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EDAPHIC AND CLIMATIC ENVIRONMENT OF SELECTED INDIGENOUS UPLAND RICE VARIETIES GROWN IN VITALI, ZAMBOANGA CITY, PHILIPPINES

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ABSTRACT

The decline of indigenous upland rice varieties, despite their resilience and high-quality traits, is driven by a combination of agronomic, socio-economic, and environmental challenges that make them difficult for farmers to maintain, despite its desirable traits such as their ability to resist pests and diseases, tolerance to abiotic stress, its aromatic characteristic, excellent palatability, and high in nutritional value; production remain low. The study was aimed to address the onsite edaphic, agronomic and climatic challenges with a goal focused on the utilization of production sites, particularly and preservation of upland rice seeds for seed and food purpose. The approach was designed to capture field information that will provide actionable insights to guide policy decisions and practical interventions for enhancing food security in Zamboanga City and across Zamboanga Peninsula. Hence, the study was carried out to profile and characterized the upland rice farms in the selected areas of barangay Vitali, Zamboanga City, Philippines. Simple descriptive method was used and purposive sampling was employed covering the five (5) identified upland areas in various sitios with recently planted with indigenous upland rice, with at least an area of 0.3 ha farmer^{-1} and above. Survey questionnaire was used to capture farmer and field profiles, soil samples were submitted for laboratory analysis to establish the edaphic, while climatic factors were analysed in collaboration with relevant agencies and secondary data. Strengthening the sustainability of indigenous upland rice production in Barangay Vitali requires a comprehensive and integrated approach. Key strategies include improving access to and conservation of indigenous seed systems, promoting cost-effective and sustainable fertilizer and pest management practices, and enhancing soil fertility through organic amendments and proper nutrient management. Addressing water challenges through efficient water management systems is also essential, particularly in the face of erratic rainfall patterns, including soil fertility management, promoting climate-resilient farming strategies, and improving access to agricultural inputs and infrastructure are key to sustainable upland rice farming systems in the uplands of Baranagay Vitali, Zamboanga City, Philippines.

Keywords: Food production, indigenous upland rice varieties, farm and environmental characterization, Zamboanga City, Philippines.

1.0 INTRODUCTION

Rice is the most important staple food in the Philippines, and it's the most sought commodity in Zamboanga Peninsula, providing more than half of the energy requirements with deep cultural and economic importance to Zamboanga City's population [1,2]. Limited productivity, high demand, and frequent climate-related damage have made Zamboanga City a top rice importer in the entire Zamboanga Peninsula as a result to a massive rice supply deficit, with only 13% sufficiency rating [3]. Although the city has about 44,400-59,200 hectares (30-40% of the total land area) characterized as lowland with high potential for agriculture, but much of it has been converted for residential and industrial purposes, reducing the land available for food production. To close the domestic supply-and-demand gap for more than 1.0 M people *(computed at 1.97% Annual Growth Rate, PSA, 2020 data)*, where 86.6% *(0.94 M or 235,000 households)* of the population resides in highly urbanized and peri-urbanized barangays *(based on the City Ordinance No. 532, s2019)*, with an estimated demand of 115.06 M kg (115.06 mt) of milled rice *(computed from 122.4 kg per capita consumption)* [4,5], local interventions to increase low-land rice productivity and farm efficiency have been promoted. With the projected increase of population to 1.3 M in 2030, while land area for agriculture continues to decline due to rapid land use changes (LUC) and land conversion, upland rice farming plays a crucial role in sustaining food production addressing food insecurity concern from years beginning in 2026 and beyond.

Large parts of the uplands in Zamboanga City are characterized by high incidence of poverty, lack physical access to market infrastructures, and often faced with subsistence-oriented agriculture with low productivity. Given the importance of upland areas with high potential for upland rice production, interventions that directly affect upland rice productivity can serve as a critical intervention and reenforcing the process of upland farming development, growth and income opportunities [6-7], particularly in the uplands of barangay Vitali, Zamboanga City, Philippines.

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Traditional upland rice varieties are rarely grown commercially due to low yields (0.5-1.5 t ha^{-1}), often replaced by modern, high-yielding varieties that can exceed (4-6 t ha^{-1}). While traditional types offer traits like drought tolerance and better taste, their slow maturity and low productivity cannot compete commercially with modern, input-responsive varieties [9-10]. However, upland traditional rice varieties possess valuable traits such as resistance to pests and diseases, tolerance to environmental stress, and desirable qualities like aroma, taste, and nutritional value [11-13]. Although traditional rice varieties have potential for export, their production remains limited due to lower yields and seasonal cultivation, especially for upland types [11]. Conserving and utilizing these varieties is essential for maintaining genetic diversity and supporting future rice improvement efforts [10,14,15].

In Barangay Vitali, Zamboanga City, which covers 11,088.05 hectares and a population of 11,118 [16], where traditional rice varieties such as (in local names) Zambales White, Zambales Red, Katugtug, Kaluis and Tumba Kasa are still cultivated, mainly for household consumption, demonstrating the community's effort to preserve this important agricultural heritage despite existing challenges. The focus of the study is on the uplands of Barangay Vitali, Zamboanga City, particularly in Sitios Baluno, Sapa Grande, Pico, Upper Linduman and Centro Linduman (Figure 1), where these traditional rice cultivars are still farmed. This study aimed to assess the edaphic and climatic environment of indigenous upland rice varieties grown in various Sitios in barangay Vitali, Zamboanga City, Philippines.

2.0 METHOD AND MATERIALS

2.1 Survey sites

The study was conducted across the five sitios of Barangay Vitali, Zamboanga City, namely: *Sitios Baluno, Sapah Grande, Pico, Upper Linduman, and Centro Linduman.* These Sitios were selected for their diversity of indigenous upland rice varieties and varying topographical features.

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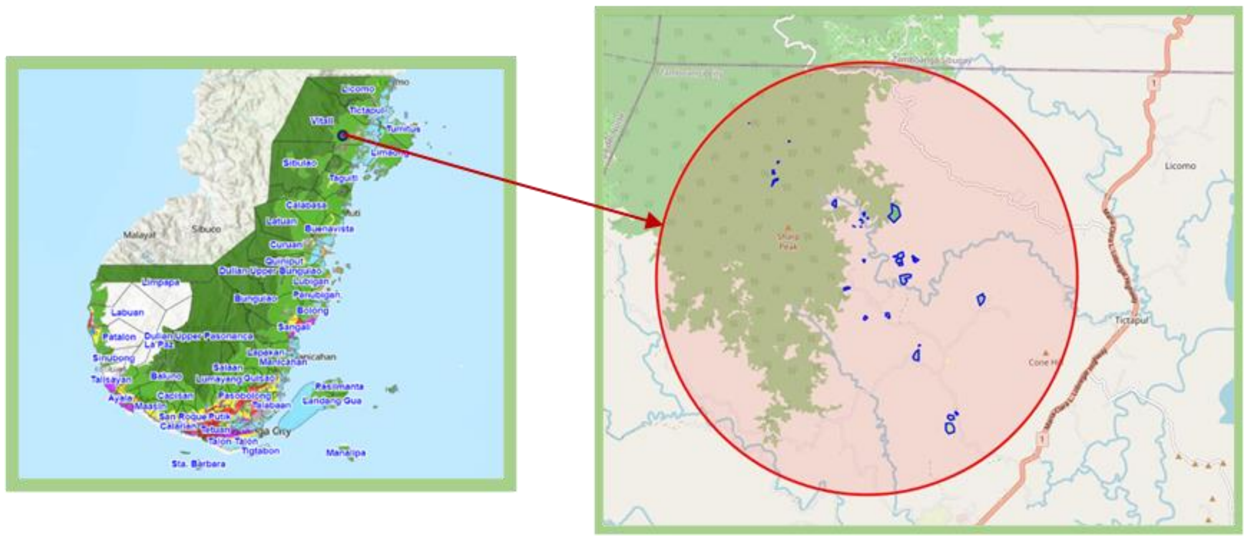

Figure 1: Study site and distribution of surveyed farms

2.2 Respondents

The respondents were selected with the assistance of the local rice association leader in collaboration with the Agricultural Field Office VI, Office of the City Agriculturist, Zamboanga City and Farmers Association Presidents, focused with those members with substantial experiences in cultivating indigenous upland rice varieties, and particularly those with ongoing production at the time of the study for one cropping season.

2.3 Data collection and analysis

Surveys were conducted with the use of a survey tool to gather information on farming practices, socio-economic conditions, and crop yields. Soil samples were collected from the surveyed farms and were submitted to the Bureau of Soils and Water Management (BSWM) based in Zamboanga City for chemical analysis specifically on Soil pH, Organic Carbon, Organic Matter, Nitrogen, available Phosphorus, Exchangeable Potassium, including Exchangeable Bases such as Ca, Mg, Na, and K. Descriptive statistics was used and summarize key results. Total, means and percent were used to described and discuss variables. Primary data were supported with secondary literatures collected from various offices and on-line access.

3.0 RESULTS AND DISCUSSION

Table 1 presents the data on the distribution of farming household who farmed indigenous upland varieties across five (5) sitios in Barangay Vitali, corresponding with their average altitude, and yield land^{-1} area (in hectare), respectively. The highest average altitude of 473.0 meters above sea level (masl) and the largest area planted (11.0 ha) were recorded in Sitio Baluno. However, this

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site produced one of the lowest yields, at 0.88 mt ha^{-1}. In contrast, Centro Linduman, which had the lowest average altitude at 95.0 masl and the smallest area planted at 3.0 ha, recorded the highest yiled of 2.67 mt ha^{-1}.

Table 1: Altitude and yield ha^{-1}

Location	Local Name	Area Planted (in ha)	Average Altitude (in Meters)	Farming Households	Yield ha^{-1} (MT)
Baluno	Zambales White	11.0	473	8	0.88
Sapa Grande	Zambales Red	6.2	268	7	1.46
Pico	Katugtug	9.5	122	12	0.7
Upper Linduman	Kaluis	2.5	110	1	1.98
Centro Linduman	Tumba Kasa	3	95	4	2.67
TOTAL		**32**		**32.2**	**1.19**

Table 2 shows the soil chemical and nutrient analysis result of the study site, indicating the pH, organic carbon, organic matter, nitrogen, available phosphorus, exchangeable potassium, and other parameters. Annual Rainfall (mm), 2022-2024 data (Figure 1), plays a key role at either influencing or affecting the production dynamic of upland rice cultivars.

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Table 2: Soil chemical and nutrient analysis result

ANALYSIS	IDEAL RANGE	RESULTS/SITIO				
		BALUNO	SAPA GRANDE	PICO	UPPER LINDUMAN	CENTRO LINDUMAN
A. SOIL CHEMICAL ANALYSIS						
Soil pH 25 °C[1]	5.5-6.5	5.18-6.64	5.61-6.33	5.48-7.19	5.55-5.97	5.62
Organic Carbon, g/100g[2]	1.5-2.5g/100g	0.83-2.75	2.14-11.34	0.17-4.02	2.45-3.22	1.23
Organic Matter, g/100g[3]	3-6% (30-60 gms)	1.45-4.73	3.69-19.5	0.29-6.91	4.22-5.54	2.11
Nitrogen, g/100g[3]	0-9g /100g of soil	0.07-0.24	0.18-0.98	0.01-0.35	0.21-0.28	0.11
Available Phosphorus, mg/kg[4]	10-20 mg/kg of soil	0.46-6.11	2.63 - 10.91	0.79 - 11.74	1.55 - 5.97	11.52
Exchangeable Potassium, mg/kg[5]	120-170 mg/kg	67.82-291.48	72.95-472.98	38.44-482.8	47.73-192.95	293.80
B. SOIL CHEMICAL ANALYSIS (SPECIALIZED PARAMETERS)						
Exchangeable Bases						
Ca, cmol/kg[6]	Above 2cmol/kg	2.63-8.05	2.67-5.42	2.38-15.49	2.35-6.86	3.11
Mg, cmol/kg[6]	0.2 cmol/kg or higher 0.03 are acceptable	2.92-8.18	3.06-25.01	4.5-15.36	3.89-16.15	3.40
Na, cmol/kg[6]	0.1-0.2 cmol/kg	0.06-0.14	0.03-0.09	0.01-0.29	0.04-0.13	0.08
K, cmol/kg[6]	0.1 cmol/kg or higher	0.15-0.64	0.16-1.26	0.09-1.29	0.13-0.45	0.71
Total Exchangeable Bases, cmol/kg soil[3]	At least 10 cmol/kg	5.89-16.63	6.14-28.75	7.79-22.34	7.75-18.91	7.30

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Exchangeable Acidity, cmol/kg soil[8]	Below 1.0 cmol/kg & preferably below 0.5 cmol/kg	7.55-20.04	7.62-17.08	7.08-15.13	12.68-14.86	9.23
C. SOIL PHYSICAL ANALYSIS						
% Moisture Content[8]	20-60%	2.25-4.8	2.55-6.75	3.00-6.35	3.50	2.70

Source: Regional Soils Laboratory, Department of Agriculture IX. ZC.

[1]*Potentiometric method.*

[2]*Walkey-Black Colorimetric Method.*

[3]*Computed.*

[4]*Olsen Method.*

[5]*Ammonium Acetate Method, pH 7.0.*

[6]*Ammonium Acetate, pH 7.0, Inductively couple plasma-optical Emission spectroscopy (ICP-EOS).*

[7]*$BaCl_2$-Triethanolamine Method.*

[8]*Gravimetric Method.*

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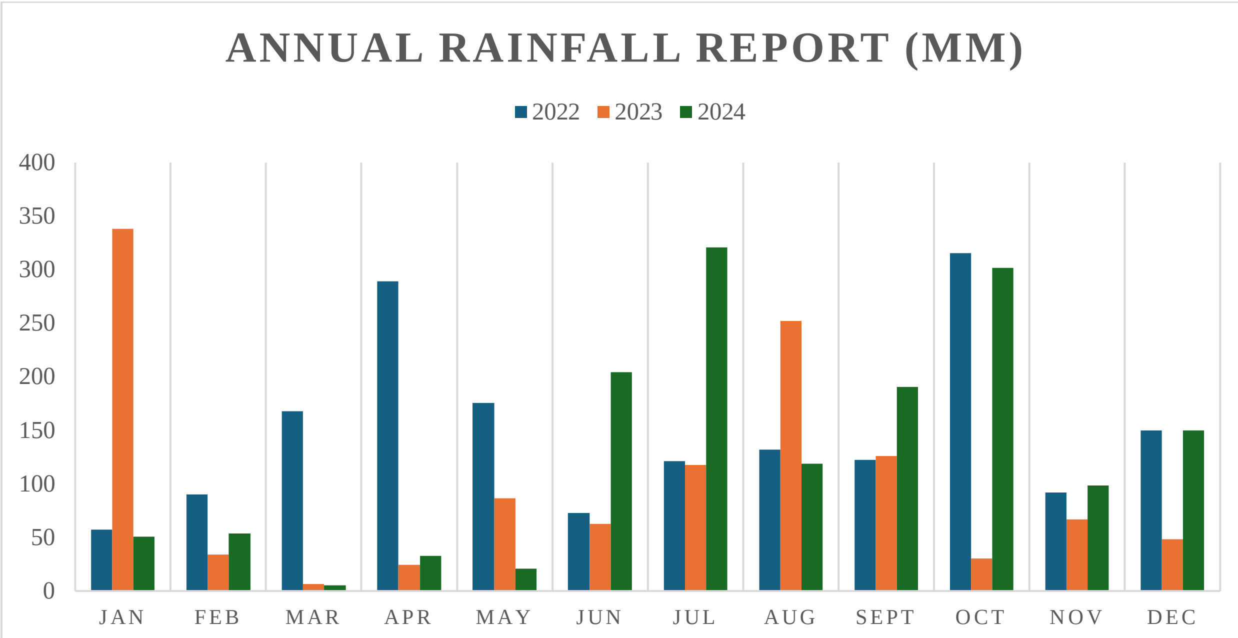

Fig. 2*:* Annual Rainfall (mm), 2022 – 2024

Source: PAGASA, ZC Station

Interviews with the different Presidents of the Rice Farmers Associations in various sitios in Barangay Vitali revealed that approximately 100 individuals were previously engaged in upland rice cultivation, including both farmers and farm workers. However, survey findings showed that only thirty-two (32) farmers continued cultivating indigenous upland rice (IUR) during the most recent cropping season. This substantial decline highlights the growing challenges faced by upland rice farmers in the area.

The reduction in IUR cultivation can be largely attributed to inadequate infrastructure, particularly the lack of reliable access roads. Poor road conditions limit farmers' ability to obtain essential agricultural inputs such as indigenous upland rice seeds, fertilizers, and agrochemicals. As a result, these inputs are not only difficult to access but also become more expensive due to transportation constraints. Moreover, unfavorable agro-climatic conditions (Figure 1) including fluctuations in temperature, irregular rainfall patterns, high humidity, and inconsistent sunlight – further intensify production risks and negatively affect crop performance (Table 1).

The demographic profile of the 32 indigenous upland rice farmers surveyed in Barangay Vitali, Zamboanga City, provides important insights into the socio-economic characteristics of the farming community. In terms of age distribution, the majority of respondents (34.4%) fall within the 41–50-year age bracket, followed by 25% (31-40 age group) and 18.8% (51-60) range. Only a small proportion belongs to the younger age group, 9.4% (20-30 years) and older groups (61-70

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years) and 71-80 years (6.3%), respectively. These figures suggest an aging farming population and limited involvement of younger individuals in upland rice cultivation. The declining participation of youth may pose long-term concerns for the continuity of indigenous farming knowledge and traditional agricultural practices.

Gender distribution among respondents is highly skewed, with males comprising 90.6% (n=29) and females accounting for only 9.4% (n=3). This indicates that upland rice farming in the community remains predominantly male-dominated. Such imbalance may limit women's participation in decision-making processes and reduce opportunities for incorporating diverse perspectives in farm management and innovation.

Educational attainment among respondents is generally low. Approximately 40.6% reached elementary level, and 28.1% completed elementary education. A smaller percentage attained high school level (12.5%) or graduated from high school (9.4%). Meanwhile, 9.4% attended college, though none completed a college degree. Limited formal education may constrain farmers' ability to adopt modern agricultural technologies, interpret technical information, or access government assistance programs that require literacy and procedural compliance.

The total number of household members across the 32 respondents is 174 individuals, resulting in an average household size of approximately 5.44 members. While larger households may provide additional labor for farm activities, they may also increase economic dependency, particularly in subsistence-based farming systems where income sources are limited. Overall, the socio-demographic characteristics of the respondents highlight the need for targeted extension services and development interventions. Programs should be culturally appropriate, literacy-sensitive, and inclusive of youth and women to strengthen the sustainability of indigenous upland rice farming in the community.

The study also documented the farming practices of indigenous upland rice farmers in Barangay Vitali, focusing on crop establishment, crop management, and postharvest operations. The predominant method of crop establishment is direct seeding by hand using a stick for dribbling. Two main land preparation techniques were identified: the traditional *kaingin* (slash-and-burn) system and chemical weed control using herbicides. Manual weeding was reported in only one case, and the overall use of herbicides for weed management was limited.

Fertilizer application varied among farmers. Of the 32 respondents, 24 partially applied fertilizer, seven (7) do not apply any fertilizer, and only one farmer reported fully applying fertilizer. This pattern suggests generally low to moderate nutrient input in upland rice farming, likely influenced by financial limitations and restricted access to agricultural inputs.

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Altitude (Table 1) plays a clear role in shaping the productivity of IUR in Barangay Vitali, with yields generally decreasing as elevation increases. The highest yield (2.67 ha^{-1}) was recorded at 96 masl, followed by 1.98 mt ha^{-1} at 110 masl. In contrast, higher elevations showed reduced productivity – for instance, a site at 473.0 masl yielded only 0.88 mt ha^{-1} despite having the largest cultivated area (11.0 has). Lower elevations likely benefit from better microclimatic conditions and soil – water availability, although altitude alone does not fully explain yield differences. This is evident from the lowest yield (0.70 mt ha^{-1}) recorded at 122 masl, suggesting that factors such as soil fertility and farm management practices also play important roles.

Yield performance (Table 1) also varied across IUR varieties. Zambales White achieved the highest yield (1.62 mt ha^{-1}) across 10.0 hectares, indicating strong adaptability to local conditions. On the other hand, Zambales Red, despite being planted on the largest area (13.9 has), produced only 0.93 mt ha^{-1}, likely because it is grown in higher-elevation areas like in Sitios Baluno and Pico where yields are generally lower. Other varieties such as Katugtug and Kaluis showed lower yields (0.64 and 0.72 mt ha^{-1}) and were planted in small areas at mid to high elevations, making it difficult to draw firm conclusions about their performance. Meanwhile, Tumba Kasa yielded 1.18 mt ha^{-1} across 7.0 hectares and performed reasonably well in mid-elevation zones (110-268 masl), suggesting it is moderately adaptable and suitable for these conditions. Overall, Zambales White is best suited for lower elevations, while Tumba Kasa shows potential in mid-altitude farming.

Soil analysis (Table 2) conducted across five sitios, revealed site-specific constraints and strengths affecting upland rice cultivation. When compared with ideal soil nutrient thresholds for upland rice production, results indicate a complex pattern of nutrient deficiencies, chemical imbalances, and physical limitations that directly influence yield performance and varietal adaptability.

Soil pH values ranged from 5.18-7.19, with most sites falling slightly below or above the optimal range of 5.5-6.5 for upland rice. Sitios Baluno and Pico recorded acidic pH values of 5.18 and 5.48, respectively. Such acidity reduces the availability of essential nutrients, particularly phosphorus, nitrogen, and potassium. In these sites, phosphorus levels (0.46 and 0.79 mg/kg), nitrogen (0.07 and 0.01 g/100 g), and exchangeable potassium (67.82 and 38.44 mg/kg) were below ideal thresholds. Moreover, all sites exhibited extremely high exchangeable acidity (7.08–20.04 cmol/kg), far exceeding the acceptable limit (<1.0 cmol/kg). These findings indicate the urgent need for liming interventions to correct soil acidity and restore nutrient balance.

Organic carbon (OC) and organic matter (OM) levels varied significantly across the study sites, with Sitios Sapa Grande and Upper Linduman exhibiting comparatively high values (up to 11.34 g/100 g OC and 19.5 g/100 g OM). In contrast, Sitios Pico and Centro Linduman fell below optimal thresholds, with Pico showing particularly low fertility indicators, including minimal organic carbon (0.17 g/100 g) and nitrogen (0.01 g/100 g). Nitrogen, a key nutrient for rice growth and

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tillering, was deficient in most areas, likely contributing to reduced crop yields; only in Sitios Upper Linduman and Sapa Grande approached adequate levels. These findings highlight the need to improve soil fertility through the application of organic amendments such as compost, animal manure, and green manure to enhance nutrient availability and soil.

Phosphorus levels were below the ideal range (10–20 mg/kg) in most sitios, except Centro Linduman (11.52 mg/kg). Adequate phosphorus in Centro Linduman may partly explain its relatively high yield (2.67 mt ha^{-1}). In contrast, Sitios Baluno and Pico recorded critically low phosphorus levels (0.46 and 0.79 mg kg^{-1}), which can restrict root development and tiller formation. Potassium levels were generally more favorable in Sitios Centro Linduman and Sapa Grande, where these areas recorded high exchangeable potassium (up to 472.98 mg kg^{-1}), while other sitios showed fluctuating levels ranging from deficient to excessive.

Exchangeable bases (Ca, Mg, and Na) were generally within or above acceptable levels in most sitios (Table 2). Sitios Sapa Grande and Pico recorded relatively high calcium and magnesium levels. However, Baluno (5.89 cmol kg^{-1}) and Centro Linduman (7.30 cmol kg^{-1}) had total exchangeable bases below the 10 cmol kg^{-1} threshold, indicating limited nutrient-holding capacity. Therefore, soil amendment strategies should address both nutrient supplementation and acidity correction.

Soil moisture content across all sitios ranged from 2.25-6.75%, far below the ideal range of 20–60% for upland rice (Table 2). These low moisture levels pose serious constraints, particularly during germination and early vegetative stages when adequate water is essential. In contrast, Centro Linduman – despite a smaller planting area, demonstrated relatively better soil pH, higher phosphorus levels, and more balanced nutrient availability, contributing to its higher yield performance (2.67 mt ha^{-1}).

Figure 2 presents the rainfall patterns in Zamboanga City from 2022-2024. In 2024, rainfall distribution had mixed implications for upland rice production, with increased precipitation during June, July, and October (rainy and typhoon months) supporting vegetative growth and grain filling, while reduced rainfall from January to March likely hindered germination and early crop establishment. In 2023, higher rainfall in the early months (January-April) favored seedling establishment; however, drier conditions in June and July may have induced moisture stress during critical growth stages, despite improved rainfall in October aiding grain filling and harvest. Overall, 2022 exhibited the most favorable and well-distributed rainfall pattern, making it the most conducive year for upland rice production among the three periods considered.

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4. CONCLUSION

Strengthening the sustainability of indigenous upland rice production in Barangay Vitali requires a comprehensive and integrated approach. Key strategies include improving access to and conservation of indigenous seed systems, promoting cost-effective and sustainable fertilizer and pest management practices, and enhancing soil fertility through organic amendments and proper nutrient management. Addressing water challenges through efficient water management systems is also essential, particularly in the face of erratic rainfall patterns.

Furthermore, investments in infrastructure such as roads and storage facilities can reduce market barriers and improve farmers' economic opportunities. Strong policy support, including incentives for organic farming and the protection of traditional agricultural systems, is equally important. Finally, increasing public awareness and education on the value of indigenous rice varieties can help stimulate demand and encourage continued cultivation. Collectively, these measures can contribute to improved productivity, environmental sustainability, and the socio-economic well-being of farming communities.

Strengthening integrated soil fertility management, promoting climate-resilient farming strategies, and improving access to agricultural inputs and infrastructure are therefore critical interventions. Overall, sustaining indigenous upland rice cultivation in Barangay Vitali requires coordinated efforts that address agronomic, environmental, and socio-economic constraints.

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