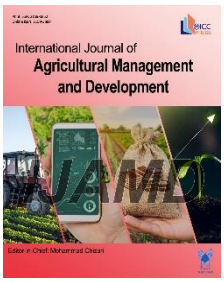

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Potential of Commercial Crops in Livelihood Sustainability in Mizoram, Eastern Extension of the Himalaya

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Abstract

Traditional agriculture remains the primary occupation and main source of livelihood in Mizoram. However, arable land is scarce, and crop production and productivity are low. This study explores the potential of commercial crops—fruits such as banana, grape, lemon, orange, and pineapple; spices such as ginger; and plantation crops such as betelnut, oil palm, and rubber—for enhancing livelihood sustainability in Mizoram, the eastern extension of the Himalaya. The study is empirical and is based on a case analysis of 16 villages, two from each of the eight districts. A purposive sampling method was used to select 1,527 households. A structured questionnaire was administered to household heads to gather information on commercial crops, their cultivated area, production levels, contribution to livelihood sustainability, and economic viability. Data were analyzed using descriptive statistics and correlation techniques. The results show that commercial crops offer strong economic viability along with notable environmental benefits. Although the area under these crops is limited, their production and productivity are comparatively high. They also demonstrate considerable potential for improving the livelihoods of rural households. Given Mizoram's ecological fragility and susceptibility to natural hazards, commercial crops—especially fruits and plantation crops—can play an important role in environmental conservation.

Keywords: Traditional agriculture; Commercial crops; Livelihood sustainability; Mizoram

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INTRODUCTION

India is the world's second-largest producer of commercial crops—fruits and vegetables—after China (Ministry of Food Processing Industries, 2024). The agricultural sector plays a crucial role in the socio-economic development and livelihood security of rural communities (Hochuli et al., 2021; Roshania et al., 2023; Sajeev et al., 2014). While this growth benefits medium- and large-scale farmers, marginal farmers continue to face food insecurity due to limited landholdings and low production. Their dependence on rainfed agriculture further intensifies this vulnerability (Rahman & Akter, 2014). Declining agricultural productivity driven by climate change (Grüter et al., 2022; Kumar et al., 2022), the slow adoption of modern farming practices (Ickowitz et al., 2019), and weak market infrastructure have pushed many farmers to shift from traditional subsistence crops to cash crops as a more sustainable livelihood option(Funk & Brown, 2009; Hashmiu et al., 2022). Marginal farmers believe that with adequate market support from government agencies, cultivating

cash crops would be more profitable than traditional agriculture (Aryal et al., 2020; Satisha, 2023; Yamane, 1973; Yeboah et al., 2023). Nonetheless, a large proportion of Indian farmers continue to grow food crops.

The sustainable livelihood approach outlines strategies for reducing poverty among disadvantaged populations (Natarajan et al., 2022; Scoones, 1998) and highlights the need to improve their overall quality of life (Li et al., 2020). It stresses the optimal use of various forms of capital—natural, physical, human, financial, and social. Livelihood strategies draw on these assets while also accounting for government support and the broader vulnerability context (Amekawa, 2011). A livelihood is considered sustainable when it can withstand shocks, use natural resources efficiently without degrading them, and create opportunities for future generations (Natarajan et al., 2022). (Li et al., 2020) noted that this framework is particularly effective for examining smallholder livelihoods. The decisions and innovations adopted by smallholders shape their livelihood strategies and ultimately lead to specific livelihood outcomes(Orsango et al., 2023).

A sustainable livelihood strategy refers to the means through which farmers and other individuals improve their living standards (Matiwane & Matiwane, 2023). One approach to achieving sustainable livelihoods is the effective use of skills and abilities to secure food, income, and essential assets(McLean, 2015). Various tactics may be employed to manage resources and meet individual goals (Rahman & Akter, 2014), making livelihood sustainability heavily dependent on people's engagement and capabilities. In regions with diverse and favorable agro-climatic conditions, agricultural intensification combined with the cultivation of commercial crops plays a central role in strengthening and sustaining livelihoods(Grafton et al., 2019). This approach enables even poor and marginal farmers to pursue livelihood sustainability (Habib et al., 2023). Commercial crops—including fruits, vegetables, and plantation crops—are economically profitable, environmentally beneficial, and contribute substantially to sustainable livelihoods. However, many of these crops are highly perishable and therefore require adequate market infrastructure and extensive cold-storage facilities. Countries with well-developed systems in these areas derive substantial economic gains from commercial crop production.

The state of Mizoram relies heavily on traditional crop cultivation and livestock farming for sustaining livelihoods (Sati, 2022). More than 70% of the population depends on agriculture and animal rearing, while arable land accounts for only 5.5% of the total geographical area (Sati, 2015). Shifting cultivation and wet rice cultivation are the two dominant agricultural systems. More than half of the available arable land is dedicated to shifting cultivation (Sati, 2019). Shifting cultivation, or Jhuming, follows a cyclical process that begins with cutting, clearing, and burning forest areas between December and February. Sowing takes place in March–April, followed by harvesting in October–November. After harvest, the land is left fallow before a new area is prepared for the next cycle. Historically, the fallow period lasted 20–25 years, but it has now shortened to 2–5 years (Sati, 2022). Typically, no more than two crops are grown in a single *Jhum* cycle. Rising population pressure, increasing variability in rainfall, temperature, and humidity, along with the inherently low production and productivity associated with shifting cultivation, have led to a reduction of more than 50% in the area under this practice over the past three decades (Sati, 2019). The movement of educated youth away from agriculture and into employment in the government and non-government service sectors has further accelerated this decline. Permanent agriculture covers a relatively small area. Within this system, wet rice cultivation is practiced in limited arable tracts along river valleys and small floodplains, such as Champhai (Sati, 2020). These areas have access to water for irrigating paddy fields. However, the output from wet rice cultivation remains low and is insufficient to meet the needs of the region's large and growing population.

Mizoram has rich agro-biodiversity and offers favorable conditions for cultivating commercial crops, particularly fruits, spices, and plantation crops (Singh, 2010). This study focuses on ten commercial crops: banana, grapes, mango, lemon, orange, and pineapple (fruits); ginger (spice); and betelnut, oil palm, and rubber (plantation crops). These crops were selected because of their high economic value and strong suitability to Mizoram's landscape and climate (Krishna, 2020). Despite this potential, their commercial value remains largely underutilized. Most of the produce is consumed locally, and a portion spoils before reaching any market (Soni et al., 2022), primarily due to inadequate market access and a lack of cold-storage facilities (Nongthombam et al., 2020). Consequently, marginal farmers cultivating these crops are unable to obtain adequate economic returns.

Although Mizoram has rich agrobiodiversity, crop area, production, and productivity remain extremely low. In addition, very few studies have examined commercial crops and their role in achieving sustainable livelihoods. This study is the first empirical, household-level investigation based on primary data. It assesses the potential of commercial crops for livelihood sustainability and identifies ways to improve their production and productivity. The study also highlights

the need for adequate market access and the establishment of cold-storage facilities. It recommends that the state government prioritize the promotion of sustainable commercial crop cultivation. Furthermore, it underscores the importance of community participation in harnessing the potential of these crops to support sustainable livelihoods for rural households in Mizoram.

Sustainable livelihood framework for commercial crops in Mizoram

A sustainable livelihood framework for commercial crops in Mizoram was developed (Figure 1), incorporating livelihood assets, transformation structures and processes, livelihood strategies, and livelihood outcomes. The framework includes five forms of livelihood capital: natural, human, social, physical, and financial. Mizoram has strong natural capital, characterized by fertile soils, a favorable agro-climatic setting, and abundant rainfall that supports crops such as ginger, orange, banana, betel nut, grape, lemon, oil palm, pineapple, and rubber (Krishna, 2020). Human capital consists of traditional farming knowledge, crop-cultivation skills, and access to training. Social capital includes farmers' cooperatives, government support programs, and community-based organizations. Physical capital covers road networks, storage facilities, processing units, and irrigation systems, while financial capital relates to access to credit, subsidies, and market connections for commercial crop producers. Government policies emphasize sustainable agriculture, financial support, and capacity-building initiatives. Institutions, market linkages, technology, and innovation act as key transformative structures and processes. Livelihood strategies such as diversification, value addition, and sustainable farming practices lead to outcomes including economic improvement, environmental stability, social well-being, and greater resilience.

METHODOLOGY

Study area

Mizoram, a state in Northeast India and the eastern extension of the Himalaya, shares international borders with Myanmar to the east and south and Bangladesh to the west. Within India, it is bordered by Tripura in the northwest, Assam in the north, and Manipur in the northeast (Figure 2). The state covers 21,087 km², of which 97% consists of hilly, undulating, and steep terrain (SSD, 2023). Forests cover about 86% of the area and support high biodiversity (FSI, 2019), while only 5.5% of the land is arable and used for both shifting and permanent cultivation. Mizoram has rich agro-biodiversity and a favorable climate, receiving an average annual rainfall of about 2,400 mm, mostly during the eight months of summer and the monsoon season. The average annual temperature is 22.5°C, but four months remain dry, creating significant water scarcity. The state grows two main categories of crops: WRC crops and crops under shifting cultivation. Traditional crops grown through shifting cultivation have low production and productivity. In contrast, commercial crops such as fruits, spices, and plantation crops hold strong potential for improving livelihoods, income, and the broader economy. However, due to limited irrigation infrastructure, most crops still depend on rainfall. Paddy, the staple crop, is cultivated under both WRC and shifting cultivation. Alongside these traditional systems, several high-potential commercial crops could substantially contribute to sustainable economic development and improved rural livelihoods.

Data collection and survey methods

Studying the potential of commercial crops for livelihood sustainability requires extensive empirical data. Because secondary data were unavailable, a case study of 16 villages across the eight districts of Mizoram—two villages per district—was undertaken. Villages were selected based on their proximity to the road head, population size, and economic activities. The variables were identified to understand how they influence the output of commercial crops. A household-level survey was conducted in 2022 using a purposive sampling method. A pilot study was first carried out to assess the status of commercial crops in each village, after which households were purposefully selected for data collection. Of the 2,010 households in the 16 villages, 1,527 were surveyed, representing 75.97% of all households. The survey was administered based on farmers' availability during village visits. Because many farmers were engaged in work away from home, surveying all households at once was not feasible, leading to variation in the number of surveyed households across villages. Differences in village population sizes also contributed to the variation in sample numbers.

The number of surveyed households across the selected villages varied, ranging from a maximum of 519 to a minimum of 35, with a mean of 95 households. The total village population was 7,480, with a maximum of 2,370 and a minimum of 193, and a mean of 467 persons. The sex ratio among the surveyed households was 976 females per thousand males, ranging from 1,070 to 854

(Table 1).

A structured questionnaire was used, focusing on the number of commercial crops, their area, and production. Additional questions addressed the inputs for each crop during sowing, nurturing, harvesting, and marketing. Questions regarding output from each commercial crop were directed to household heads. Data for these variables were collected for two periods—2014 and 2022. During the 2022 survey, the same set of questions was asked for 2014 to ensure consistency.

Data analyses

The data were analyzed using descriptive statistics, frequency percentages, Pearson correlation, index and level analysis, flow charts, and models. Productivity was calculated and used to assess the potential of commercial crops. Their economic value was estimated at current market rates and converted from Indian Rupees to United States Dollars. Input–output analysis was used to determine net benefits. Commercial crops were grouped into fruits, spices, and rubber plantations, and households cultivating these crops in the 16 villages were identified. For each household, area, production, productivity, and net benefits were calculated. Along with describing the area, production, and productivity of individual crops, the total area, production, and productivity of all commercial crops were assessed. Changes in these variables between 2014 and 2022 were also calculated.

Table 1. Descriptive statistics of total households and surveyed households (n=1527 HHs)

Variables	Mean	Maximum	Minimum
No. of HHs	126	735	35
Surveyed HHs	95	519	35
% of HHs	87	100	42.9
Population (people)	467	2370	193
Sex ratio	976	1070	854
Age (year)	50	60	40

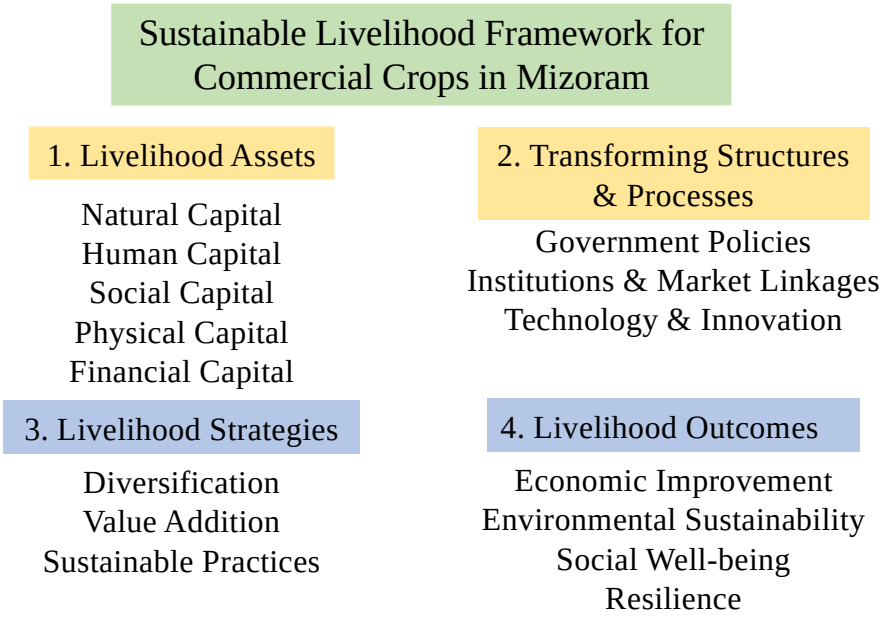

Figure 1. Sustainable livelihood framework for commercial crops in Mizoram

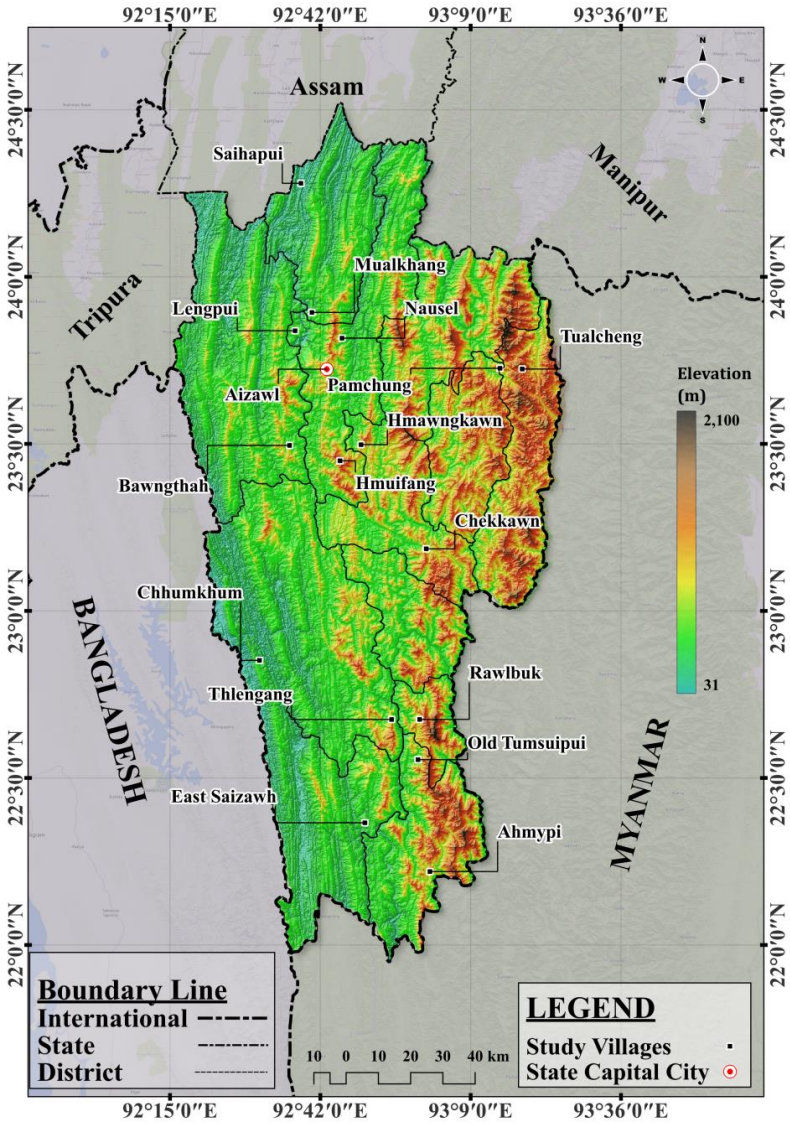

Figure 2. Location map of Mizoram state showing case study village

A Pearson correlation analysis was carried out for area and production, economic value and benefits, and production and economic value, all of which showed significant relationships. To reinforce the study, a sustainable livelihood framework for commercial crops was developed, complemented by a flowchart outlining the overall study process. A map of Mizoram was prepared to locate the case study villages, and empirical data were presented through graphical illustrations. The flowchart (Figure 3) depicts the introduction and methodology, the role of commercial crops—fruits, spices, and plantation crops—and their livelihood contributions in terms of income, employment, and livelihood opportunities. It also identifies major challenges such as limited market access, climate variability, inadequate storage, and transport constraints. The flowchart includes the role of state government and institutional support through subsidies, training, and research and development. Finally, it highlights the future prospects for commercial crops, focusing on sustainable practices, market expansion, and improved irrigation.

RESULTS

This section is organized into two parts: (1) the status of commercial crops in Mizoram and (2) their potential. The empirical findings are presented in detail.

Status of commercial crops in Mizoram

This presets a detailed account of the status of commercial crops in Mizoram, including crop classification, village-wise distribution, and the area, production, and productivity of key crops, along with changes recorded over the eight-year period. It also includes input-output analysis and the economic value of each commercial crop.

Table 2. Classification of commercial crops

Types	Major crop under each type
Fruits	Banana, Grapes, Mango, Lemon, Orange, and Pineapple
Spices	Ginger
Plantation crops	Betelnut, Oil palm, and Rubber

Classification of commercial crops

There are three major crop groups: fruits, spices, and plantation crops. Across these categories, several crops are grown. The main fruit crops include banana, grapes, mango, lemon, orange, and pineapple. Ginger is the only spice crop cultivated, while plantation crops consist of betel nut, oil palm, and rubber (Table 2). All these crops carry strong economic value in Mizoram. Although they are grown widely across the state, their area and production differ among the study villages.

Major fruits, spices, and plantation crops are shown in Figure 4 Ginger is grown under shifting cultivation, and because shifting plots change each year, the ginger fields also move accordingly. Oil palm plantations were introduced in 2005 and have since expanded across the state. These plantations are established on permanent plots, though their expansion has been slow. Banana is an important fruit crop in Mizoram, thriving both under cultivation and in the wild. Orange, a newer commercial crop, has seen notable increases in both area and production in recent years.

Households involved in cultivating commercial crops

A total of 1,527 households across 16 villages cultivated 10 commercial crops. Of these, 83.9% grew banana, and the same share cultivated pineapple, with farmers from 13 villages involved. About 77.1% cultivated mango, and 72.4% grew oranges. Mango was cultivated in 12 villages, while oranges were grown in 11 villages. Lemon was grown by 65.4% of households, and rubber by 60.1%. Betel nut and oil palm are emerging crops, cultivated by 54% and 49% of households. Ginger was grown by 24.6%, and grapes by 12.6%, with grape cultivation limited to two villages (Table 3).

Table 3. Major commercial crops and their village-wise distribution

Major commercial crops	Villages, where these crops are grown	Number of villages	HHs	HHs (%)
Banana	Hmuifang, Mualkhang, Saihapui K, Hmawngkawn, Chekkawn, Chhumkhum, Thlengang, Rawlbuk, E.Saizawh, Ahmypi, Old Tisopi, Bawngthah, and Lengpui	13	1281	83.9
Betelnut	Mualkhang, Saihapui K, Chhumkhum, Bawngthah, Lengpui	5	825	54
Ginger	Tualcheng, Pamchung, Hmuifang, Chekkawn, and Bawngthah	5	376	24.6
Grapes	Tualcheng and Pamchung	2	193	12.6
Lemon	Hmuifang, Mualkhang, Saihapui K, Hmawngkawn, Chekkawn, Chhumkhum, Ahmypi, Old Tisopi, and Lengpui	9	998	65.4
Mango	Pamchung, Hmuifang, Mualkhang, Hmawngkawn, Chhumkhum, Thlengang, Rawlbuk, E.Saizawh, Ahmypi, Old Tisopi, Bawngthah, and Lengpui	12	1177	77.1
Oil palm	Mualkhang, Saihapui K, Chhumkhum, and Lengpui	4	751	49.2
Orange	Nausel, Mualkhang, Hmawngkawn, Chekkawn, Thlengang, Rawlbuk, E.Saizawh, Ahmypi, Old Tisopi, Bawngthah, Lengpui	11	1105	72.4
Pineapple	Hmuifang, Mualkhang, Saihapui K, Chekkawn, Chhumkhum, Thlengang, Rawlbuk, E.Saizawh, Ahmypi, Old Tisopi, Bawngthah, and Lengpui	13	1281	83.9
Rubber	Pamchung, Hmuifang, Mualkhang, Saihapui K, Chekkawn, Chhumkhum, and Lengpui	7	917	60.1

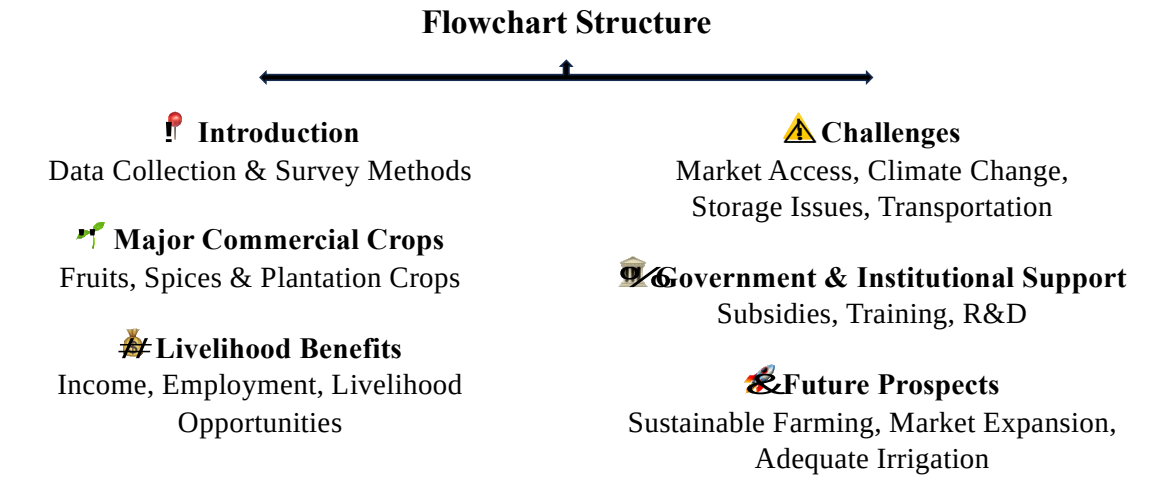

Figure 3. Flowchart structure of the study

Figure 4. Commercial crops: (a) Ginger (b) oil palm (c) banana (d) orange

Area, production, and productivity of crops and changes during 2014-2022

The area, production, and productivity of 10 commercial crops, along with changes between 2014 and 2022, were analyzed (Table 4). In 2014, lemon occupied the largest cultivated area (63 ha), followed by orange and banana, each exceeding 40 ha. Rubber, betel nut, and oil palm covered 26–34 ha, while the remaining crops occupied less than 20 ha. By 2022, lemon still had the largest area (171 ha), with banana rising to second place. Cultivated areas for oil palm and rubber increased to 72 ha and 71 ha, respectively, while orange and betel nut reached 65 ha and 64 ha. The other crops remained under 40 ha. The highest percentage increase in area was observed for pineapple (309.09%), followed by oil palm (176.92%) and lemon (171.43%). Significant increases were also noted for banana and ginger. Overall, the analysis

indicates that the cultivated area for all commercial crops expanded substantially over this period.

In 2014, banana recorded the highest production at 2,133 kg, followed by grapes (1,736 kg) and pineapple (1,110 kg). Ginger and lemon yielded between 500 kg and 1,000 kg, while orange, mango, and betel nut produced 200–500 kg. Rubber and oil palm had the lowest output, each under 100 kg. By 2022, banana remained the leading crop, with production rising significantly to 6,192 kg, followed by orange (5,716 kg), grapes (3,628 kg), pineapple (2,967 kg), lemon (2,158 kg), and betel nut (2,100 kg). All other crops produced less than 100 kg.

In 2014, grapes had the highest productivity among all crops at 115.7 kg/ha, followed by pineapple (101 kg/ha), ginger (66.2 kg/ha), and banana (49.6 kg/ha). The remaining crops had productivity below 20 kg/ha. Grapes retained the highest productivity in 2022, reaching 129.6 kg/ha. Orange, pineapple, and banana achieved productivity levels between 50 and 90 kg/ha, while the other crops remained below 50 kg/ha. Regarding changes in productivity, orange recorded the largest increase (1,340.98 kg/ha), followed by lemon (447.83 kg/ha) and betel nut (412.5 kg/ha). Most other crops saw increases of less than 60 kg/ha. However, mango, ginger, and pineapple experienced a decline in productivity over this period.

Although the agro-climatic conditions across all altitudinal zones are suitable for cultivating various fruits, the productivity of certain crops—particularly ginger, mango, and pineapple—remains low due to several constraints. A major factor is the lack of adequate market facilities. Additionally, transportation infrastructure, value-addition processes, and fruit-processing centers are underdeveloped in the state. Consequently, these crops are largely consumed within households or local urban centers. Pineapple is a seasonal crop available during the rainy season, with mango following a similar pattern. Inadequate storage and limited market access often lead to post-harvest losses, discouraging farmers from investing in these crops. Enhancing value-addition activities—such as producing ginger paste, pineapple juice and jam, and mango pickles—can increase both production and economic returns. Improving transportation and market infrastructure will further strengthen the potential of these crops to support sustainable livelihoods.

Descriptive statistics were used to calculate the mean area and production of key crops across the case study villages (Table 5). The N value, representing the number of households cultivating each commercial crop, varied by crop. Although 1,527 households across 16 villages were surveyed, not all households grew every crop. In terms of cultivated area, lemon recorded the highest mean, followed by oil palm. Grapes had a mean area of 14 ha, and betel nut averaged 12.78 ha, while the remaining crops had mean areas below 10 ha. For production, grapes had the highest mean output, followed by pineapple and ginger.

Figure 5 illustrates the area, production, productivity, and economic value of the principal commercial crops in 2022 (expressed as percentages). Lemon occupied the largest cultivated area, followed by banana and oil palm. Banana recorded the highest production, followed by orange and grapes. Grapes led in productivity, followed by orange and pineapple. In terms of economic value, orange ranked highest, followed by grapes and banana.

Economic value (in USD) of commercial crops

The economic value of all commercial crops was calculated by multiplying each crop's production by its current market price. The values, initially in Indian Rupees, were converted to USD. Data from 2014 and 2022 were analyzed to assess changes over time. In 2014, grapes had the highest economic value, followed by banana and ginger, while the remaining crops were valued below 1,000 USD. By 2022, the economic value of all commercial crops had increased, with orange leading, followed by grapes, banana, and betel nut. Pineapple, ginger, and lemon had economic values ranging between 1,300 and 1,450 USD, while other crops remained below 500 USD. Mango experienced a notable decline in economic value due to reduced production. All other crops showed increases, with orange recording the largest rise at 12,937 USD, followed by banana, grapes, and betel nut. The remaining crops increased by less than 1,000 USD (Table 6).

Input-output analysis and benefits

An input–output analysis was conducted to assess the economic viability of commercial crops, and the net benefit for each crop was calculated (Table 7). Inputs included human labor, seeds, fertilizers, machinery, and transportation from farmland to market. Human labor, a critical component, was valued using the current minimum wage rates set by the state government. Many commercial crops require substantial input during initial planting but need minimal additional investment once fruiting begins. The analysis showed that input requirements varied with the area under cultivation and production levels. Higher inputs corresponded with higher outputs; for example, orange cultivation required the highest input (1,600 USD), followed by grapes and banana, which also produced the highest outputs, ranging from 11,000 to 13,773 USD. Crops with inputs

below 1,000 USD generated correspondingly lower outputs. Overall, all crops yielded positive net benefits, though at varying levels. Orange provided the highest net benefit (12,173 USD), followed by grapes (7,542 USD) and banana (6,360 USD). Betel nut also demonstrated substantial profitability. Other crops generated benefits below 1,000 USD, while mango, rubber, and oil palm offered relatively lower returns.

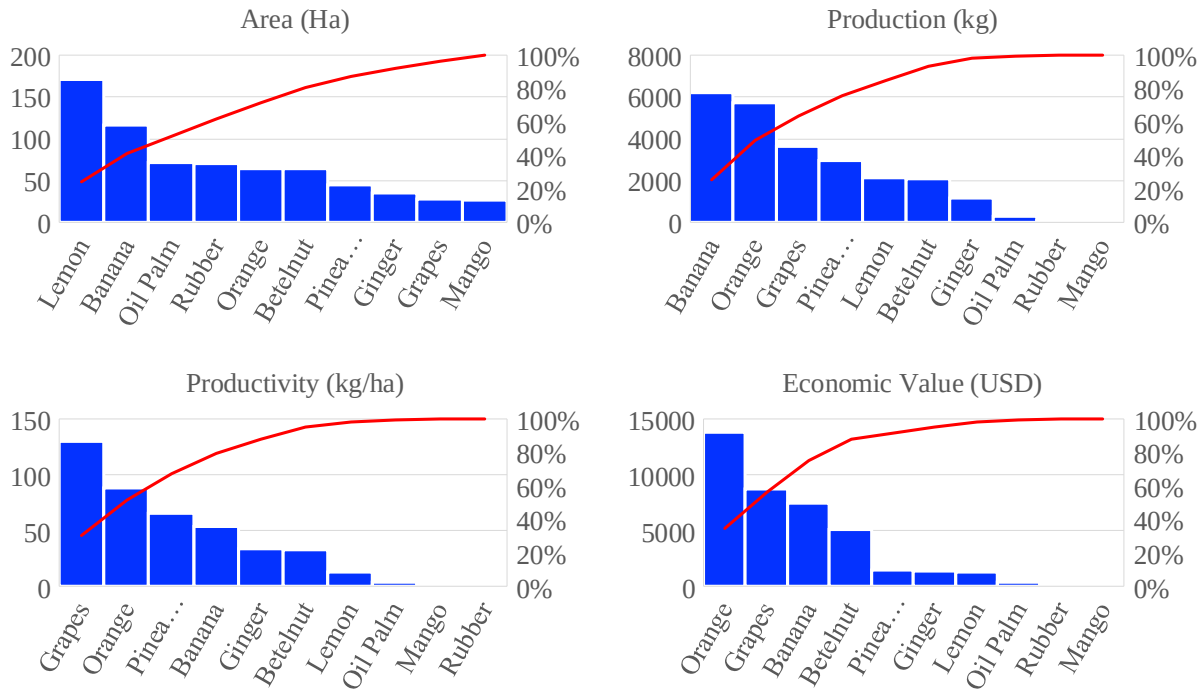

Figure 5. Total area, production, and productivity of the principal commercial crops and their economic value

Table 4. Area, production, and productivity of commercial crops and change (n=1527 households)

Commercial crops	Area (ha)			Production (kg)			Productivity (kg/ha)		
n=households	2014	2022	Change (%)	2014	2022	Change (%)	2014	2022	Change (%)
Banana (1281)	43	116	169.77	2133	6192	190.3	49.6	53.4	7.66
Betelnut (825)	33	64	93.94	210	2100	900	6.4	32.8	412.5
Ginger (376)	13	35	169.23	860	1180	37.21	66.2	33.7	-49.1
Grapes (193)	15	28	86.67	1736	3628	108.99	115.7	129.6	12.014
Lemon (998)	63	171	171.43	584	2158	269.52	2.3	12.6	447.83
Mango (1177)	16	27	68.75	297	51	-82.83	18.6	1.9	-89.78
Oil Palm (751)	26	72	176.92	65	278	327.69	2.5	3.9	56
Orange (1105)	57	65	14.04	347	5716	1547.26	6.1	87.9	1340.98
Pineapple (1281)	11	45	309.09	1110	2967	167.3	101	65.9	-34.75
Rubber (917)	34	71	108.82	37	85	129.73	1.1	1.2	9.09
Total (1527)	311	630	102.57	7379	21977	197.83	23.7	38.9	64.14

Table 5. Mean value of area and production of commercial crops

Commercial crops (n=households)	Area (mean value)	Production (mean value)
Banana (1281)	8.9	774.1
Betelnut (825)	12.78	700
Ginger (376)	7	1180
Grapes (193)	14	3628
Lemon (998)	19	359
Mango (1177)	6.3	140
Oil Palm (751)	18.1	138.8
Orange (1105)	5.9	1143
Pineapple (1281)	7	1180
Rubber (917)	11.75	2

Table 6. Economic value (USD)* of commercial crops

Commercial crops (n=households)	2014	2022	Change (2014-2022)
Banana (1281)	2570	7460	+4890
Betelnut (825)	506	5060	+4554
Ginger (376)	1036	1422	+386
Grapes (193)	4183	8742	+4559
Lemon (998)	352	1300	+948
Mango (1177)	179	31	-148
Oil Palm (751)	94	402	+308
Orange (1105)	836	13773	+12937
Pineapple (1281)	534	1430	+895
Rubber (n=7)	76	174	+98
Total (n=16)	10366	39794	+29428

*Current market prices; Dec 2025 (1 USD=83 INR). Source: By author

Table 7. Input and output analysis and benefits from commercial crops

Commercial crops (n=households)	Input (USD)	Output (USD)	Benefits (USD)
Banana (1281)	1100	7460	+6360
Betelnut (825)	900	5060	+4160
Ginger (376)	500	1422	+922
Grapes (193)	1200	8742	+7542
Lemon (998)	800	1300	+500
Mango (1177)	8	31	+23
Oil Palm (751)	30	402	+372
Orange (1105)	1600	13773	+12173
Pineapple (1281)	510	1430	+920
Rubber (917)	22	174	+152
Total (n=1527)	6670	39794	+33124

Net benefits (expressed as percentages) from all commercial crops were calculated (Figure 6). The analysis showed that orange generated the highest net benefit (12,173 USD), followed by grapes, banana, and betel nut, reflecting strong potential in both production and profitability. In contrast, the remaining six crops produced minimal net benefits during the period, indicating lower economic returns.

Household-level area, production, productivity, and income (USD)

Household-level area, production, and productivity for each crop were analyzed (Table 8). Household-level area was calculated by dividing the total cultivated area of each crop by the number of households engaged in its cultivation, with production and productivity calculated similarly. The highest household-level area was recorded for lemon (0.2 ha), followed by grapes and oil palm (0.1 ha each), while mango had the lowest. Other crops had household-level areas ranging from 0.04 to 0.09 ha. In terms of household-level production, grapes had the highest output (5.17 kg), followed by orange (5.17 kg) and banana (4.83 kg). Ginger, betel nut, lemon, and pineapple ranged from 2 to 4 kg per household, while mango and oil palm had the lowest production. For household-level productivity (kg/ha), grapes again led with 0.67 kg/ha, followed by ginger, orange, pineapple, betel nut, and banana. The lowest household-level productivity was observed in mango, rubber, and oil palm.

Indices and levels of commercial crops

Table 9 presents the indices and levels of area, production, productivity, economic value, and net benefits for commercial crops. Values for all variables were indexed based on their minimum and maximum, then categorized into four levels: very high, high, medium, and low. Because the minimum and maximum values differ across variables, the indices are not directly comparable. In terms of area, lemon and banana fall into the very high and high categories, respectively, while the remaining crops are classified as medium or low. For production, banana and orange rank very high and high. Productivity is highest for grapes, orange, pineapple, and banana, ranging from very high to high. Economic value is very high to high for orange and grapes, whereas banana and betel nut fall into the medium category. Regarding net benefits, orange provides the highest

benefit, followed by medium benefits from grapes, banana, and betel nut. A key observation is that banana, orange, and grapes consistently exhibit very high to high levels in production, productivity, and economic value, with betel nut following in terms of benefits.

Correlation among the area, production, productivity, economic value, and benefit

The correlation analysis (Table 10) reveals strong positive relationships among area, production, economic value, and net benefits. Larger cultivated areas lead to higher production, which in turn elevates economic value and benefits.

The correlation between production and both economic value and benefits is particularly strong, indicating that higher yields directly enhance financial returns. Similarly, increases in cultivated area are associated with higher economic value and benefits, although these correlations are slightly weaker than those with production. Overall, expanding cultivation area and improving production strongly contribute to the economic performance and net benefits of commercial crops.

Potential of commercial crops in livelihood sustainability

Mizoram's diverse agro-climatic conditions—from tropical wet to sub-tropical and montane temperate—support the cultivation of a wide range of crops. The state primarily produces food grains such as rice and maize; spices including garlic, ginger, and chili; fruits like banana, orange, lemon, pineapple, papaya, and mango; various vegetables; and plantation crops such as oil palm, rubber, and betel nut. Rice and maize remain staple subsistence crops, but their production and productivity are low, with most output consumed at the household level. A large portion of arable land is under shifting cultivation, which further limits productivity. The area devoted to major commercial crops—spices, fruits, and plantation crops—remains relatively small. The study highlights that certain commercial crops—ginger, banana, orange, oil palm, betel nut, and rubber—have strong potential for promoting sustainable livelihoods. Even allocating a small portion of arable land to these crops can enhance income and economic stability. Developing adequate markets, improving transportation, implementing value-addition processes, and establishing village-level processing centers can generate employment and boost the local economy. These crops also have export potential to neighboring countries such as Myanmar and Bangladesh through well-organized market chains. Additionally, the river valleys in Mizoram provide sufficient water resources; harnessing river water for irrigation could significantly improve the production and productivity of commercial crops.

Livelihood strategy in commercial crops

Table 11 presents the livelihood strategies of rural households engaged in commercial crop cultivation. It is organized into three columns: key impacting factors, important aspects, and the outcomes of livelihood strategies. Four primary factors are identified as influencing livelihoods: economic, social, environmental, and policy/institutional. The table also highlights key aspects and strategies, emphasizing the need for well-planned interventions to enhance livelihood opportunities through commercial crop cultivation.

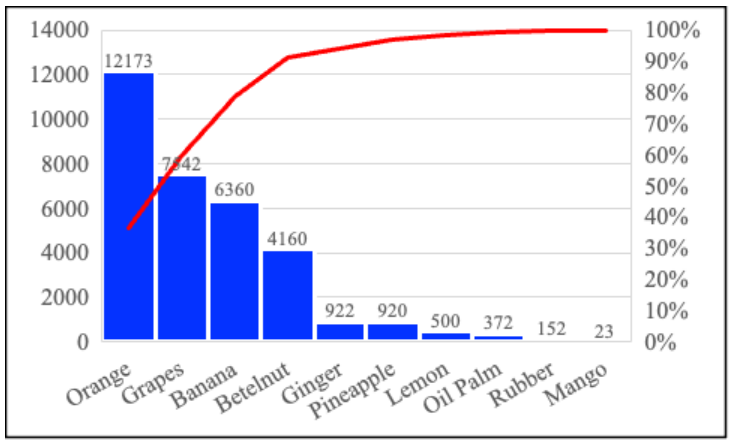

Figure 6. Benefits (USD) from commercial crops

Table 8. Household-level area, production, and productivity, and income (USD) (n=1527)

Commercial crops	Household-level area (ha)	Household-level production (kg)	Household-level productivity (kg/ha)
Banana	0.09	4.83	0.041
Betelnut	0.08	2.55	0.04
Ginger	0.09	3.14	0.09
Grapes	0.1	18.8	0.67
Lemon	0.2	2.16	0.012
Mango	0.023	0.043	0.002
Oil Palm	0.1	0.37	0.005
Orange	0.06	5.17	0.08
Pineapple	0.04	2.32	0.051
Rubber	0.08	0.09	0.0013

Table 9. Indices and levels of area, production, productivity, economic value, and benefits from commercial crops

Area (ha)		
Indices	Level	Commercial crops
>150	Very high	Lemon
100-150	High	Banana
50-100	Medium	Oi palm, rubber, orange, and betelnut
<50	Low	Pineapple, ginger, grapes, and mango
Production (kg)		
>6000	Very high	Banana
4000-6000	High	Orange
2000-4000	Medium	Grapes, pineapple, lemon, and betelnut
<2000	Low	Ginger, oil palm, rubber, and mango
Productivity (kg/ha)		
>100	Very high	Grapes
75-100	High	Orange, pineapple, and banana
50-75	Medium	Ginger and betelnut
<50	Low	Lemon, oil palm, mango, rubber
Economic value (USD)		
>12000	Very high	Orange
8000-12000	High	Grapes
4000-8000	Medium	Banana, Betelnut
<4000	Low	Pineapple, ginger, lemon, oil palm, rubber, mango
Benefits (USD)		
>12000	Very high	Orange
8000-12000	High	Nil
4000-8000	Medium	Grapes, banana, betelnut
<4000	Low	Ginger, pineapple, lemon, oil palm, rubber, and mango

Table 10. Pearson correlation for the variables area, production, economic value, and benefit

Variable Pair	Correlation coefficient
Area vs. Production	0.91
Area vs. Economic Value	0.85
Area vs. Benefit	0.78
Production vs. Economic Value	0.95
Production vs. Benefit	0.92
Economic Value vs. Benefit	0.88

Table 11. Rural households' livelihood strategy in commercial crops (People's perception and observation methods)

mpacting factors	Key aspects	Results on livelihood strategy
Economic factors	Income diversification through commercial crops	Shift towards cash crops for better income opportunities
	Market accessibility and price fluctuations	Dependence on middlemen if direct market access is lacking
	Availability of credit and financial support	Investment in high-yielding varieties and technology
	Input costs and profitability	Profit-driven shift but risk of high investment costs
Social factors	Education and awareness on modern techniques	Improved productivity and adaptation to new methods
	Farmer cooperatives and knowledge-sharing networks	Increased collaboration and better market negotiation
	Cultural influences on farming practices	Preference for traditional crops despite economic potential
Environmental factors	Soil fertility and land degradation	Need for sustainable land management and agroforestry
	Climate variability affecting crop yield	Risk management through crop diversification
	Sustainable land use practices	Adoption of organic farming and conservation techniques
Policy & institutional factors	Government support, subsidies, and training programs	Increased participation in commercial farming
	Infrastructure development (roads, storage, irrigation)	Reduced post-harvest losses and better market reach
	Land tenure policies and access to resources	More secure farming investments and long-term planning

DISCUSSION

Mizoram's economy is predominantly agricultural, with shifting cultivation serving as a traditional practice. The state is rich in agrobiodiversity, cultivating a wide variety of crops year-round. Its diverse climate—from tropical to subtropical and montane temperate—provides an ideal environment for growing a broad range of crops. Although a large portion of the population engages in agriculture, limited arable land results in relatively low production and productivity. Despite the small area allocated to commercial crops, the state demonstrates significant potential, particularly in fruits, spices, and plantation crops.

Shifting cultivation is both economically unsustainable and environmentally detrimental, contributing to soil degradation and deforestation. In contrast, fruit trees and plantation crops offer a promising alternative for environmental restoration and protection. Crops such as ginger, banana, pineapple, orange, lemon, mango, grapes, betel nut, oil palm, and rubber show strong potential due to their adaptability to Mizoram's agro-climatic conditions. These crops generate economic benefits while supporting environmental sustainability by enhancing soil health and preventing erosion. Transitioning to commercial crop production can increase household incomes, strengthen food security, and create opportunities for value addition through processing and export, thereby reinforcing the rural economy. While several studies have explored aspects of primary economic activities in the region, this study is among the first to empirically examine the role of commercial crops in livelihood sustainability.

The findings indicate that all commercial crops in Mizoram contribute to livelihood improvement, with four crops—orange, grapes, banana, and betel nut—showing the highest potential. Their economic value is substantial, and input-output analysis demonstrates significant net benefits. However, many fruit crops, particularly highly perishable ones like pineapple, remain underutilized. Pineapple, abundantly produced during the summer and rainy seasons, often spoils due to limited market access. Remote production areas and poor transportation infrastructure further restrict farmers' ability to sell beyond local consumption. Additionally, limited awareness and training in sustainable farming and value addition constrain farmers' capacity to maximize profits. Financial limitations, including restricted access to credit and subsidies, also hinder investment in high-value crops. As a result, farmers are often reluctant to cultivate fruit crops on a commercial scale.

To address these challenges, the study recommends enhancing market facilities for fruit crops to encourage commercial cultivation. Establishing cooperative

societies and strengthening supply chains can empower farmers by ensuring fair prices for their produce. Training programs on value-addition techniques should be offered to equip farmers with the skills needed to increase both profitability and sustainability. Community participation will be vital for promoting commercial crop cultivation, while the State Government plays a key role in policy formulation, resource provision, and infrastructure development to support the growth of these high-potential crops.

CONCLUSIONS

The study investigated the potential of commercial crops to promote livelihood sustainability in Mizoram, located in the eastern extension of the Himalaya. Empirical data were collected and analyzed to assess the role of these crops. The study classified commercial crops and identified the principal crops within each category. Area, production, and productivity were analyzed comprehensively, with mean values calculated for each crop. Economic value was assessed, and input-output analysis was conducted to determine net benefits. Correlations among key variables were established. A sustainable livelihood framework for commercial crops in Mizoram, along with a flowchart of the study, was developed. Indices and levels of area, production, productivity, economic value, and benefits were analyzed.

The findings indicate that all commercial crops cultivated by 1,527 households across 16 villages have significant potential for supporting livelihood sustainability. Lemon occupied the largest area, followed by banana and orange. Banana recorded the highest production, followed by orange and grapes, while grapes led in productivity, followed by orange and pineapple. Notable increases in cultivated area were observed for pineapple, oil palm, lemon, ginger, and banana. In terms of production, orange and betel nut showed substantial growth, and the greatest increases in productivity were recorded for orange, lemon, and betel nut.

The study recommends dedicating arable land to key commercial crops such as banana, orange, grapes, and betel nut, which offer high economic value, support sustainable livelihoods, and contribute to environmental conservation. Developing irrigation facilities in river valleys can further enhance productivity. Additionally, improving market infrastructure, establishing cold storage units, and creating rural fruit-processing centers can maximize the benefits of commercial agriculture. Value addition through processing techniques—such as producing chips, juices, jams, pickles, and other products from fruits and spices—can generate income and strengthen rural livelihoods.

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Authors Contribution
This paper is single authored. All works carried out by Vishwambhar Prasad Sati.

Availability of data and materials
The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests
The author declares no financial or non-financial interests exist that are directly or indirectly related to this work.

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