direct forest benefits [68].

3. Results

This section describes the socioeconomic and demographic characteristics of the study population and elaborates the findings based on the study objectives, where the typologies of forest users were identified, their perceptions of management and utilization were assessed, their socioeconomic characteristics were evaluated, and the factors influencing the typologies of forest utilization were identified.

3.1. Socioeconomic and Demographic Characteristics of the Study Population

This study visited 159 households, out of which 83 (52%) were male-headed, and 76 (48%) were female-headed, showing a good representation of genders. Table 2 indicates further characteristics, with age variation from younger households (20 years) to older ones (83), and an average mature household age (47 years). This situation indicates a pattern of younger people migrating to other cities for economic reasons.

Table 2. Descriptive statistics of the study population.

Variable	Obs	Mean	Std. Dev.	Min	Max
Age (years)	159	46.79	15.16	20	83
Education (years)	159	6.23	2.01	0	11
Household size (AEU)	159	4.22	1.48	1.5	11
Forest distance (min)	159	30.93	13.04	2	60
Market distance (min)	159	27.59	14.46	2	60
Food shortage (months)	159	2.18	1.21	0	5
Area farmed (acres)	159	2.71	1.374	0	6
Livestock units (TLU)	159	0.78	0.59	0	2.8
Total income (USD/AEU)	159	203.23	146.34	29.39	881.01

The WUM community is generally poorly educated, with the majority of the members only having primary education. The average household size supports the known fact that the WUM is a highly populated area, creating pressure on forest resources. The average distance walked to the forest, and the market is 38 and 28 min, respectively. The distance to the forest may be due to the mountainous characteristics of the area and the larger degraded parts of the forest on the mountains making villagers require a longer time to walk to the forest. On the other hand, market distance makes people concentrate on selling products from their farms, with few forest products. However, the distance may not be a limiting factor if people were to access some of the more valuable products from the forest. Although up to 146 households (92%) among the surveyed villagers in the WUMs were farmers, food shortages up to an average of 2 months are common due to the small farming areas and poor farming methods. Farmers, therefore, keep livestock to support their livelihoods at an average of 0.78 and a maximum of 2.8 tropical livestock units. Generally, the community members in the WUMs are poor, with an average annual income of 203.23 USD (470,757 Tsh), well below the poverty line. The forest, therefore, provides very important supplemental income among the household income sources.

3.2. Cluster Analysis for Typology Identification

In the dendrogram (Appendix A), three clusters (C1 = Low Forest Income Share, C2 = High Forest Income Share, and C3 = Medium Forest Income Share) solutions were obtained. These three clusters identified typical households' forest livelihood strategies.

3.3. Factor Analysis on the Perception of Forest Management and Utilization

Table 3 outlines the 17 variables used in the factor analysis procedure. The decision for each variable's appropriateness in the factor analysis was based on the Kaiser–Meyer–Olkin (KMO) statistic [77], which provided an overall score of 0.739 and a significant Bartlett Sphericity Test (X^2 = 1348, d.f = 190, $p < 0.0001$), indicating the validity of the analysis [42]

by satisfying the necessary conditions to run the factor analysis [78]. A reliability test with a Cronbach's Alpha of 0.80 indicated a high level of scale consistency [57].

Table 3. Principal Component Factors Summarized by the Factor Analysis Procedure.

Variable	PCF1	PCF2	PCF3	PCF4	PCF5	Uniqueness
Trust-NGOs			0.5128			0.3759
Trust-VNRC			0.9024			0.1506
Trust-LG			0.9151			0.1528
Importance-fuelwood	0.7329					0.4588
Importance-timber	0.8474					0.2539
Importance-NTFP	0.7300					0.2259
Importance employment	0.7787					0.3333
Importance-income	0.7580					0.3873
Meeting-frequency		0.8544				0.1996
Meeting-learning		0.8936				0.1474
Meeting-influence		0.7860				0.2934
Tree planting					0.6047	0.4934
Firefighting				0.7992		0.2810
Reporting-illegality				0.5802		0.4585
Firebreak-participation				0.8165		0.2589
Erosion control					0.7362	0.3844
Mitigating adversity					0.8451	0.2191
Eigenvalue	4.174	2.147	1.591	1.032	1.102	
Variance explained	18%	12%	10%	11%	9%	

Note: The blanks represent factor loading <0.5. The sampling adequacy measure (KMO) was 0.7. NGOs stands for Non-Governmental Organizations, VNRC for Village Natural Resource Committee, LG for Local Government, and NTFP for Non-Timber Forest Products.

To avoid overestimation of the factors to be retained, this study employed Horn's parallel analysis, taking advantage of its robustness [77,79]. Therefore, five principal factors (Table 2) were retained with adjusted eigenvalues greater than one. The factors retained cumulatively explained about 60% of the total variability. Table 3 indicates the factor loadings for each variable based on the Kaiser rotation (varimax) method.

Principal component factor 1 (PCF1) was correlated with perceptions of economic benefits from timber, employment, income, and fuelwood for the households. PCF2 correlated with communities' perceptions of learning various matters associated with forests in meetings, their influence on those meetings, and the frequency with which they attended these meetings. PCF3 was mostly associated with trust in institutions such as non-governmental organizations, community institutions, and the local government. Communities' perceptions of efforts to protect the forest, including maintaining firebreaks, occasional firefighting, and reporting illegality within the forest were correlated with PCF4. Further, communities' perceived ecological benefits from minimizing adverse effects, erosion control, and involvement in tree planting were correlated with PCF5. Accordingly, the principal component factor dimensions related to typology perception are summarized as PCF1 = economic benefits, PCF2 = decision-making engagement, PCF3 = trust in institutions, PCF4 = protection engagement, and PCF5 = ecological benefits. Supplementing these findings, the FGDs from natural resource committee members raised concerns that a lack of management equipment, such as boots and fire beating tools, as well as incentives, such as funds, decrease their efforts related to forest protection. Further, key informants reported an increase in the distance and time needed to find some forest products, notably medicinal plants.

3.4. Characterization of Forest Dependency Typologies

Table 4 indicates the typology clusters based on variations in socioeconomic characteristics. There is typical variation in age ($F = 72.56$, $p \leq 0.0001$), years of education ($F = 271.8$, $p \leq 0.0001$), livestock ownership ($F = 19.68$, $p \leq 0.0001$), and distance to the forest ($F = 4.44$, $p = 0.0133$). Further, there was variation in perception related to the importance of the forest in cultural issues ($F = 4.24$, $p = 0.0112$), biodiversity ($F = 3.43$, $p = 0.00348$)

and minimizing adverse effects ($F = 3.88$, $p = 0.0228$). In addition, there was variation in perceptions on meeting frequency ($F = 6.05$ $p = 0.0029$) and benefits to the communities in learning forest matters in the meetings ($F = 4.75$, $p = 0.01$).

Table 4. Variation of socioeconomic characteristics management and utilization of the forest by typologies.

Variable	Typology Clusters			Pooled (*N* = 159)
	LFIS (*N* = 43)	HFIS (*N* = 51)	MFIS (*N* = 65)	
Age (years) **	62.81 (9.72)	35.74 (9.42)	44.86 (12.74)	46.79 (15.16)
Education (years) **	4.58 (1.67)	7.03 (1.83)	6.70 (1.71)	6.23 (2.01)
Household size (AEU) **	4.76 (1.85)	4.18 (1.31)	3.90 (1.22)	4.22 (1.48)
Livestock Unit (TLU) **	1.18 (0.67)	0.75 (0.49)	0.53 (0.44)	0.78 (0.59)
Forest distance (min) **	33.48 (11.47)	26.56 (10.41)	32.67 (15.05)	30.93 (13.04)
Food insecurity (months)	2.02 (1.29)	2.11 (1.16)	2.35 (1.18)	2.18 (1.21)
Area farmed (acres)	1.25 (0.42)	1.24 (0.32)	1.20 (0.47)	1.23 (0.41)
Importance for culture **	2.97 (0.51)	2.72 (0.60)	3.00 (0.5)	2.91 (0.54)
Importance for water	3.46 (0.54)	3.23 (0.51)	3.38 (0.55)	3.35 (0.54)
Importance for biodiversity **	3.13 (0.41)	2.92 (0.44)	3.06 (0.39)	3.03 (0.41)
Importance for fuelwood	3.32 (1.08)	3.37 (1.16)	3.43 (1.24)	3.38 (1.17)
Importance for timber	2.88 (1.02)	2.74 (1.01)	2.90 (1.08)	2.85 (1.04)
Importance for NTFPs	3.25 (1.00)	3.25 (1.05)	3.07 (1.10)	3.18 (1.06)
Importance for employment	3.04 (1.02)	2.66 (1.07)	2.78 (1.11)	2.81 (1.08)
Importance for income	2.93 (1.00)	2.52 (1.04)	2.81 (1.07)	2.75 (1.05)
Meeting frequency **	2.16 (1.37)	2.00 (1.20)	1.46 (0.81)	1.82 (1.15)
Learning from meetings **	2.09 (1.28)	1.82 (1.10)	1.47 (0.75)	1.75 (1.05)
Meeting influence	1.97 (1.14)	1.66 (0.86)	1.58 (0.91)	1.71 (0.97)
Tree planting *	3.20 (1.35)	2.76 (1.28)	3.29 (1.37)	3.10 (1.36)
Firefighting in forest	3.37 (1.25)	2.94 (1.28)	2.90 (1.31)	3.04 (1.29)
Reporting illegalities **	2.58 (1.31)	2.03 (1.19)	1.86 (1.19)	2.11 (1.26)
Firebreak maintenance **	3.11 (1.31)	2.35 (1.24)	2.32 (1.25)	2.54 (1.30)
Erosion control	3.76 (0.92)	3.86 (0.74)	4.01 (0.81)	3.89 (0.82)
Mitigating adversities **	3.09 (1.23)	2.98 (1.31)	3.55 (1.01)	3.24 (1.19)

**; * Significant difference at 5% ($p < 0.05$) and 10% ($p < 0.1$), respectively. ANOVA test used for significance testing of the continuous variables. Note: (Low Forest Income Share [LFIS]); (High Forest Income Share [HFIS]); (Medium Forest Income Share [MFIS]).

The typologies reported variation in the perception of activities related to protection of the forest, including reporting on illegal activities ($F = 4.57$, $p = 0.00118$), firebreak maintenance ($F = 5.96$, $p = 0.0032$), and tree planting ($F = 2.40$, $p = 0.0945$). Though slight variations were observed, no significant differences were observed in food insecurity, farmed area, importance of the forest (for water, fuelwood, timber, NTFPs, employment, and income), firefighting activities, or erosion control.

Generally, those in the HFIS typology were younger, had more years of education, owned moderate amounts of livestock, walked shorter distances to the forest, had a medium frequency of meeting attendance, attached less importance to biodiversity and tree planting activities in the forest, reported fewer illegal activities, and had moderate participation in forest fire fighting.

3.5. Typology Pathways and Income Shares

Figure 3 illustrates the patterns of shares across typologies based on income from the forest, agriculture, livestock, and off-farm livelihood strategies. The forest shares of HFIS (9.91) and MFIS (9.33) were significantly higher ($p = 0.0076$) than those of LFIS cluster (4.73). Moreover, there was only a small variation in the agricultural income share with LFIS (59.44) and HFIS (59.66), but this variation was slightly significantly higher ($p = 0.0812$) than MFIS (52.38). The livestock share showed a significant difference ($p \leq 0.0001$) with a decreased pattern: LFIS (27.33), HFIS (13.62), and MFIS (7.63). Conversely, the off-farm income source showed significant variation ($p \leq 0.0001$) with an increasing pattern: LFIS (8.81), HFIS (16.81), and MFIS (32.35).

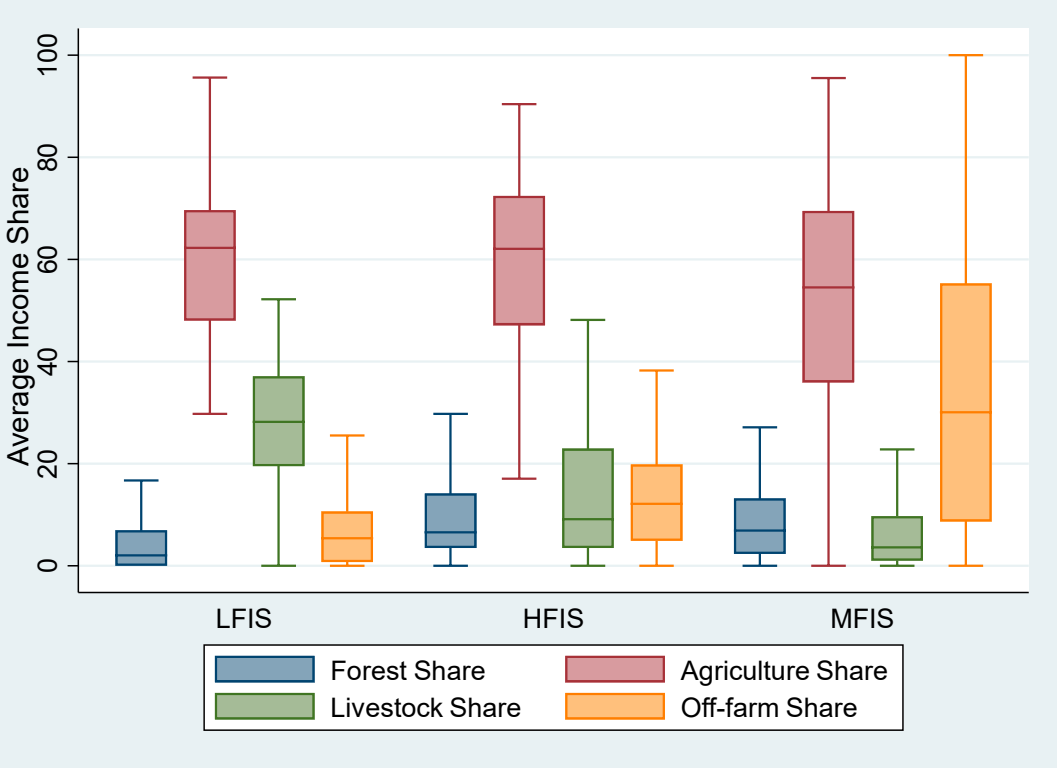

Figure 3. Average Income Share by typology. Note: LFIS = Low Forest Income Share, HFIS = High Forest Income Share, and MFIS = Medium Forest Income Share.

3.6. Typology Perception of Management and Utilization

Figure 4 indicates the pattern of typology perception based on indicators of management and utilization of the forest. The perception of decision-making generally had a lower score, with an average increasing trend for MFIS (1.50), HFIS (1.83), and LFIS (2.07). Therefore, the MFIS and HFIS typologies had significantly stronger reservations ($F = 5.22$, $p = 0.0064$) about their roles in decision-making compared to LFIS households.

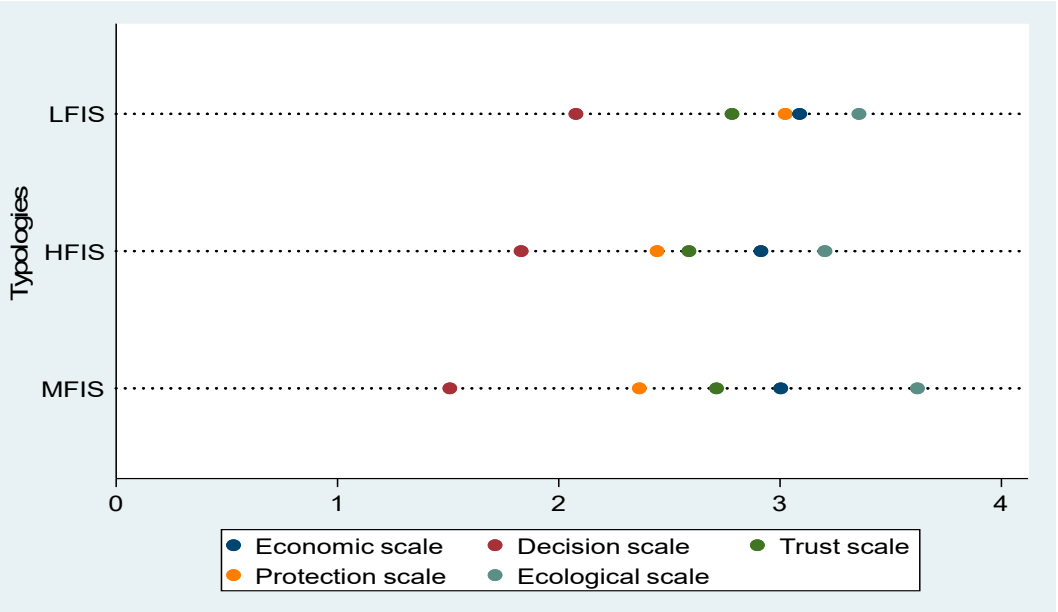

Figure 4. Variation of management and utilization perceptions between the farming typologies. Note: LFIS = Low Forest Income Share, HFIS = High Forest Income Share, and MFIS = Medium Forest Income Share.

Regarding forest protection, the user typologies indicated a perceived significant ($F = 6.22$, $p = 0.0025$) average increase in the role from low for MFIS (2.36) and HFIF (2.44) to medium for LFIS (3.02). The level of trust in institutions among the users' typologies was generally low, with an increasing average trend for HFIS (2.58), MFIS (2.71), and LFIS (2.78). Similarly, the perception of benefits from the forest varied from low for HFIS (2.91) to moderate for MFIS (3.00) and LFIS (3.08). Figure 4 illustrates a response to the question of whether high forest users are more interested in conservation, indicating a consistent pattern of a low score in the three conservation dimensions (decision, trust, and protection) for high (HIFS) compared to low forest users (LFIS).

Generally, the perceptions of ecological benefits for the typologies were moderate but comparatively higher among all other forest utilization and management perception scores. The MFIS households indicated a moderately higher average score (3.62) compared to LFIS (3.35), while this score was significantly higher ($F = 3.67$, $p = 0.0277$) compared to HFIS households (3.20).

The MUI (Figure 5), on the other hand, indicated a significant variation among the typologies based on an ANOVA followed by Tukey's post-hoc tests, with LFIS households perceiving medium level on the MUI (0.50), which was significantly higher ($F = 3.67$, $p = 0.0277$) compared to the low perceived MUI for the MFIS (0.40) and HFIS (0.38) groups. This study tested the hypothesis of whether proximity to agriculture has a negative impact on the willingness to participate in forest activities. The proximity to agriculture (captured by agricultural income) showed a significantly positive correlation ($r = 0.2996$, $p < 0.05$) to willingness to participate in forest activities (captured by the MUI). However, the share of the household agricultural income was not significant.

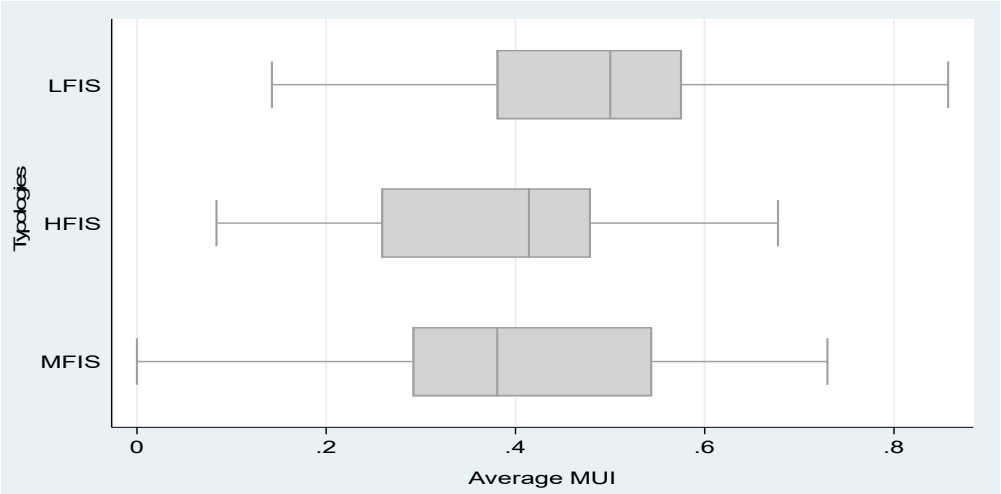

Figure 5. Average Score on the Management and Utilization Index by typology. Note: LFIS = Low Forest Income Share, HFIS = High Forest Income Share, and MFIS = Medium Forest Income Share.

3.7. Factors Influencing Typologies of Forest Utilization

Table 5 indicates the factors influencing the odds of particular households to have high or medium forest dependency relative to the base category, LFIS. The measure of the model fit indicates that independent variables can explain about 80% of the variance among the typologies (Cox and Snell = 0.795). The results show that this model is fairly credible and stable [80].

Table 5. Determinants of Forest Typologies in West Usambara.

TYPOLOGIES	Coef.	St.Err.	*t*-Value	*p*-Value	[95% Conf]	[Interval]	Sig
LFIS (base outcome)							
HFIS							
Farmed	2.253	1.029	1.78	0.075	0.920	5.515	*
Livestock (TLU)	0.019	0.024	−3.18	0.001	0.002	0.220	***
Gender	1.216	1.247	0.19	0.849	0.163	9.083	
Age	0.735	0.051	−4.44	0.000	0.642	0.842	***
Household size	1.053	0.377	0.14	0.886	0.522	2.125	
Education	2.635	0.936	2.73	0.006	1.313	5.287	***
Training	0.724	0.559	−0.42	0.675	0.159	3.286	
Remittances	0.302	0.361	−1.00	0.317	0.029	3.147	
Institutional regime	0.929	1.019	−0.07	0.946	0.108	7.978	
Forest distance	0.930	0.043	−1.58	0.115	0.850	1.018	
Market distance	1.069	0.059	1.22	0.223	0.960	1.191	
Constant	142,000	825,000	2.05	0.041	1.660	1.22×10^{10}	**
MFIS							
Farmed	1.493	0.576	1.04	0.299	0.701	3.179	
Livestock (TLU)	0.008	0.011	−3.78	0.000	0.001	0.100	***
Gender	0.983	0.992	−0.02	0.986	0.136	7.103	
Age	0.827	0.050	−3.14	0.002	0.735	0.931	***
Household size	0.417	0.143	−2.55	0.011	0.213	0.816	**
Education	3.013	1.061	3.13	0.002	1.511	6.009	***
Training	0.158	0.144	−2.02	0.043	0.026	0.942	**
Remittances	0.555	0.623	−0.53	0.600	0.061	5.008	
Institutional regime	0.618	0.685	−0.44	0.664	0.070	5.424	
Forest distance	1.017	0.045	0.38	0.701	0.932	1.110	
Market distance	0.801	0.043	−4.16	0.000	0.722	0.889	***
Constant	3.02×10^{8}	1.79×10^{9}	3.30	0.001	2813.106	3.25×10^{13}	***
Pseudo r-squared	0.732	Number of obs	159				
Chi-square	252.247	Prob > chi2	0.000				
Akaike crit. (AIC)	140.485	Bayesian crit. (BIC)	214.138				
		ML (Cox-Snell) R^2: 0.795					

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Note: LFIS = Low Forest Income Share, HFIS = High Forest Income Share, and MFIS = Medium Forest Income Share.

As shown in Table 5, in comparison with the LFIS category, possession of large farming plots and increases in years of education are most likely to place a household in the HFIS typology. Similarly, relative to LFIS, households with more educated members were more likely to be in MFIS but were less likely if they attended training, had older household heads, located far away from market center and owned many livestock.

4. Discussion

The section responds to the research question by discussing the study findings using a characterization of typologies based on the socioeconomic variables, discussing the typologies' livelihood strategies and the forest benefits accrued, the perception of the typologies of forest management and utilization, and the factors determining household forest dependency.

4.1. Socioeconomic Variation between Typologies

This study identified age, education, household size, and forest distance as the main socioeconomic variables characterizing the typologies. The households with low forest income shares were older, less educated, had bigger household sizes, and lived further away from the forest. This situation can be explained by settling patterns, as the older members established farms closer to their homes and more commonly at the valley bottoms, while younger members had to expand further away from their homes towards the mountains and forest frontiers. The young members can thus extract forest products more

often, as they spend time working on their farms close to the forest. Increases in age were found to limit forest access among households with older head members, similar to other studies [55]. Education, on the other hand, was shown to reduce dependency on forest resources. However, in the WUMs, most villagers have only some primary education; only the younger members have finished their primary education, which does not provide much difference in terms of remunerative alternatives. The older household heads also had a bigger household size, which is counter-intuitive in terms of low forest dependency. These household members likely spend much more time on farming and livestock feeding, leading to their low forest income share.

4.2. Typologies' Livelihood Strategies and Benefits from the Forest

Planning for the development process, including the management and utilization of natural resources such as forest ecosystems, requires research that describes the socioecological interactions between community members and the ecosystem. The present study used a typological assessment to identify community livelihood heterogeneity and its influence on forest use [52]. The data were collected by household surveys [81], although a participatory approach could also be employed [82].

In this study, three typologies of forest users were identified among community members in West Usambara. The clustering procedure in our study did not identify distinct diverse livelihood strategies based on the dominance of a particular economic activity, but rather identified a share of forest income in the clusters. Many households were in the MFIS category (41%), followed by the HFIS (32%) and LFIS categories (27%). These results revealed that all the typologies received most of their livelihood support from farming activities, with forest and other sources mainly serving supplementary roles. Therefore, the chance for concrete livelihood diversity in West Usambara is slim due to the dominance of agriculture and few other economic pathways. However, forest income, contributing only 4.73%, 9.33%, and 9.91% for LFIS, MFIS, and HFIS, respectively, although supplemental, is an indispensable day-to-day need for the communities. The range of the forest income share is lower than that provided in other studies on Africa [12,55], indicating the low harvesting and protective nature of the forests in Usambara.

The household structure and composition proved to be important in shaping the households' needs for forest resources. The patterns categorized the households with older heads and bigger sizes as LFIS compared to the rest. These findings suggest a particular situation in Usambara, where the mountainous nature of the area restricts older people from accessing forest resources.

In the WUMs, resource ownership in terms of livestock limits farmers to a low forest income share. Households with a large composition of livestock units were categorized as LFIS. This situation is typical in the study area, as farmers own only small pieces of land, and the majority planted grasses that serve as animal feed and provide erosion control [20]. Therefore, the farmers likely spend more time attending to their animals using their farms' feed sources than depending on the forest. Conversely, a study in Benin [83] indicated a direct relationship between livestock ownership and forest access for livestock feed.

Considering the individual types of benefits, the typologies perceived medium to low benefits from the forest. The water benefit was perceived to be the highest, while direct income from selling products from the forest was the lowest. Indeed, as farmers, the villagers in West Usambara reported water originating from the forest to be an important benefit. For direct income, the benefits are certainly fewer, as large portion of WUM forest is currently protected by the institutional regime [8].

The LFIS category was limited by time allocation in the accessibility of forest resources, as these individuals live further from the forest. This result is also due to the mountainous characteristics in West Usambara. Time has shown to be a limiting factor in terms of resource access and utilization due to the effort required to access the resources [84].

4.3. Perception of Management and Utilization of the Forest

This study identified five factors related to the self-reported perception of management (decision-making, trust in institutions, and protection engagement) and utilization (economic benefits and forest ecological benefits) of the forest. The factor score scales are very important to relate the actual benefits realized from the forest captured by forest income. The findings revealed an interesting situation in the WUMs, as forest user typologies were concerned with the low levels of engagement in decision-making through meetings. Meetings provide a good platform for communities to express and negotiate their interests related to resource management [85]. Therefore, the score scale related to the meetings indicated the community's dissatisfaction—more so for the MFIS category. Meetings related to resource management provide communities with the opportunity to make decisions [86], engage in social learning [87], and minimize their skepticism [88] and are, therefore, important in forest management.

In West Usambara, through JFM and CBFM arrangements, communities are the stakeholders in forest protection, so their engagement is of the utmost importance. The results, however, demonstrated a low perceived input by community members to this protection effort. This low protection perception, understandably, was more pronounced among the MFIS and HFIS typologies, likely due to a feeling that protection activities, such as reporting perpetrators, largely limit themselves as high forest dependents. This low level of protection may jeopardize forest conservation, as community members may be the primary protectors or destroyers of the forest. Improving forest incentives through programs that enhance community benefits may improve the community outlook towards forest protection. If such benefits can contribute to individual households and the community at large, these benefits may help improve the perception and protection effort by the communities since protection efforts are linked to benefits [89]. Similarly, incentives and equipment are important to the village's natural resource committee members, who complained of a lack of these necessities needed to improve forest protection.

The findings also show that the trust level between community members and institutions is low, indicating tension in forest utilization. Trust, as a component of social capital, lowers the transaction costs involved in working together and improves cooperation [90]. Successful outcomes in forest management are partly determined by the cooperation between community members and the institutions in place [91]. A lack of trust or low trust in planning systems—for example, through injustices or corruption—can erode interest among communities to engage in forest activities [92]. In the FGDs, community members lamented that village natural resource committee members occasionally treated them unfairly or allowed some members to acquire forest products because they were related or knew each other. Trust can be built upon or improved by multiple partners, both public and private, working together through the provision of capacity building and various services (e.g., training, social services, fundraising, or business improvements) [90]. In the WUMs, a previous study [76] found a high level of trust between the community and non-governmental organizations that operated projects related to soil and environmental conservation, indicating that such communities respond favorably to situations that they feel represents a win–win scenario. Further, communication and trust are intertwined, and in the WUMs, this situation can be improved with regular meetings. These meetings would reduce asymmetrical information exchanges, thereby also minimizing the risks for embezzlement and benefits being captured by elites [93].

The highest perception scores for the typologies were found for economic and ecological benefits. These were direct incentives for the households and the community as a whole. Nevertheless, these benefits were only of medium importance, thus explaining the lower perception score for the other activities requiring community efforts for forest management, such as meetings, protection, and trust levels. Individual households, therefore, vary in their forest utilization and perception in forest conservation. This variation stems from the fact that households differ in their resource allocation and challenges, indicating that each household faces a unique decision-making process [13]. It can, therefore, be inferred that

an increase in benefits for households would improve the management motivation from the communities.

The MUI gives a snapshot of typologies based on the aggregated score of the perception indicators combining the management (protection, meetings, and trust) and utilization (economic and ecological) dimensions. The MFIS and HFIS typologies have a low and medium average MUI score, respectively, indicating that these households, despite having a comparatively higher forest share than LFIS, perceive lower benefits from the forest, resulting in potentially low efforts in terms of forest management activities. These households depend more on the forest and thus feel low satisfaction with current provisions.

This study, admittedly, did not explicitly examine the reasoned action theory [64] linkages to forest management. However, as outlined by Brown and Reed [94], the MUI is linked with reasoned action theory in that perceptions express the beliefs of the communities towards forest benefits and management efforts. These beliefs inform the community's attitude (whether positive or negative), shaping their intentions to take part or not in forest activities, and eventually determine the actual community behavior towards forest management.

4.4. Determinants of the Typologies' Dependence on the Forest

The results indicate that several factors determine the categorization of a household under a particular forest use typology (low, medium, or high), based on the share of forest income. The education level of the household head and the area used for farming by the household showed a strong link in increasing the forest share typologies. In the WUMs, unlike other areas where an increase in education reduces dependency on the forest or environmental resources [95], the results here showed a linkage to a medium and high-income share. This difference in the situation in the WUMs can be explained by the presence of fewer members in the sample educated beyond primary school and the lack of more remunerative choices for more educated members.

There are also entry barriers to higher forest income shares. Livestock ownership and the age of the household head highlight the limitations in upward trends for those with both medium and high forest shares, while the size of the household, training, and market distance were shown to limit the upward movement towards medium forest dependency. Livestock ownership means that the household must allocate time to provide feed and water since animals in the WUMs are kept in stalls. The situation in the WUMs is peculiar, as farmers themselves provide the grass for feeding their animals. Other studies [83,96] have indicated that forests can represent a good source of livestock feed, thereby increasing the income share of the households. Older people, on the other hand, are limited in the distance they can travel and their ability to traverse mountains to acquire various forest products. Therefore, the elderly largely remain in the lower category of forest utilization.

The size of the household indicates labor potential but also the presence of more mouths to feed with respect to forest use in the household. However, according to the household size in adult equivalent units, this study showed a high consumer to worker ratio in the households. Therefore, the income per adult equivalent unit (AEU) is likely lower [71].

Training sensitizes people to the importance of the forest for the environment and providing support for other production activities, such as agriculture. Some projects with various areas of specialization have operated in Usambara in the past [19,97], which may be linked to sensitization to the importance of the forest, thereby limiting the likelihood of a high-income share among the villagers who attended training. This is especially important in the WUMs, where communities in the valley bottoms of the mountains engage in agricultural crops, which depend on mountain water sources. Training has also been shown in other parts of the world to build the capacity for higher returning ventures, such as entrepreneurship or greater returns from agriculture, consequentially improving forest management [80].

Market distance has been proven to limit households towards medium and high forest income shares. Indeed, increasing the market distance requires greater effort to bring resources from the forest to sell them. Therefore, in the WUMs, households focus mostly on subsistence utilization of forest products and not trading. More effort is concentrated on other productive means, specifically agriculture, livestock, and, to some extent, off-farm sources, notably remittances. Trading for specialized lightweight forest products is also observed at the weekly markets. Such products include medicine and a few types of vegetables and fruits, which do not attract very high income and affect few people. The situation in the WUMs differs from the situation outlined in a review study by Vedeld et al. [98], who indicated an increasing pattern of forest income with an increase in market distance. The authors cautioned, however, to interpret the results with care, as normal expectations relate market access with increased forest income.

The limitations of this study are linked to the traditional methodology we employed to define the forest dependency among the typologies using relative income. This study is aware of the robust forest dependence index introduced by Nerfa et al.'s study in Malawi [63]. This index went beyond income forest dependency by also indexing efforts involved in acquiring forest products, the relative wealth based on assets, and non-forest livelihood sub-indices. Future studies could employ the introduced index to understand forest typologies in other situations, such as those in Tanzania, and compare the performance of the index.

5. Conclusions and Recommendations

This study sought to understand forest users' typologies and propose some interventions to improve forest management in West Usambara, Tanzania. The typification enabled the identification of characteristics of users around forest areas and the typologies' strengths and weaknesses required for improvement strategies. This study was grounded on questions intended to explore the socioeconomic characteristics and benefits of typologies, the perception of management and utilization, and the determining factors for a household to be placed in a particular typology.

This study identified three main typologies of forest users in the WUMs, each of which differed in its share of income from the forest. Different socioeconomic characteristics and resource ownership types were also observed between the typologies. The hypothesis testing indicated a direct relationship between agriculture and forest management activities, suggesting that community members are willing to conserve the forest relative to the perceived benefits. This is especially true for the WUM farmers who practice agriculture in the bottom valleys and are dependent on the natural water sources from the mountains.

The age of the household heads, education, size, and livestock assets were important socioeconomic characteristics for categorizing forest use typologies. Similarly, the location relative to the forest favored high forest users. The forest use typologies varied based on the perception of the management and utilization of the forest, indicating that certain attitudes towards this resource are reflected in the actual utilization. Therefore, the influence of negative attitudes towards the forest may improve forest management. Generally, an increase in years of education and larger farming plots increased the likelihood of upward trends towards high forest utilization. Forest conservation measures may also provide benefits through engaging villagers with larger farming plots and younger villagers who are more educated but harbor fewer conservation concerns.

This study recommends that activities that can improve forest conditions but are infrequently practiced by HFIS households should be encouraged. These activities include timely and frequent meetings from government institutions or NGOs, encouraging tree planting around homesteads and in the forest, motivating greater community engagement in reporting perpetrators of illegal activities, and engaging in firefighting activities through various incentives.

Regarding perceptions of forest management and utilization, this study recommends that incentives for the various typologies to take part in management through changing

their beliefs (e.g., through enhancing trust or training) and behaviors (e.g., protective behaviors, such as reporting illegal activities) towards the forest should also be enhanced. The HFIS and MFIS typologies need special consideration to encourage greater forest management activities by offering incentives that may not be highly extractive in nature. For example, policies with income incentives in areas benefiting from ecosystems services far away from the forest could be explored with a keen interest in improving motivations among resource custodians.

This study further recommends that factors shown to be 'friendly' to forest use by communities be extended in the WUMs, such as improving livestock assets and investments in training activities for forest income-generating activities, agriculture, and other types of natural resource management. Government extension agents or NGOs with the opportunity to work with communities in the WUMs could provide frequent training in natural management, especially to younger community members. These recommendations may eventually improve forest management in the WUMs, as linked to national forest policy, which advocates sustainable forest management and the achievement of broader global sustainable development goals, particularly goals 1 (fighting to reduce poverty), 2 (using forest food sources to fight hunger), 13 (enhancing climate action), and 15 (improving life on the land). Our study concedes the spatial limitation of its assessment, as forest areas in Tanzania are very diverse. However, most mountainous areas in Tanzania, especially along the Eastern arc, are similar to the WUMs, so our results may explain similar patterns in other areas along the arc.

Author Contributions: Conceptualization, H.L.; methodology, H.L.; software, H.L.; validation, H.L. and E.-A.N.; formal analysis, H.L.; investigation, H.L.; resources, H.L. and E.-A.N.; data curation, H.L.; writing—original draft preparation, H.L.; writing—review and editing, H.L. and E.-A.N.; visualization, H.L.; supervision, E.-A.N.; project administration, E.-A.N.; funding acquisition, H.L. and E.-A.N. All authors have read and agreed to the published version of the manuscript.

Funding: German Academic Exchange Service (DAAD) and the Russel E Train Education for Nature Program funded this study, grant number SS 44.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors acknowledge the Lushoto district council for the opportunity to conduct this study and leaders and villagers in Goka, Kibaoni Sunga and Viti for their study participation. The effort of the data collection team is also highly appreciated.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

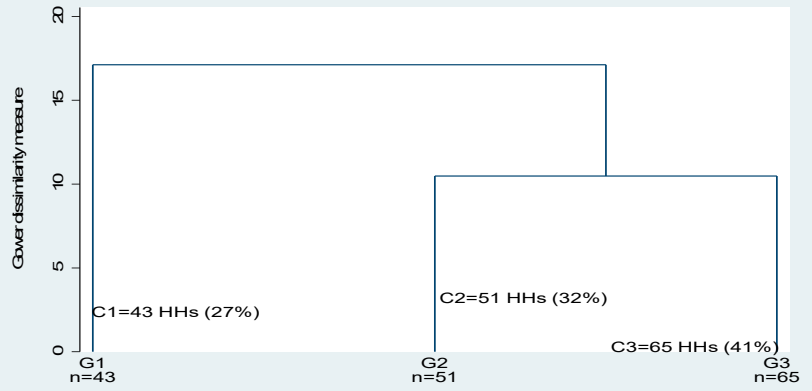

Figure A1. Note: C1 = Cluster 1(LFIS); C2 = Cluster 2 (HFIS); C3 = Cluster 3 (MFIS).

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