RESEARCH PAPER

Inventory and GIS Mapping of the Three Existing Coffee Types at Cagayan State University Lal-lo Old Coffee Valena Plantation

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Abstract

The study was conducted at Cagayan State University Lal-Lo Campus from November 2, 2022 to February 18, 2023, focusing on the inventory and geo-tagging of coffee trees in an old plantation. Utilizing GPS devices and smartphones, researchers identified coffee types based on their morphological characteristics. The findings indicated that the plantation spans 11.4 hectares and contains a total of 3,801 coffee trees across caves 1 and 2. Among these, Robusta coffee trees showed a high percentage of non-bearing trees at 86.33% (2,489 trees), while only 13.66% (394 trees) were bearing fruit. Similarly, Liberica coffee trees were predominantly non-productive, with 94.46% (819 trees) not bearing fruit, compared to 5.54% (48 trees) that were productive. For Excelsa coffee trees, 58.82% (30 trees) were unproductive, while 41.17% (21 trees) bore berries.Data collected were geo-tagged using Google Earth applications, creating a map illustrating the distribution of the three coffee types. Factors contributing to the lack of berries included tree age, overgrowth of secondary vegetation, wildling proliferation, and insufficient water supply during dry seasons. The morphological analysis confirmed the presence of Robusta, Liberica, and Excelsa coffee types in the plantation.The study emphasizes the significance of inventory and geo-tagging for students and faculty engaged in coffee production research at CSU Lal-Lo. It recommends rehabilitating old coffee plants to enhance berry quality and suggests further studies on sustainable coffee management at the old coffee plantation at the valena site for regional sustainability in the coffee industry.

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Introduction

Coffee is one of the most popular beverages in the world. Global coffee consumption is expected to rise, with non-traditional coffee-drinking countries in Africa, Asia, and Oceania leading the way (+4.1 percent). Demand in conventional markets is expected to rise by 1% in Europe and 2.5% in North America. Innovations in out-of-home consumption, internet commerce potential, and novel brewed coffee beverage varieties are the primary drivers of coffee industry development. Consumers are concerned about the quality and origin of coffee, as well as the social, environmental, and economic sustainability of the industry.

Coffee contributes more antioxidants to the daily diet than tea, fruit, and veggies combined. After evaluating the most popular beverages for bioactive non-nutrient content, instant coffee was found to have the highest overall bio-phenol concentration. In two more investigations, coffee were shown to have the highest overall antioxidant capacity when compared to other beverages, such as green and black tea and herbal infusions. The biochemical makeup of a cup of coffee is determined by the degree of roasting, the kind of bean (Arabica versus Robusta), and the coffee brewing technique, which includes grind type. (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6471209/) Coffee contributes more antioxidants to the daily diet than tea, fruit, and veggies combined. After evaluating the most popular beverages for bioactive non-nutrient content, instant coffee were found to have the highest overall bio-phenol concentration. In two more investigations of Samoggia, *et.al.*, 2019 coffee was shown to have the highest overall antioxidant capacity when compared to other beverages such as green and black tea and herbal infusions. The biochemical makeup of a cup of coffee is determined by the degree of roasting, the kind of bean (Arabica versus Robusta), and the coffee brewing technique, which includes grind type. (Samoggia, *et.al.*, 2019). According to Felicitas "Joji" Pantoja, founder and CEO of Coffee for Peace, Inc., was inspired when she observed coffee being given at a peace meeting. Coffee was ubiquitous, this ancient product as a medium for a new generation of peaceful conversation, as a symbol of peace. However, for this to work, the coffee has to be delicious. The procedure of manufacturing high-quality coffee has to take place. Such a method may reflect the hard effort and patience required to develop excellence in people's lives. As well as the sustainable existence in coffee might provide hope – spiritually, physically, and financially. Coffee has the potential to jolt us awake to the possibility of optimism.

Furthermore, the presence of 11 coffee brand products in Cagayan Valley is an advantage or opportunity to produce more coffee seedlings, coffee trees, and coffee bean products to help sustain the coffee products of the different entrepreneurs and for the upcoming coffee product development of the institution. On the other hand, the Municipality of Lal-lo wherein the Cagayan State University Lal-lo Campus situated has a tropical monsoon climate wherein rain forests grow because the dry period is short, and the trees survive off of soil moisture from the abundant summer rains. The Cagayan State University at Lal-lo has a total land holding of more or less 1,500 hectares (based form latest land relocation survey by the Department of Environment and Natural Resources-(DENR). More significant portion of this lot is utilized for poultry and livestock production, production of various annual crops such as cereals and legumes and high-value vegetable commercial crops (HVCC); and some for-plantation crops like mango, coconut, cacao, coffee, and other perennials. Despite this vast land and potential for agri-tourism destination through its existing old coffee plantation, the inventory of coffee plants is inaccessible and identification of the coffee types. Hence, this study aimed to conduct rehabilitation and different management technologies for the old coffee plantation of CSU Lal-lo. Specifically, it aims to determine the following: geo-tagged and mapped the existing three coffee types; identified their morphological characteristics and generated map for the identified coffee types were secured at the old coffee plantation or valena site.

Materials and method

Experimental Design and Treatments

The study used descriptive analysis, GIS tool, and ARC-GIS Map tool. Total enumeration used in the study by subdividing into blockings (1 ha) per block.

Perimeter survey

The actual areas were measured using a GPS device and cellphones. Tracking in the whole area and way pointing in the four (4) different boundaries were done which served as landmarks.
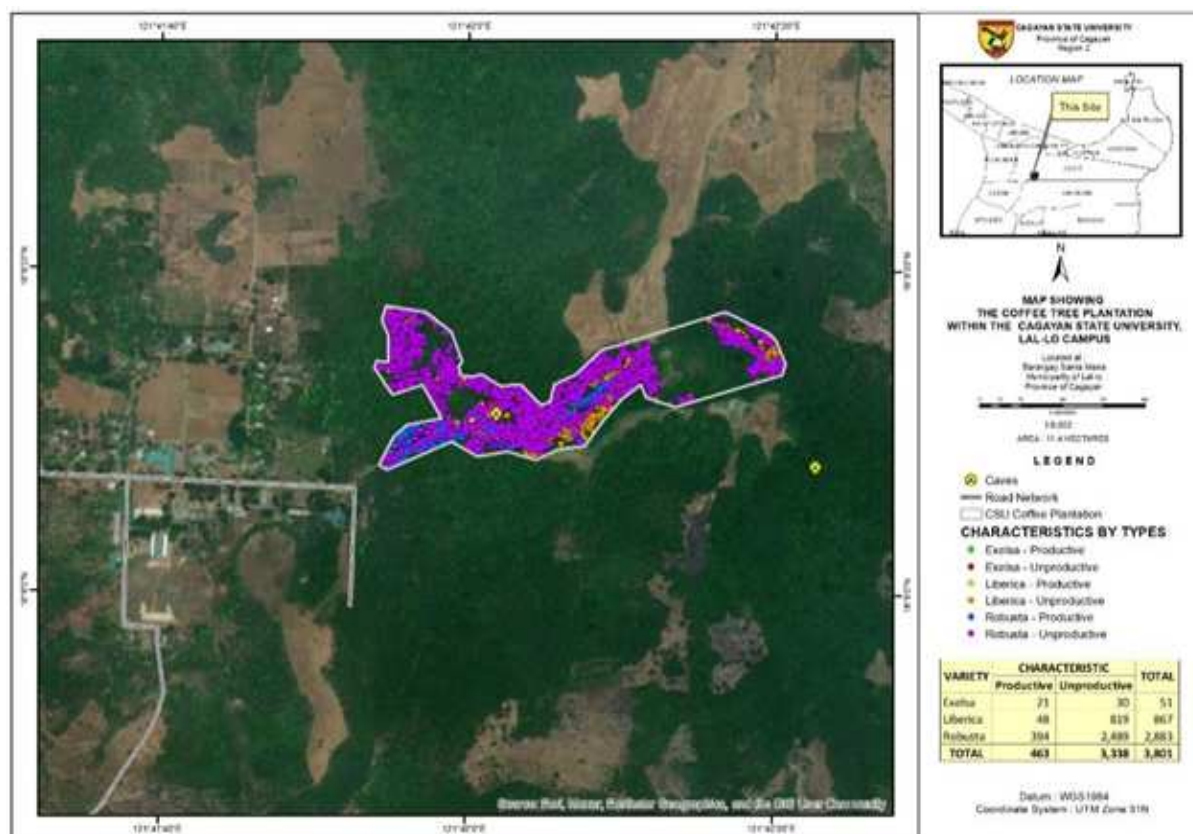
Fig. 1. Map of the total productive and unproductive coffee trees at old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.

Designing of Identification Number for the Coffee Tree

The validation of the data were prioritized to create a unique identifying number per coffee types.

Geo Tagging using the tool

Each coffee tree were marked with a waypoint and tagged based on its color. Robusta coffee was tagged with a purple and yellow color, liberica coffee was tagged with orange and red color and excelsa coffee was tagged with green and red color.

This was taken to identify the tree's unique character using a Global Positioning System (GPS) device. The complete data collected in the GPS were converted into attributes, and table were created, afterwards the unique identifier were linked.

Morphological Characterization

The morphological characteristics of the coffee trees were determined based on their leaves, flowers, and berries using the guide from the National Coffee Research Development and Extension Center, Indang Cavite, Philippines.

Simulating Coffee Farm Management

The perimeter were used to project a map of Cagayan State University Old coffee plantation.

The map projected was utilized to build the map using Google Earth to simulate the monitoring of the coffee plantation using Geographic Information System

technology.

Data gathered

The data gathered were the following:

a) Number of coffee types in the area. Total coffee trees per coffee type (robusta, liberica and excelsa) were tagged using a geographical positioning system (GPS) device;

b) Number of Coffee trees with berries and without berries. The number of productive and unproductive coffee trees were tagged using a geographical positioning system (GPS device;

c) Morphological characteristics per coffee type- Coffee trees was tagged based on their morphological characteristics using the guide from the National Coffee Research Development and Extension Center, Indang Cavite through different coffee plant parts such as leaves, flowers and berries;

d)Total area of coffee Plantation- The GPS application was used to examine the complete area of the coffee plantation, by conducting a perimeter survey of the whole area; and

e) Map per coffee type- The map generated per coffee types using the generated coordinates during the tagging per coffee trees in the area, using the Garmin tech, google Maps, and ARC-GIS map tools.

Result and discussion

Map of the total productive and unproductive coffee trees

Figure 1 shows the map of the total productive and unproductive coffee trees at the old coffee valena coffee plantation. Based on the result of the study, robusta coffee obtained the highest number with 75.85% or 2,883 plants followed by liberica coffee with 22.81% or 867 and excelsa coffee obtained the lowest with 1.34% or a total of 51 plants (Fig. 2). Majority on the robusta coffee trees, were non-bearing coffee trees with 86.33% or 2,489 coffee trees while 13.66% or 394 coffee trees are bearing.

Fig. 2. Morphological characteristics of robusta coffee trees at old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.

The liberica coffee trees are mostly non-productive with 94.46% or 819 coffee trees while 5.54% or 48 coffee trees are bearing. Moreover, on the excelsa coffee trees 58.82 % or 30 coffee trees unproductive while 41.17% or 21 coffee trees are with berries. Based on the result of the inventory, significant differences among the three (3) trees revealing that robusta coffee obtained the highest number of trees with productive and unproductive followed by liberica and excelsa coffee. This implies on the study of Wang *et al.*, 2015 that poor management practices results to unproductive coffee trees and low coffee plant density on the coffee production.

Morphological characteristics of robusta coffee trees

Figure 2 shows the morphological characteristics of a robusta coffee. The results shows that robusta coffee has thin leaves, curved elliptical shapes with wavy margins, white flowers with five –six (5-6) petals, with heavy clusters of small and round berries, and a

thin layer pulp. Likewise, robusta coffee trees have an umbrella-shaped growth pattern and reach a height of 4.5-5 meters.
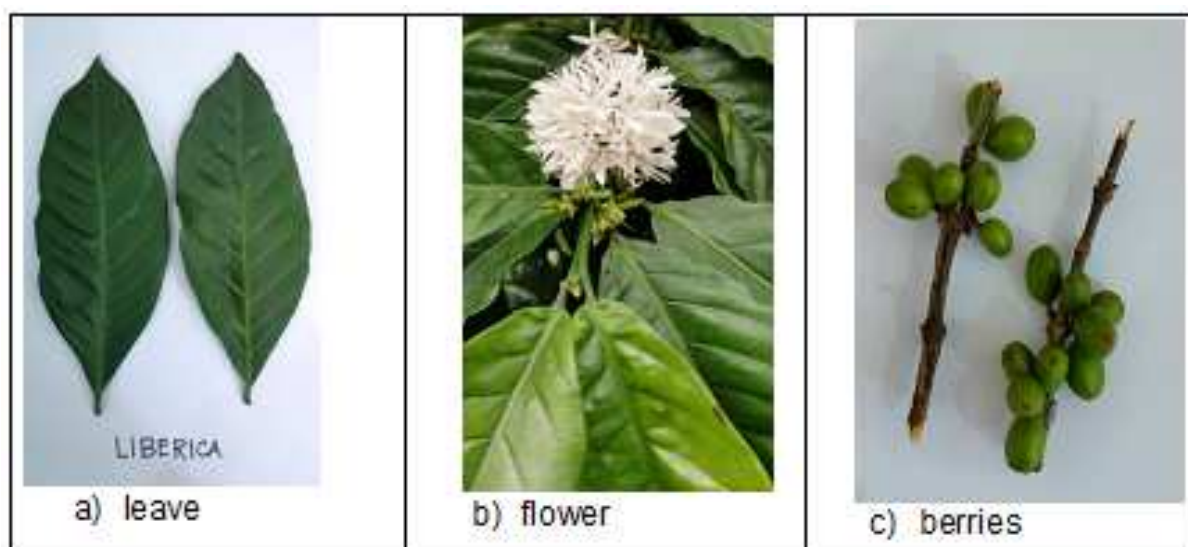
Morphological characteristics of excelsa coffee trees
Figure 3 shows the morphological characteristics of excelsa coffee. The excelsa coffee possesses broad and young leaves, usually shiny bronze-violet leaves,

which are thicker than robusta but thinner, smoother, and more rounded compared to liberica coffee. It produces large white flowers with four to six (4-6) petals and heavy clusters, roundish bigger than arabica but smaller than liberica coffee berries. Moreover, the pulp is thicker than liberica coffee. Furthermore, excelsa coffee grows up to 3-4 meters high.
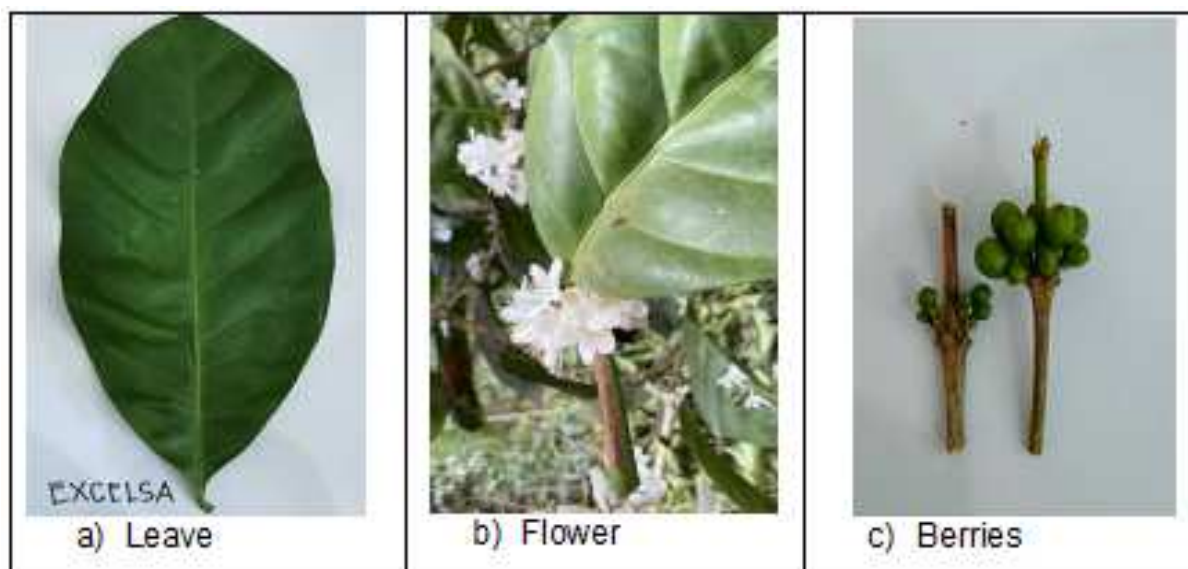
Fig. 3. Morphological characteristics of excelsa coffee trees at old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.

Fig. 4. Morphological characteristics of liberica coffee trees at old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.

Morphological characteristics of liberica coffee
Figure 4 presents the morphological characteristics of a liberica coffee. The results revealed that liberica

coffee also has a distinctive characteristic in the leaves are thicker than excels and twice as long as arabica coffee leaves, oriented sideways, and shaped like a

lance. The white flowers of liberica have four to six (4-6) petals. Moreover, liberica coffee berries are the largest among the three (3) varieties, appearing singly or in small clusters and turning dark red when ripe.

The pulp is thick, and the parchment is woody with a protruding nipple. Thus, liberica trees grow upright with straight trunks and reach 9-10 meters height.
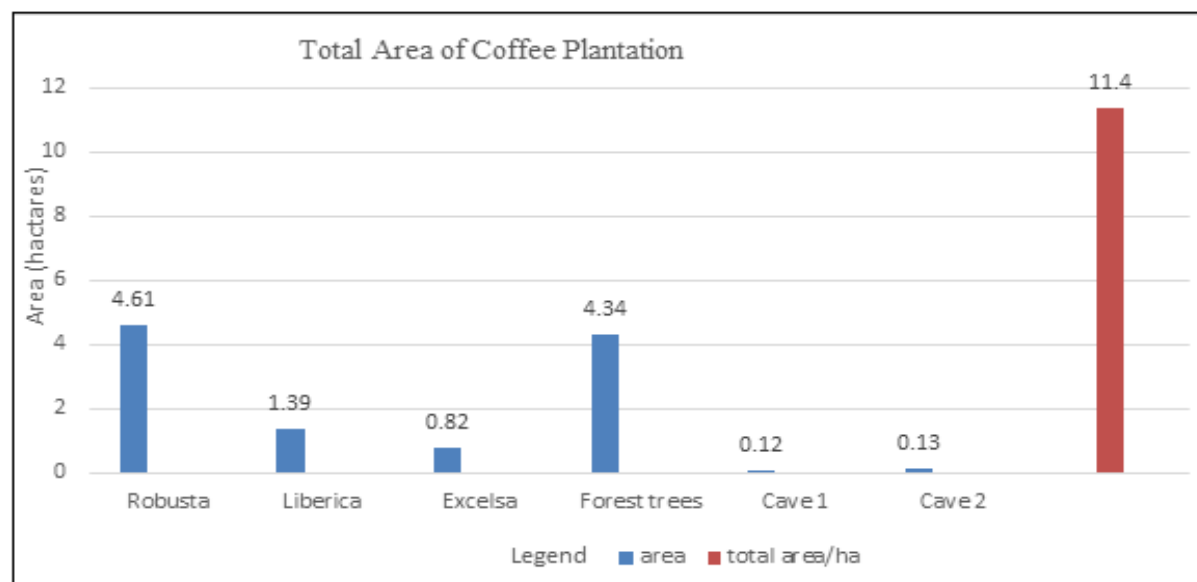
Fig. 5. Total land area of old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.

Total land area of the old coffee plantation

Figure 5 shows the total land area of the valena old coffee plantation. A total of 11.4 hectares, composing the following: 4.61 hectares cover the robusta coffee, 0.82 hectares are covered by excelsa coffee, 1.39 hectares are for the liberica coffee, 4.34 hectares cover the forest trees, bamboo, wild vine species, and spring, and 0.25 hectares cover cave 1 and cave 2 (Fig. 5). The results revealed that the old coffee plantation is rich in natural resources that are very valuable and play a vital role for the researcher and economist.
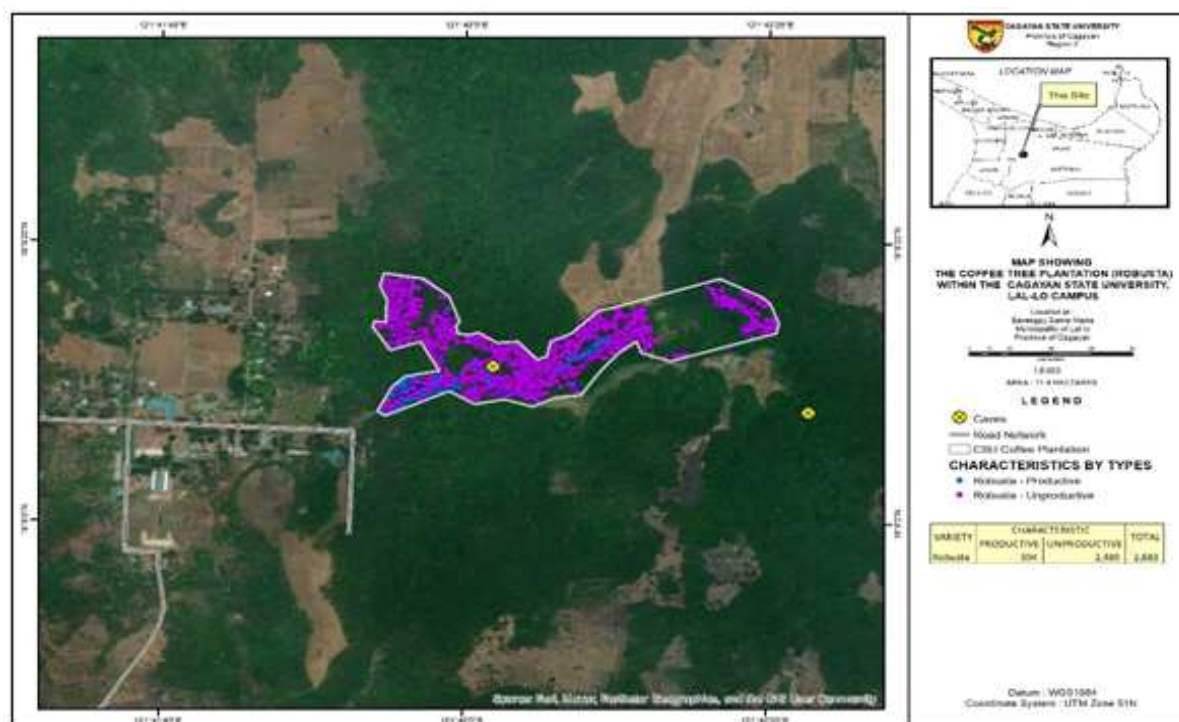
Map of the fruit-bearing and non-bearing robusta coffee

Figure 6 shows the map of the fruit-bearing and non-bearing robusta coffee. Based on the inventory, it revealed that the majority, with 86.33% or 2, 489 coffee trees of the robusta at the Valena site, were old and unproductive and 13. 66% or 394 coffee robusta trees, are productive and bear coffee berries. This implies in the study of Yilma *et al.*, 2020 that losing the coffee tree productive center more than 70% invites to rehabilitate the coffee tree. The coffee tree can be more productive only for 12 cropping years

after intensively applying all management practices starting at nursery and in all cropping years at field level. As the coffee tree became older, up to 15 years, the bean size also became more of a medium to small size and cup quality was below the specialty standard. In general, the coffee should be rejuvenated after 15 years by considering the first three years of vegetative growth stage and twelve cropping years when progressive yield decline begins. Therefore, pruning, stamping, and other special management should be employed in the area.

Map of the fruit-bearing and non-bearing Liberica coffee

Figure 7 shows the map of the fruit-bearing and non-bearing Liberica coffee. Based on the inventory, it was revealed that the majority of the Liberica coffee was unproductive (94). 46%, or 819 coffee trees, while the productive obtained the least with 5.544%, or 48 coffee trees. However, according to the study of Lagman, 2023, *Coffea 'liberica'* or liberica coffee is often referred to as the rare and even elusive variety of commercially grown coffee. This is because only 2% of the global coffee production is *C. liberica.*

Fig. 6. Map of fruit bearing and non-bearing robusta coffee at old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.
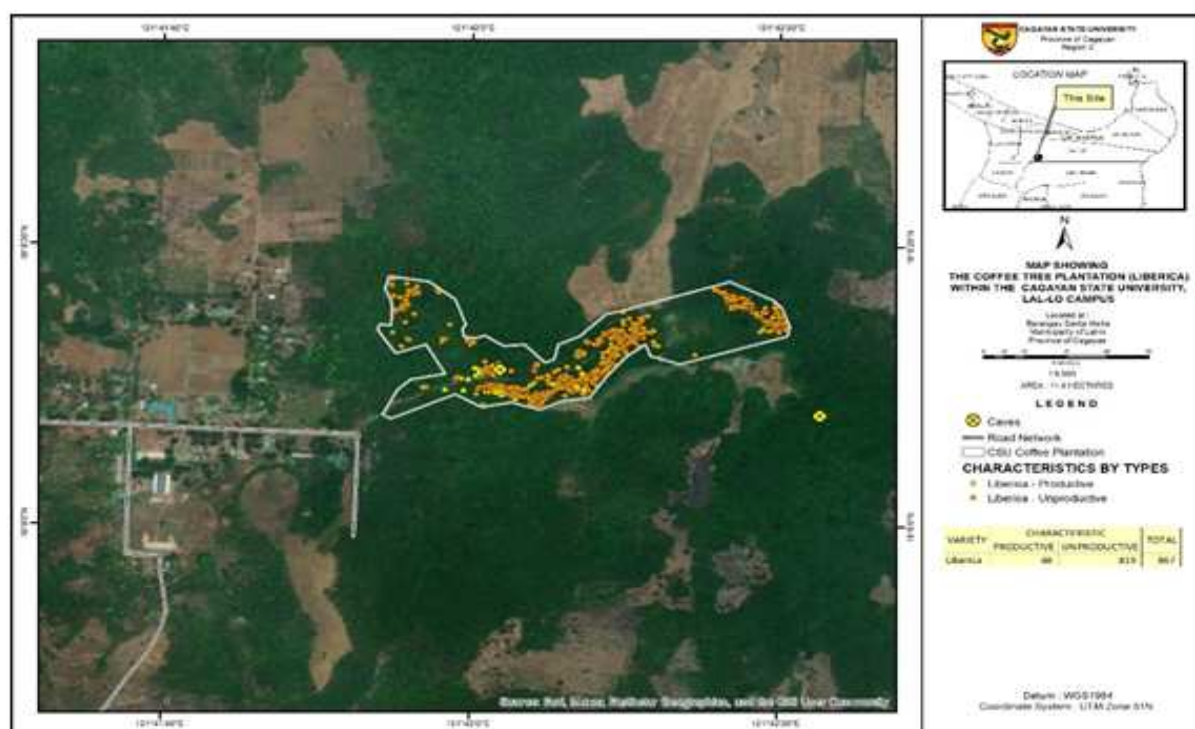
Fig. 7. The map of the fruit bearing and non-bearing liberica coffee at old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.

The species is grown commercially in five countries—Indonesia, Malaysia, Vietnam, Ethiopia, and the Philippines—mainly for local consumption, although some have exported to the emerging specialty coffee industry. Surprisingly, *C. Liberica* comprises 90% of coffee cultivated in Malaysia. *C. Liberica* is locally well known to the countries that produce them; however, *C. Liberica* remains a gem to be discovered

for the rest of the world. *C. Liberica* is referred to as an 'heirloom species' in the Western world, where it is sold. In Australia, it is called a 'heritage variety'. Therefore, we need to give importance to these coffee types for the sustainable coffee industry in the north.

Map of the fruit-bearing and non-bearing Excelsa coffee

Figure 8 shows the map of the fruit-bearing and non-bearing Excelsa coffee trees at old valena coffee plantation of Cagayan State Unversity Lal-lo, Cagayan, Philippines. Based on the inventory, it was revealed that the majority of the Excelsa coffee are non-bearing trees with a total of 58.82% or 30 coffee trees, while bearing trees obtained the least with a total of 41.17% or 21 coffee trees, with an overall total of 51 excelsa coffee trees in the area.

The lower production result of excelsa coffee at valena old coffee plantation is in accordance with the study of Udarno, 2015, where in Excelsa coffee is a type of lowland coffee cultivated in Indonesia. This coffee variety shares morphological similarities with liberica coffee, another type of coffee plant.
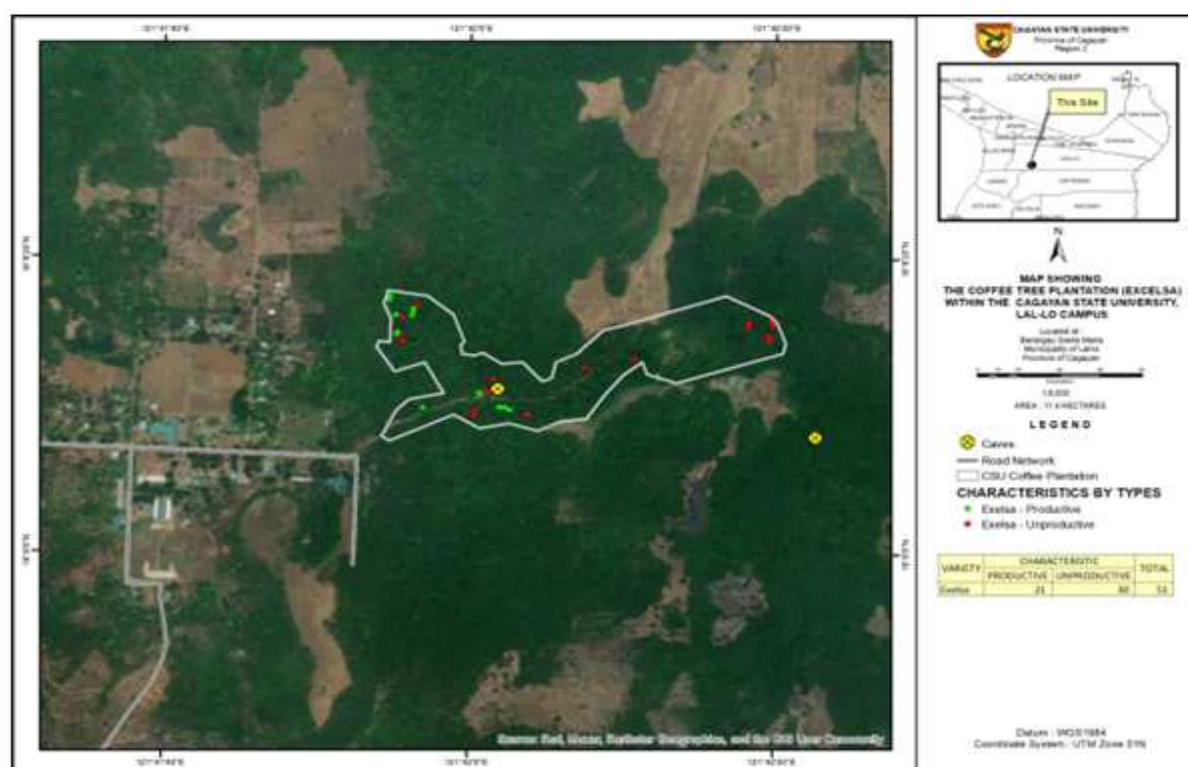
Fig. 8. The map of the fruit bearing and non-bearing excelsa coffee at old valena coffee plantation, Cagayan State University, Lal-lo, Cagayan, Philippines.

The genetic diversity of Excelsa coffee has been explored, revealing various morphological traits that can influence cultivation practices. While Excelsa coffee shows promise in terms of economic potential and quality, challenges remain, such as its lower production rates and sour flavor profile compared to other coffee varieties.

Thus, addressing these issues through improved cultivation and processing techniques could enhance its marketability.

Conclusion

The study titled "Inventory and GIS Mapping of the Three Existing Coffee Types at Cagayan State University Lal-lo Old Coffee Valena Plantation" was conducted from the Municipality of Lal-lo, Cagayan, Philippines from November 2, 2022 to February 18, 2023.

The coffee plantation covers 11.4 hectares with 3,801 trees, including 2,883 Robusta (394 with berries, 2,489 without), 867 Liberica (48 with fruits, 819

without), and 51 Excelsa (21 with fruits, 30 without). Trees without berries were affected by factors such as aging, overgrowth of secondary vegetation, wildling proliferation, and water scarcity.

Morphological characterization identified three coffee types: Robusta, Liberica, and Excelsa**.** Robusta has thin, wavy-edged elliptical leaves, compact berry clusters, and an umbrella-shaped growth reaching 4.5–5 meters. Excelsa features glossy bronze-violet leaves, large flowers, thick pulp, and grows up to 3–4 meters. Liberica, with its thick lance-shaped leaves, large berries, and woody-textured parchment, grows the tallest among the three.

Recommendations

This study is recommended for the accessibility and availability of the needed information in coffee production at CSU-Lal-Lo Campus. The researchers recommend similar studies and studies along with the preservation of the existing coffee types through rehabilitation such as pruning and rejuvenation, as well as pests and diseases such as coffee borer (CBB) and coffee rust, cultural management, nutrient management, and water management towards a sustainable coffee industry in the area. Moreover, a similar studies should be conducted to other sites of coffee areas in the campus as well as in the Municipality of Cagayan.

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