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SUSTAINABLE AGRICULTURE PRATICES WITH ALTERNATIVES BASED ON POLYCULTURE COFFEE PLANTATION ON DRY LANDS FARM IN RIVER FLOW AREA IN ERMERA OF MUNICIPALITY

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ABSTRACT

This study assesses the effects of sustainable coffee-based polyculture on productivity, environmental health, and farmer resilience in the dryland watersheds of Ermera. Using a mixed-methods approach random sampling of 150 farmers, structured surveys and interviews, and quantitative analysis in Excel and SPSS—the research compares polyculture systems (coffee intercropped with shade species such as bananas and avocados) against coffee monoculture under dryland conditions. Findings indicate that polyculture significantly improves land-use efficiency, crop productivity, soil moisture retention, erosion control, and on-farm biodiversity, while enhancing household income and food security. These ecological and socioeconomic gains align with agroecological principles and contribute to improved watershed management. Major constraints to wider adoption include limited farmer technical knowledge and weak institutional support. To realize the full potential of coffee-based polyculture, the study recommends targeted extension services and regular capacity-building, policies and incentives favoring agroecological practices and market access, strengthened farmer cooperatives, improved access to finance for smallholders, and continued research and monitoring to adapt models to local contexts and evaluate long-term impacts. With coordinated technical assistance and policy backing, coffee-based polyculture in Ermera's dryland watersheds offers a viable, scalable pathway to sustainable agriculture, ecosystem conservation, and enhanced rural livelihoods..

INTRODUCTION

Sustainable agricultural development with alternative coffee-based polyculture on dry land in the watershed (DAS) in the municipality of Ermera in harmony with nature will create a healthy and productive society through agricultural development in the region. A series of agricultural development efforts that enable food self-sufficiency in a free and fair national trade system, reduce the number of poor farmers, and lead to equitable distribution of development results. Bureau Central de Estatística (BPS) do Municipio de Ermera. 2014.

Sustainable agriculture is also crucial approach to addressing global challenges related to food security, climate change, and environmental degradation. In the Ermera region, sustainable coffee-based farming practices, using polyculture systems on dryland watersheds, offer a potential solution to increase productivity, environmental health, and farmer resilience. This polyculture system combines coffee plants with shade crops such as bananas and avocados, which maintain soil moisture, reduce erosion, and enhance biodiversity and land use efficiency.

The agricultural context of Ermera, coffee-based polyculture practices demonstrate superior yields compared to monocultures, especially in dry conditions. This aligns with agroecological principles that emphasize the importance of crop diversification to improve productivity and watershed management. This study used qualitative and quantitative methods, including random sampling, surveys, interviews, and data analysis using Excel and SPSS, to assess the income and sustainability of 150 farmers in the region.

The results indicate that polyculture not only increases productivity but also improves watershed management. However, several key barriers remain, including farmers' limited technical knowledge and weak institutional support. Therefore, sustained policy support and training are essential to maximize the ecological and economic benefits of this practice.

Coffee-based polyculture in the Ermera dryland watershed offers a viable pathway to sustainable agriculture, increasing incomes, conserving ecosystems, and enhancing food security. Successful implementation of this practice depends heavily on capacity building, institutional support, and supportive policies to expand benefits across the region. Recommendations include targeted extension services and regular training on polyculture techniques, soil conservation, and water management.

Developing policies and incentives to support agroecological practices and access to markets is also crucial. Strengthening farmer cooperatives to increase bargaining power and knowledge sharing, facilitating access to finance for smallholder farmers to invest in diverse crops and sustainable inputs, and promoting research and monitoring to adapt polyculture models to local conditions and measure long-term impacts are all strategic steps that must be taken.

Minimize the use of inputs (seeds, chemical fertilizers, pesticides, and fuel) from outside the ecosystem in the long term. Sustainable agriculture will lead to the use of environmentally friendly biological products and can maximize the social benefits of biological resource management while maintaining the productivity and efficiency of agricultural commodity production, maintaining the quality and productivity of the environment. resources in a sustainable manner. Salikin, 2003

LITERATURE REVIEW

Dryland Farming: Drylands are characterized by limited rainfall and long dry seasons, which impact water availability and soil fertility (FAO, 2020). Coffee Polyculture: Polyculture is a cultivation system that integrates various types of crops on a single plot. In the context of coffee, shade plants such as lamtoro and bananas help maintain soil moisture and reduce erosion (Smith et al., 2019). Sustainable agriculture emphasizes resource efficiency, environmental conservation, and the economic sustainability of farmers (Altieri, 1995).

RESEARCH METHODS

This research was conducted in the municipality of Ermera in two different sub-districts: Ermera and Railaku, with three villages: Estadu, Tokoluli, and Lihu, in the municipality of Ermera, Timor-Leste. This research focused on the implementation of coffee polyculture systems, dryland management, natural resource conservation, improving farmer welfare, and sustainable agricultural strategies. This research was limited to landowners. Primary data were collected through interviews and observations, while secondary data were obtained from government sources and previous research. The questionnaire consisted of a series of questions answered directly by respondents. Camera and Recorder: Used to record interviews at the research site. GPS device: Used to record the specific location of coffee plantations and map the research area. Notebooks were used to note important things, make lists, plan schedules, or store other important information. Stationery is very important in the process of writing, drawing, or taking notes. Census was used as a method of collecting data from all farmers. The total number of farmers in this study, after proportional allocation, was 150 people. The distribution of farmers consisted of 50 respondents from Estadu Village, 50 respondents from Tokoluli Village, and 50 respondents from Lihu Village. Data management was carried out using MS Excel and SPSS for data distribution visualization to describe data from all coffee income and production, mixed crops with several variables: farmer name, age, gender, residence, and livelihood. Descriptive analysis was used to calculate the mean, median, and standard deviation.

RESULTS AND DISCUSSION

1) Interaction of cropping patterns with agricultural extension on community plantations at the research site

In recent decades, sustainable agricultural practices have become a major focus in global efforts to address the environmental and social challenges facing the agricultural sector. One approach gaining increasing attention is the use of polyculture systems in agriculture, particularly in dryland coffee plantations. In the Ermera watershed, this practice offers significant potential for improving agricultural productivity and sustainability. However, to fully understand the benefits and challenges of this approach, it is important to explore the interaction between cropping patterns and agricultural extension services on smallholder farms.

The results of the interaction between cropping patterns and agricultural extension services on smallholder farms indicate a significant positive relationship between the two variables. This is demonstrated by the Cartesian diagram, which depicts the abscissa and ordinate coordinates of the coordinates, with frequency ratios of 120%, 14%, 9%, and 7%. When associated with the analysis of variance table and evaluation of soil physical properties in monoculture and polyculture land use, the highest score achieved was 120%, indicating yes, and the lowest was 7%, indicating no. This indicates that the majority of the community perceives a positive relationship between cropping patterns and agricultural extension services, and those who responded no indicate minimal or no resistance to the relationship between the two variables.

Research by Rajab Alfaredzi Syakur Khairullah (2022) supports this finding by stating that improved soil structure quality can result from polyculture land use. The average increase in organic matter yields was higher in polyculture compared to monoculture, which showed lower average yields. In this context, the use of polyculture systems in dryland coffee plantations in Ermera could provide an effective solution to improve soil quality and overall agricultural productivity.

Furthermore, sustainable agricultural practices must also consider the challenges faced by smallholder farmers, including limited access to appropriate agricultural knowledge and technology. Agricultural extension services play a crucial role in bridging this gap by providing the information and training necessary to adopt more sustainable agricultural practices. Effective interaction between cropping patterns and agricultural extension services can help farmers optimize their land use and increase yields.

However, despite the numerous benefits to be gained from the use of polyculture systems, challenges remain. One of these is the need to develop more effective and targeted extension strategies that can be tailored to local conditions and the specific needs of farmers. Furthermore, it is crucial to ensure that these sustainable agricultural practices are accessible to all farmers, including those in remote areas and with limited resources.

In this context, this study aims to further explore the potential of using polyculture systems on dryland coffee plantations in the Ermera watershed. By focusing on the interaction between cropping patterns and agricultural extension, this research is expected to provide deeper insights into how sustainable agricultural practices can be effectively implemented at the local level. Furthermore, this study aims to identify key factors that can support the adoption of sustainable agricultural practices by smallholder farmers, as well as the challenges that need to be addressed to achieve long-term sustainability.

2) Farmers plant various types of agricultural crops in one season by rotating them.

In recent decades, sustainable agricultural practices have become a major focus in global efforts to address the environmental and economic challenges facing the agricultural sector. One approach that has gained increasing attention is the use of polyculture farming systems, particularly in dryland coffee plantations. In the Ermera river basin, this practice has begun to be implemented as an alternative to increase agricultural productivity and sustainability. However, the implementation of this system still faces various challenges, including farmer knowledge, extension services, and land availability.

In particular, farmers in this region have begun implementing crop rotation, where they grow different types of crops in a single season by rotating them. Based on the available data, a frequency analysis revealed four categories of respondents: 49%, 68%, 30%, and 3%. Analysis of variance (ANOVA) results showed that the highest score was 68%, with 3-5 respondents stating "sometimes," and the lowest score was 3%, with respondents stating "never." This indicates that although crop rotation has begun to be implemented, consistency among farmers remains a challenge (Source: Abdul Karim Makarim et al., 2019).

Furthermore, the analysis shows that the implementation of crop rotation is still limited, depending on farmer knowledge, extension services, and land availability. Abdul Karim Makarim et al. (2019) emphasized that annual crop rotation is crucial for improving agricultural sustainability. However, inconsistent implementation indicates the need for improved extension and education for farmers to ensure this practice can be implemented effectively and sustainably.

In this context, this study aims to explore sustainable agricultural practices using alternatives based on polyculture coffee plantations in dryland areas in the Ermera river basin. This study will examine the extent to which polyculture systems can improve agricultural productivity and sustainability, and identify factors influencing their implementation. Therefore, this research is expected to make a significant contribution to the development of sustainable agricultural strategies in this region..

3) Good agricultural practices and how to care for agricultural crops

Based on the analysis of variance, the relationship between good agricultural practices and crop care practices, moment analysis, or correlation between the independent variable (X) and the dependent variable (Y), and data obtained from respondents showed relationships of 34%, 62%, 49%, and 5%. Based on the vertical analysis graph, the highest score was achieved by the second respondent, "sometimes" (3-5 times), with 62%, and the lowest score was 5%. The results indicate that the implementation of good agricultural practices remains inconsistent, in line with research findings that indicate that farmer awareness is quite high, but not yet followed by routine implementation in the field. Factors such as lack of training and access to information are major obstacles.

This is reinforced by Bariot Hafif et al. (2014), who used a descriptive qualitative research method. Production results from cropping patterns that utilize land consist of several categories: long-term, medium-term, and short-term.

4) Polyculture and monoculture farming patterns based on conservation in dryland farming.

The use of correlation analysis test by looking for the relationship between variables on the (X) axis with the (Y) axis variable and the graph is formed perpendicularly, namely the conservation-based polyculture and monoculture farming patterns in land farming of 29%, 70%, 40%, and 11%. Comparison of the results of the analysis of variance for each respondent shows that the highest results are sometimes achieved at 70% and the lowest results are not achieved at 11%. Comparison of the results of the analysis of variance shows that the conservation-based farming pattern in dry land.

Showing the results of the comparison in line with the accumulated results found that the application of the conservation pattern is still sporadic and not yet fully consistent among farmers. According to Sitorus et al. (2009), the plantation management model must be supported by biophysical conditions, human resources, and government.

5) Monoculture or polyculture crops and how do you know which ground cover crops to plant on your plantation?

Sustainable agricultural practices have become a major focus in global efforts to address the environmental and social challenges facing the agricultural sector. One approach gaining increasing attention is the use of polyculture systems in coffee plantations, particularly in dryland areas located along river basins, such as those found in Ermera, a municipality in Timor-Leste. Polyculture systems, which involve growing multiple crops in a single area, are considered a more sustainable alternative to traditional monoculture systems. In this context, it is important to explore how polyculture practices can be effectively implemented in coffee plantations in Ermera to achieve sustainable agriculture goals.

Specifically, this study aims to understand the relationship between farmers' knowledge of cropping patterns and cover crops and successful plantation management. Based on a correlation analysis, farmers' awareness of polyculture practices varied significantly. The analysis revealed that 19% of farmers were very aware, 111% were aware, 15% were somewhat unaware, and 5% were unaware of the importance of cropping patterns and cover crops in successful plantation management. This correlation confirms that farmers' knowledge plays a crucial role in determining the success of polyculture systems in coffee plantations.

In this context, it is important to highlight the differences between monoculture and polyculture systems. Monoculture systems, which involve the large-scale cultivation of a single crop, are often associated with various environmental problems, such as decreased soil fertility, increased pesticide use, and reduced biodiversity. In contrast, polyculture systems offer a variety of benefits, including increased soil fertility, reduced pesticide use, and enhanced biodiversity. Therefore, understanding how to select the right cover crops for plantations is a crucial step in implementing effective polyculture systems.

This is reinforced by Arinda Eka Putri, who stated that monoculture and polyculture agriculture are crucial sectors for human life, particularly in maintaining food security, including the availability of medicines, industrial materials, feed, and other necessities.

This research focuses primarily on dryland coffee plantations in the Ermera watershed. This area was chosen due to its unique geographic and climatic characteristics, which present unique challenges in plantation management. By utilizing polyculture systems, it is hoped that sustainable solutions can be found to address these challenges, while simultaneously increasing the productivity and sustainability of coffee plantations in the area.

6) Farmers implement agricultural patterns that can increase coffee production by adding organic matter to the soil.

Farmers implement agricultural practices that can increase coffee production by adding organic matter to the soil. This is demonstrated by the frequency graphs for each vertical and horizontal measurement, with cumulative statistical analysis results showing: very knowledgeable 17%, knowledgeable 114%, less knowledgeable 16%, and unaware 3%. Thus, the highest yields were achieved at the knowledgeable level of 114%, and the lowest at the unaware 3% level.

The results indicate that the application of agricultural patterns that add organic matter increases coffee production. This finding aligns with research analysis that emphasizes the importance of farmer knowledge in sustainable agricultural practices to increase yields. This is reinforced by Bambang Prastowo et al. (2014), who stated that land for plantation commodity businesses is generally dryland with low crop productivity.

7) Farmers' participation in maintaining environmental sustainability in coffee plantation areas by maintaining ground cover.

From the frequency comparison graph above, each cluster of points in the coordinate comparison graph corresponds to the results of the statistical accumulation analysis of respondents who stated: "very aware" (14%), "aware" (88%), "somewhat aware" (28%), and "don't know" (20%). Through the results of the confirmatory variance analysis, 88% of respondents reported knowing, with the lowest score being "very aware" (14%).

The results of the confirmatory variance analysis indicate that farmer participation in maintaining environmental sustainability in coffee plantation areas by maintaining soil cover must be in line with farmer knowledge in supporting sustainable environmental conservation practices, which is crucial for maintaining environmental sustainability in coffee plantations, particularly in land cover management. This is reinforced by previous research by Domingos CBB Gomes (2024) regarding farmers' perspectives on the environmental impacts of chemical fertilizer use in the Municipality of Ermera, including their awareness of soil, water, and ecosystem quality.

8) The advantages of polyculture and monoculture farming patterns in crop rotation.

The analysis of variance between the advantages of polyculture and monoculture farming patterns in crop rotation indicates an interaction, connected by a frequency comparison graph between two points X and Y on each comparison graph. The cumulative statistical analysis of respondents indicated that 14% were very knowledgeable, 108% were knowledgeable, 17% were not knowledgeable, and 11% were not knowledgeable at all.The highest cumulative statistical analysis showed 108% were knowledgeable, and the lowest was 11% not knowledgeable at all.

The cumulative statistical analysis results showed that respondents with both knowledgeable and not knowledgeable levels differed, confirming that farmer knowledge significantly influences the implementation of effective and sustainable cropping patterns.

The above results are supported by a study by the University of Kansas (2024): Jim Bever et al. showed that polyculture crop rotation helps control soil pathogens and maintains more stable and healthy crop productivity compared to monoculture.

9) Recognize dryland farming and what ground cover plants are available on your plantation.

Dryland farming is the cultivation of crops on land lacking water. This can be demonstrated by the frequency comparison graphs in each comparison chart, with cumulative statistical analysis results indicating that carica plants accounted for 6%, lamtoro trees for 36%, tobacco for 5%, and casuarina trees for 103%.

Therefore, the highest yields were achieved by casuarina trees (103%), and the lowest yields were achieved by tobacco (5%). The highest yields were achieved by casuarina trees (103%), and the lowest yields were achieved by tobacco (5%). The results show that casuarina trees are more widely known and commonly used as cover crops in dryland areas due to their ability to retain moisture and prevent erosion, compared to crops like tobacco, which are less effective in conservation functions.

These results are supported by Nzeyimana et al. (2021), who showed that the use of cover crops such as peanuts and sun hemp (Crotalaria juncea) between coffee rows significantly reduced soil loss, with an estimated 28% reduction in erosion.

10) Implement conservation measures in dryland farming with any kind of organic agricultural materials on your plantation.

These soil and water conservation efforts are crucial for the future, as land degradation has been demonstrated in various research areas, resulting in decreased soil productivity and water quality, primarily due to erosion and runoff. This is demonstrated by the frequency comparison graph between vertical and horizontal angles for each comparison. The statistical accumulation analysis shows that organic fertilizer yields 101%, urea 6.0%, tobacco 36%, and red potatoes 7%.

The analysis shows that the highest accumulation was achieved with organic fertilizer at 101%, while the lowest was achieved with urea at 6.0%. This finding aligns with the fact that organic fertilizers are more effective in supporting soil conservation and dryland fertility than chemical fertilizers such as urea.

This is reinforced by research conducted by Citarum, Indonesia (2018–2019), which showed that combining coffee and habanero chili peppers with organic fertilizers resulted in the best vegetative growth, optimal nutrient content, and the highest income from intercropping.

11) The extension on what form mulch is usually used in your area.

The accumulated results of the mulch extension program are illustrated with a frequency comparison graph between vertical and horizontal angles at each position. Statistical analysis shows that barrier plants contribute 61%, soil-fertilizing plants 25%, water supply 46%, and weed control and rainwater utilization contribute 18%.

Thus, statistical analysis shows that barrier plants provide the highest contribution of 61% and the lowest is weed control and rainwater utilization which contribute 18%. This finding is in line with research results that show that barrier plants are better known and applied as a form of natural mulch, while other aspects such as rainwater utilization are still not optimally utilized by farmers. Strengthened by research by Wiganda et al. (1992–1993) at IPB on the comparison of mulch types (corn, gamal, vetiver) and their dosages, it was found that vetiver and galiricidia are most effective in suppressing evaporation.

12) Typical plants found around coffee plantations that are usually very difficult to replace in crop rotation on your plantation.

The results of the extension of indigenous plants around coffee plantations can be demonstrated by comparing frequency graphs in each graph, with the results of the cumulative statistical analysis indicating that cabbage accounted for 29% of the total number of plants, leeks for 44%, tobacco for 42.0%, and potatoes for 35%.

From the confirmatory analysis of variance (AVA) table, the highest value was achieved for leeks at 44%, and the lowest value was achieved for cabbage at 29%. This finding aligns with research findings that leeks respond more strongly to treatment than cabbage. This finding is supported by Helder Lains E. Silva (1956), who stated that there are two important indigenous plants that are very difficult to replace in traditional polyculture coffee farming practices in Ermera: Albizia moluccana and Casuarina junghuniana, both of which have been used since colonial times and have vital ecological functions.

13) Agricultural conservation methods do you often use to make your own organic materials.

Conservation agriculture methods often produce their own organic matter. This is demonstrated by the comparison graph between X and Y, which shows the difference in the amount of organic matter naturally produced by each conservation method. This is evident from the cumulative statistical analysis of respondents, which shows that 58% of respondents reported frequent use, 68% reported occasional use, 11% reported infrequent use, and 17% reported never use. The highest yield was achieved by 68%, while the lowest yield was achieved by 11%, rarely.

This aligns with research findings showing that more frequent treatments tend to produce more optimal results. The above findings, supported by Marguerite Cogné & Guillaume Lescuyer (2024), who mapped agroforestry practices in Timor-Leste, demonstrating the effectiveness of integrating trees with other crops in maintaining soil fertility, improving soil structure, and reducing erosion.

14) Mulching the most effective and efficient method to increase the harvest yields of local residents

The effect of mulch use on increasing crop yields can be demonstrated by variable X (Abscissa): the type of conservation method used by the population, specifically mulch use (organic mulch such as straw, dry leaves, litter, or plastic mulch). Variable Y (Ordinate): The results of the cumulative statistical analysis

showed that 33% of respondents stated that it was very influential, 61% that it was influential, 31% that it was somewhat influential, and 25% that it was not influential.

Therefore, 61% of the results indicated an influence, and the lowest yield achieved was 25%, with no influence. The cumulative statistical analysis showed that the categories "very influential" and "not influential" were categorized. This finding is supported by the analysis results, which indicate that these variables do indeed have a significant influence on the observed results.

The discussion above is reinforced by Wei Qin et al. (2015), who conducted a meta-analysis of 1,310 observations from 74 studies in 19 countries, found that soil mulch (either plastic or straw) can increase crop yields, water efficiency, and nitrogen efficiency by up to 60% compared to no mulch.

15) Methods that have been implemented by the community, such as planting pepper as a ground cover crop.

How to plant chili peppers as a ground cover crop. This can be demonstrated using the x variable (abscissa). The frequency of each graph is shown with the results of the cumulative statistical analysis of respondents who stated "Yes" (47%), "No" (49%), "Don't know" (24%), and some answered "Yes" (30%). Therefore, the confirmatory variance analysis table shows that the highest percentage was 49% and the lowest result was "Don't know" (24%). Respondents provided the highest confirmation due to a good understanding of what was happening according to the variable, while those who stated "Don't know" due to a lack of information, according to the findings.

The above results are supported by Marguerite Cogné & Guillaume Lescuyer (2024), who describe various traditional agroforestry systems in Timor-Leste, such as home gardens, fields and cropping intervals (crop fields and fallow), as well as young agroforestry, forest gardens, and silvopastoral, with pepper as a ground cover crop.

16) Beyond Ridges Economic and Ecological Reasons Mechanical Methods Aren't Preferred

Mechanical methods as the primary choice for dryland agricultural conservation can be demonstrated by the variables in the X (Abscissa) analysis, namely the mechanical conservation methods used in the construction of ridges. The Y (Ordinate) variable, based on the results of the cumulative statistical analysis, shows: 18% are very knowledgeable, 60% are knowledgeable, 46% are somewhat knowledgeable, and 26% are not knowledgeable. Thus, the highest level of knowledge is 60%, and the lowest level is not knowledgeable, at 26%.

The analysis results indicate that farmers are both knowledgeable and not knowledgeable. Despite the relatively high level of knowledge, farmers do not choose mechanical methods as their primary choice for dryland conservation using ridges due to limitations in cost, labor, and access to mechanical equipment. This is consistent with research showing that farmers tend to choose conservation methods that are simpler, less expensive, and more suited to local conditions.

17) Innovative Terracing Approaches on Coffee Plantations by Community, Design, and Policy Tools.

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18) Terms of costs, what is the most efficient method for agricultural management.

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19) Conservation measures in farming.

The influence of conservation measures on yield and land quality in farming can be shown by variable X (Abscissa), and Variable Y (Ordinate), the impact on yield and land condition, is the dependent variable influenced by conservation measures. The results of the respondent analysis are in accordance with the accumulated statistics which state: always (every farming) as much as 59%, Often (more than 5 times) as much as 29%, sometimes (1-3 times) as much as 38% and never as much as 24%.

The confirmatory variance analysis table with a comparison of results can be obtained in the answer always (every farming)

always (every farming) as much as 59% and the smallest results were obtained in the answer never as much as 24%. The confirmatory variance analysis table shows that always carry out conservation measures when farming, while never doing it. This is in line with the results of the analysis which states that most farmers are starting to realize the importance of land conservation, although there are still those who have not implemented it consistently.

20) Common Soil-Stabilizing Materials Used by Residents

Residents' use of plants as soil stabilizers on agricultural land can be demonstrated by the X (abscissa) and Y (ordinate) variables, which are the dependent variables influenced by the use of vegetation by residents. Based on the results of the cumulative statistical analysis of respondents, it was stated that urea fertilizer was used at 21%, manure at 33%, and compost at 51%, with all correct responses at 45%.

From the analysis of variance table, confirming the results by comparison, compost fertilizer achieved the highest percentage at 51%, and urea fertilizer achieved the lowest percentage at 21%. The analysis of variance table shows that compost fertilizer is most frequently used as a soil stabilizer, while urea fertilizer is used the least.

These results align with the cumulative table results, which indicate that farmers prefer compost fertilizer because it is more environmentally friendly, affordable, and effective in improving soil structure compared to chemical fertilizers like urea. This finding is reinforced by the planting of slope-stabilizing trees. Under the UNDP GCF project (currently ongoing since 2020), Ermera residents have planted numerous pine and mahogany trees on slopes to protect the land from landslides. This planting has proven effective in strengthening the soil and increasing stability on sloping land.

CONCLUSION AND SUGGESTIONS

1) Conclusion

a) Sustainable agricultural practices have become a major focus in global efforts to address the environmental and social challenges facing the agricultural sector. One approach gaining increasing attention is the use of polyculture systems in coffee plantations, particularly in dryland areas located along river basins, such as those found in Ermera, a municipality in Timor-Leste. Polyculture systems, which involve growing multiple crops in a single area, are considered a more sustainable alternative to traditional monoculture systems. In this context, it is important to explore how polyculture practices can be effectively implemented in coffee plantations in Ermera to achieve sustainable agriculture goals.

b) Based on a correlation analysis, farmers' awareness of polyculture practices varied significantly. The analysis revealed that 19% of farmers were very aware, 111% were aware, 15% were somewhat unaware, and 5% were unaware of the importance of cropping patterns and cover crops in successful plantation management. This correlation confirms that farmers' knowledge plays a crucial role in determining the success of polyculture systems in coffee plantations.

c) To highlight the differences between monoculture and polyculture systems. Monoculture systems, which involve the large-scale cultivation of a single crop, are often associated with various environmental problems, such as decreased soil fertility, increased pesticide use, and reduced biodiversity. In contrast, polyculture systems offer a variety of benefits, including increased soil fertility, reduced pesticide use, and enhanced biodiversity. Therefore, understanding how to select the right cover crops for plantations is a crucial step in implementing effective polyculture systems.

d) This research emphasized on dryland coffee plantations in the Ermera watershed. This area was chosen due to its unique geographic and climatic characteristics, which present unique challenges in plantation management. By utilizing polyculture systems, it is hoped that sustainable solutions can be found to address these challenges, while simultaneously increasing the productivity and sustainability of coffee plantations in the area.

e) Adopting polyculture in Ermera's dryland coffee plantations can improve soil health, reduce input costs, enhance biodiversity, and stabilize farmer incomes. Focused training, appropriate species selection, soil and water conservation, market linkages, and inclusive institutional support will be essential to convert farmer awareness into sustained practice and long-term landscape resilience.

2) Recommendation

1. Farmer training and extension

- Prioritize practical training on cropping patterns, cover-crop selection, and polyculture management, targeting the 20% of farmers with low awareness.
- Use demonstration plots and farmer-to-farmer exchanges to show benefits (soil fertility, pest suppression, yield stability).
- Provide simple, illustrated guides in Tetum and Portuguese.

2. Cover-crop and intercrop selection

- Choose drought-tolerant, locally adapted species that fix nitrogen, conserve moisture, and support coffee: e.g., leguminous cover crops (Desmodium, Mucuna, Crotalaria), deep-rooted grasses for erosion control, and native shrubs/trees for shade.
- Prioritize species that provide multiple benefits: soil improvement, fodder, green manure, or marketable products (e.g., chili, banana, medicinal plants).

- Test and phase new species in small plots before large-scale adoption.

3. Spatial and temporal cropping patterns

- Promote alley cropping and multi-strata systems: shade trees + coffee + understory cover crops.
- Use contour planting and vegetative strips along riverbanks to reduce erosion and protect water quality.
- Rotate cover crops with fallow periods or incorporate green manures during the coffee tree establishment and low-yield seasons.

4. Soil and water conservation

- Practice mulching with pruned biomass and cover-crop residues to conserve soil moisture and suppress weeds.
- Build simple water-harvesting and infiltration structures on slopes (check dams, terraces) to reduce runoff and recharge soils.
- Protect riparian zones with native vegetation buffers to stabilize banks and filter runoff.

6. Seedling and nursery management

- Establish community nurseries for shade trees, cover-crop seed, and high-quality coffee seedlings.
- Train farmers in nursery techniques and proper timing for interplanting and shade establishment.

8. Institutional support and policy

- Encourage municipal and national agricultural services to include polyculture extension in coffee development plans.
- Provide targeted incentives (seed/seedling subsidies, technical support) for adoption in fragile dryland areas.
- Facilitate partnerships with NGOs, research institutions, and donor programs for long-term support.

9. Monitoring, evaluation, and adaptive management

- Set up simple farmer-managed monitoring indicators: soil cover, erosion signs, coffee yield, pest incidence, and income changes.
- Use participatory evaluation to adapt practices to local conditions and scale successful models.
- Document successes and challenges to inform wider adoption across Ermera and other watershed areas.

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