RESEARCH PAPER

Cacao mapping using Geographic Information System (GIS) in the Province of Cagayan, Philippines

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Abstract

The study was conducted to determine the locations of the cacao areas in the province of Cagayan and to map the cacao using Geographic Information System (GIS) specifically in the three districts with known cacao plantation. Baseline data were gathered in each municipality of the Province of Cagayan to find out the different location and to map the cacao in the three districts of Cagayan using Geographic Information System (GIS). The cacao plantations were then validated by reconnaissance survey with the aid of Global Positioning System (GPS) and a survey questionnaire form developed by National Mapping and Resource Information Authority (NAMRIA). The surveys determine geographic locations and the agricultural land use systems of cacao growers. Land use systems data gathered were capital intensity, market orientation, labor intensity, mechanization and power usage in relation to mechanization, farm size, infrastructure requirements, cropping characteristics and cultural management practices. A cacao map was generated using Quantum Geographic Information System 2.18.4 (QGIS 2.18.4). All data gathered were spatially analyzed using QGIS software and the resulting map is a glimpse of where large areas of cacao plantation in Cagayan are located. Based on the results generated, it was found out that bulk of cacao plantations is located in the municipality of Lasam and Sta. Praxedes which are covered by 2nd District. Other areas are located in District I (Gonzaga, Sta. Teresita, Lal-lo, Gattaran, and Sanchez Mira). For District III, Peñablanca and Rizal were also surveyed to have a vast area for cacao.

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Introduction

Cacao (*Theobroma cacao)* is a small evergreen tree which means *"food of the gods".* The discoverers of cocoa the Mayans named it as such, from the word *Kak Kow,* meaning *"God Food."* For the longest time, cacao has been introduced and considered as a high-valued crop and commodity in the world market. Not only is it used for food consumption, but it also exhibits great potential for business and market profit. Asia is one of the recently fastest growing consumers of cacao, experiencing a 12% growth between 2003 and 2008. In the Philippines, the average annual cocoa consumption is 50,000MT according to a Department of Agriculture (DA, 2014). Euromonitor International expects the Philippine chocolate market to grow by 13% by 2017. And that is forecasted to reach 100,000MT by 2020. Cacao production is a developing industry in the province. Compared to other crops, only a few hectares is devoted for the production of this crop. Many farmers have developed interest since there is an increasing demand locally to lack of supply of this commodity. Geographic information system (GIS) is computer system for capturing, storing, checking and displaying data related to positions on Earth's surface. GIS can show many different kinds of data in one map. This enables people to more easily see, analyze, and understand patterns and relationships.

Data in many different forms can be entered into GIS. Data that are already in map form can be included in GIS. This includes such information as the location of rivers and roads, hills and valleys. Digital, or computerized, data can also be entered into GIS an example of this kind of information is data collected by satellites that show land use the location of farms, towns, or forest. GIS can also include data in table form, such as population information. GIS technology allows all these information, no matter their source or original format, to be overlaid on top of one another on a single map. The result of the study in the survey through mapping by using GIS would serves as the information for the local government and farmers as basis to easily find out the location of the different plantation of cacao.

The study aimed to map the different plantation of cacao in the three District of Cagayan using Geographic Information System (GIS). It specifically aimed to establish a benchmark information and location of cacao plantation in the three districts of Cagayan as a basis for the three districts.

Materials and methods

Baseline Data Gathering

The data was collected based on records of all reported cacao farmers in the province. The cacao plantations were then validated by reconnaissance survey with the aid of Global Positioning System (GPS) and a survey form developed by National Mapping and Resource Information Authority (NAMRIA) Land use (cacao) systems data gathered were capital intensity, market orientation, labor intensity, mechanization and power usage in relation to mechanization, farm size, infrastructure requirements, cropping characteristics and cultural management practices including nutrient and pest managements, harvest and post-harvest operations, land preparation management. The cacao plantations were then validated by reconnaissance survey with the aid of Global Positioning System (GPS) and a survey form developed by National Mapping and Resource Information Authority (NAMRIA). The surveys determine geographic locations (using GPS) and the agricultural land use systems of cacao growers (using NAMRIA survey form). Land use (cacao) systems data gathered were capital intensity, market orientation, labor intensity, mechanization and power usage in relation to mechanization, farm size, infrastructure requirements, cropping characteristics and cultural management practices including nutrient and pest managements, harvest and post-harvest operations, land preparation and water management. The survey was dependent on the top cacao growers and top cacao plantations determined in baseline data gathering. The number of respondents was pre-determined based on the initial data generated.

Reconnaissance Survey

The cacao plantations were then validated by reconnaissance survey with the aid of Global Positioning System (GPS) and a survey form

developed by National Mapping and Resource Information Authority (NAMRIA). The surveys determine geographic locations (using GPS) and the agricultural land use systems of cacao growers (using NAMRIA survey form). Land use (cacao) systems data gathered were capital intensity, market orientation, labor intensity, mechanization and power usage in relation to mechanization, farm size, infrastructure requirements, cropping characteristics and cultural management practices including nutrient and pest managements, harvest and post-harvest operations, land preparation and water management.

The survey was dependent on the top cacao growers and top cacao plantations determined in baseline data gathering. The number of respondents was pre-determined based on the initial data generated.

Spatial Analysis
All data gathered including the geo-referenced cacao locations and the qualitative data was spatially analyzed using Quantum Geographic Information System 2.18.4 (QGIS 2.18.4) software. The software was also used to generate the cacao map of Cagayan province.

Results and discussion
Baseline Data on Cacao Production in Cagayan
The municipalities that were identified with significant areas for cacao production were municipalities of Lal-lo, Gattaran, Gonzage and Sta Teresita in District 1, Lasam, Sta. Praxedes, and Sanchez Mira (Disrict II) and Peñablanca and Rizal (District III).

Cacao Areas based on Reconnaissance Survey
The cacao map generated through this study is presented in Fig. 1. Based on the results generated, it was found out that bulk of cacao plantations is located in Lasam and Sta.

Praxedes municipalities which are covered by 2nd District. Other areas are located in District I (Gonzaga, Sta. Teresita, Lal-lo, Gattaran, and Sanchez Mira). For District III, Peñablanca and Rizal were also surveyed to have a vast area for cacao.
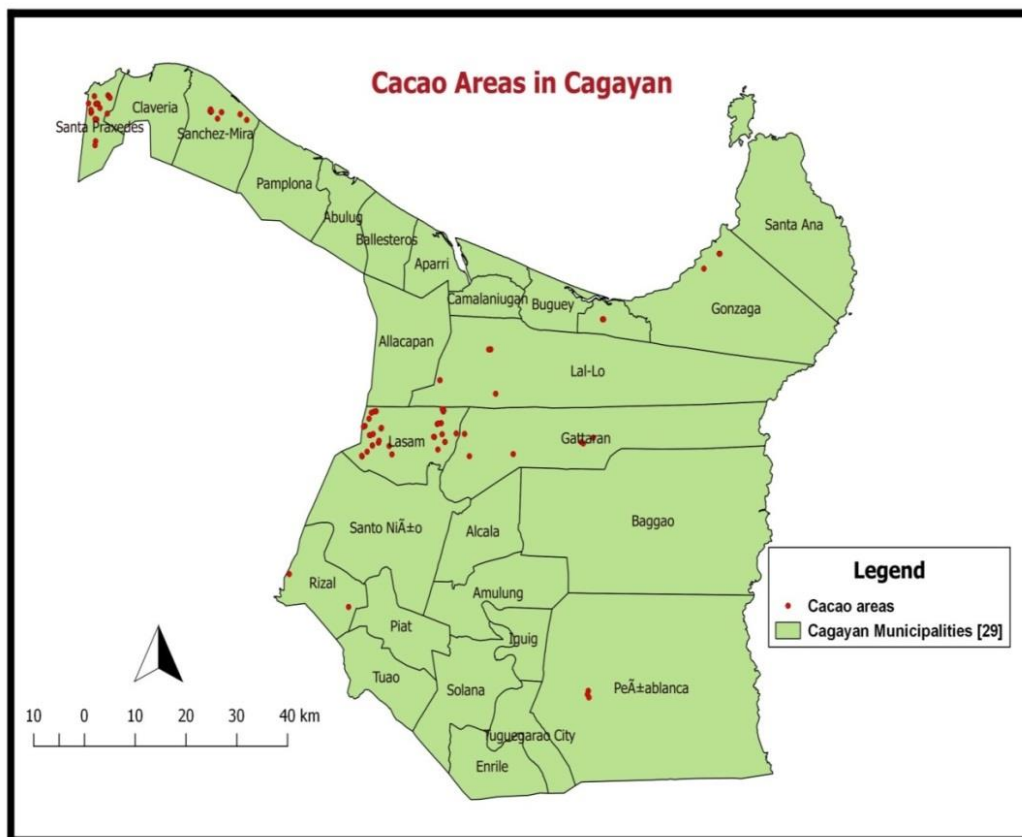

Fig. 1. GPS generated cacao areas in Cagayan.

Land use (cacao) systems in the selected municipalities in Cagayan
Benchmark Information.
Seventy three (73) Cacao Farmers were interviewed from the nine municipalities of the Province of Cagayan, namely; Lal-lo, Gonzaga, Sta. Theresita, Lasam, Sta. Praxedes, Sanchez Mira, Gattaran, Penablanca and Rizal (Table 1). The following information was gathered:

Market Orientation, Capital and Labor Intensity
All of the farmers engaged in cacao production for commercial with subsistence purposes. It means they grow cacao for family consumption and marketing purposes to have additional income. The capital intensity is traditional where in the farmers does not require high initial capital investment to establish their farm. The cacao seedlings were subsidized by the government through Department of Agriculture (DA), Department of Environment and Natural Resources (DENR) and Local Government Unit (LGU). The farm operations were done manually thus, it does not require heavy equipment and machines. Consequently, the labor operation is highly intensified.

Cultivation Technique/Practices. For seed and seedlings as planting materials
Seed selection is based on visual assessment method. In almost all of the cacao production areas in the province, seedlings are subsidized. There are farmers who got their planting materials from their own produced. However most of them got their seedlings from the subsidy given by the government, neighboring barangays and other municipalities. Farmers preferred to plant *BR25, UIT, K2, UF18* and *K1* cacao varieties.

Cropping System.
The system of farming is dominantly semi-commercial with an area ranges from 0.2-30 hectares. Most of the cacao plantations were intercropped with banana and coconut plants.

Planting and Harvesting
Planting
The usual practice of the farmers is to plant cacao from the month of June to November.

Not all farmers follow the recommended distance of planting cacao which is 3mx3m. The rest plants with a distance that varies between 4mx4m, 4mx5m and 6mx6m. They also plants seedlings without doing asexual propagations.

Harvesting
Most farmers harvest continuously when the trees bear fruits but some harvests twice a week. There were also farmers who harvest once and twice a year. They do harvesting manually.

Crop Management Practices
Land Preparation
Using manual operations, the farmers prepare the land by clearing and brushing prior for planting.

Fertilizer Application
Majority of the farmers apply fertilizers both organic and inorganic. For organic fertilizer, they used manures or any crop residues by just putting it on the side of the cacao trees and for inorganic, they applied 14-14-14, 16-20-0 and 45-0-0 at different rate or some of them just apply whenever they want through basal and side dressing method. However, few farmers do not apply fertilizers.

Disease and Pest Observed
Most of the farms are newly planted therefore there were no occurrence of diseases and pests yet but it was observed that some of the newly planted trees died and the farmers can't diagnose the cause of the death of plants. For some plantation areas which were already established and bore fruits, there were pests observed like rodents and cacao pod borer however the infestation is moderate.

The results show that cacao is grown on small, family-owned farms in the province of Cagayan, employing family labor and sometimes "pakyaw systems" in bigger plantations. Cacao is observed to be promising commodity suitable to the environmental condition of the region, thus may play a vital role in food security for rural communities that in the future will rely on cocoa and other specialty crops to improve their incomes and livelihoods. The cacao production is increasing yearly.

Table 1. Cacao plantation systems in the selected municipalities in Cagayan.

Municipality	Cacao Farmers	Farm Orga nization	Cacao Farmer/ Farm size	Market orientation	Capital intensity	Labor Intensity	Mechanization	Power Usage	Cultivation	Weeding	Harvesting
Lasam[1]	33	LCFA	▪ 7 with <1 ha ▪ 3 with 1ha ▪ 13 with 1-2 ha ▪ 1 with 2-5 has* ▪ 3 with 3-5 has* ▪ 4 with 5-10 has* ▪ 2 with 10-15 has*	Subsistence to commercial w/ subsistence	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Gonzaga[2]	2	None	▪ 1 with <1 ha ▪ 1 with 1-2 ha	Commercial w/ subsistence	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Sta. Teresita[3]	1	None	▪ 1 with 1-2 ha	Commercial	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Lal-Lo[4]	4	None	▪ 1 with <1 ha ▪ 2 with 1-2 ha ▪ 1 with 5 ha*	Subsistence to commercial	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Gattaran[5]	9	None	▪ 2 with 1-2 ha ▪ 4 with <1 ha ▪ 3 with 3-5has* ▪	Subsistence to commercial	traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Sanchez Mira[6]	3	None	▪ 3 with 1-2 ha ▪ 2 with <1 ha ▪ 1 with 3-5 ha*	Subsistence to commercial w/ subsistence	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Sta Praxedes[7]	16	None	▪ 13 with <1 ha ▪ 1 with 1-2 ha ▪ 1 with 3-5 ha* ▪ 1 with 15 ha*	Subsistence to commercial w/ subsistence	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Rizal[8]	2	None	▪ 2 with <1 ha	Subsistence to commercial w/ subsistence	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual
Peñablanca[9]	3	None	▪ 2 with <1 ha ▪ 1 with 1-2 ha	Subsistence to commercial w/ subsistence	Traditional	High	non-mechanized to partially mechanized	Human labor	Manual	Manual	Manual

*partially mechanized;

Thus to strengthen cacao -growing communities and promoting social development of cacao farmers, the Department of Agriculture of the province must ensure access to basic services, such as continuous

capablitiy building and community based training programs for cacao farmers' education and skill. Therefore, to supply smallholder farmers with the knowledge, inputs and finance they need to make good decisions and run a successful farm over the long term. Providing farmers with the knowledge, skills and support they need to increase the productivity and profitability of their farms in a responsible and sustainable way. Therefore, these result to Strengthening cocoa-growing communities and promoting social development by ensuring access to basic services, such as education and training.

In addition, supplying smallholder farmers with the knowledge, inputs and finance they need to make good decisions and run a successful farm over the long term for a more successful developed cacao farms for higher income.

Conclusions and recommendations

The study "cacao mapping using GIS (Geographic Information System)", was conducted in the different municipality of the Province of Cagayan to locate and map the different location of cacao growers and plantations. The spatial analysis was used to analyze all the data gathered using quantum geographic information system 2.18.4 (QGIS 2.18.4) software to generate the cacao map of Cagayan. Result of the study showed that among all the districts, district II has the largest area and no. of respondents in the municipality of Lasam, Sta. Praxedes and Sanchez Mira respectively.

Using Global Positioning System (GPS) and a survey form developed by National Mapping and Resource Information Authority (NAMRIA) gave benchmark information in the production of cacao in the three districts of Cagayan. Based on the result of the study, it is concluded that the largest area of cacao plantation is district II, followed by district I and III, respectively. It is recommended that Cagayan State University Research, Development and Extension office may conduct technical briefing on the management practices of cacao production for the farmers. It is further recommended that a continuous surveillance of emerging, growing and expanding cacao plantation in the province of Cagayan should be conducted.

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