The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 3 | Issue 2 | February 2025
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Performance and Determinants of Arecanut-Based Mixed Cropping System in Mizoram: A Field Based Investigation

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ARTICLE DETAILS

Research Paper

Accepted: 28-02-2025

Published: 14-03-2025

Keywords:

Arecanut cultivation, Farmer's livelihood, Mixed cropping, Soil health, Sustainable agriculture

ABSTRACT

The arecanut-based mixed cropping system is a traditional and sustainable agricultural practice adopted in Mizoram due to its ecological and economic benefits. This paper investigates the performance and determinants of arecanut-based mixed cropping systems through a field-based investigation in Mizoram. Data were collected from 300 farmers across two districts (Kolasib and Mamit) in four villages; Bilkhawthlir, Vairengte, Kawrthah and Zamuang, focusing on crop combinations, yield, income, and labour efficiency. The results revealed that integrating crops like stink beans, climbing wattle, fruits, and vegetables significantly enhanced farm productivity of upto ₹44,000 as the average revenue. It further suggested that, considering the local demands and duration of crops, teak, rubber, oil palm, coffee and broom grass could be profitably incorporated as a mixed crop in the study areas. However, challenges such as labour intensity, market access, and knowledge gaps were identified as constraints. The study highlights the potential of arecanut-based mixed cropping systems to promote sustainable agriculture, improve livelihoods, and ensure food security. Policy interventions, such as farmers training, awareness programme, etc are recommended to enhance the adoption and performance of this system, as well as providing valuable insights for aiming to optimize arecanut-based

mixed cropping systems in similar agro-ecological regions.

DOI : https://doi.org/10.5281/zenodo.15065481

I. Introduction

One of the most significant commercial plantation crops in the world is the arecanut (Areca catechu). It is a seed that comes from the areca palm and is most commonly consumed in dried and fresh forms. It is also known as "betel nut." Although the actual origin is unknown, some historical and epigraphic documents indicate that the first known cultivators were from Indonesia, and then came people from various regions of South Asia, Southeast Asia, and the Philippines. The Pacific Ocean and East Africa have both seen extensive use of it. Arecanuts have likely been consumed for at least 4,000 years, according to archaeological findings from Thailand and Indonesia. Arecanuts were first consumed in India in the 16th century, during the early Gupta era, when they were fused into other foods. Its popularity increased steadily, and it became one of the most important cash crops grown in India.

One of the advantages of planting arecanut is that mixed-cropping is possible. Arecanut normally required five to eight years for bearing fruits and during those periods, the cultivator grows different fruits and vegetables in the same field which can supplement their income. Most of the crops suitable for inter- cropping were banana, pepper, citrus, betel vine, pineapple etc. In the arecanut field, it was observed that around 30% of the land area is utilised by the main crop and the remaining 70% can be used for mixed-cropping.

The long pre-bearing period, low returns during the initial bearing period, fluctuation in market prices, unexpected loss due to pests and diseases are some of the problems associated with the cultivation of arecanut. Considering that only 5% of the arecanut fruit growing tree leads to seed growth, the time required for the cultivation of arecanut and weather stipulations put a restraint on the market growth. This limits the market growth at the farmers end.

Introduction of mixed cropping pattern in arecanut gardens aimed at increasing the net returns from unit area which helps the farmers to withstand the fluctuating prices of arecanut. It also has tremendous potential to generate employment for improving quality of rural life. It not only provides additional income; it can also act as a social security against instability of prices of the main crop. Therefore, establishing demonstration plots in an arecanut gardens helps to encourage many others to follow mixed cropping system for the improvement of their livelihood.

II. Materials and Methods

Data and Data Sources

Primary as well as secondary data sources were used for the study. Primary data was collected through interview and questionnaire methods from 300 respondents from the four villages; Bilkhawthlir, Vairengte, Kawrthah and Zamuang in the Kolasib and Mamit districts of Mizoram. With the help of comprehensive interview scheduled designed by the authors, data have been collected using convenience sampling method. Secondary sources were collected through unpublished research data, reports from the Arecanut Grower's society, Report of Horticulture Department, Government of Mizoram, as well as Statistical Abstract published by the Economics and Statistics Department, Government of Mizoram.

Sample Design

The study was conducted in the Kolasib and Mamit district as these districts are the only clusters where arecanut-based mixed cropping has been properly practiced in the state. Kolasib district is the smallest district among the eleven districts of Mizoram state. The district is bounded on the north and northwest by Hailakandi district of Assam state, on the west by Mamit district, on the south and east by Aizawl district and on the northeast by Cachar district of Assam state. The district occupies an area of 1382.51 km². The district has two R.D. Blocks: Bilkhawthlir and Thingdawl consisting of 31 villages. Bilkhawthlir, Thingdawl, Buhchangphai, Vairengte, Bairabi and Rengtekawn are the villages in Kolasib district where arecanut cultivators were found in abundance.

Kolasib is agriculture-dominated economy with a few service sector jobs. Due to its moderate climate owing to its tropical location, it is neither very hot nor too cold throughout the year, thus offers suitable condition for the cultivation of arecanut. Majority of the people in this region cultivate arecanut for their livelihood which is both consumed and exported to other districts within and outside the state, while a few number of people cultivate oil palms, rice, wheat and rearing fish.

Similarly, Mamit District is the fourth largest district in Mizoram, situated in the western part of the state bounded on the north by Hailakandi district of Assam state, on the west by North Tripura district of Tripura state and Bangladesh, on the south by Lunglei district and on the east by Kolasib and Aizawl districts. It has three revenue sub-divisions viz. Mamit, West Phaileng and Kawrthah and three

rural development blocks; Reiek, Zawlnuam and West Phaileng , comprises of 86 villages.

The economy is agro-based. About 51.7% of the populations are workers where 55.3% are males and 48.1% females, showing equitable participation of both males and females in workforce. Majority of the arecanut plantations are found in the northern part of the district like Bawngva, Tuidam, Kawrthah, Rengdil, Zamuang and Zawlnuam. These areas with low altitudinal range and warm climate favours the cultivationof arecanut. Few patches of the plantations are also found near Rawpuichhip and Tutphai (Dapchhuah) villages. The plantation of arecanut covers an area of 0.72 Sq. km, which accounts for 0.02% of the total area of the district. The agro-climatic conditions, fertile soil and abundant rainfall of these regions are favourable for horticultural crops like oranges, banana, rubber, oil palm, arecanut and vegetables like cabbage, cauliflower, tomatoes, leafy vegetables, ginger etc. There are also a few voluntary organisations and arecanut farmers' groups in this district who works for the overall development of the welfare of farmer's community.

Data Analysis

Simple statistical tools like ratios, percentages and proportions were used and analyse using descriptive statistics.

The following table highlights some of the details of mixed cropping systems in arecanut farm in the four sample villages of Mizoram; Bilkhawthlir ,Vairengte at Kolasib district and Kawrthah, Vairengte at Mamit district.

Details of mixed cropping system in the study areas

Table 1: Years of practising mixed cropping by the respondents

No. of Years	Kolasib District		Mamit District		All
	Bilkhawthlir	Vairengte	Kawrthah	Zamuang	
5-10yrs	6(6%)	4(4%)	4(8%)	10(20%)	24(8%)
10-15yrs	21(21%)	13(13%)	14(28%)	8(16%)	56(18.7%)
15-20 yrs	59(59%)	20(20%)	23(46%)	28(56%)	130(43.3%)
Above 20 yrs	14(14%)	63(63%)	9(18%)	4(8%)	90(30%)

Source: Field survey, 2024

Note: Figures in Parentheses are Percentages

From the table, it was observed that 130 respondents (43.3%) from the total of 300 practised arecanut-based mixed cropping over the last 15-20 years. About 30% practised the same over 20 years. The lowest experience group is 5-10 years (8%). I**n district wise distribution, in Bilkhawthlir** majority (59%) have **15-20 years** of experience while in **Vairengte the** highest proportion (63%) have **above 20 years'** experience. **Kawrthah village has** 46% falls in **15-20 years** category, 28% in **10-15 years. Zamuang** is the most experienced village, with **56% having 15-20 years**, and **20% having 5-10 years. It can be revealed that most farmers (73.3%) have at least 15 years of experience. Vairengte (63%) has the most highly experienced farmers and Zamuang has the highest share of new farmers (20%) with 5-10 years).** This evidence clearly suggests that mixed cropping has been practised over a long period of time and utilised for income supplementary in the study areas.

Table 2: Details of the type of crops cultivated

Types of crop cultivated	**Kolasib District**		**Mamit District**		**All**
	Bilkhawthlir	**Vairengte**	**Kawrthah**	**Zamuang**	
Vegetables, fruits and betel vines	63(63%)	37(37%)	22(44%)	39(78%)	161(53.7%)
fruits and vegetables	35(35%)	50(50%)	27(54%)	11 (22%)	123(41%)
Broom grass	0	11(11%)	0	0	11(3.7%)
Teak	0	2(2%)	0	0	2(0.7%)
Rubber, oil palm, coffee	2(2%)	0	1(2%)	0	3(1%)

Source: Field survey, 2024

Note: Figures in Parentheses are Percentages.

It was observed that different vegetables like **stink beans, climbing wattle, Alocasia fornicate,** East Indian glory bower, snowflake plant, Pithraj tree and pumpkin plant as well as betelvines plant are the most widely cultivated category, with **161 instances (53.7%)** across all study areas; the highest in **Zamuang (78%) and the** least in **Vairengte (37%). Fruits and vegetables alone** are the second most common, making up **41% (123 instances)** of total crops, highest in **Vairengte (50%) and the** least in **Zamuang (22%), whereas minor crops like Broomgrass** is only found in **Vairengte (11%)**, making up **3.7%** of the total crop distribution. **Fruits like** pineapple, oranges, banana, jackfruits, mango, litchi, papaya, lime, guava etc are mostly grown. **Teak** is minimally grown, appearing only in **Vairengte**

(2%), contributing to **0.7%** of the total. **Rubber,oil palm and coffee** are rarely cultivated, with only **3 instances (1%)**, distributed among Bilkhawthlir and Kawrthah.

Bilkhawthlir & Zamuang focus primarily on mixed crops, **Vairengte** and Kawrthah has a more balanced distribution of fruit & vegetable farming with some broom grass and teak. Thus, it can be analysed that the primary crops cultivated under mixed cropping system across the study areas are **fruits and vegetables along with betel vines plants** with secondary emphasis on **fruits & vegetables alone**.**Broom grass, teak, rubber, and oil palm** are grown on a much smaller scale. **Zamuang appears to have the highest specialization in a single category (78% in mixed crops), whereas Vairengte shows more crop diversity.**

Table 3: Village wise break down on whether mixed farming provides sufficient income to the respondents

Village	Yes (%)	No (%)	Observation
Bilkhawthlir	24	76	Income is largely insufficient.
Vairengte	63	37	Majority find mixed farming sufficient
Kawrthah	42	58	More people find mixed farming insufficient.
Zamuang	74	26	Most people find mixed farming sufficient.

Source: Field survey, 2024

Note: Figures in Parentheses are Percentages.

The table presents data on whether mixed farming provides sufficient income in the four villages. It was observed that 48.3% (145 respondents) said mixed farming provides sufficient income while 51.7% (155 respondents) said it does not. This suggests a nearly equal split, with slightly more people (51.7%) finding mixed farming insufficient for income. Zamuang has the highest satisfaction (74%) regarding the mixed farming income, followed by Vairengte (63%). This suggests that there is more profitable or sustainable farming in these villages, and there is a possibly better crop selection, suitable of soil for crops, better market access etc whereas Bilkhawthlir has the highest dissatisfaction (76%), indicating the lower profitability or market access and there is a possible challenges with land productivity or expenses. Income satisfaction varies significantly among the villages of which Zamuang and Vairengte have better mixed farming outcomes, while Bilkhawthlir struggles the most. This could be due to differences in crop types, market accessibility, land productivity, or support systems. Overall, mixed

farming is not a fully reliable income source for over half of the population (51.7%), suggesting the need for alternative livelihoods or improved agricultural policies.

Analysis of Average Annual Revenue from Mixed Cropping

The table presents data on the annual revenue generated from mixed cropping across four villages in **Kolasib and Mamit districts.**

Table 4: Overall Revenue Generated by the respondents

Revenue Range	**Respondents (%)**
₹10,000-₹ 50,000	78.3% (235)
₹ 50,100-₹ 1,00,000	18% (54)
₹ 1,10,000- ₹ 2,00,000	2.3% (7)
Above ₹2,00,000	1.3% (4)

Source: Field survey, 2024

Note: Figures in Parentheses are Percentages

It can be analysing that majority (78.3%) of farmers earn ₹10,000–₹50,000 annually, indicating that mixed cropping is a low-income-generating activity for the most. Only 3.6% farmers (11 respondents) had received higher than ₹1 lakh annually, which suggest that high-revenue farming is insignificant.

Calculation of Average Revenue:

To calculate the **average revenue** from the given table, midpoint values is assigned to each revenue range, multiplied by the number of respondents, and summed up the total revenue. Dividing this by the total number of respondents (300);

Average Revenue=Total Respondents/Total Revenue=3001, 31, 87,700/300= ₹43,959/-

Therefore, the **average annual revenue** is approximately **₹43,959**

Table 5: Village wise breakdown of the revenue generated

Village	₹10-50K (%)	₹50.1-1L (%)	₹1.1L-2L (%)	Above 2L
Bilkhawthlir	87%	12%	0%	1%
Vairengte	72%	21%	4%	3%
Kawrthah	78%	22%	0%	0%

Zamuang	74%	20%	6%	0%

Source: Field survey, 2024

Note: Figures in Parentheses are Percentages.

Similarly, the villages wise distribution of revenue generation with mixed farming is depicted in table 5 and shows that Bilkhawthlir village registered the highest share (87%) of farmers in the lowest income group which reveals that most farmers struggle with low revenue while Vairengte has the most diverse income distribution, with 3% earning above ₹2 lakh and 4% earning ₹1.1-2 lakh, indicating better revenue potential (more high-income farmers). Kawrthah and Zamuang lack high-income earners, while Zamuang has a small number (6%) in the ₹1.1-2 lakh range i.e. mid-range income is limited. Only Bilkhawthlir and Vairengte have farmers earning above ₹2 lakh annually, but the percentage is very low. Thus the data reveals **that f**arming improvement methods like better market access, higher-value crops, and improved techniques in all the selected villages needs to be practiced to enhance revenue.

Table 6: Details of reasons for practising mixed cropping

Reasons	Kolasib		Mamit		All
	Bilkhawthlir	**Vairengte**	**Kawrthah**	**Zamuang**	
To supplement the income	82(82%)	66(66%)	39(78%)	42(84%)	229(76.3%)
Hand out to friends & families	7(7%)	8(8%)	3(6%)	3(6%)	21(7%)
For subsistence	4(4%)	21(21%)	6(12%)	2(4%)	33(11%)
Practise as a family tradition	7(7%)	5(5%)	2(4%)	3(6%)	17(5.7%)

Source: Field survey, 2023

Note: Figures in Parentheses are Percentages.

The respondent's perception on the causes of practising mixed cropping across all selected villages is shown in table 6. The data indicates that majority of respondents (76.3%) have stated that they had practised mixed cropping to supplement their income, followed by 11% for subsistence needs, whereas there are 7% who practised the same to hand out friends & families. There are 5.7% who practised mixed cropping system as a family tradition. Among the villages, Zamuang (Mamit) has registered the highest percentage (**84%**) of practising mixed cropping to supplement the income, followed by

Bilkhawthlir (Kolasib) at **82%**, and Kawrthah (Mamit) at **78%**. Vairengte (Kolasib) has the lowest percentage (**66%**). **This study reveals that income generation is the dominant factor behind mixed cropping in both districts.**

Table 7: Details of labourers employed and wage rate (average)

Labour employed (Per Acre)	**Kolasib**		**Mamit**		**All**
	Bilkhawthlir	**Vairengte**	**Kawrthah**	**Zamuang**	
< 5 (Man Days)	13(13%)	54(54%)	35(70%)	24(54%)	126(42%)
> 5 (Man Days)	--	5(5%)	--	3(6%)	8(3%)
Wage rate per day (in ₹)	400	450	400	400	412.5

Source: Field survey, 2023

Note: Figures in Parentheses are Percentages.

Distribution of labour utilisation and wage rate is depicted in table 7. The data indicates that small-scale employment (1-5 labourers) is predominant across all selected villages, averaging 42%, highest in **Kawrthah (Mamit) at 70%**, followed by **Vairengte (Kolasib) and Zamuang (Mamit) of 54% each. Bilkhawthlir (Kolasib) has the lowest percentage (13%),** indicating a lower reliance on hired labour and utilising their family labour in all farm activities during the mixed farming. On the other hand**, labour absorption of more than 5 labourers is very insignificant and the overall is just 3% comprising of** 5% in Vairengte (Kolasib) and 6% in Zamuang (Mamit).There is no respondent reported in Bilkhawthlir (Kolasib) and Kawrthah (Mamit) who utilised more than 5 laboures in their mixed farming system during the study period.

Similarly, the wage distribution for the hired labourers in all selected villages indicates that the labourers use to get ₹ 400 per day in all farm activities involved in mixed farming except in Vairengte of which the labourers use to get a litter higher of ₹450 than their counterpart villages. Thus, it can be revealed that the hired labour absorption in all selected villages are less significant and most of the families utilising their own family labourers during the farm operations. One noteworthy observation was found during the survey that mixed cropping reduces the number of labours employed as well as the labour costs by combining tasks such as planting, weeding, and harvesting for multiple crops along with the arecanut field simultaneously.

III. Results

- The study finds that mixed cropping has been used for supplemental income in the studied areas for a considerable amount of time. It turns out that the majority of farmers (73.3%) have been engaged in mixed farming for at least 15 years. Zamuang has the largest percentage of new farmers (20%) with five to ten years of experience, whereas Vairengte has the most experienced farmers (63%).
- It can be analysed that fruits and vegetables, along with betel vine plants are the main crops grown in the studied areas under mixed cropping systems, with a secondary focus on fruits and vegetables alone. On a much smaller scale, oil palm, rubber, teak, and broomgrass are grown. While Vairengte exhibits the highest level of specialization in a single area, Zamuang seems to have the highest (78% in mixed crops).
- There are notable differences in income satisfaction between villages. Bilkhawthlir struggle the most, whereas Zamuang and Vairengte have superior mixed farming results. Variations in crop types, market accessibility, land productivity, or support systems may be the cause of this. For more than half of the population (51.7%), mixed farming is not a completely dependable source of income, indicating the need for better agricultural policies or alternate sources of income.
- Majority of farmers (78.3%) make less than ₹50,000 annually, indicating that mixed cropping is not very profitable. Significant economic diversity is found in Vairengte and substantial low-income farmers are found in Bilkhawthlir. Kawrthah is particularly impacted by the lack of high-income farmers. To increase revenue, farming improvements are required, such as enhanced practices, higher-value crops, and better market access etc.
- It can be determined that the primary driver of mixed cropping in both districts is income generating. Compared to Kolasib, farmers in the Mamit district particularly those in Zamuang rely somewhat more on mixed farming for their income. Compared to Mamit, food security is a more significant issue in Kolasib especially in Vairengte.
- The study also find out that Kawrthah has the largest percentage of small-scale employment (70%) and that it is the norm for workers ranging from 1 to 5. Only 8 respondents (3%) of large-scale employment (more than 5 labourers) were reported in all locales. Bilkhawthlir is notable since just 13% of it employs 1–5 workers, maybe depending more on mechanization or family labour.

IV. Discussion

For the successful implementation of the mixed cropping system in arecanut field as well as to enhance better productivity and generating more income for sustainable livelihood across the study areas, the following implications must be consider;

1. **Crop Selection and Planning**: Choose crops with complementary growth habits, nutrient requirements, and pest resistance and use crop rotation to prevent soil nutrient depletion and break pest and disease cycles.
2. **Integrated Pest Management (IPM)**: Combine biological, cultural, and mechanical pest control methods to minimize chemical inputs and introduce beneficial insects or trap crops to manage pests naturally.
3. **Soil Health Management**: Regularly test soil and apply organic amendments (e.g., compost, manure) to maintain fertility and use cover crops or green manure to prevent erosion and improve soil structure.
4. **Water Management**: Implement efficient irrigation systems (e.g., drip irrigation) to optimize water use and mulch the soil to retain moisture and reduce evaporation.
5. **Farmer Training and Support**: Provide access to training programs, extension services, and farmer cooperatives to share knowledge and resources and encourage peer-to-peer learning and community-based initiatives.
6. **Research and Innovation**: Invest in research to develop crop varieties and technologies tailored for mixed cropping system and promote the use of digital tools, such as mobile apps, for crop planning and monitoring.
7. **Policy and Institutional Support**: Governments and organizations should provide subsidies, incentives, and infrastructure support for mixed cropping systems and develop policies that promote sustainable agriculture and market access for diverse crops.
8. **Market Development**: Create value chains for mixed cropping products, including processing, packaging, and branding and establish farmer-market linkages to ensure fair prices and reduce post-harvest losses.

While mixed cropping systems present challenges, they offer significant benefits in terms of productivity, sustainability, and resilience. By addressing these challenges through strategic planning, farmer education, and supportive policies, mixed cropping can become a viable and sustainable

agricultural practice. Collaboration among farmers, researchers, policymakers, and market stakeholders is essential to unlock the full potential of mixed cropping systems.

V. Conclusion

Mixed cropping in arecanut fields can be regarded as one of the sustainable practice that maximizes land use efficiency and improves farm resilience. By selecting compatible crops and managing the system effectively, farmers can enhance productivity, soil health, and income while reducing risks. Proper planning and implementation is a key to the success of mixed cropping in arecanut plantations.

Acknowledgement

The authors would like to thank the households of the four sample villages in Kolasib and Mamit districts for their participation in the survey. Special thanks to the local authorities and field investigators for their support in data collection. We would also like to express our sincere gratitude to the Department of Economics, Mizoram University for their invaluable support and resources that made this research possible.

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