PHILIPP AGRIC SCIENTIST
Vol. 106 No. 1, 15-25
March 2023

ISSN 0031-7454

The Use of Open Data Kit (ODK) in Characterizing the Cacao Industry Sites in Panay Island

Rhea J. Subong-Espina*, Reynold D. Tan, and Christine Mae D. Hernando

College of Management, University of the Philippines Visayas, Iloilo City

*Author for correspondence; E-mail: rjsubong@up.edu.ph; subong_rhea@yahoo.com; Tel.: 09778899043/ 09296937505

Received: February 28, 2022/ Revised: September 23, 2022/ Accepted: October 5, 2022

Cacao is one of the world's most valuable export commodities and cash crops. Western Visayas, along with the other regions of the Philippines, has committed to participate in national efforts to strengthen the production capacity of the cacao industry and address prospects and opportunities for the industry growth and development. This paper presents the results of a region-wide study that mapped out and assessed key cacao-producing areas in the Western Visayas, specifically Aklan, Antique, Capiz, and Iloilo. The study sought their current production levels, important agricultural properties of farming areas, production densities, and growth potentials. Geospatial data was generated, analyzed, and mapped using Open Data Kit (ODK), an electronic data management system. Findings revealed that cacao plantations are not evenly distributed in Panay Island. Most cacao farms are located in the Province of Iloilo; however, tree density was highest at farms in the Province of Capiz. The geophysical characteristics of most cocoa-producing areas were consistent with the geophysical elements mentioned in the literature. These findings can be used for science-based decisions for promoting the emerging cacao industry in Panay Island.

Keywords: cacao, ODK, Open Data Kit, Panay Island

Abbreviations: DA – Department of Agriculture, DTI – Department of Trade and Industry, GIZ – Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, ODK – Open Data Kit

INTRODUCTION

Cacao has become a highly valued agricultural product worldwide. Ranked third among the most significant export commodities globally, cacao is also the second most important tropical cash crop (Blare and Useche 2013; Diaz-Montenegro et al. 2018). According to the records, 80% of cacao is produced by 7 – 8 million small family-managed cacao farms in over 50 countries around the world (ECLAC et al. 2015). The global cacao market distinguishes between two broad categories of cacao beans: "fine or flavor" and "bulk or ordinary" cacao beans (ICCO 2020). Given their excellent characteristics, fine flavor cacao beans sold for a premium represent 5 – 10% of the world market (ICCO 2006; Melo and Hollander 2013; Diaz-Montenegro et al. 2018). As such, fine flavor cacao creates a global demand exceeding supply and resulting in lucrative macro-level chain expansion with premium pricing benefits equitably spread out to all chain actors (ICCO 2012; Blare and Useche 2013).

In the past years, the cacao industry has gained recognition in domestic and export markets as cacao beans' supply-and-demand gap has increased. The world demand for cacao has nearly tripled since 1970, with an annual growth rate of 3% in China and 7.9% in India. Cacao may significantly contribute to poverty alleviation and inclusive growth through livelihood and job generation since cacao production requires only a small monetary investment or start-up capital the reason why 80–90% of the growers are of small farm holdings and family-run farms (DTI 2016; Lena 2017). The cacao plant is suitable for intercropping with coconut and banana, especially during its gestation period. The gestation period takes a minimum of two to three years, from seed to fruit-bearing tree (Olasupo and Aikpokpodion 2019). While waiting for the cacao to bear fruits, farmers earn from the produce of the other crops. These are some of the most valued advantages of this high-value crop. The early return on investments and the high profitability of the product also ensure good income augmentation potential. Significantly, the industry is market-driven, considering that cacao has no product substitute. Such a high-value crop has diversified its usage as food and non-food, which shows potential for a sustainable marketing opportunity.

In the Philippines, there was an increasing volume of imports for cocoa, with 31,920 mt in 2011 and 48,480 mt in 2015. Moreover, there was an enormous increase in the value of cocoa imports from US$ 103,370,000 to US$ 199,690,000 in 2011 and 2015, respectively (PSA 2016). The Philippine government reported that the global demand for cacao would reach between 4.7 and 5 million mt by 2020. However, a global cocoa shortage is predicted at 1 million mt by 2020 (2017 – 2022 Philippine Cacao Industry Map). The Philippines alone consumes 50,000 mt annually, while the local supply is between 10,000–15,000 mt from the 20,000 – 25,000 ha of land planted with cacao per industry estimate (DTI 2016; Colby-Sy 2020). Nonetheless, the Philippine Statistical Authority (PSA) reports an estimate of 6,020 MT produced in the year 2015.

Realizing such a critical need, the Philippine Cacao Industry Roadmap was crafted to guide the country's cacao industry development for the next five years (DA-DTI 2022). Cacao stakeholders envision a competitive and sustainable Philippine cacao industry by 2022 which is expected to be achieved through the 2022 Cacao Challenge. The goal is to produce 100,000 mt of fermented beans by the year 2022 for the export and domestic markets through a 40% annual increase in production, an increase in production productivity to 2 kg per tree per year, an increase in cacao farmers' income to at least PhP 130,000 per ha per year, and export sales by at least US$ 250,000,000 per year.

There were 17 regions in the country that signified their commitment to participate in attaining the industry's goals. Region VI (Western Visayas) committed to producing 1,000 mt of cacao annually. However, aiming toward this direction requires an assessment of the region's capability to meet its annual production targets.

Panay Island is located in the Western Visayas area of the Philippines and comprises four provinces: Aklan, Antique, Capiz, and Iloilo. It has a total land area of 2,011 km^2 (4,637 sq mi) and a population of 7,954,723 as of the 2020 census (PSA 2021). The natural forest on the island is the most important carbon sink in the region (GIZ extends Panay cacao program 2016). Valentin Tutur, the Philippine Cacao Industry Council chairman, noted that Panay Island has "great potential" for cacao (Lena 2017). In the past years, the Department of Trade and Industry (DTI) promoted cacao as one of the crops to be planted in the region. The Department of Agriculture (DA) also identified areas in Panay Island suitable for cacao. Furthermore, the Iloilo Provincial Agriculture Office (PAO) classified the cities of Dingle and Passi as a highly suitable areas for cacao planting (Panay News 2018).

In the identification and mapping of resource areas such as in the case of suitable planting areas for cacao production, there has been a growing number of users venturing into the use of mobile phones and Android-based applications for such purposes. One of the mobile phone applications gaining popularity is the Open Data Kit (ODK), which is an open-source software that allows organizations to build and manage application-specific information services and collect data in resource-constrained environments (Brunette et al. 2013). Google's Android mobile phone application was used in the Netherlands to collect data related to hydroinformatics (Abbot and Jonoski 2001; Jonoski et al. 2013). In the study of Signore (2016), several vegetable crops at risk of genetic erosion were mapped using ODK and Google Fusion Tables.

Furthermore, studies in plant breeding and genetics (Rife and Poland 2014) as well as community well-being and household living standards also used open-source and mobile phone applications for electronic data capture (Bell et al. 2016). Researchers used free, Android-based applications to lower the cost of data collection, decrease technological barriers, and promote the adoption of electronic data management. Extensive mobile data collection through Android and iOS mobile phones was used to gather geospatial locations and images (Salvati et al. 2021). The digital version of the forms using the Open Data Kit (ODK) and GISCloud client-server approach captured geospatial data which were analyzed and mapped to evaluate the possible impacts of exposed buildings on potential geo-hydrological processes.

Extant literature shows that using electronic data management has become essential in research. This data collection method lessens the scribing and transcribing of a massive amount of data from the paper-pen method, enhances the effectiveness of data collection, increases data integrity, and facilitates data organization in digital form (Rife and Poland 2014).

In the agricultural sector, there are studies that show the use of mobile phone and Android applications. In 2018, de Oliveira Júnior et al. developed an application for smartphones and Android tablets to measure climatological variables such as air temperature, black globe temperature, and relative humidity. Montoya et al. (2013) used an application for Android tablets that interact with a control system based on Linux, Apache, MySQL, PHP, Perl, and Python (LAMP) to collect and monitor variables in precision agriculture. This proves that the application of mobile technology for data collection can be effectively implemented and is cost-efficient (Salvati et al. 2021). However, despite the extensive use of mobile device applications, there is a gap in the use of ODK for data collection in the agricultural sector, specifically in the cacao industry.

Scientific studies on cacao production, especially those aimed at determining the suitability of planting areas for cacao in the Philippines, particularly in Western Visayas, would greatly benefit government and private sector efforts in increasing cacao production in the region. However, no such local studies have been undertaken yet, as existing literature focuses on the understanding of the genetic character and physiology of cacao beans (Kothe et al. 2013; Wickramasuriya et al. 2018; Coulibaly and Erbao 2019); the processing of cacao (Alean et al. 2016; Kysiak 2016); and the effects of cacao products on human health (Katz et al. 2011; Martín et al. 2020; Daussin 2021).

Given the absence of empirical studies on cacao-producing areas in Region VI, there is an urgent need to investigate and assess cacao-growing areas' quality and production potential in Western Visayas. Moreover, these assessments could benefit from using the nine Principles for Digital Development and the Open Data Kit in data generation. This paper presents the results of a region-wide study that mapped out and assessed key cacao-producing areas in Western Visayas, specifically Aklan, Antique, Capiz, and Iloilo. The potentials for agricultural production of cacao in Western Visayas were examined. Specifically, the study sought to answer the following issues and concerns: 1) Where are the key cacao-producing areas in the region? Where is the concentration of cacao in elevated areas in the region?; 2) What are the physio-chemical properties of the cacao-production areas?; and 3) What is the growth potential of the cacao-production areas in Panay island? As a corollary, what is the density (tree density, number of farms, indicative production in kg per area) of production in these areas?

This research also provided much-needed scientific data and information on Western Visayas's key cacao production sites as well as their production capacities and growth potentials. National government agencies such as the DTI and DA, which assist the cacao industry, can find a scientific basis for relevant policy measures for promoting and expanding the local cacao industry. In addition, local government units (LGUs) concerned can use the data to strengthen governance efforts in delivering agricultural and business development services to the cacao industry.

MATERIALS AND METHODS

Using a qualitative research design, the study adopted a framework for data collection and analysis that conforms to the Principles of Digital Development (Fig. 1). The said framework outlines nine living guidelines designed to help integrate best practices into technology-enabled programs and are continuously updated and refined over time. Each pillar serves as a guide in every phase of the project life cycle, eventually forming the guidance in each of its phases. Adopting the Principles of Digital Development enables establishing a community-developed decision support tool enhanced by using information and communication technologies (ICTs).

These nine principles are: (1) Design With the User; (2) Understand the Existing Ecosystem; (3) Design for Scale; (4) Build for Sustainability; (5) Be Data Driven; (6) Use Open Standards, Open Data, Open Source, and Open Innovation; (7) Reuse and Improve; (8) Address Privacy & Security; and (9) Be Collaborative.

Principle #1: Design With the User

It is important to engage all the user groups in the planning, development, implementation, and assessment processes involved in integrating a technology-based program or project.

Principle #2: Understand the Ecosystem

An ecosystem may refer to the regulatory environment (i.e., policies, laws, rules), political environment (i.e., structure, government, ministries), and technical environment (i.e., standards, platforms, and tools for interoperability). Understanding the regulatory environment and aligning the project to the ecosystem is a crucial aspect in the conduct of the study.

Fig. 1. Principles of Digital Development (c2023).

Principle #3: Design for Scale

The design of the project and the technology used are easily adaptable and customizable.

Principle #4: Build for Sustainability

The project must factor in the physical, human, and financial resources necessary for long-term sustainability. Sustainability involves government engagement with diverse consortium partners.

Principle # 5: Be Data Driven

The objectives are based on the information needs of the intended users and guarantees relevant data collection, i.e., how data will be acquired, used, stored, and shared. This also implies that accurate information is available to the right people when they need to make sound decisions — an evidence-based approach for decision-makers.

Principle #6: Use Open Standards, Open Data, Open Source, and Open Innovation

In congruence with Principle #7, developing another software entails tedious effort and consumes enormous resources. Moreover, project-based solutions often duplicate and may not be sustainable in the long run. In contrast, ODK is readily available since it is open-source software. It can be customized based on the project's needs and updated because it is anchored in an open-source community. With ODK, long-term sustainable development is achieved.

Principle #7: Reuse and Improve

Since software design and development can be expensive for cash-strapped organizations, the reuse of existing tools sans alteration can be a practical alternative. A resource inventory and review can determine possibilities for reuse of resources. On the other hand, improvement implies that existing tools can be adapted to specific programs or needs (Waugaman 2016).

Principle #8: Address Privacy and Security

How the information is collected, stored, analyzed, shared, and used has serious implications for whom data is transmitted and for the organization transmitting the data. Access to ODK Aggregate was given only to authorized individuals. Authentication can be embedded in ODK Aggregate, use of the dedicated server, and encryption with the ODK forms.

Principle # 9: Be Collaborative

Project sustainability can be established by collaborating with project partners and engaging them within or across sectors thru open standards, data, and platforms (Waugman 2016).

In compliance with the principles of Digital Development and given the critical role of user engagement and stakeholders' inputs in the long-term success of the project, the study sought the involvement of representatives from various stakeholder groups (i.e., technical staff from GIZ and DA) in crafting the questionnaire and its digital design format. Partnerships were established among government agencies and representatives from the private sector, such as the cacao councils of the different provinces in Region VI.

Selection of the Study Sites

The study covered 70 barangays in 17 municipalities in the four provinces of Aklan, Antique, Capiz, and Iloilo. The cacao farms and plantations were mapped using Android devices with Open Data Kit (ODK). Secondary data from the DA, DTI, and Deutsche Gesellschaft für Internationale Zusammenarbeit – Forest and Climate Protection in Panay (GIZ-ForClim) project were used a reference to select the areas to be prioritized for the survey. The study was conducted from July until October 2017. Given the size of Panay Island and the limited time to conduct the survey, sample sites were selected. The selection was based on the following methodology: (1) The data of GIZ and DA from the years 2015 until 2017 on the number of cacao trees per municipality and barangay were calculated and used as the basis for the prioritization -making matrix, which includes the 25, 50, and 75 percentiles of cacao trees per local government unit. The top 25% are the highest priority and are marked in red (Table 1); the next 25% (from 50–75%) are a medium priority and colored orange. The remaining areas are of the lowest priority and are indicated in yellow.

The team coordinated with the Municipal Agriculturist or Municipal Agriculture Officer (MAO) to identify the cacao farmers in their respective areas. From the list of cacao farmers provided by the MAO, 10–20% of them were selected based on (a) number of seedlings they planted, (2) location of the farm, and (3) responsiveness and willingness of the farmers to participate in the study.

Table 1. Example for the priority area (in the Province of Aklan).

Area
Ibajay
Libacao
Malinao
Madalag
Altavas
Balete
Malay

Data Collection

The first step in any survey is to set clear objectives. The objectives should be based on the

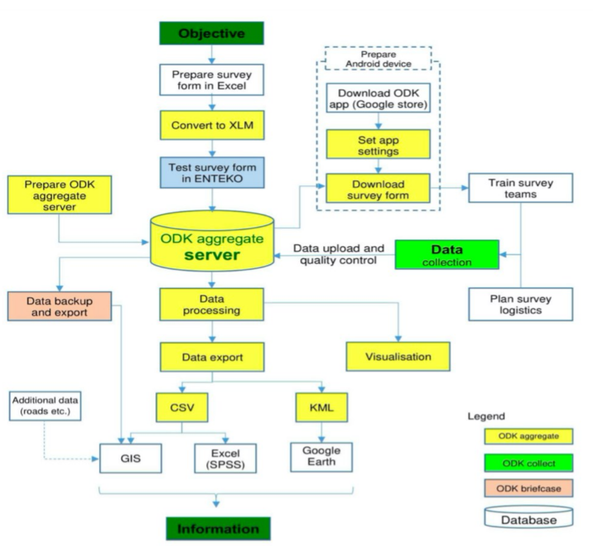

Fig. 2. Technical preparation for the ODK setup and data collection workflow (Pakes et al. 2018).

information needs of the intended users of the information. In the study, the data that can be processed into information useful to the intended users were collected, stored in the server database, and analyzed. Data collection protocols were designed on this basis.

The framework and all stages of the ODK workflow was shown in Fig. 2. The objective, data, database, and information are highlighted in green in the flow chart, and the database (server) is placed in the center of the process flow.

The technical infrastructure for the data collection was constructed using the Open Data Kit before the survey. Efforts were made to ensure that the methodology conformed to the Principles of Digital Development. The setting-up stage was divided into three steps: (1) ODK Aggregate server/website preparation, (2) survey forms/ questionnaires design, and (3) Android devices for mapping set-up.

ODK Collect was the tool used for data collection. It renders forms into a sequence of input prompts that apply form logic, entry constraints, and repeating sub-structures (ODK 2017). During the data collection, end-users (data surveyors) work through the prompts (questions) and can save the form at any point during the survey. The form is automatically saved at the end of the survey. The data collected are then automatically uploaded to the server database. If there is no Internet connection, data is uploaded as soon as the users have a connection.

Data Analysis

ODK Aggregate is the server that accepts both the forms and the data collected (ODK 2017). Once data has been collected with ODK Collect and uploaded to the database, ODK Aggregate is used for data processing and export. ODK Aggregate can generate basic graphs and maps. Data were exported to comma-separated-value (CSV) file format and Keyhole Markup Language (KML) file format for further analysis. These data were processed and maps were generated through the QGIS, a Geographic Information System software that can generate maps. Moreover, the ODK Briefcase was used for data backup on a computer which data can be used for further analysis. Fig. 2 details the technical preparation for the ODK setup and data collection.

RESULTS AND DISCUSSION

Cacao-Producing Areas

Cacao farms and plantations are not evenly distributed throughout the island. Most farms are located in the eastern portion of the Panay mountain range and in relatively low-lying areas in which cacao trees are planted in approximately 1,501 ha (Fig. 3). These farms are also bigger than those found in the eastern part of the island (average of 61,197 trees vs. 14,126 trees).

A total of 252 farms were mapped in Panay Island with most of the farms being located in the Province of Iloilo, amounting to a total of 125 farms. On the other hand, Capiz, with only 26 farms, has the least number of farms. On average, Antique has the smallest number of cacao trees planted, with 14,126 trees out of the 197,718 cacao trees. However, although Capiz has the least number of farms, 45,650 trees are planted in the province (Table 2).

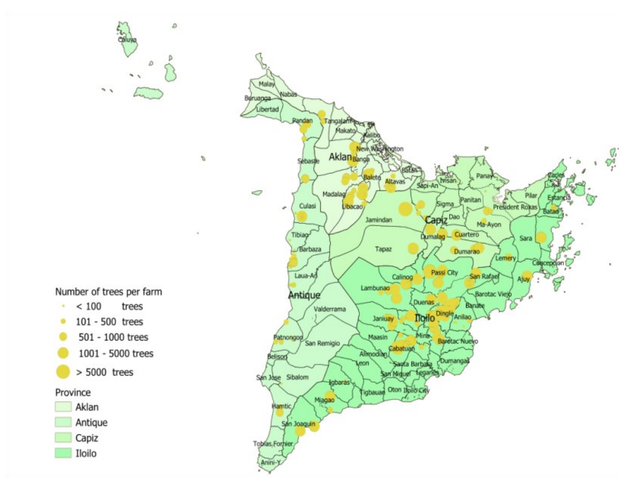

Fig. 3. Cacao area and density in the Panay Island.

Table 2. Cacao farms and trees in Panay Island.

Province	No. of Farms	No. of Trees	Trees per Farm
Aklan	48	35,329	738
Antique	53	14,126	266
Capiz	20	45,650	2282
Iloilo	125	102,613	820
Total	246	197,718	803

The province of Iloilo, with 102,613 trees, has the greatest number of trees planted. Moreover, the study found that the minimum farm size consists of only one tree. This can be attributed to the high mortality of cacao plants. Moreover, various government and private organizations such as the DA, DTI, and the Department of Environment and Natural Resources (DENR), in partnership with GIZ – ForClim II project, distributed cacao seedlings to identified farmer-beneficiaries through their local government units. However, the beneficiaries received some of these seedlings after the planting season; thus, most did not survive.

A. Area Covered, Density, and Concentration of Cacao Trees

Cacao thrives at altitudes of 30 – 300 m (100 – 1,000 ft) above sea level in areas where the temperature is at a minimum of 18 – 21°C (64.4 – 69.8°F) and a maximum of 32°C (89.6°F). The climatic and site requirements of cacao are usually in the tropical regions of the world and generally within 15° of the equator (QLD-DAF 2015). A high mortality rate is evident in growing cacao due to the projection of the negative impact of climate change on cacao establishment (Läderach et al. 2013; Anokye 2021). Thus, it is essential to satisfy the environmental requirements for cacao production.

The elevation is the distance above sea level. It is usually shown on maps by contour lines, by bands of color, or by numbers giving the exact elevation of points on the Earth's surface. The map (Fig. 4) shows the elevation in the eastern part of the island — the western part is less elevated than the other side.

The concentration map of the cacao plantations (Fig. 5) shows four major areas of cacao growers on the island. Two of these areas are found in the western part of the island, specifically in the Iloilo province. The main area is within the zone stretching from the municipalities of Janiuay, Badiangan, and Cabatuan. Another concentration that is visible is in the zone ranges from Passi City to the municipalities of Dingle and Anilao. Furthermore, two other hotspots are found in the eastern part of the island. One is located in the province of Aklan within the zone of Libacao stretching to Balete, while the other is in the province of Antique in the municipality of Barbaza.

B. Physio-chemical Characteristics of Cacao-producing Areas

The economic value of cacao is determined mainly by the quality of the beans, which includes the flavor, fat content, average seed weight, shell content, moisture content, and defective seeds. To achieve good quality cacao, environmental requirements should be fulfilled. Climatic factors such as temperature, rainfall, humidity, and soil suitability can affect agricultural output. These factors have an integrated impact on cacao growth. Cacao is cultivated in hot-humid climates with an average rainfall of between 1,150 mm and 2,500 mm and a temperature range of 18 – 32°C . These areas lie along the equator in West Africa, Central and South America, and

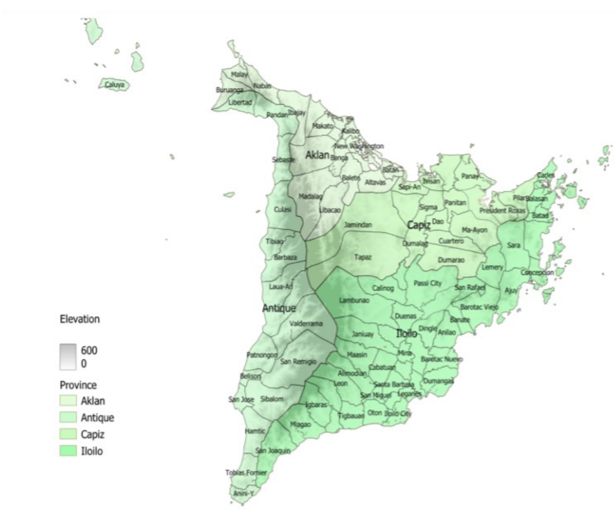

Fig. 4. Elevation in the Panay Island.

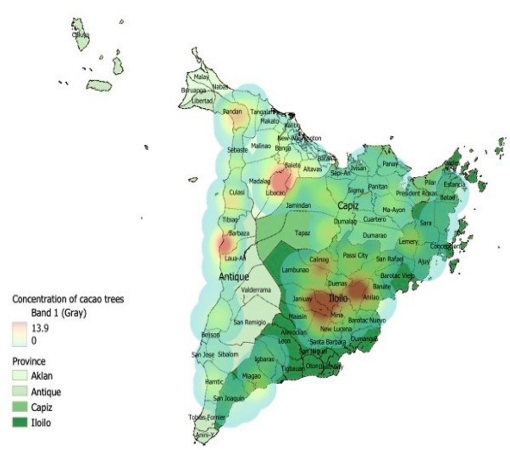

Fig. 5. Concentration of cacao trees in the Panay Island.

Asia (Ojo and Sadiq 2010; Okongor et al. 2013; Yoroba et al. 2019).

Temperature

The temperature range in the study areas is between 29 – 32°C. Cacao temperatures range from a minimum of 18–21°C and a maximum of 30 – 32°C. Although cocoa will grow above 32°C, the upper-temperature limit is not well -defined, and shade cover will influence maximum temperatures for the cacao. High temperatures may also affect bean characteristics and yield (QLD-DAF 2015). Most of the study areas have a maximum temperature of 32°C except for the following municipalities: Madalag and Malinao in Aklan; Laua-an, Patnongon, and Tibiao in Antique; Tapaz in Capiz; and Miag-ao, Iloilo. In these municipalities, the temperature is at 29°C. This implies that the temperature range in Panay is ideal for growing cacao plants. However, the risk associated with climate change, specifically with the rising temperatures, may lower the survival rate of the cacao establishment (e.g., the case in Ghana [Anokye 2021]).

Rainfall

Cacao growing requires more rigorous pedological and climatic conditions than other tropical crops like coffee, palm, and rubber tree. Cacao needs wetter conditions of about a minimum of 1,150 mm rainfall per year (Yoroba et al. 2019) with a limited number of dry days of not more than 90 d or three months (QLD-DAF 2015; Yoroba et al. 2019). The rainfall distribution in Panay Island is diverse and ranges from 2,539 – 5,066 mm annually (Table 3).

Soil Suitability

Cacao is grown on a wide range of soil types, but soils with moderate to high fertility are favored since fertilizer inputs under traditional production systems are low (QLD-DAF 2015). The Department of Agriculture created a crop suitability map which farmers and growers can use to assess if the soil is suitable for the crop they intend to grow. The bases for the suitability map are water source availability, shade newly planted for crops, Type IV climate, loamy soil, and well-porous and well-aerated soil. The Type IV climate is characterized as evenly distributed yearly rainfall (PIDS 2005). Among the study sites, the soil in Pandan, Patnongon, and Sebaste in Antique, Ivisan, and Pontevedra in Capiz is unsuitable for cacao plants. However, this does not mean that cacao plants could not be grown in the area. Soil suitability is only one factor to be considered. The areas mentioned met the required temperature and rainfall per annum.

C. Opportunities for Growth

Findings also showed that the cacao farmers in Panay Island are satisfied with their crops and the profit they earn from them (91.85%). They also want to plant more cacao seedlings on their respective farms. Table 4 shows the prospective number of seedlings to be planted in the next five years.

Furthermore, various agencies in the region, such as the DA, DTI, and Land Bank of the Philippines (LANDBANK), provide different types of assistance to cacao farmers and growers on the island. The DA assists the farmers through their technical training and support (i.e., land-suitability tests, product development, planting materials and inputs, cacao nursery, among others). DTI provides product development and market facilitation. DTI also extends trainings and recently facilitated the symposiums that led cacao industry stakeholders to meet and discuss possible collaborations (e.g. the Cacaolink). They also offered technical assistance to strengthen the

Table 3. Rainfall distribution in the Panay Island.

Province	Municipality	Rainfall (mm) Annual	Province	Municipality	Rainfall (mm) Annual
Aklan	Altavas	3008	Iloilo	Ajuy	2539
	Balete	3008		Anilao	2082
	Ibajay	5066		Badiangan	2539
	Libacao	3639		Batad	3008
	Madalag	3639		Cabatuan	2539
	Malinao	3639		Calinog	2539
Antique	Barbaza	ranging from 3659 to 5066		Dingle	2082
	Culasi	5066		Duenas	2539
	Hamtic	3008		Igbaras	ranging from 2539 to 3008
	Laua-An	3639		Janiuay	2539
	Pandan	5066		Lambunao	ranging from 2539 to 3008
	Patnongon	3639		Lemery	2539
	Sebaste	5066		Miagao	2539
	Sibalom	3008		New Lucena	2082
	Tibiao	5066		Passi City	2539
Capiz	Cuartero	2539		Pototan	ranging from 2082 to 2539
	Dumalag	2539		San Dionisio	2539
	Dumarao	2539		San Enrique	2539
	Ivisan	2539		San Joaquin	2539
	Jamindan	3008		San Rafael	2539
	Ma-Ayon	2539			
	Mambusao	2539			
	Pontevedra	2539			
	Tapaz	3008			

Table 4. Perspective number of seedlings to be planted in the next five years.

Province	Municipality	No. of seedlings	% in the Province	% in Panay
Aklan	Altavas	16,000	11.76	3.34
	Balete	22,000	16.18	4.60
	Ibajay	9,500	6.99	1.99
	Libacao	55,500	40.81	11.60
	Madalag	7,000	5.15	1.46
	Malinao	26,000	19.12	5.43
Total in Aklan		136,000	100.00	28.43
Antique	Barbaza	13,450	36.25	2.81
	Culasi	1,850	4.99	0.39
	Hamtic	5,000	13.48	1.05
	Laua-An	4,000	10.78	0.84
	Pandan	6,000	16.17	1.25
	Patnongon	3,300	8.89	0.69
	Sebaste	2,000	5.39	0.42
	Tibiao	1,500	4.04	0.31
Total in Antique		37,100	100.00	7.75
Capiz	Cuartero	5,000	6.13	1.05
	Dumalag	24,500	30.05	5.12
	Dumarao	3,500	4.29	0.73
	Ivisan	100	0.12	0.02
	Jamindan	29,000	35.57	6.06
	Ma-Ayon	4,150	5.09	0.87
	Mambusao	1,250	1.53	0.26
	Pontevedra	1,020	1.25	0.21
	Tapaz	13,000	15.95	2.72
Total in Capiz		81,520	100.00	17.04
Iloilo	Ajuy	5,000	2.23	1.05
	Anilao	2,250	1.01	0.47
	Badiangan	6,650	2.97	1.39
	Batad	6,000	2.68	1.25
	Cabatuan	8,150	3.64	1.70
	Calinog	1,600	0.71	0.33
	Dingle	8,100	3.62	1.69
	Duenas	15,000	6.70	3.14
	Igbaras	5,000	2.23	1.05
	Janiuay	3,000	1.34	0.63
	Lambunao	8,500	3.80	1.78
	Lemery	5,600	2.50	1.17
	Miagao	500	0.22	0.10
	New Lucena	50	0.02	0.01
	Passi City	117,500	52.50	24.56
	Pototan	20,100	8.98	4.20
	San Dionisio	4,500	2.01	0.94
	San Enrique	3,300	1.47	0.69
	San Joaquin	2,000	0.89	0.42
	San Rafael	1,000	0.45	0.21
Total in Iloilo		223,800	100.00	46.78
Total in Panay		478,420		100.00

cacao industry in the Visayas area through training related to product development (e.g., chocolate-making). In addition, state-owned financial institutions such as LANDBANK provide credit facilities and financing programs to farmers and agri-based micro, small, and medium enterprises (MSMEs) to accelerate the growth of these enterprises (LANDBANK launches credit facility for rapid growth of farmers, agri-based MSMEs 2021).

The LGUs and private organizations concerned also took the lead in promoting cacao in Panay Island. There is also the emergence of organized groups or industry associations of cacao producers in the island, such as the Panay Organic Producers Association, Libacao Banana Cacao Planters Association (LIBACAPA) in Aklan, Pototan Cacao Growers Association, and Dingle Cacao Growers Association in Iloilo, as well as the Regional Cacao Council that serves as the federation for all cacao farmers and growers in the Region VI.

Indeed, there is a wide opportunity for the growth and development of the cacao industry in Panay Island as manifested in the cacao farmers' commitment to expand their farms, the existence of institutionalized assistance, and the presence of organized groups and associations that assist in the promotion of cacao cultivation.

CONCLUSION

This study characterized the cacao industry in Panay Island, Philippines. Specifically, it investigated the key producing provinces, production densities, and common geophysical characteristics and identified growth opportunities. In the absence of previous studies of a similar nature, this pioneering work utilized the combination of ODK and GIS, following the Principles of Digital Development in characterizing cacao — a fast-growing commodity in Western Visayas.

The study found that cacao plantations are not evenly distributed in Panay Island and that its dominance is found in areas located east of the Panay Mountain Range. Except for soil suitability, the geophysical characteristics of the cacao-producing areas were seen to be consistent with the geophysical elements mentioned in the literature. Most farms and cacao trees were documented in the Province of Iloilo, but tree density is highest in farms in the Province of Capiz. Areas in Antique and Capiz were observed not to exhibit soils suitable for cacao but met the temperature and rainfall requirements. Projected farm expansions were noted with the Province of Iloilo having approximately half of the estimated increase in the next five years. Growth opportunities are also indicated with documented support from government and private institutions for meeting requirements in finance, production, human resource development, and marketing and processing of produce. The research underscored the potential of Panay Island as a primary contributor to the realization of the 2022 Cacao

Challenge as stipulated in the Philippine Cacao Industry Roadmap.

Managers and academics are aware of the importance of science-based decisions. However, to promote the growth of new industries such as cacao, decisions must be anchored on sound projections. This paper worked on characterizing the potential of Panay Island as an expansion area for cacao plantation. The evidence is vital not only technically (geophysical characteristics) but also institutionally (sectoral industry support).

Issues in the design present one of the limitations of the study. Only farms listed in the Office of the Municipal Agriculturist were included in the study. In addition, no town-specific geophysical characteristics were documented — data were aggregated at the provincial level, which may have failed to capture municipal-level peculiarities. Other geophysical features were also not available and remain undocumented.

ACKNOWLEDGMENT

This research has been funded by the Deutsche Gesellschaft für Internationale Zusammenarbeit – Forest and Climate Protection (GIZ-ForClim) in the Panay project. Special thanks to Dr. Klaus Schmitt, Ingr. Ubo Pakes, and Prof. Mary Ann Gumban for their guidance and trust throughout this research project.

REFERENCES CITED

ABOU RAJAB Y, LEUSCHNER C, BARUS H, TJOA A, HERTEL D. 2016. Cacao cultivation under diverse shade tree cover allows high carbon storage and sequestration without yield losses. Hu S, editor. PLOS ONE. [accessed 28 October 2021] 11(2):e0149949. doi:10.1371/journal.pone.0149949.

ABBOTT MB, JONOSKI A. 2001. The democratisation of decision-making processes in the water sector II. J Hydroinform. 3(1):35-48. doi:10.2166/hydro.2001.0005.

ALEAN J, CHEJNE F, ROJANO B. 2016. Degradation of polyphenols during the cocoa drying process. J Food Eng. 189:99-105. doi:10.1016/j.jfoodeng.2016.05.026.

ANOKYE E, LOWOR ST, DOGBATSE JA, PADI FK. 2021. Potassium application positively modulates physiological responses of cocoa seedlings to drought stress. Agronomy. 11(3):563. doi:10.3390/agronomy11030563.

BELL AR, WARD PS, KILLILEA ME, TAMAL MEH. 2016. Real-time social data collection in rural Bangladesh via a "microtasks for micropayments" platform on Android smartphones. PLOS One. 11 (11):e0165924. doi:10.1371/journal.pone.0165924.

BLARE T, USECHE P. 2013. Competing objectives of smallholder producers in developing countries: examining cacao production in Northern Ecuador. Environ Econ.; 4(1):71-79. https://www.researchgate.net/publication/269278023_Competing_objectives_of_smallholder_producers_in_developing_countries_examining_cacao_production_in_Northern_Ecuador.

BRUNETTE W, SUNDT M, DELL N, CHAUDHRI R, BREIT N, BORRIELLO G. 2013. Open data kit 2.0: expanding and refining information services for developing regions. HotMobile '13: Proceedings of the 14th Workshop on Mobile Computing Systems and Applications; 2013 Feb 26-27; Jekyll Island (GA). New York (USA): Association of Computing Machinery; 2013. doi:10.1145/2444776.2444790.

BRUNETTE W, SUDAR S, SUNDT M, LARSON C, BOERSE J, ANDERSON R. 2017. Open data kit 2.0: A Services-based application framework for disconnected data management. MobiSys '17: Proceedings of the 15th Annual International Conference on Mobile Systems, Applications, and Services. New York, USA: Association of Computing Machinery; 2017 Jun 16. [accessed 2021 November 01]. doi:10.1145/3081333.

COLBY-SY A. 2020. Betting big on Philippine cacao. CNN Philippines Life. [accessed 2021 October 28]. https://www.cnnphilippines.com/life/leisure/food/2020/1/28/philippine-chocolate.html?fbclid

COULIBALY SK, ERBAO C. 2019. An empirical analysis of the determinants of cocoa production in Cote d'Ivoire. J Econ Struct. 8:5. doi:10.1186/s40008-019-0135-5.

DAUSSIN FN, CUILLERIER A, TOURON J, BENSAID S, MELO B, AL REWASHDY A, VASAM G, MENZIES KJ, HARPER ME, HEYMAN E, BURELLE Y. 2021. Dietary cocoa flavanols enhance mitochondrial function in skeletal muscle and modify whole-body metabolism in healthy mice. Nutrients. 13(10):3466. doi:10.3390/nu13103666.

[DTI] Department of Trade and Industry. 2016. The Philippines in the cocoa-chocolate global value chain.

[DA-DTI] Department of Agriculture-Department of Trade and Industry. 2022. 2017-2022 Philippine cacao industry roadmap. [accessed 2021 Oct 28]. http://bpi.da.gov.ph/bpi/images/PDF_file/Cacao%

20Industry%20Roadmap%20- %20Signed%20%20%20March%2010,%202017.pdf

DE OLIVEIRA JÚNIOR AJ, DE SOUZA SRL, DA CRUZ VF, VICENTIN TA, GLAVINA ASG. 2018. Development of an android APP to calculate thermal comfort indexes on animals and people. Comput Electron Agr. 151:175-184. doi:10.1016/j.compag.2018.05.014.

DÍAZ-MONTENEGRO J, VARELA E, GIL JM. 2018. Livelihood strategies of cacao producers in Ecuador: effects of national policies to support cacao farmers and specialty cacao landraces. J Rural Stud. 63:141-156. doi:10.1016/j.jrurstud.2018.08.004.

[ECLAC, FAO, IICA] Economic Commission for Latin America and the Caribbean, Food and Agriculture Organization, Inter-American Institute for Cooperation on Agriculture. 2015. The outlook for agriculture and rural development in the Americas: a perspective on Latin America and the Caribbean 2015-2016. Economic Commission for Latin America and the Caribbean.

GADM maps and data. 2018. GADM [accessed 2021 October 29]. https://gadm.org/

GIZ extends Panay cacao program. 2016 May 23. The Manila Times. https://www.manilatimes.net/2016/05/23/business/giz-extends-panay-cacao-program/263757.

[ICCO] International Cocoa Organization. 2006. Annual Report 2004/2005. Retrieved 14 October 2017 from https://www.icco.org/wp-content/uploads/2019/07/anrep0405english-1.pdf.

[ICCO] International Cocoa Organization. 2012. The world cocoa economy: past and present. In: Executive Committee (Ed.), One Hundred and Forty-sixth Meeting. International Cocoa Organization, pp. 1–43.

[ICCO] International Cocoa Organization. 2013. Growing cacao. Retrieved October 28, 2021 from https://www.icco.org/

[ICCO] International Cocoa Organization. c2020. Growing cacao. Retrieved October 28, 2021 from https://www.icco.org/

JONOSKI A, ALMORADIE A, KHAN I, POPESCU I, VAN ANDEL SJ. 2013. Google Android mobile phone applications for water quality information management. J Hydroinform. 5(4):1137-1149. doi:10.2166/hydro.2012.147.

KATZ DL, DOUGHTY K, ALI A. 2011. Cocoa and chocolate in human health and disease. Antioxid Redox Signal. 15(10):2779-2811. doi:10.1089/ars.2010.3697.

LÄDERACH P, MARTINEZ-VALLE A, SCHROTH G, CASTRO N. 2013. Predicting the future climatic suitability for cocoa farming of the world's leading producer countries, Ghana and Côte d'Ivoire. Climatic Change. 119:841-854. doi:10.1007/s10584-013-0774.

LANDBANK launches credit facility for rapid growth of farmers, agri-based MSMEs. 2021 Feb 2. Philippines: Landbank of the Philippines; [accessed 2021 Dec 10]. https://www.landbank.com/news/landbank-launches-credit-facility-for-rapid-growth-of-farmers-agri-based-msmes

LENA P. 2017. Choco CEO inspires farmers to grow cacao. Philippines: Philippine News Agency; [accessed 2021 Nov 02]. https://www.pna.gov.ph/articles/1011959.

MARTÍN MA, GOYA L, DE PASCUAL-TERESA S. 2020. Effect of cocoa and cocoa products on cognitive performance in young adults. Nutrients. 12(12):3691. doi:10.3390/nu12123691.

MELO CJ, HOLLANDER GM. 2013. Unsustainable development: alternative food networks and the Ecuadorian Federation of Cocoa Producers, 1995–2000. J Rural Stud. 32:251-263. doi:10.1016/j.jrurstud.2013.07.004.

MONTOYA FG, GÓMEZ J, CAMA A, ZAPATA-SIERRA A, MARTÍNEZ F, DE LA CRUZ JL, MANZANO-AGUGLIARO F. 2013. A monitoring system for intensive agriculture based on mesh networks and the android system. Comput Electron Agr. 99:14-20. doi:10.1016/j.compag.2013.08.028.

NAMRIA Department of Natural Resources - National Mapping and Resource Information Agency. Philippines: DENR. [accessed 2021 October 10]. http://www.namria.gov.ph

OKONGOR GN, AFANGIDEH IA, OBONG LB. 2013. Impact of rainfall regime on cocoa production in Etung Local Government Area, Cross River State - Nigeria. Asian J Agr Food Sci. https://www.ajouronline.com/index.php/AJAFS/article/view/641.

OLASUPO FO, AIKPOKPODION P. 2019. Cacao genetic resources conservation and utilization for sustainable production in Nigeria. In: Aikpokpodion P, editor. Theobroma cacao - deploying science for sustainability of global cocoa economy. London (United Kingdom): IntechOpen Limited. doi:10.5772/intechopen.82703.

PAKES U, SUBONG R, GUMBAN MT, SCHMITT K. 2018. Mapping cacao farms and plantations using Android devices. Philippines: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. [accessed 2019 Nov 5]; https://faspselib.denr.gov.ph/node/1360.

[PIDS] Philippine Institute for Development Studies. 2005. Basics on Philippine climatology. 2005. [accessed 2021 Nov 03]; http://www.pids.gov.ph.

[PSA] Philippine Statistics Authority. 2021. 2020 Census of population and housing (2020 CPH) population counts: Region VI (Western Visayas); [accessed 2021 Nov 26]. https://psa.gov.ph/content/2020-census-population-and-housing-2020-cph-population-counts-declared-official-president. 38.

[QLD-DAF] Queensland Government - Department of Agriculture and Fisheries. 2015. Fruits and vegetable crops: cocoa. State of Queensland; [updated 2015 Nov 24; accessed 2021 December 3]. https://www.daf.qld.gov.au/business-priorities/agriculture/plants/fruit-vegetable/fruit-vegetable-crops/cocoa.

RIFE TW, POLAND JA. 2014. Field book: An open-source application for field data collection on Android. Crop Sci. 54(4):1624-1627. doi:10.2135/cropsci2013.08.0579.

SALVATI P, ARDIZZONE F, CARDINALI M, FIORUCCI F, FUGNOLI F, GUZZETTI F, MARCHESINI I, RINALDI G, ROSSI M, SANTANGELO M, ET AL. 2021. Acquiring vulnerability indicators to geo-hydrological hazards: an example of mobile phone-based data collection. Int J Disast Risk Re. 55:102087. doi:10.1016/j.ijdrr.2021.102087.

SIGNORE A. 2016. Mapping and sharing agro-biodiversity using Open Data Kit and Google Fusion Tables. Comput Electron Agr. 127:87-91. doi:10.1016/j.compag.2016.06.006.

WAUGAMAN A. 2016. From principle to practice: implementing the principles for digital development. Washington, DC: The Principles for Digital Development Working Group. [accessed 2021 Nov 10]. https://digitalprinciples.org/wp- content/uploads/From_Principle_to_Practice_v5.pdf.

WICKRAMASURIYA AM, DUNWELL JM. 2017. Cacao biotechnology: current status and future prospects. Plant Biotechnol J. 16(1):4-17. doi:10.1111/pbi.12848.

YOROBA F, KOUASSI BK, DIAWARA A, YAPO LAM, KOUADIO K, TIEMOKO DT, KOUADIO YK, KONÉ ID, ASSAMOI P. 2019. Evaluation of rainfall and temperature conditions for a perennial crop in tropical wetland: a case study of cocoa in Côte d'Ivoire. Adv Meteorol. 2019:1-10. doi:10.1155/2019/9405939.