SPATIOTEMPORAL VISUALIZATION AND ANALYSIS AS A POLICY SUPPORT TOOL:

A CASE STUDY OF THE ECONOMIC GEOGRAPHY OF TOBACCO FARMING IN THE PHILIPPINES

by

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DEDICATION

I dedicate this document to my mom and dad for always supporting me in my academic endeavors and encouraging me to stay curious, and explore the world.

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LIST OF ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
FCTC	2003 WHO Framework Convention on Tobacco Control
GADM	Database of Global Administrative Layers
GAUL	Global Administrative Unit Layers
GDP	Gross Domestic Product
GIS	Geographic Information Systems
NRCCW	National Resource Center for Information Technology in Child Welfare
NTA	National Tobacco Administration
PSA	Philippine Statistics Authority
SEATCA	Southeast Asia Tobacco Control Alliance
SQL	Structured Query Language
UNSALB	United Nations Administrative Level Boundaries Dataset
USC	University of Southern California
USD	United States Dollar
VAT	Value Added Tax
WHO	World Health Organization

ABSTRACT

This study demonstrates the utility of visualization-based spatiotemporal analysis as a policy support tool in the agricultural sector through a case study analyzing changes in the spatial distribution of tobacco farming in the Philippines from 1990 through 2012. Tobacco farming remains divisive in the Philippines; although often touted by tobacco companies and supportive government agencies as integral to the Philippine economy and an effective crop for poverty alleviation, recent studies dismiss these claims altogether, suggesting that farmers would be better off diversifying or even switching crops altogether (SEATCA 2008; Espino et al. 2009; World Health Organization 2012). This study does not argue for or against tobacco farming; it simply illustrates how spatiotemporal analysis can be successfully implemented to uncover deeper, more nuanced insights that could be drawn upon to design efficient and effective tobacco farming policies.

The analysis considers provincial level agricultural data from the Philippines Bureau of Agricultural Statistics for tobacco area planted, volume of production and farm gate pricing of three unique tobacco varieties: Native, Virginia, and Burley. Stationary and dynamic techniques of spatiotemporal data visualization are used, and data are analyzed for trends using outlined methods. The results holistically describe tobacco farming in the Philippines and are drawn upon to determine which tobacco growing provinces and types of tobacco are on the rise or decline, to investigate causation behind spikes and dips in production, and to outline the future direction of the industry as a whole. The spatiotemporal analysis provides empirical evidence for policy makers to better understand regional and provincial trends in tobacco farming over time.

CHAPTER 1: INTRODUCTION

The negative health implications of tobacco use are well documented, with one in 10 adults killed by smoking worldwide according to the World Bank. Historically, the smoking epidemic primarily affected rich countries, however by 2020 it is expected that seven out of 10 smoking related deaths will be in low-income and middle-income countries (World Bank 1999). Although there is no single panacea to reducing demand for tobacco, increasing the price to consumers combined with innovative public health education campaigns and government restrictions on marketing and packaging, have recorded fair success at reducing consumption, particularly in high-income countries (SEATCA 2008).

Still, as transnational tobacco companies continue to expand aggressively, both production and consumption have steadily increased in the Association of Southeast Asian Nations (ASEAN) region. The 2003 WHO Framework Convention on Tobacco Control (FCTC), developed in response to the globalization of the tobacco epidemic, asserts the importance of addressing both tobacco supply-side issues and demand reduction in an attempt to structure global regulatory policy. It is within this framework that governments in ASEAN have increasingly implemented policies and programs to combat tobacco demand, primarily through strategy dependent on a combination of price and tax measures with non-price measures.

As stated in the FCTC, one of the main tools for reducing consumption while simultaneously raising funds for valuable government programs is the successful implementation of a tobacco tax, often a combination of excise tax, value added tax (VAT), import tariffs, and other inventive measures. Every country in ASEAN has some form of tobacco tax burden, ranging from 16 percent of retail price in Lao PDR to 70 percent of retail price in Thailand (SEATCA 2013). The Philippines sits relatively in the middle of the pack, with a tax burden of 53 percent of retail price. A new excise tax regime was approved by the Philippines government in 2012, leading Phillip Morris, with a market share of 79.3%, to implement price increases of 30% to 75%.

A 2014 study by Citi Research shows just how effective a strong excise tax can be. In 2013, after the excise tax was bolstered under Republic Act No. 10351, tobacco sales volumes declined by 15.6% in the Philippines, a notable reversal from the 3.5% compound annual growth rate experienced from 2007-2012. Although revenue from tobacco taxes in ASEAN exceeded USD 13 billion in 2011, healthcare costs remain far greater, up to 13.7 times the cumulative tax revenue in some instances. This conclusion indicates that although the financial benefits of an excise tax remain significant, the more important fight is to cut tobacco consumption, using tax revenue simply to mitigate negative tobacco related externalities. It is also important for the countries in the ASEAN region to work collaboratively to coordinate tobacco pricing, as illicit trade of tobacco products is widespread and relatively difficult to prevent in total.

Surprisingly, although every country in ASEAN has some sort of policy to reduce tobacco consumption, tobacco farming is still encouraged and supported by many governments throughout the region. The Tobacco Regulation Act of 2003 represented the first fully comprehensive national legislation on tobacco control in the Philippines. The Act included five years of funding for the Tobacco Growers' Assistance Program and the Tobacco Growers' Cooperative, with the intent of financially supporting farmers displaced due to stricter tobacco policies and assisting tobacco farmers to develop alternative farming systems and livelihoods.

Over the past century, tobacco production has increasingly shifted towards low-income and middle-income countries (World Bank 1999). Tobacco cultivation not only requires significant tracts of land that could be otherwise used for much-needed food crops, but also is detrimental to the environment and notoriously linked to strenuous working conditions, health hazards, and child labor (WHO 2012). It is an industry that is dominated by a vertically integrated, globalized oligopoly, which is able to exert immense power, often exploitatively, on tobacco farmers and national governments.

Regional advocacy groups such as the Southeast Asia Tobacco Control Alliance (SEATCA), Save our Farmer, and Unfair Tobacco, have helped to shed light on many of these issues, particularly the poverty cycle in tobacco farming perpetuated by the global tobacco industry. Yet, even with much of this information well known, tobacco is still a cash crop that remains an economically attractive option for many otherwise impoverished farmers in suitable climates, particularly those already familiar with the process and invested in necessary equipment and technology.

The positive economic ramifications of tobacco farming on a local economy are often heralded by the tobacco industry as reason enough not to put pressure on tobacco farming. However recent rebukes to this notion claim sustainable paths towards alternative livelihoods are not only feasible, but would improve the economic standing of local farmers by diversifying an economy that is currently undermined by corporate practices (SEATCA 2008; Espino et al. 2009; WHO 2012).

The tobacco industry consists primarily of three sub-sectors in the value-added production chain: farming, processing, and product manufacturing. Tobacco is a globally traded commodity, with farming operations in over 120 countries, producing an estimated global farm gate value of USD 8 billion (Geis et al. 2009). In the Philippines alone, tobacco farming produced over USD 100 million in farm gate value in 2012 and provided livelihood for 840,415 people, including those directly employed and their dependents (National Tobacco Administration 2012).

Although inarguably significant, the total number of employed farmers is still small when compared to overall national employment (SEATCA 2008). The relative impact may be misleading however, as tobacco farming is heavily concentrated in only a couple of provinces, playing a much more significant role in certain localized economies.

The cumulative lobby of the tobacco industry and those dependent on it for livelihood, directly hinders efforts to increase tobacco control measures that would be beneficial to public health. If sustainable alternative livelihoods can be realized for tobacco growers, the tobacco industry will lose much of its political influence to negotiate less stringent government policies towards tobacco consumption (SEATCA 2008). Ramifications could prove quite significant, particularly for the Philippines, which is described by Alechnowicz and Chapman (2004) as having the strongest tobacco lobby in Asia.

In this context, it is beneficial to analyze whether spatially nuanced trends in tobacco farming emerge in the Philippines over time. The intent of this analysis is to contribute novel research towards effective tobacco farming policy making. The motivating research question is thus as follows: How does spatial variation in tobacco farming change over time?

1.1 Project Objectives and Organization

This thesis is guided by the principle that detailed quantitative and qualitative research is essential to building effective policy measures, particularly on controversial issues. The main objective of this research is to demonstrate how spatiotemporal visualization and analysis can contribute effectively towards informed policy development, exemplified in this case by tobacco farming in the Philippines.

The project study uses available agricultural data to holistically investigate tobacco farming through spatiotemporal visualization and analysis. Key questions were developed to address challenges faced from the perspective of a national level policy maker. The key questions are:

1. What provinces and regions are most dependent on tobacco farming and how has this changed spatially over time?
2. What provinces and regions produce the highest total volume of tobacco production and how has this spatially changed over time?
3. Is there any spatial variation in farm gate prices and, if so, how has this changed spatially over time?
4. Considering the first three key questions, is there any spatial variation between the three types of tobacco grown in the Philippines: Native, Virginia, and Burley? If so, how has this changed over time?
5. If clear spatiotemporal trends are identified, can possible causes also be reasoned?

The investigation of the five key questions begins in chapter two, which describes the country context behind tobacco farming in the Philippines and provides a literature review of previous studies that have linked spatiotemporal visualization and analysis to policy decision making. Chapter three follows with a detailed description of the data sources and the methodology used to investigate each of the five key questions, followed by chapter four, which contains the results. The first subsection of chapter four addresses the relative dependence of each province on tobacco farming by normalizing the total area of planted tobacco to the total area of each province. The second subsection examines the total volume of production by province, including a section that uses dynamic visualization to trace the center of tobacco production by year for each available tobacco type. The third subsection examines spatiotemporal variation in farm gate prices, including a section focused on a detailed comparison of data from La Union province. Chapter five presents the discussion, which reasons possible causes from the observed trends, discusses the broader significance of the results, validates methods used, and presents suggestions for future work that could further strengthen the utility of spatiotemporal analysis in support of tobacco farming policy development in the Philippines. Lastly, Chapter six provides a summary of conclusions.

It is my working hypothesis that clear spatiotemporal trends will emerge from the investigation of the first four key questions identified above and that it will be possible to link these trends to potential causes. Combined, the results of this thesis will provide novel information, useful to tobacco farming policy decision makers in the Philippines.

CHAPTER 2: BACKGROUND

Prior to outlining the methodology used in this study, it is critical to understand the physical, economical, and historical context of the Philippines and to examine similar work that has been completed on related topics. The country profile section aims to establish a basic awareness of the local setting related to tobacco geography while additionally serving as a springboard for deeper investigation into the causes behind trends observed during the performed analysis. Following the Country Profile section, the literature review discusses a range of techniques and insights drawn from previous studies that provide a rationalization for the approach of this study.

2.1 Country Profile

The Philippines is a Southeast Asian archipelagic nation consisting of 7,107 unique islands in the western volcanic rim of the Pacific Ocean with a cumulative area of nearly 300,000 square kilometers (Villaluz 2012). Approximately 95 percent of the land area and a similar percentage of the population of 96.71 million Filipinos are associated with one of the 11 largest islands in the archipelago (World Bank 2012). The islands are split into three major island groups: the northern Luzon, 141,000 square kilometers; the central Visayas, 57,000 square kilometers; and the southern Mindanao, 102,000 square kilometers (Moog 2006).

The Philippines is politically divided into 81 provinces which are grouped into one of 17 different regions. The National Capital Region, commonly referred to as Metro Manila, is the largest urban area, with a population of nearly 12 million people. Each province is subdivided into cities and municipalities, which are further subdivided into *barangays*, the smallest local government unit. Figure 1 shows each of the 81 provinces of the Philippines grouped into the 17 regions.

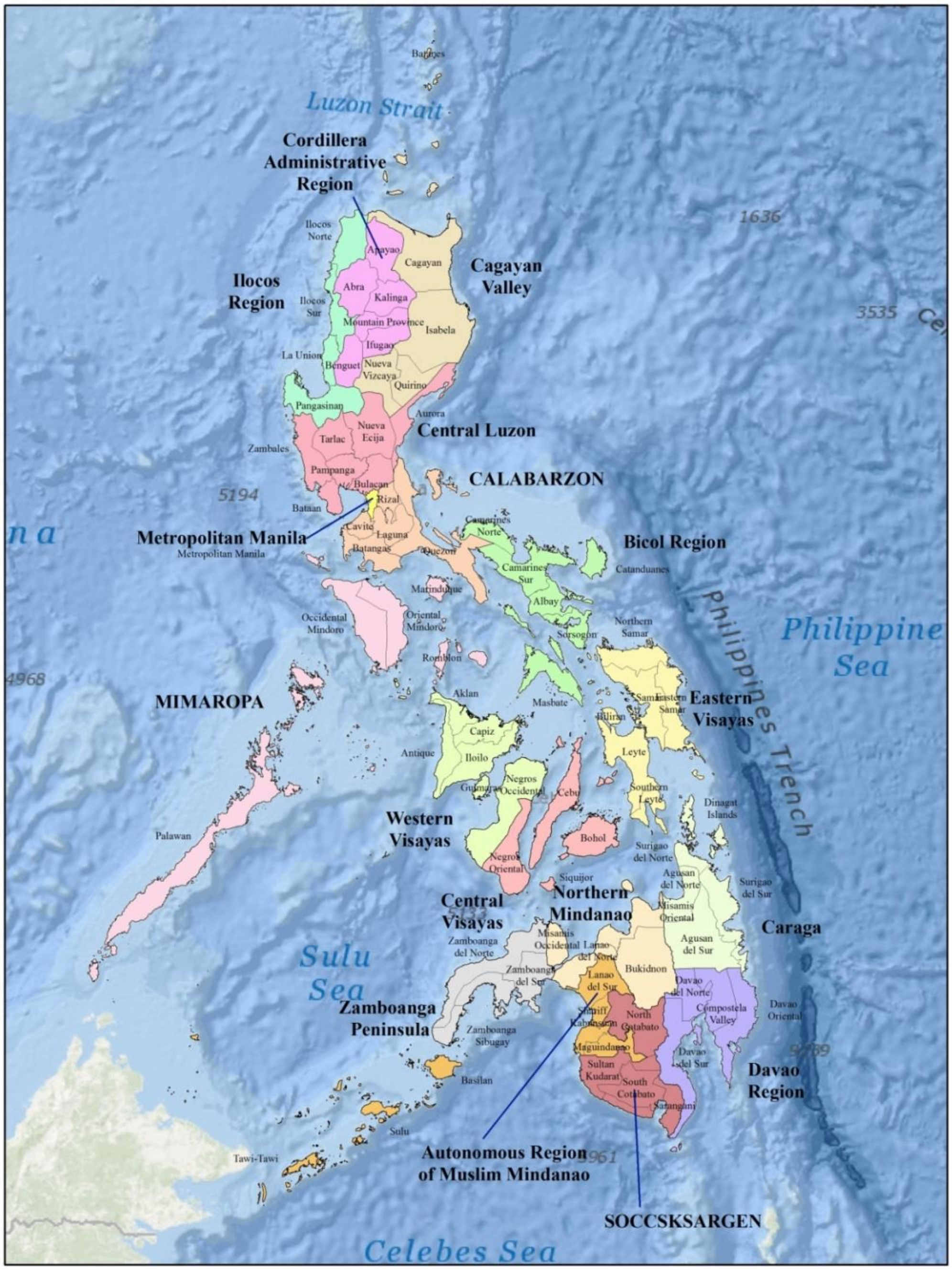

Figure 1 Philippines Regions and Provinces
Source: GADM Database of Global Administrative Areas

In 2012, the GDP of the Philippines totaled (current) USD 250.2 billion, with an impressive growth rate of 6.8 percent (World Bank 2012). The past decade has seen accelerated growth from the previous two decades, averaging about five percent per year and raising gross national income per capita from (current) USD 1,000 in 2002 to (current) USD 2,500 in 2012, as measured using the Atlas method (World Bank 2012).

Despite a decade of sustained growth, the economy of the Philippines is still struggling to create more and better jobs (Chua et al. 2013). Policy distortions have particularly hampered growth and productivity in the agriculture and manufacturing sectors and much more needs to be done to accelerate inclusive growth and reduce poverty. From 2003 to 2009, the percentage of the population living below the national poverty line actually increased from 24.9 percent to 26.5 percent (World Bank 2012).

The Philippines is a warm and tropical climate, with a mean annual temperature of 27 degrees Celsius that makes it ideal for tobacco farming (Moog 2006). The climate is dominated by wet and dry seasons, more or less pronounced depending on localized geography. Agricultural holdings account for approximately 33 percent of total land utilization in the Philippines, encompassing nearly 100,000 square kilometers (Moog 2006).

According to the 2002 Agricultural Census, approximately 40,000 square kilometers grow rice, 24,000 square kilometers grow maize, and 32,000 square kilometers grow coconut, accounting for roughly 96 percent of total agricultural lands. The 2002 Agricultural Census further reported a total of nearly five million agricultural holdings, over 96 percent of which are less than seven hectares in area. In total, close to six million Filipinos are engaged full-time in agricultural work, primarily on their own small holdings.

2.2 Tobacco in the Philippines

Tobacco was first introduced to the Philippines in the late 16th century by the Spanish; however, full commercialization did not begin for another 200 years (De Jesus 1980). In the late 18th century, the colonial Spanish government began searching for ways to make the Philippines a profitable and self-financing colony. Although the Manila galleon trade had proven quite successful for those directly involved, the Philippines remained largely financially dependent on subsidies from Mexico (Crouch 1985). One of the first acts to raise revenue was the creation of a government supported tobacco monopoly, established on March 1, 1782 by Governor-General Jose Basco y Vargas (De Jesus 1980).

Although initially unsuccessful, the business quickly took off and made the colony self-sustaining once it became open to foreign shipping and businessmen (Crouch 1985). Over the subsequent 100 years, the Philippines emerged as the largest tobacco producer in Asia, realizing profits of USD 3 million in 1881, the year before the monopoly’s eventual dissolution (De Jesus 1980).The tobacco monopoly focused on cultivation solely in Luzon, particularly the Cagayan Valley, the Illocos provinces, Nueva Ecija and Marinduque. The legacy of the tobacco monopoly remains strong, and tobacco farming is still most prevalent in the Luzon provinces.

Three types of tobacco are currently grown in the Philippines: Native, Virginia, and Burley. In total, the National Tobacco Administration (NTA), reports that tobacco farming in the Philippines only encompasses an area slightly larger than 30 square kilometers as of 2012. Different types of tobacco are traditionally grown in different provinces. The Native tobacco type constitutes 24 percent of total area planted and is grown to some extent in nearly all tobacco growing provinces. The Virginia tobacco type, introduced to the Philippines in 1927, constitutes 58 percent of all tobacco area planted, and is concentrated in Ilocos Sur, Abra and La Union (NTA 2014).

The Burley tobacco type was the last to be cultivated in the Philippines. Today, Burley tobacco constitutes 18 percent of total area planted and is primarily grown in Pangasinan, Tarlac, Nueva Ecija and Occidental Mindoro. Burley tobacco also produces the highest average yield per hectare (2,200 kilograms) followed by Virginia (2,000) and Native (1,653). Seventy-five percent of Virginia and Burley tobacco is distributed domestically, compared to only 30 percent for Native tobacco. The remaining tobacco is distributed to foreign markets all over the world.

Figures 2 and 3 give a visual overview of tobacco producing provinces in the Philippines using data from the Bureau of Agricultural Statistics (BAS). Figure 2 shows all provinces that reported tobacco production for at least one year since 1990.

Of the 52 provinces where tobacco production was reported, 24 produced tobacco for the entire 23 year period and 45 out of 52 provinces reported tobacco production for at least 10 years out of 23. No province that reported tobacco production reported less than five total years.

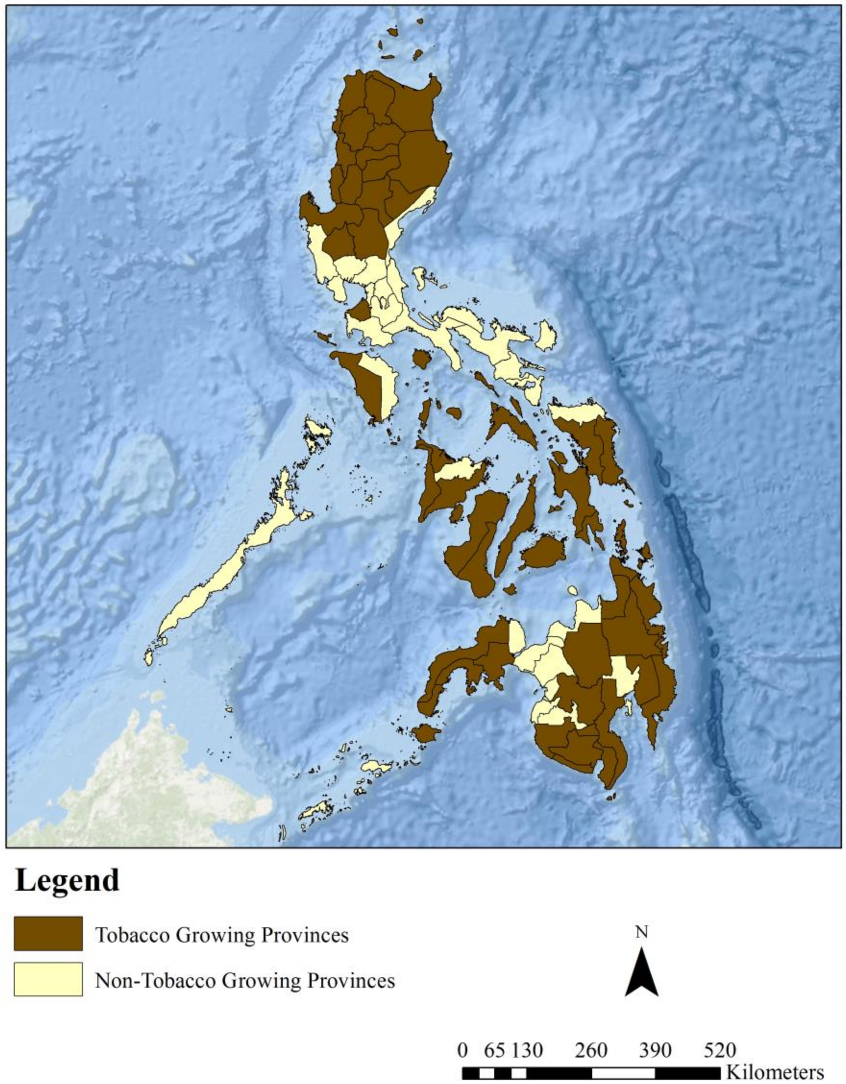

Figure 2 Provinces Producing Tobacco at least 1 Year Since 1990
Source: Data from the Bureau of Agricultural Statistics

Figure 3 shows all of the provinces that produced Virginia and/or Native type tobacco over the duration of this study. Note that Burley type is excluded from this map. The BAS does not have any segregated data on Burley type production, yet it is inferred to be included in all cumulative tobacco statistics.

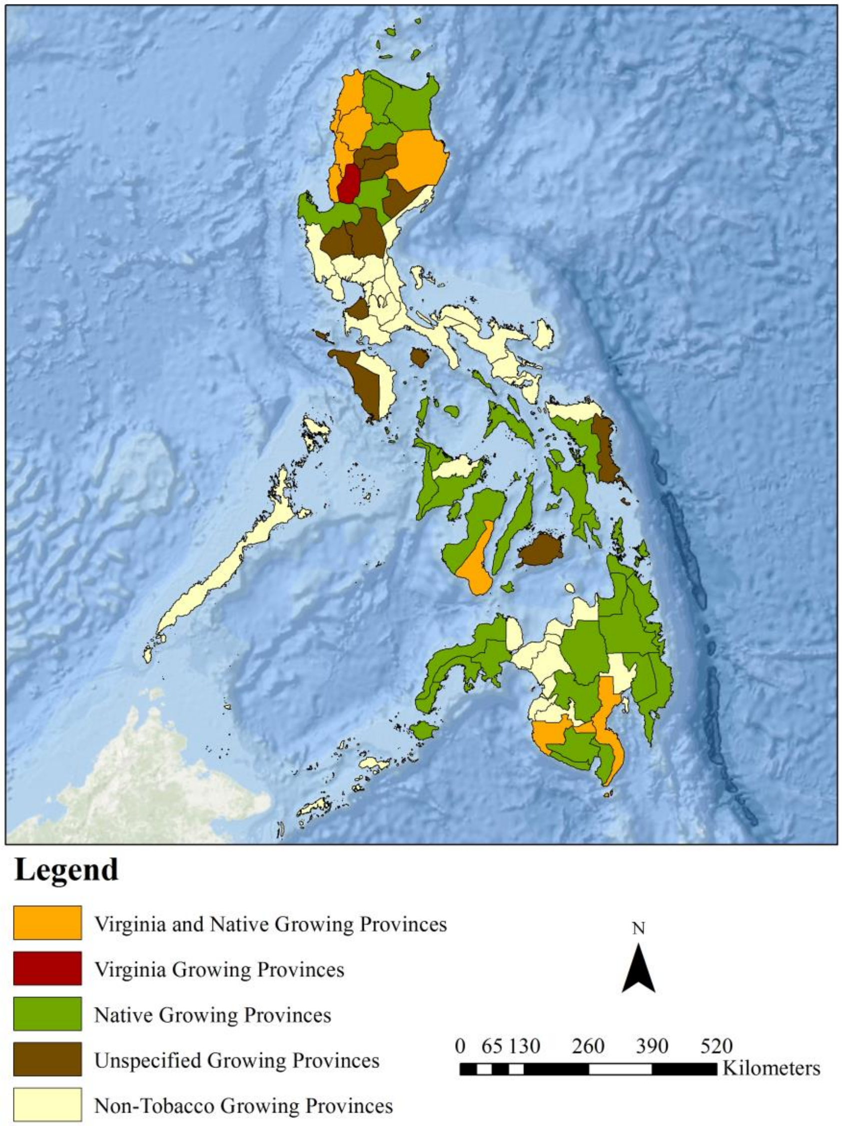

Figure 3 Provinces Producing Virginia and/or Native Type Tobacco at least 1 Year Since 2000

Source: Data from the Bureau of Agricultural Statistics

The NTA indicates that Burley type tobacco accounts for approximately a quarter of total production, which the "unspecified" type in Figure 4 is inferred to be from 2000 onward, when segregated statistics of Virginia and Native type tobacco were first recorded by the BAS. Even so, because this was not explicitly stated, it is not included in the analysis.

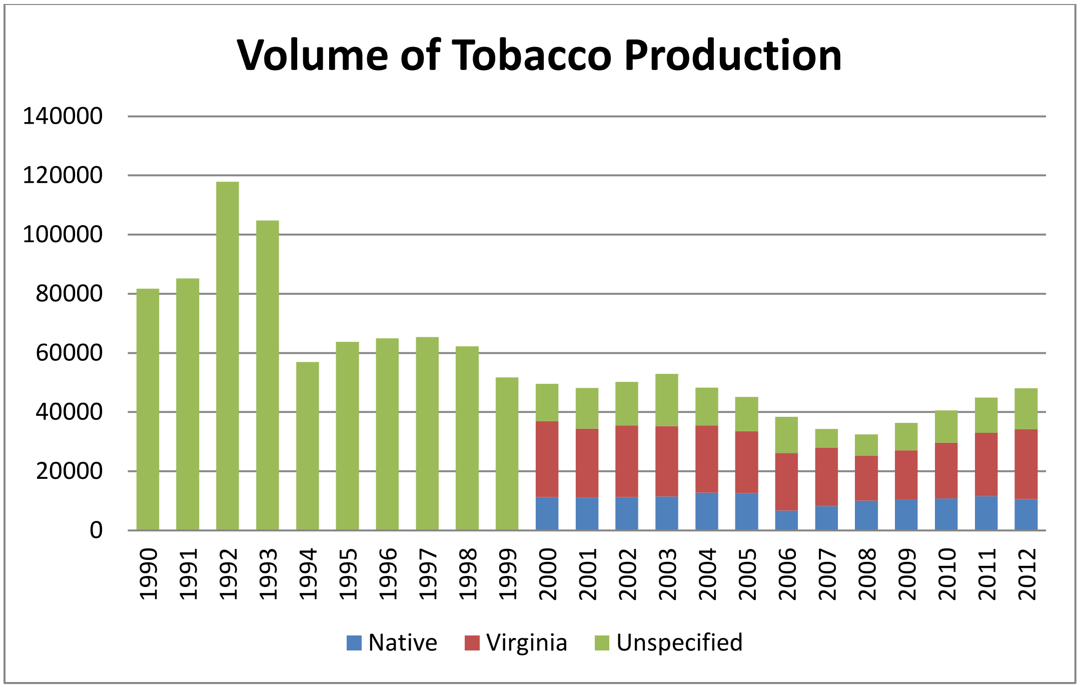

Figure 4 Volume of Tobacco Production in the Philippines, by Type (Metric Tons)
Source: Data from the Bureau of Agricultural Statistics

Also note that although Virginia type tobacco production accounts for roughly half of cumulative production, BAS data show that it is limited to only nine provinces, of which, only Benguet does not also grow Native type tobacco. From tabular analysis, it is possible to see that only four provinces reported growing Virginia type tobacco for the full 13 years statistics are available: Abra, Ilocos Norte, Ilocos Sur, and La Union. Each of these four provinces is located in the northwestern section of the island of Luzon.

In contrast, 41 provinces reported growing Native type tobacco at some point during the 13 years and of these provinces, 26 produced Native type tobacco continuously throughout the entire period. Although this initial gross level of data analysis can provide a general level understanding of the distribution, the significance of these varying continuity records becomes apparent only with the application of spatiotemporal visualization.

2.3 Literature Review

The literature review focuses on three topics; policy and spatial analysis, tobacco geography, and spatiotemporal visualization and analysis. Each of the topics was chosen after considering their relative importance to the study. The first section focuses on the relationship between policy analysis and spatial analysis. The focus on policy is integral to understand the utility of spatial analysis as a support tool for policy decision making and can be seen as the overarching theme of this thesis. The next section focuses on tobacco geography and is particularly important for drawing parallels to research previously completed in this area, where it has been done, and to determine the comparative novelty of this thesis in the context of tobacco farming and the Philippines.

The final section focuses on spatiotemporal visualization and analysis. The literature sheds light into the future of spatiotemporal analysis and provides a template for examining spatiotemporal data using readily available visualization techniques. Taken as a whole, the literature review provides important context for the present study, shows how the study extends the research base in the area of spatiotemporal visualization, and illustrates how policy analysts can make use of some emerging capabilities for analyzing spatiotemporal data.

2.3.1 Policy and Spatial Analysis

Geographic Information Systems (GIS) technology has increasingly played an important role as a decision support tool to policy makers in a wide variety of sectors. Although occasionally criticized as gratuitous, GIS offers a powerful range of operational functions, from simple spatial pattern identification to complex statistical analysis, which allow for raw data to be transformed to digestible information useful in policy making (Dyke et al. 1996). Map presentation of data can often communicate large amounts of spatially nuanced information more effectively than other methods which may only provide a tabular display of results.

Many studies have come out in recent years illustrating cases and outlining practice for successful GIS implementation as a support tool for policy decision making. The National Resource Center for Information Technology in Child Welfare (NRCCW) recognized the potential of GIS for child welfare policy and planning for child welfare quite early, publishing a GIS tips, tools, and trends document in 2002 (NRCCW 2002).

The document highlights the utility of GIS to help support effective management decisions, illustrate the flow of clients to and from community services, and predict future needs. NRCCW also present a brief case study of how GIS has helped New York City better monitor resource allocations, performance evaluations, and quality improvements after first integrating GIS into their service networks beginning in 1999.

Desai et al. (2009) illustrate the increasing volume of applications for GIS as a tool for policy decision making through a case study of Medicaid expenditures in Ohio. The article describes the myriad of analysis tools available, and emphasizes the responsibility of the analyst to educate decision makers on source data and underlying assumptions.

Despite taking a critical look into the pitfalls of data distortion and misrepresentation, Desai et al. (2009) make it quite clear that spatial visualization remains a powerful tool to present and understand policy implications and guide decision making. Yet, full utility remains unrealized in many instances, as advancements in spatial analysis and modeling often outpace the rate of adoption.

Almost two decades ago, Worrall and Bond (1997) illustrated some of the struggles of implementing GIS into successful spatial decision support systems, particularly at the local government level. The study analyzed the early days of GIS from a uniquely British perspective, dating back to the inception of the 1987 Department of Environment Chorley Report, which explored the potential significance of GIS in operational and applied policy settings. The Chorley Report also delved into issues surrounding the development and integration of spatial data systems into public sector organizations.

Suggesting that hype had played a role in unrealistically heightened expectations, Worrall and Bond viewed the state of GIS in the British public sector at the time of publication as a considerable failure. The article outlined many of the early challenges of linking spatial analysis effectively in a policy making context, discussed root causes for these setbacks, and itemized tensions that must be resolved. One of the main problem areas discussed is the inability to keep up with the dynamic and progressive nature of GIS technology in a fully functional manner, particularly in the development of spatial decision support systems in public sector organization.

Even today, many of the problems mentioned by Worrall and Bond are magnified in the developing world, where limited budgets and technical expertise often delay adoption and restrict utility of GIS in government policy analysis and operations. Berisso and de Vries (2010) illustrate these impediments through a case study of the utility sector in Ethiopia. The study suggests that contextual determinants related to economic, technological, legal and financial infrastructure present major impediments to technology access, and thus to technology adoption in developing countries. These impediments also lead to inherent internal weaknesses in government-created and government-maintained authoritative data, which severely limits the utility of complicated methods of spatial analysis.

The World Bank recognizes the increasing importance of making data driven decisions for development, pushing governments around the world to escalate investments in open, countrywide authoritative data (World Bank 2013). Hillygus et al. (2006) discuss the political and social challenges of census mobilization, including inherent difficulties accounting for displaced individuals in hard to reach areas. These difficulties tend to be magnified in countries where capacity is underdeveloped, documentation is less stringent, and corruption is more prolific.

GIS adoption in the Philippines has progressed continually and important policy studies utilizing spatial analysis have come out in recent years, yet full application of GIS analysis remains unrealized in some instances. Launio et al. (2008) use data from household surveys of Philippine rice growers to analyze the spatial diversity of modern rice varieties. The article focuses on indices of spatial diversity for each province in the Philippines, providing strong analytical interpretation but without much spatial visualization. The analytic conclusions of Launio et al. are meant to encourage policy makers to strengthen the public rice breeding program. However, the authors miss out on the opportunity to strengthen the argument through visual representation.

An example of a more effective use of spatial analysis is demonstrated in the study by Dahly et al. (2013) which analyzes the spatial distribution of obese Filipinos in

Metro Cebu. The article successfully identifies obese clusters and relates them to urban areas at the neighborhood level. The authors include multiple maps showing where these clusters exist, and suggest that these results may facilitate research aimed at combatting the increasing prevalence of obesity in the Philippines.

Over the past twenty years, spatial analysis has evolved from a relative novelty for policy makers to an essential tool in their decision making process. Large increases in the scope and volume of spatial applications have been made, however much of this additional utility is dependent on the availability and fidelity of authoritative data, and a capacity to manage and analyze the data effectively. The National Statistics Office in the Philippines has made strides in recent decades to bolster local authoritative data and encourage GIS use, including an initiative to widely distribute CDs containing census data preloaded into a program that allows for basic GIS analysis (Philippine Statistics Authority 2010). Quick adoption and availability of high-quality data have become increasingly important for policy decision making in countries such as the Philippines, which still face steep development challenges.

2.3.2 Tobacco Geography

The geography of tobacco farming has yet to be directly explored in the Philippines. Although a SEATCA survey of tobacco growing regions by Espino et al. (2009) provides considerable detailed insight into overarching trends in tobacco farming, it neither probes into local variation nor provides spatial visualization of the data collected. Studies on tobacco geography done in other countries and regions are helpful in providing relevant insight.

In the pre-GIS era, Coppock (1965) examined tobacco geography in Nigeria, producing multiple maps showing the different tobacco growing regions and the different types of tobacco grown. Using rudimentary observations made from hand-drafted maps, the author analyzed the geography of where different types were grown. The study uses these findings to predict where production of different types might increase based on factors such as availability of machinery, access to infrastructure, and climate.

Although not much has been done since to look into spatial trends of tobacco farming geography in the developing world, many studies exist detailing the geography of tobacco farming in the United States. Both the United States and the Philippines have concentrated belts of tobacco production, and parallels can be drawn for determining the driving forces behind historical geographic change.

Grise (1970) provided insight into the optimum geographic location of Burley type tobacco production in the United States. The study created a model that detailed the intricate geographic and economic drivers behind the tobacco farming industry that enable certain competitive advantages. Considering all crop alternatives, inputs to the model included: available resource supplies, crop yields, prices for inputs and outputs, and prices for land and labor. The results help to understand the driving economic force behind changes in tobacco geography.

The National Agricultural Statistics Service (NASS) under the United States Department of Agriculture (USDA) provides detailed statistics of tobacco farming back to 1934 and basic statistics on acreage and production by state back to 1866. Visualization of the data facilitates analysis of tobacco farming trends. Birdsall (2001) uses historical tobacco statistics to look into the implications of the federal Tobacco

Stabilization Program, which was aimed at buffering the region's small-farm tobacco landscapes from change. The author argues that the increasing geographic fragmentation of tobacco growing communities drives the introduction of alternative crops.

Lessons from previous studies on the geography of tobacco farming such as Birdsall's conclusions regarding geographic fragmentation are important for determining the factors of analysis for this thesis, and for drawing parallels with policy measures taken by other countries. The United States is particularly of interest because of the similarities between the Virginia, Kentucky, Tennessee, South Carolina and North Carolina tobacco belt and the Luzon tobacco region of the Philippines; both have hundreds of years of historical roots, and both represent highly concentrated, regional tobacco farming landscapes.

2.3.3 Spatiotemporal Visualization and Analysis

Integration of time and space is useful for visualizing real time tracking, transactional changes, and temporal attributes. Generally, spatiotemporal visualizations can be grouped into four types: dynamic, discrete, stationary, and change. A dynamic feature follows a path or track, a discrete feature displays separate events in distinctive areas, a stationary feature changes value but not location, and a change feature may change both value and location (Esri 2012).

Visualization techniques remain a challenge, particularly when presented in a format that restricts or is not compatible with animations or videos. It is possible to adapt to static images by displaying time in a series of maps, possibly using trackers to show movement for dynamic visualization, or supplementing discrete and stationary maps with graphs.

In this thesis, the locations for each of the Philippines provinces do not change over time, but the values do; making stationary spatiotemporal visualization the most straightforward approach. This approach is analyzed by Pickle (2009), who evaluates the effectiveness of American mortality atlases in exploratory spatial analysis.

Although occasionally criticized as ineffective (Tukey 1979), Pickle proves that despite their inherent limitations, mortality atlases served the purpose of describing patterns in United States mortality data. Each mortality atlas reviewed had between 99 and 148 citations, contributing to novel etiologic findings such as the discovered links between asbestos and arsenical air pollution to lung cancer.

Much of the inspiration to include an additional focus on dynamic visualization in this thesis comes from a McKinsey global Institute study that tracks the world's economic center of gravity across time (McKinsey 2012). The study, based off of work done by Angus Maddison at the University of Groningen, took each nation's geographic center of gravity and weighted the locations by GDP in three dimensions, which was then projected to the nearest point on the earth's surface.

A line connects points beginning with historical estimates from AD 1 and ending in projections for 2025. A clear trend northwestward trend emerges from the year 1000 to 1950, at which point the trend sharply transitions back eastward, where it is projected to continue through 2025. While historical estimates and future projections can be inexact, the method quite effectively visualizes large-scale trends that transcend possible inaccuracies within each data set.

Recently, algorithm-based methods of spatiotemporal analysis and modeling have advanced substantially. Sahu and Mardia (2005) cite the desire to predict time evolution of select response variables over a certain domain as the primary reason for this development. As computing advances, so does the desire to create more intricate statistical models that can better analyze and predict spatial patterns.

Deng et al. (2013) present an example of recent advancements. The authors consolidate spatiotemporal clustering analysis methods into three types: space-time scanning methods, density-based methods, and distance-based methods, and propose a novel algorithm that addresses autocorrelation and heterogeneities in space and time.

The techniques presented by Deng et al. are incredibly useful for fields with many data points such as climate change, epidemiology, earthquake, and crime analysis. The cumulative yearly data in this thesis however, are not sufficient to effectively implement higher powered statistical analysis, leaving visualization techniques as the primary source for spatial analysis.

Andrienko et al. (2003) consider the confines and potential of visualization-based techniques for exploratory analysis of spatiotemporal data. The study provides a useful catalog of existing techniques, recognizing elementary and general methods for identifying and comparing visualizations supporting tasks of different types. The identified techniques for representation and exploration of spatiotemporal data are grouped into four categories and summarized in Table 1.

Table 1: Summary of Visualization-Based Techniques of Exploratory Spatiotemporal Analysis (from Andrienko et al. 2003)

Category	**Technique**
Universal techniques	Querying Map animation Map iteration
Techniques suitable for data about existential changes	Time labels Representation of age by color Aggregation of data about events Space-time cubes
Techniques for studying thematic images	Change map Time-series graphs Aggregation of attribute values
Techniques applicable to data about moving objects	Trajectory lines Arrows Tracing Time labels Space-time cube Animation modes, i.e. snapshot in time, movement history, and time window

Each technique identified by Andrienko et al. (2003) is described in detail in relation to the analysis scenario. For example, for map iteration of stationary data, change can be detected through visually scanning each map and comparing fragments. The analysis can be supplemented by overlay or fading techniques, however for the stationary data in this thesis, scanning is the most reasonable option due to the required format lacking the capacity to display short animations.

Unfortunately, as is explained in the following chapter, the intrinsic limitations of tobacco data in the Philippines restrict the potential for advanced spatiotemporal modeling and statistical analysis. This thesis, therefore, instead relies on the visualization-based techniques outlined by Andrienko et al. (2003) to temporally analyze available stationary data and derived dynamic data. Although such analysis is not as detailed as it would be using statistical models, Pickle (2009) and McKinsey (2012) support the notion that visualization-based techniques are still quite valuable for recognizing general trends and hypothesis generation.

CHAPTER 3: DATA SOURCES AND PREPARATION

This section contains a description of the data, their sources and characteristics, used in the analysis and a step by step outline of the process used to incorporate that data into the project geodatabase and integrate it into the spatiotemporal analysis. The intent of this section is to illustrate the process that a policy analyst might be able to follow with limited data and GIS tools.

The study joins administrative boundaries from the database of global administrative areas (GADM) to provincial level tobacco farming data acquired through CountrySTAT Philippines. The tobacco farming data are then prepared and spatiotemporally analyzed using stationary and dynamic visualization techniques for each tobacco type. The analysis is focused on determining spatiotemporal trends in tobacco farming for relative provincial dependence, volume of production, and farm gate prices.

3.1 Data Sources

The major source of tobacco statistics used in this study is the CountrySTAT Philippines database. As explained below, although data limitations exist, CountrySTAT represents a landmark achievement in the collection and retention of basic agricultural statistics in the developing world. This study presents an opportunity to highlight the potential of spatial analysis derived from data available through the Food and Agriculture Organization of the United Nations (FAO)'s global FAOSTAT databases.

Additionally, public and participatory GIS efforts such as the GADM database used to acquire data for the Philippines administrative areas illustrate how, in countries that lack resources to develop a strong infrastructure for spatial information, a more inclusive approach can be used to increase integration of spatial analysis in public policy decision making.

3.1.1 Administrative Boundaries from GADM

Country boundary and provincial boundary layers were acquired from GADM Version 2.0 (www.gadm.org). GADM is a high-resolution database of global administrative areas, which allows for free and open use towards academic pursuits. The user can download the entire global dataset or select by country. Data are available in multiple file formats including: shapefile, Esri personal geodatabase, Esri file geodatabase, Google Earth .kmz file, or Rdata file.

The database is hosted by Prof. Robert Hijmans' lab at the University of California Davis. Regional, municipal, and *barangay* layers are also available on GADM, however none are used in this project. The coordinate reference system for all GADM data is latitude/longitude and the WGS84 datum.

Gleditsch and Weidmann (2012) refer to GADM as one of the most comprehensive databases for national and subnational political borders and the World Bank (2013) highlights its flexibility for quickly responding to public feedback and resolving problems. The database is constantly updated, however it does not track changes over time.

GADM Version 2.0 included Shariff Kabunsuan as a province, even though it only existed from 2006 to 2008. Before becoming a province, Shariff Kabunsuan made up the northern half of Maguindanao. After the law establishing Shariff Kabunsuan was ruled void by the Supreme Court of the Philippines, the land returned to Maguindanao. I chose to keep Shariff Kabunsuan in this study to reflect its brief existence over the study period. Tobacco farming in Maguindanao exists but is marginal when compared to the Luzon provinces.

Two other two sources of administrative data considered for use in this project were the Global Administrative Unit Layers (GAUL) and the United Nations Second Administrative Level Boundaries Dataset (UNSALB). Although each has advantages and drawbacks, GADM was ultimately chosen due to the dynamic nature of Philippines administrative units over the past decade, and the personal desire to support open and community-driven data.

3.1.2 Agricultural Data from CountrySTAT

CountrySTAT is an initiative by the Food and Agriculture Organization of the United Nations (FAO), aimed at providing reliable statistical data on food and agriculture for the many countries that lack the internal capacity (www.countrystat.org). Developing countries may have limited staff, a lack of adequate tools, insufficient budgets, or a lack of analytic capacity to effectively monitor national trends. CountrySTAT provides a web-based information system, based on the open-source FENIX platform currently used in the global FAOSTAT, to improve access to food and agriculture statistics at a national and sub-national level. The data are intended to support data analysis and evidence-based decision making and facilitate policy making.

There are currently 25 member countries, each with their own CountrySTAT team responsible for collecting and maintaining data, and making sure that all 80 uniform agricultural indicators conform to international standards. The network is expanding rapidly, with the latest launch in Sierra Leone on 13 February 2014. A further 16 countries remain interested in launching a CountrySTAT system in the next couple years.

The Philippines CountrySTAT team was founded in 2006 and the database now consists of national core and sub-national statistics for 9 categories: production, trade, food consumption, prices, fertilizer and pesticides, land use, labor and employment, costs and returns, and others. Each category is broken down into sub-categories from which the user can extract information through a basic query interface. The data can then be downloaded by the user into an XLS, XML, TXT, or CSV file. This thesis focuses on provincial statistics because they are the most detailed and most comprehensive available on this system. Each of the data sets used are described below:

- *Tobacco Area Planted*
    - Availability: Data for total annual tobacco area planted by province are available from 1990 – 2012 (Burley, Native, and Virginia types). Also, segregated data for Native and Virginia tobacco types total annual area planted by province are available from 2002 – 2012.
    - Units: Hectares
    - Source: Bureau of Agricultural Statistics
- *Tobacco Volume of Production*
    - Availability: Data for total annual tobacco volume of production by province are available from 1990 – 2012 (Burley, Native, and Virginia types). Also, segregated data for Native and Virginia tobacco types total annual volume of production by province are available from 2000 – 2012.
    - Units: Metric tons

    - Source: Bureau of Agricultural Statistics

- *Tobacco Farm Gate Price*
    - Availability: Data for yearly average tobacco farm gate price by province are available for Native, Virginia, and Burley tobacco types from 1990 – 2012.
    - Units: Pesos per kilogram
    - Source: Bureau of Agricultural Statistics

3.1.3 Provincial Areas Data from the Philippine Statistics Authority

Data for provincial areas in hectares were not included in the GADM database, and were thus acquired for all provinces from the Philippine Statistics Authority (PSA). The PSA manages the Philippine Statistical System, which provides both the government and the general public with basic data in support of planning and decision making.

3.1.4 Limitations

One of the major limitations in this study is that data collection only began in 1990, with distinction between unique tobacco types not being made until 2002 and 2000 respectively for tobacco area planted and tobacco volume of production. Additionally, no statistics have been kept for area planted and volume of production for Burley type tobacco. Farm gate prices are available from 1990 – 2012 however a comparative analysis of farm gate prices and percent area planted or volume of production can only be done for Native and Virginia tobacco types from 2002 or 2000 to 2012. Another limitation is that there are only 81 provinces, of which, the National Tobacco

Administration (NTA) reports only 23 grew tobacco in 2012. Such a lack of basic data, as is common in the developing world, makes this collection largely insufficient for the most comprehensive spatial analysis techniques. Despite this limitation, as this study shows, it is still useful and productive to base a policy analysis study such as this on visualization-based techniques.

Another major limitation is the lack of consensus on tobacco production statistics in the Philippines, particularly between the Bureau of Agricultural Statistics (BAS) and the NTA, both surprisingly housed within the Department of Agriculture. According to the NTA, tobacco is currently grown in 23 out of the 81 provinces however the BAS reports that 37 provinces grew tobacco in 2012. Additionally, Euromonitor International, a privately owned market intelligence firm, received significantly different production statistics from the NTA for their 2013 industry profile on tobacco in the Philippines compared to CountrySTAT data from the BAS, as shown in Table 2.

Table 2 NTA and BAS Statistics on Total Tobacco Production in the Philippines, 2007-2011 (Metric Tons)
Source: NTA Data extracted from Euromonitor (2013)

	2007	**2008**	**2009**	**2010**	**2011**
NTA	41,951	42,779	58,572	73,767	79,092
BAS	34,289	32,466	36,383	40,530	44,944

NTA statistics indicate tobacco production nearly doubled from 2007 to 2011 while BAS statistics only show an increase of approximately 34 percent. Figure 5 shows the nationwide downward trend in tobacco production from 1990 to 2012 as reported by

BAS. The data indicate a slight increase in tobacco production beginning in 2008 that could possibly signal a slight trend in the opposite direction.

If NTA statistics prove true, tobacco production in only 4 years trends from a recorded low to the highest level in nearly 20 years. This example serves as a reminder that statistics, particularly in the developing world, are to be approached cautiously. Unfortunately, the NTA data are not available at the provincial level, so it is not possible to compare the statistics spatially over time against data from the BAS.

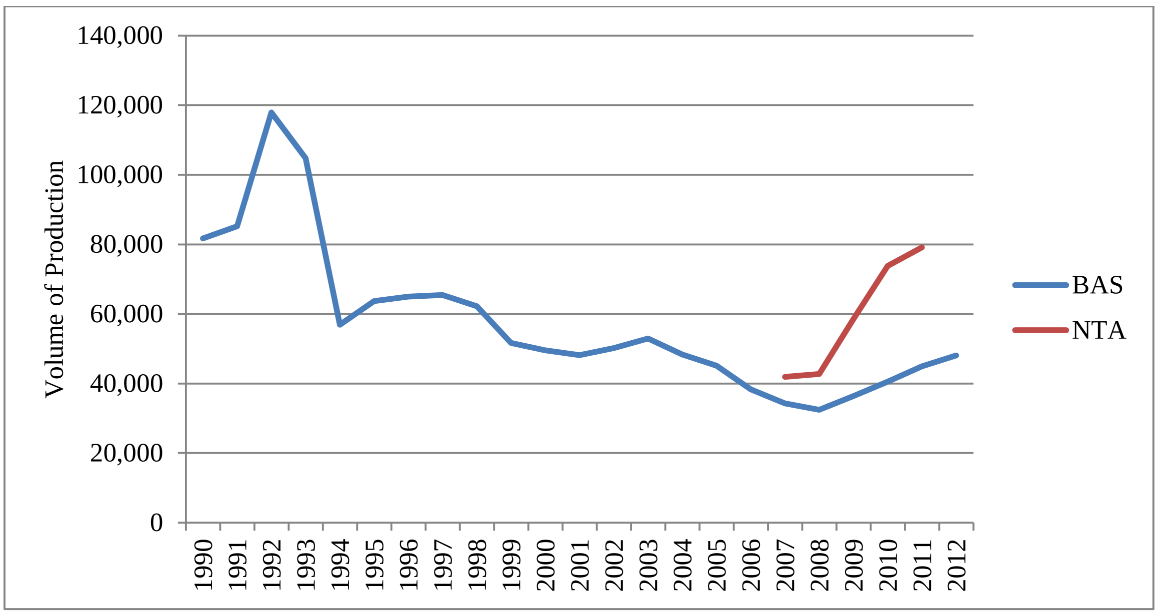

Figure 5 Statistics on Total Tobacco Production in the Philippines, 1990-2012 (Metric Tons)

For this study, full data sets are only available from the CountrySTAT data supplied by BAS. Yet, even with these limitations, it is still possible to find significance in spatial trends. Although data are often incomplete and unreliable in the developing world, it can still be used as an important tool in policy analysis as long as the limitations are communicated and understood by policymakers.

3.2 Methodology

The methodology for this thesis can be broken down into two parts: the steps taken to construct the geodatabase, and the techniques used for visualization-based spatiotemporal analysis. Geodatabase construction consisted of downloading and formatting CountrySTAT data, merging the data to the GADM provincial administrative boundaries, and producing the necessary output layers to be used in the visualization-based spatiotemporal analysis. The analysis focused on the created layers of both stationary and dynamic time-enabled data, using techniques guided by the framework outlined in Andrienko et al. (2003).

3.2.1 Construction of the Geodatabase

An Esri file geodatabase was created to hold the following 15 layers necessary for visualization-based spatiotemporal analysis:

- Base Layers
  1. Country level administrative boundary
  2. Provincial level administrative boundaries
  3. Provincial mean centers
  4. Country mean center
- Stationary Visualization
  5. Percent of total provincial area devoted to growing tobacco, all types
  6. Percent of total provincial area devoted to growing tobacco, Native type

7. Percent of total provincial area devoted to growing tobacco, Virginia type
8. Total volume of tobacco production by province, all types
9. Total volume of tobacco production by province, Native type
10. Total volume of tobacco production by province, Virginia type
11. Farm gate pricing by province, Native type
12. Farm gate pricing by province, Virginia type
13. Farm gate pricing by province, Burley type

- Dynamic Visualization

14. Mean center by year for volume of tobacco production, all types
15. Mean center by year for volume of tobacco production, Native type
16. Mean center by year for volume of tobacco production, Virginia type

All layers used for stationary visualization required provincial level administrative boundaries to be joined with CountrySTAT data. All layers used for dynamic visualization required the mean center of each province to be joined with CountrySTAT data. This required the mean center of each province first to be calculated and exported from the provincial level administrative boundaries layer prior to the join. Unjoined base administrative boundaries were also included to provide background spatial reference for spatiotemporal analysis of dynamic data.

To begin, it was necessary to download GADM layers and CountrySTAT data. GADM layers were downloaded from the website into a file geodatabase. The database attributes can be seen in Figure 6. Importantly, ID_1 served as the key field for joining

GADM provincial administrative boundaries to CountrySTAT data. Each province name corresponds to a number in the ID_1 field. It should also be noted that the Shape_Area field downloaded from the GADM database is not in hectares. This was manually replaced with provincial data from the Philippine Statistics Authority (PSA) prior to export into the project file geodatabase.

Province_Boundary

OBJECTID *	Shape *	ID_1 *	NAME_1	Shape_Length	Shape_Area
1	Polygon	1	Abra	2.624149	0.338042
2	Polygon	2	Agusan del Norte	3.121485	0.246035
3	Polygon	3	Agusan del Sur	4.747092	0.704798
4	Polygon	4	Aklan	5.062669	0.137958
5	Polygon	5	Albay	5.279539	0.209616
6	Polygon	6	Antique	5.596146	0.226414
7	Polygon	7	Apayao	2.750477	0.334058
8	Polygon	8	Aurora	5.904005	0.256673
9	Polygon	9	Basilan	5.434092	0.111927
10	Polygon	10	Bataan	2.499904	0.110494
11	Polygon	11	Batanes	1.647157	0.017983
12	Polygon	12	Batangas	5.207404	0.269322
13	Polygon	13	Benguet	2.012646	0.223432
14	Polygon	14	Biliran	1.407967	0.044297
15	Polygon	15	Bohol	6.574511	0.327914
16	Polygon	16	Bukidnon	4.294833	0.746473
17	Polygon	17	Bulacan	2.977772	0.214832
18	Polygon	18	Cagayan	9.852749	0.752678
19	Polygon	19	Camarines Norte	5.532607	0.176627
20	Polygon	20	Camarines Sur	10.216609	0.442805
21	Polygon	21	Camiguin	0.60327	0.020078

Figure 6 Portion of Attribute Table for GADM Provincial Administrative Boundaries

From the downloaded GADM file geodatabase, the country administrative boundary (layer 1) and provincial administrative boundaries (layer 2) were exported to the project file geodatabase. The mean center of each province was then calculated, and the resulting provincial mean centers layer was exported to the project file geodatabase (layer 3). Lastly, the geographic mean center of all the provinces was calculated and exported to the project geodatabase as well (layer 4).

CountrySTAT data were downloaded from the website into three separate Microsoft Excel files; one for area planted, one for volume of production, and one for farm gate prices. These three files were then joined into a single Excel file and the ID_1 field was added to align province names with the ID_1 field used in GADM provincial administrative boundaries, as seen in Figure 7. The Date_1 field was also slightly reformatted to ensure that it would import into ArcGIS as a time field. Once complete, the data were imported into ArcGIS as a table within the project file geodatabase.

	A	B	C	D	E	F	G	H	I	J	K	L
1	ID_1	Province	Date_1	AP_Total	AP_Native	AP_Virginia	FG_Burley	FG_Native	FG_Virginia	TP_Total	TP_Native	TP_Virginia
2	1	Abra	1/1/1990	1212.00	0.00	0.00	0.00	0.00	23.78	975.00	0.00	0.00
3	7	Apayao	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	13	Benguet	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	33	Ifugao	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	38	Kalinga	1/1/1990	35.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00
7	50	Mountain Province	1/1/1990	40.00	0.00	0.00	0.00	0.00	0.00	23.00	0.00	0.00
8	34	Ilocos Norte	1/1/1990	4428.00	0.00	0.00	0.00	20.92	19.02	4337.00	0.00	0.00
9	35	Ilocos Sur	1/1/1990	17199.00	0.00	0.00	0.00	0.00	20.09	24107.00	0.00	0.00
10	39	La Union	1/1/1990	11976.00	0.00	0.00	12.21	19.74	22.82	23273.00	0.00	0.00
11	61	Pangasinan	1/1/1990	14194.00	0.00	0.00	18.06	0.00	16.38	14902.00	0.00	0.00
12	11	Batanes	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	18	Cagayan	1/1/1990	815.00	0.00	0.00	0.00	13.29	0.00	962.00	0.00	0.00
14	37	Isabela	1/1/1990	3850.00	0.00	0.00	0.00	10.34	0.00	5369.00	0.00	0.00
15	56	Nueva Vizcaya	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	63	Quirino	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	8	Aurora	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	10	Bataan	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	17	Bulacan	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	55	Nueva Ecija	1/1/1990	190.00	0.00	0.00	23.63	0.00	0.00	300.00	0.00	0.00
21	60	Pampanga	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	77	Tarlac	1/1/1990	710.00	0.00	0.00	0.00	0.00	0.00	748.00	0.00	0.00
23	79	Zambales	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	12	Batangas	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	24	Cavite	1/1/1990	8.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00
26	40	Laguna	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	62	Quezon	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	64	Rizal	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	45	Marinduque	1/1/1990	5.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00
30	57	Occidental Mindoro	1/1/1990	1500.00	0.00	0.00	14.50	0.00	0.00	1403.00	0.00	0.00
31	58	Oriental Mindoro	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	59	Palawan	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	65	Romblon	1/1/1990	107.00	0.00	0.00	0.00	0.00	0.00	75.00	0.00	0.00
34	5	Albay	1/1/1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 7 Portion of Joined Excel Files from CountrySTAT with Added ID_1 Field

To create the necessary stationary and dynamic visualization layers, this study used ArcGIS's Make Query Table tool. A sequence of SQL queries were applied to the imported table of tobacco data, each time joining the selected data to the provincial administrative boundaries layer (layers five through 13) or the provincial mean centers layer (layers 14 through 16). Each run of the Make Query Table tool produced a single, ephemeral output layer, which then had to be imported into the file geodatabase.

Layers five through seven were additionally normalized to the total area of each province. The idea behind this was that normalization would help account for the large variation in geographic area between many of the provinces, address the key question regarding relative provincial dependence on tobacco farming, and provide a metric more distinct from volume of production. Normalization of these layers required a couple of extra steps; first a new field was created and labeled for percent area, then the field calculator was used to divide the total area of tobacco planted by the total provincial area.

Layers 14 through 16 also required an extra step for preparation; the weighted mean center of the joined provincial mean centers was calculated for each year, allowing change over time to be visualized as a single, dynamic point. Mean center for layer 14 was weighted using volume of tobacco production for all types, layer 15 for Native type, and layer 16 for Virginia type.

In total, the project geodatabase contained 16 layers; nine of which were analyzed by stationary visualization techniques, three by dynamic visualization techniques, and four for reference.

3.2.2 Stationary Visualization for Spatiotemporal Analysis

Stationary spatiotemporal visualization requires a static feature to change value over time (ESRI 2012). In this case, individual, stationary provinces change field values yearly for layers five through 13. Change over time is displayed in a series of choropleth maps that when strung together, can be viewed as an animation or displayed as a time series. In this document, since each time series produced a multi-page figure, the maps were placed in the appendices.

While in most instances, it is difficult to distinguish substantial changes year by year, this type of analysis is able to highlight important trends that emerge in the tobacco geography, particularly when the different types of tobacco are considered against each other for each of the three indicators: percent of provincial area planted, volume of production, and farm gate prices.

For each layer, it was first necessary to enable time, using the Date_1 field to define the temporal intervals. Data were then visually analyzed to spot regional trends and changes over time, guided by techniques outlined in Andrienko et al. (2003) for exploratory analysis using visualization. Although animations were produced to guide the analysis of each layer, the confines of static presentation limit the presentation of results to individualized choropleth maps for each year in the time series.

In regions or provinces where trends were spotted, supplemental graphs were used to look at comparative relationships at a more nuanced level. Without first understanding the larger scale spatiotemporal trends however, it would be difficult to pick out the important bits of information simply from tabular data.

3.2.3 Dynamic Visualization for Spatiotemporal Analysis

A dynamic feature changes location over time (Esri 2012). For layers 14 through 16, the dynamic feature is the weighted mean center for volume of tobacco production of all tobacco types, Native tobacco type, and Virginia tobacco type. While it is possible to visualize dynamic temporal features using a time series approach, dynamic features can also be displayed on a single output map, connecting the yearly locations by line. Andrienko et al. (2003) refer to this method as a form of overlay visualization.

Layers 14 through 16 each contained a single data point for each year data were available. The points were connected from one year to the next, and the length of these lines was calculated to determine the magnitude of change year by year. The direction of the change was also considered in the analysis to spot major events and trends over time.

The findings from dynamic visualization were considered with the findings from stationary visualization for volume of tobacco production, and were additionally supplemented by graphs to analyze spotted trends in further detail. Unfortunately, it would not be effective to produce dynamic visualization for area planted data because they were normalized to provincial area, and it would also not be effective for farm gate data, as they were already mean statistics for each province.

CHAPTER 4: RESULTS OF SPATIOTEMPORAL ANALYSIS

The results of the spatiotemporal analysis are split into three subchapters: percent total provincial area devoted to growing tobacco, tobacco volume of production, and tobacco farm gate prices. Each subchapter provides a different perspective on the economic geography of tobacco farming in the Philippines.

The subchapters are further split into second-level subchapters based on the technique used for visualization-based spatiotemporal analysis. Each subchapter has a second-level subchapter for stationary visualization. The tobacco volume of production subchapter has an additional second-level subchapter for dynamic visualization, and the tobacco farm gate prices subchapter has an additional second-level subchapter for an in-depth comparative analysis of farm gate prices in La Union province.

4.1 Percent Total Provincial Area Devoted to Growing Tobacco

Three long map series which illustrate the percent of total provincial area devoted to growing tobacco by year for all types (Native, Virginia, and Burley), and segregated for Native and Virginia types are included in Appendix A (Figures 21 through 23). The CountrySTAT database contains statistics on the total hectares of tobacco farming by province. For this analysis, the total area of tobacco farming by province was normalized to the total area of each province. The idea behind this is to distinguish area planted data from volume of production in a way that provides another perspective on tobacco farming. By normalizing to the area of each province, Appendix A makes it possible to compare provincial dependence on tobacco farming by year. The next sections discuss the results of a visual analysis of these map series.

4.1.1 Stationary Visualization of Percent Area

Figure 21 in Appendix A shows the percent of total provincial area planted for all tobacco types. Data for Figure 1 are available over the full period from 1990 to 2012, so change can be examined through a succession of 23 maps showing percentage by year. A quick glance at 1990 shows a small concentration of provinces with a higher percentage of area planted in the Ilocos Region of Luzon. Lower percentages are scattered throughout the rest of the country, with a small gap of no tobacco growing provinces between the northern and southern growing regions.

As the time series progresses, the provincial dependence on tobacco farming in the Ilocos Region declines substantially. Additionally, there is an increasing geographic separation between the northern and southern tobacco growing provinces. Figure 8 details the three provinces with the highest percent area planted of all types; La Union, Ilocos Sur, and Pangasinan, as well the province that recorded the highest recorded percent area planted of all types outside of Luzon; Misamis Oriental.

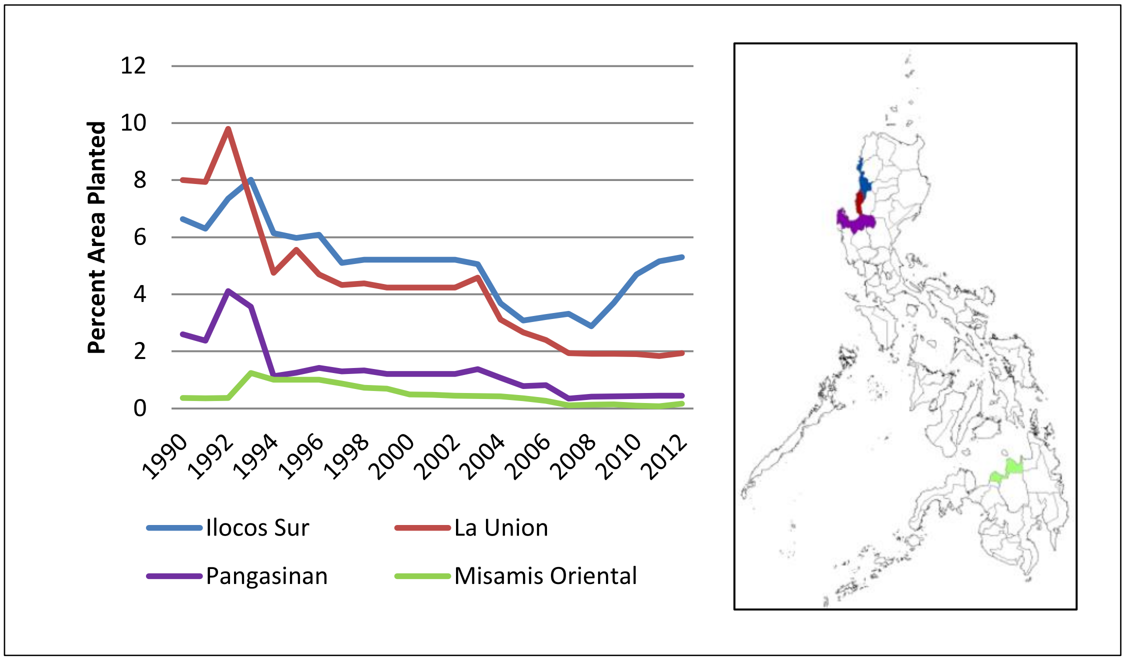

Figure 8 Percent of Total Provincial Area of Select Provinces Devoted to Growing Tobacco, All Types
Source: Data from the Bureau of Agricultural Statistics

The single highest recorded percentage of total provincial area devoted to growing tobacco was 9.8 percent in La Union in 1992. It is very interesting to see the quick decline in tobacco farming in La Union. Each of the three Luzon provinces in Figure 8 experiences a sharp downturn from 1992 to 1994 and again from 2003 to 2006. Interestingly, the later downturn corresponds with the passage of the Tobacco Regulation Act of 2003. Ilocos Sur remains at approximately five percent in 2012, about three percent higher than the next highest province, La Union. This appears to be an anomaly in the northwestern Luzon tobacco growing region, yet remains much lower than the highs experienced in the early 1990s.

Percent area planted was further broken down in Figures 22 and 23 of Appendix A to look at the distinction between Native and Virginia tobacco types. Although data on Native and Virginia tobacco are only available from 2002 to 2012, there are still several distinct differences in spatial distribution and temporal trends between the two types. Native type tobacco, as discussed earlier and shown in Figure 4, is grown in many more provinces than Virginia type tobacco.

Figures 22 and 23 further illustrate precisely how much more dispersed Native type tobacco farming is than Virginia type tobacco farming. During the 13 years of record, total Native type tobacco area planted never exceeded one percent of total provincial area. In contrast, Virginia type tobacco farming accounted for higher percentages dispersed between fewer provinces, even managing to exceed five percent in Ilocos Sur in 2002 and 2003. Interestingly, despite the higher rate of dispersion, the provinces with the highest concentration of Native tobacco farming are still La Union and Ilocos Sur, with the southern province of Davao del Sur coming in a distant third.

One of the more important temporal observations for the Native tobacco type is the rise observed within Ilocos Sur. No Native type tobacco farming was reported in Ilocos Sur until 2004, when a marginal .13 percent was first reported. This number rose to a high of .66 percent by 2008, making it the highest of any province that year, before dropping down to .33 percent in 2012. This trend was first spotted through visual analysis of Figure 22.

Percent area for Virginia type tobacco is first dominated by Ilocos Sur and La Union before a decline of La Union that mirrors the observed decline in La Union for all types in Figure 8. Negros Oriental is the only province that consistently grows Virginia type tobacco outside of Luzon, although total area planted is marginal when normalized by provincial area.

4.2 Tobacco Volume of Production

Unlike percent total area planted, this spatiotemporal analysis for volume of production is not normalized by area. The total volume of production metric shows the total output of the tobacco farming industry in each province. Although normalizing by area provides unique insights into dependence of a province on tobacco farming, it is also important to assess the total size of the industry within a province's economy.

4.2.1 Stationary Visualization of Volume of Production

Appendix B contains Figures 24 through 26, which collectively illustrate the total volume of tobacco production in each province by year and type. General trends over time are consistent with the patterns observed in Appendix A, however the dominance of the northern Luzon provinces appears even more demarcated from southern counterparts when larger provinces that grow high volumes of tobacco, such as Isabela, Cagayan, and Pangasinan, are not normalized by area. Figure 9 details the four provinces with the largest tobacco producing years by volume and additionally includes Davao del Sur, the largest tobacco producing province by volume in the southern provinces.

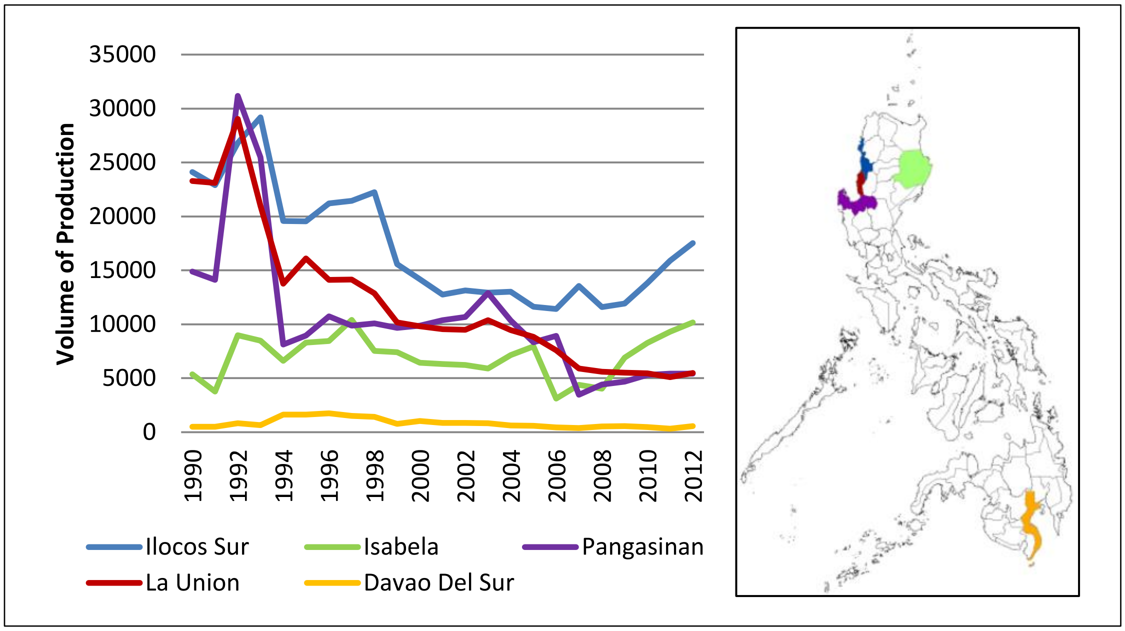

Figure 9 Total Volume of Tobacco Production in Metric Tons, All Types
Source: Data from the Bureau of Agricultural Statistics

The most visible trend in both Figure 24 and Figure 9 is the sharp decline in production from 1992 to 1994 by the three provinces in the Ilocos Region: Ilocos Sur, Isabela and La Union. All three provinces set record highs in 1992 or 1993, followed by an incredible collapse in production in 1994. Pangasinan experienced the most significant decrease in tobacco production, dropping from over 30,000 metric tons in 1992 to approximately 8,000 metric tons in 1994.

Each of the three provinces of Figure 9 located in the Ilocos Region follows a similar trend until 2008, when Ilocos Sur increases production by approximately 5,000 metric tons over the subsequent four years while production in La Union and Pangasinan stagnates. A similar rise in production begins in 2008 for Isabela, which is located in the Cagayan Valley Region, still on the island of Luzon. Davao del Sur represents the largest tobacco growing province by volume in the southern provinces, yet it remains largely trivial in comparison to volumes produced in Luzon.

Figure 25 in Appendix B shows the spatial distribution of total production for Native type tobacco from 2000 to 2012. The northern provinces of Luzon dwarf the volume of production in the southern provinces continuously from 2000 to 2012. Isabella is visibly the largest producer of Native type tobacco in the Philippines, reaching a high of nearly 6,000 metric tons in 2005. Ilocos Sur reached a record high for Native type tobacco production in 2008, recording over 2,700 metric tons. La Union also recorded high levels of Native type tobacco production in the mid-2000s and Cagayan, located just north of Isabela, has produced significant volumes as well.

Figure 26 in Appendix B shows the spatial distribution of total production for Virginia type tobacco from 2000 to 2012. The map reinforces the point that the Ilocos Region, with the exception of Pangasinan, contains a vast majority of total Virginia type tobacco production, and thus a majority of total tobacco production in the Philippines. The only other province with significant Virginia type tobacco production is the adjacent Abra province, officially placed in the Cordillera Administrative Region. Lastly, although small in volume, it is important to note that the provinces of Isabela and Davao del Sur both reported Virginia type tobacco production for the first time in 2012.

Overall, there does not appear to be a large increase in the tobacco yield per hectare over the last 23 years, at least in the Ilocos Region. Table 3 looks at the productivity in tons per hectare of three provinces, Ilocos Sur and La Union from the Ilocos Region, and Isabela from the Cagayan Valley Region. It is important to note that changing ratios of tobacco types grown in each province may influence average yield per hectare in addition to poor crop years, new technologies, or variations in productivity.

Table 3 Average Yield in Metric Tons per Hectare
Source: Data from the Bureau of Agricultural Statistics

	1990	1995	2000	2005	2010	2012
Ilocos Sur						
Total Production	24107	19542	14174	11629	13833	17527
Total Area Planted	17199	15488	13515	7989	12171	13758
Tons per Hectare	1.40	1.26	1.05	1.46	1.14	1.27
Isabela						
Total Production	5369	8296	6448	7944	8273	10183
Total Area Planted	3850	10271	6521	3911	4873	6235
Tons per Hectare	1.39	0.81	0.99	2.03	1.70	1.63
La Union						
Total Production	23273	16117	9814	8830	5464	5487
Total Area Planted	11976	8327	6364	3987	2841	2911
Tons per Hectare	1.94	1.94	1.54	2.21	1.92	1.88

4.2.2 Dynamic Visualization of Volume of Production

Building on the example from McKinsey (2012) discussed in Chapter 2 in which they tracked the economic center of gravity, a similar form of dynamic visualization was used here as a means of capturing and tracking the movement over time of the center of tobacco production in the Philippines on a single map.

By calculating the mean center (also known as the centroid) of each province and attributing volume of production data to those points, it is possible to perform a weighted mean center calculation for each type of tobacco for each year, using all tobacco growing provinces of the selected type for the input features. The output of this calculation shows the center of tobacco production, and the temporal change each year can provide valuable insights into tobacco production trends. Because the Philippines is an archipelago, it is possible for the center of production to be in the ocean.

Figure 10 shows the geographic mean center of the Philippines based on the centroids of all provinces. The mean center is located in the Visayas Islands, near the provinces of Capiz, Aklan, and Masbate. Figure 10 also shows the bounding rectangles that surround the set of points for each of the tobacco type weighted mean centers by year, all of which are located in the northern section of Luzon.

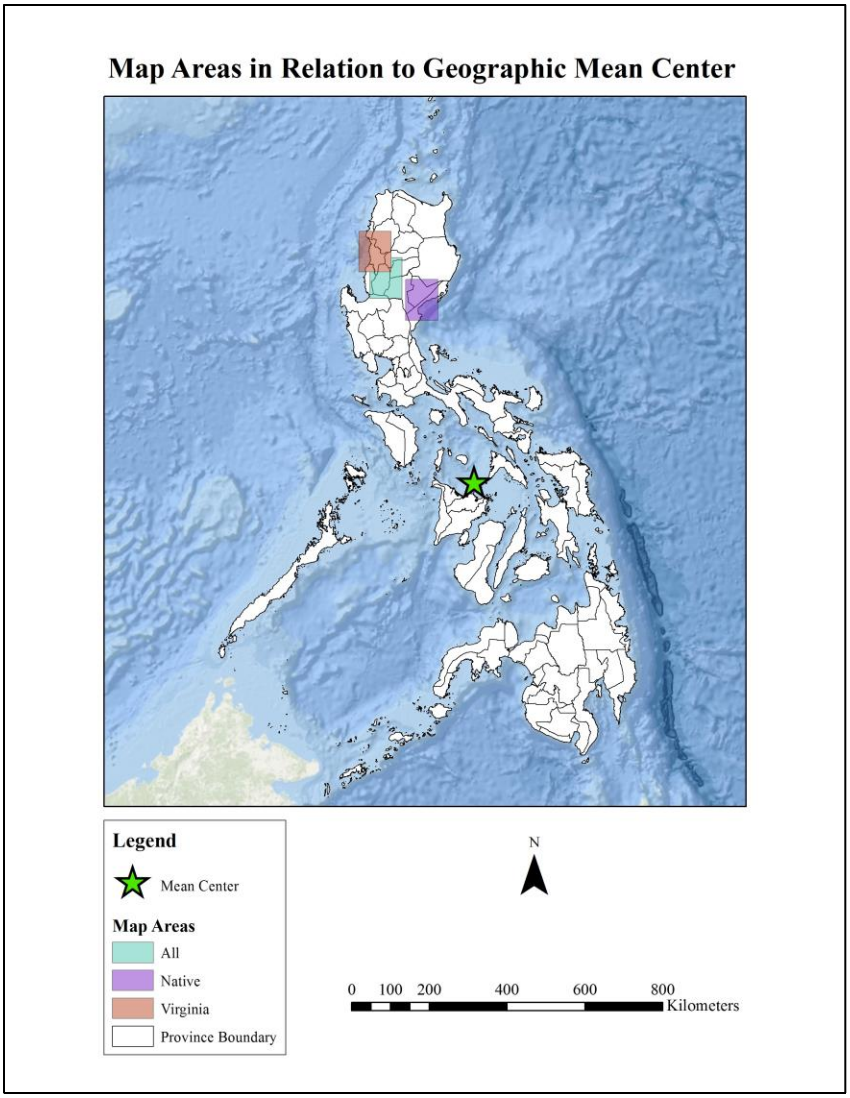

Figure 10 The Philippines' Geographic Mean Center and Focus Areas of the Mean Centers of Each Type of Tobacco

Figure 11 looks closer into the individual focus areas, and shows individual points indicating mean center calculations by year for all tobacco types, Native tobacco type, and Virginia tobacco type. It is quite apparent that the spatial volatility is highest year by year for the calculated mean center of Native tobacco. This is likely attributed to a greater rate of spatial distribution for Native tobacco in comparison to Virginia tobacco.

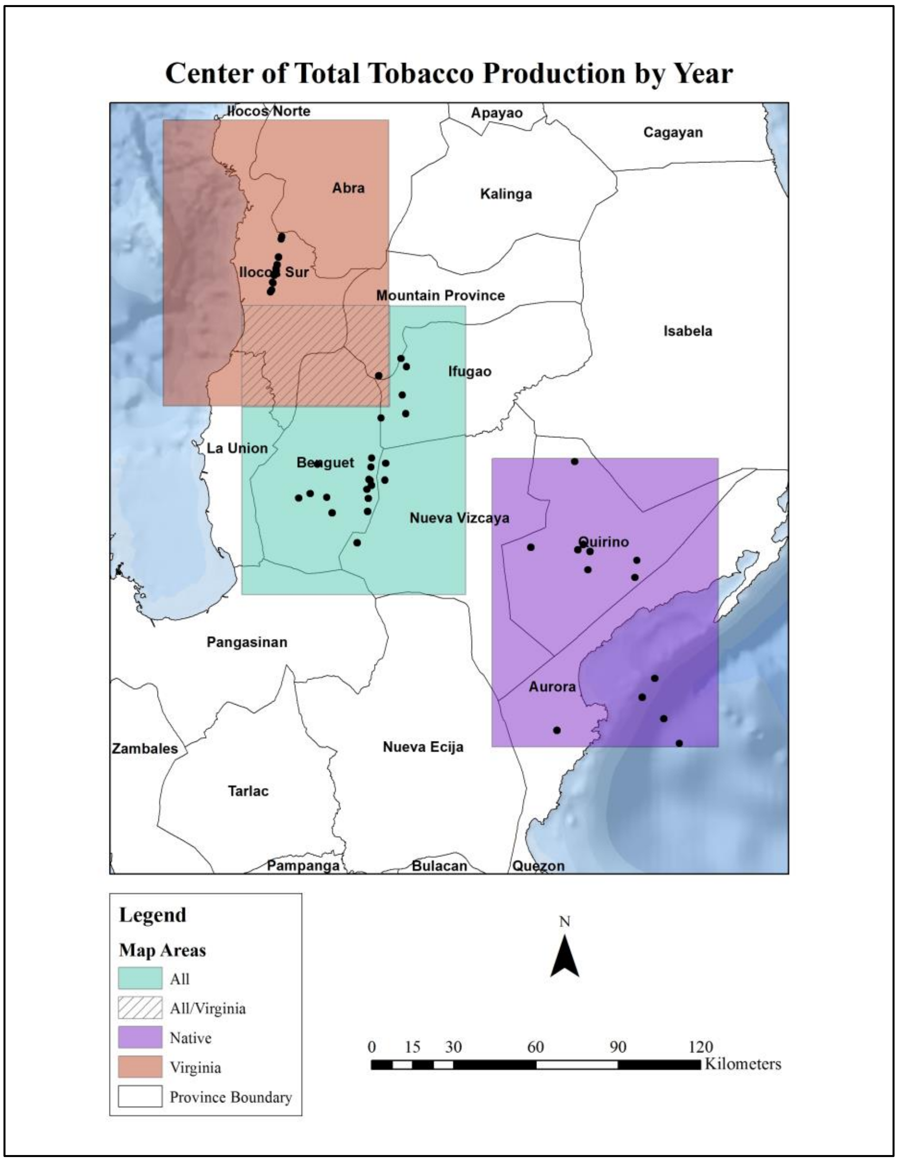

Figure 11 Centers of Total Production by Year for Each Tobacco Type

Virginia tobacco production is largely confined to four provinces, and all of the yearly mean center calculations fall right in the middle, in the province of Ilocos Sur. Although Native tobacco is heavily weighted towards the Ilocos region as well, it is also grown in large quantities in the Cagayan Valley Region and in smaller quantities throughout select southern provinces. The mean center for all types of tobacco falls between the two other map areas, a bit closer to the mean center calculations for Virginia tobacco because yearly Virginia tobacco production is two times higher than yearly native tobacco production.

Figure 12 looks at the center of total tobacco production by year for all types. A line connects dots representing each year from 1990 to 2012. The center of production begins near the center of Benguet province then drifts eastward from 1991 to 1997. From 1998 to 2006, the center of production floats slightly north or south along the border between Bunguet province and Nueva Vizcaya province before experiencing a massive shift northward of 52.37 kilometers in 2007.

This shift was likely caused by the increase in production in Ilocos Sur and Isabella, both located north of where the center of total tobacco production had been located in previous years, coupled with the stagnation in production in Pangasinan and the decline in production in La Union. By 2012, the center of tobacco production had shifted nearly 50 kilometers northeast into Ifugao province.

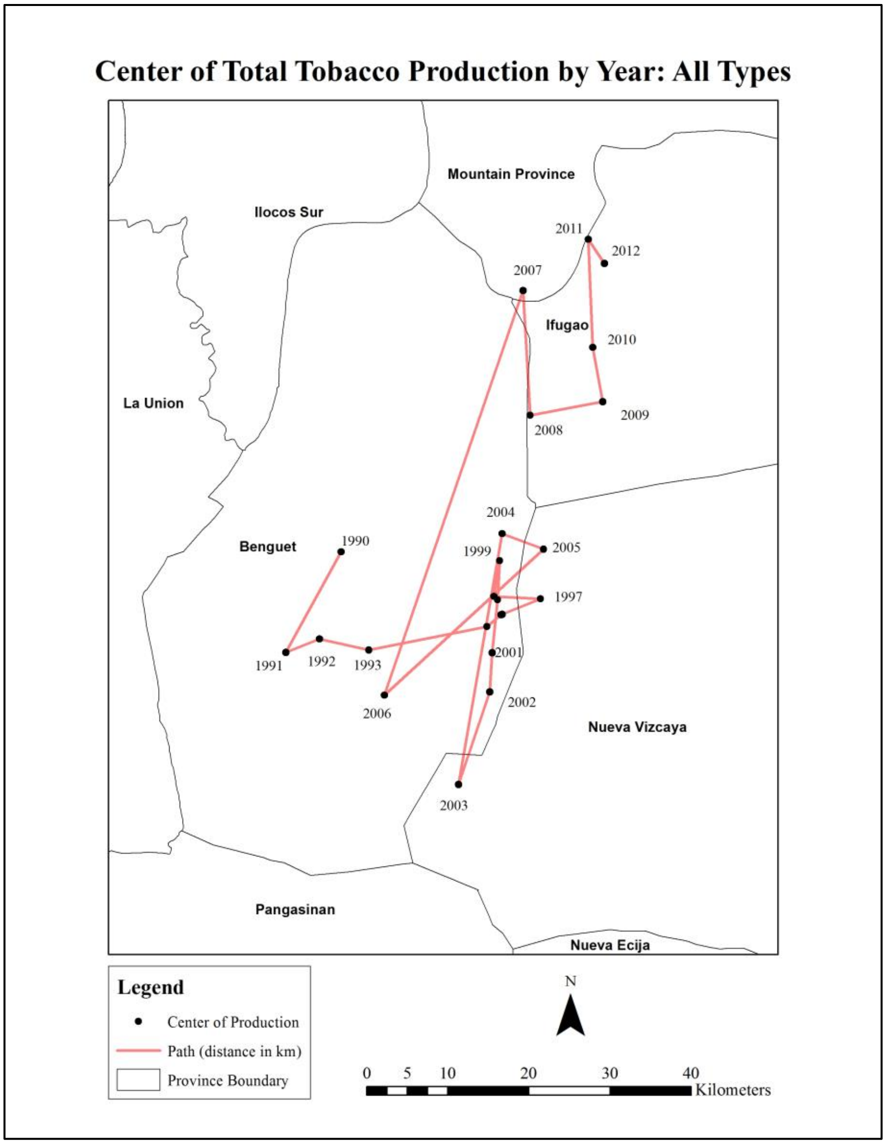

Figure 12 Center of Total Tobacco Production by Year, All Types

The center of production for Native type tobacco, visible in Figure 13, was off the coast of Aurora province in the year 2000, taking a big jump of 53.53 kilometers northward from 2003 to 2004, another big jump of 67.78 kilometers southward from 2005 to 2006, and a final big jump of 66.04 kilometers northward from 2006 to 2007.

From 2007 to 2012, the center of production jumps around Quirino province, ending up nearly 80 kilometers northwest of where it began in 2000 as shown in Figure 13.

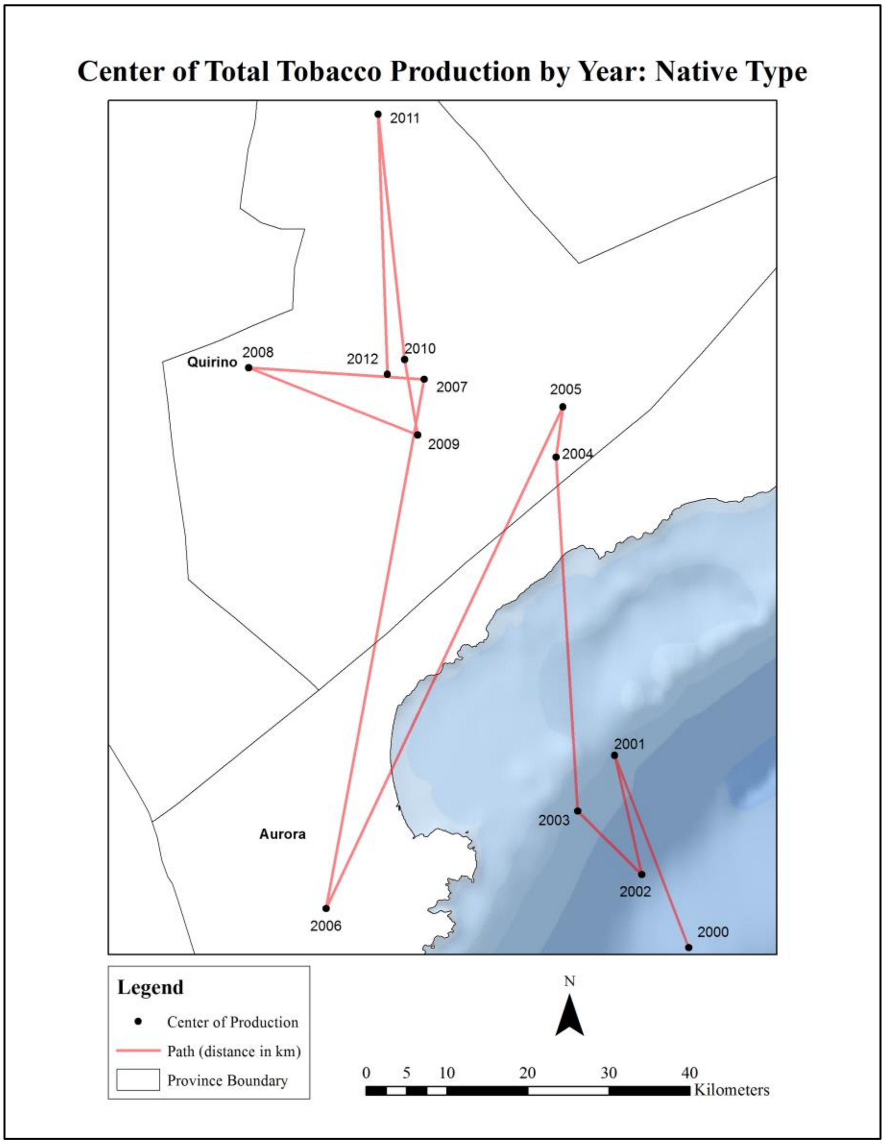

Figure 13 Center of Total Tobacco Production by Year, Native Type

Figure 14 shows the changes in volume of production from 2000 to 2012 for Native type tobacco. Both the Isabela and Cagayan provinces are in the Cagayan Valley

Region, while the La Union and Ilocos Sur provinces are in the Ilocos region. Most of "All other" provinces represent the large distribution of southern provinces with very low levels of production.

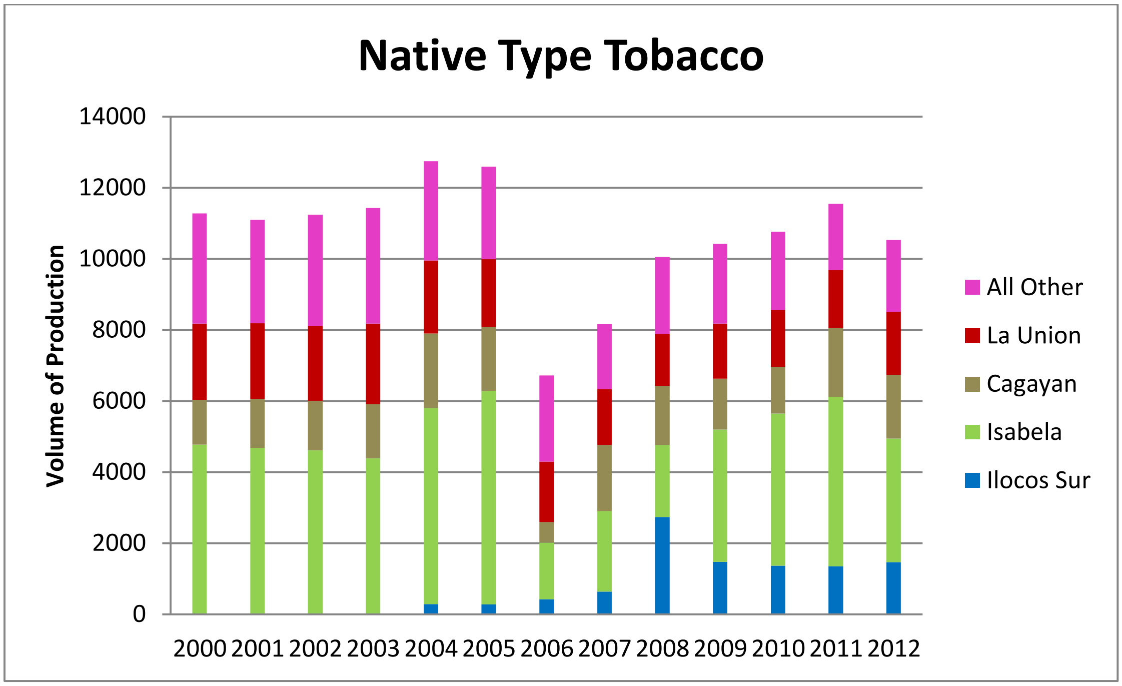

Figure 14 Total Volume of Production for Native Type Tobacco (Metric Tons)

There is a substantial dip from 2005 to 2006, particularly for Isabela and Cagayan that likely explains the shift southwestward experienced by center of production at that time; note that in 2006, roughly one third of Native type tobacco came from "All other" provinces. The general trend northwestward is likely explained by the increased production on Ilocos Sur in the latter half of the timeframe.

As visible in Figure 15, the center of production for Virginia type tobacco never leaves Ilocos Sur. It begins by slowly drifting southward until 2003 when the trend reverses, shifting slightly northward instead each year until 2012. The changes by year all follow the same line, bearing roughly five degrees east of north. The largest change by year occurred from 2010 to 2011 when the center of production moved 6.46 kilometers. The final position for center of production is less than 15 kilometers north of the initial position in the year 2000.

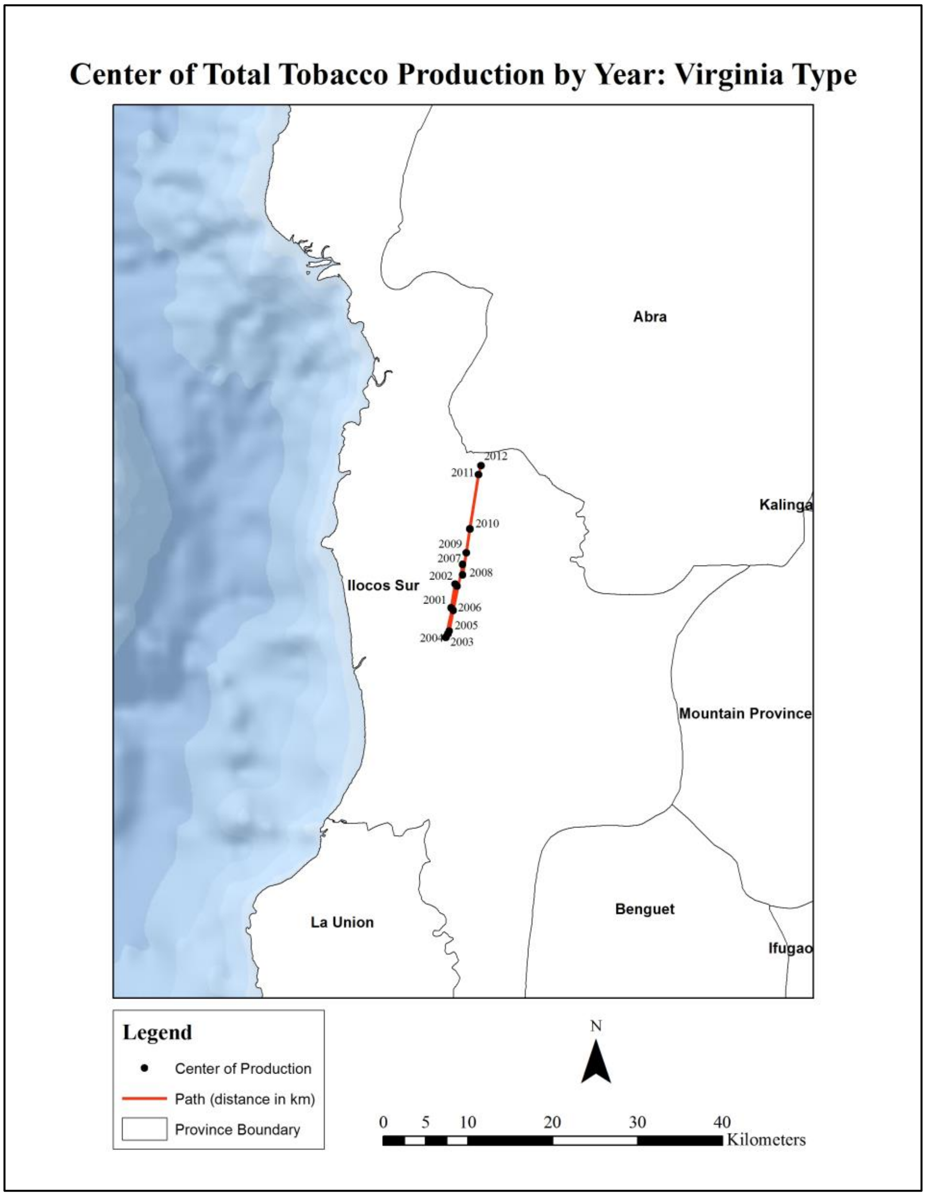

Figure 15 Center of Total Tobacco Production by Year, Virginia Type

Figure 16 illustrates precisely how dominant Ilocos Sur is for total Virginia production. Including statistics for all tobacco types, Ilocos Sur accounted for over 30 percent of the total volume of all tobacco produced in the Philippines from 2000 to 2012. The northward drift that begins after 2003 for the center of tobacco production is likely due to the proportional decrease in tobacco produced in La Union province, the southernmost of the four dominant Virginia tobacco producing provinces. The largest shift for the Virginia type center of production occurred between 2010 and 2011, when Ilocos Sur and Ilocos Norte both experienced their largest increases in total production over the timeframe.

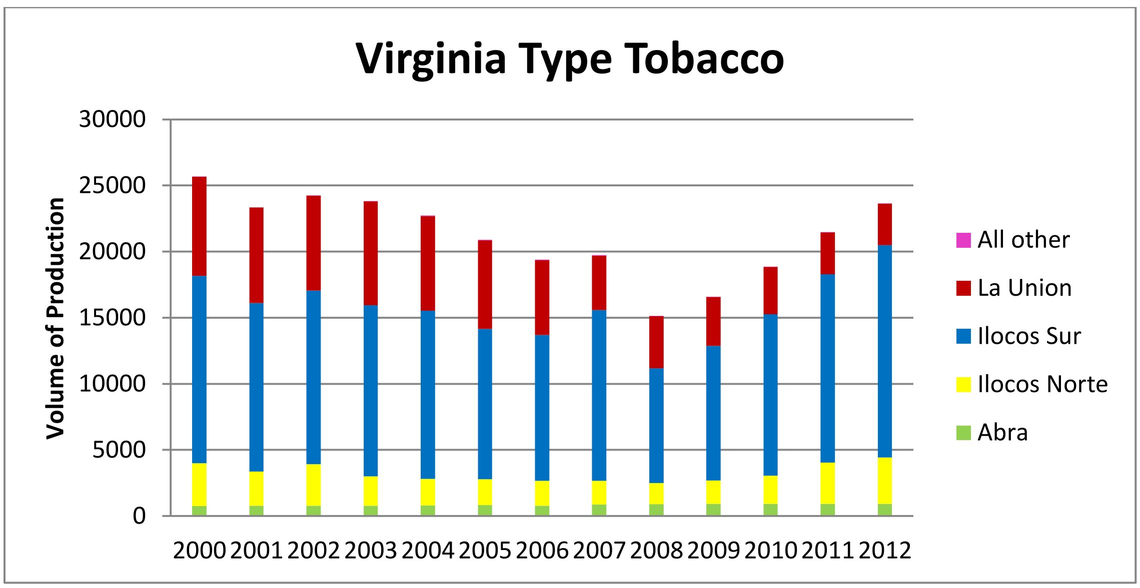

Figure 16 Total Volume of Production for Virginia Type Tobacco (Metric Tons)
Source: Data from the Bureau of Agricultural Statistics

4.3 Tobacco Farm Gate Prices

Farm gate prices are available for Native, Virginia, and Burley type tobacco from 1990 to 2012 for each province in the Philippines. These prices are shown spatially over time in Appendix C for each of the tobacco types in Figures 27 through 29. Although unable to fully determine causality, changing patterns in farm gate prices may explain some of the increases and decreases in tobacco production over time. Factors such as provincial price volatility, rate of price change, and spatial distribution and variation of price each have implications that provide insight into industry shifts. These are explored in detail in a subsection focusing on La Union province.

4.3.1 Stationary Visualization of Farm Gate Prices

Farm gate prices for the native tobacco type are shown in Figure 27. Native tobacco has the largest volatility of all tobacco types, with farm gate prices ranging from just over 10 pesos per kilogram in Davao del Sur in 1994 to nearly 450 pesos per kilogram for the same province in 2012. Map 7 also shows the geographic variability of farm gate prices for native type tobacco. In 2012, when farm gate prices in Davao del Sur reached the record high of 450 pesos per kilogram, farm gate prices in Abra remained under 50 pesos per kilogram. Interestingly, prices in Luzon remained much less volatile, as indicated by Isabela and La Union provinces in Figure 18.

The geographic variability of farm gate pricing for Native type tobacco is in direct contrast to Virginia type tobacco, where the range in prices remains similar for each province by year, with only slight variations. In 2012, the highest farm gate price for Virginia type tobacco was in Ilocos Sur, at 68.36 pesos per kilogram and the lowest was in Ilocos Norte, at 53.34 pesos per kilogram. Of course, there were only four total provinces reporting farm gate prices for Virginia type tobacco in 2012, all of which located in the same geographic area. The farm gate price of Virginia type tobacco tends to increase gradually over time, with a slight decrease from 2002 to 2004 before recovering again in 2005.

Burley type tobacco farm gate pricing also remains similar in each of the provinces by year, with slightly higher prices consistently found in Isabela and Cagayan provinces. Interestingly, the farm gate price of Burley has increased at a faster rate than that of Virginia type tobacco, inferring that production should also increase in relation. Unfortunately, we do not have production information for Burley type tobacco however we can conclude that more and more tobacco farmers may be tempted to switch from Virginia type tobacco to Burley type tobacco if this trend continues.

Figure 17 shows farm gate prices for select provinces over time. Trend lines were added on each graph for La Union province because La Union province has the highest percentage of its total area devoted to tobacco farming and it has consistently reported farm gate prices for the entire 23 year period for all three types of tobacco. For the regression, y is the farm gate price, and x is the year. The multiplier before x is the slope for each of the trend lines, indicating the rate of change for farm gate prices each year. The R squared value describes how well the data fit the trend; the closer to 1, the better the fit. Also note that the graph for Native type in Figure 17 has a different scale than for Burley type or Virginia type. This is to accommodate for the large temporally variability in farm gate price in Davao Del Sur.

The slope and R squared values of the created trend lines confirm much of what was observed by visually analyzing the maps in Appendix C. The slope for both Native and Burley tobacco types far exceeds that of Virginia type tobacco and the lowest R squared value is associated with Native type tobacco.

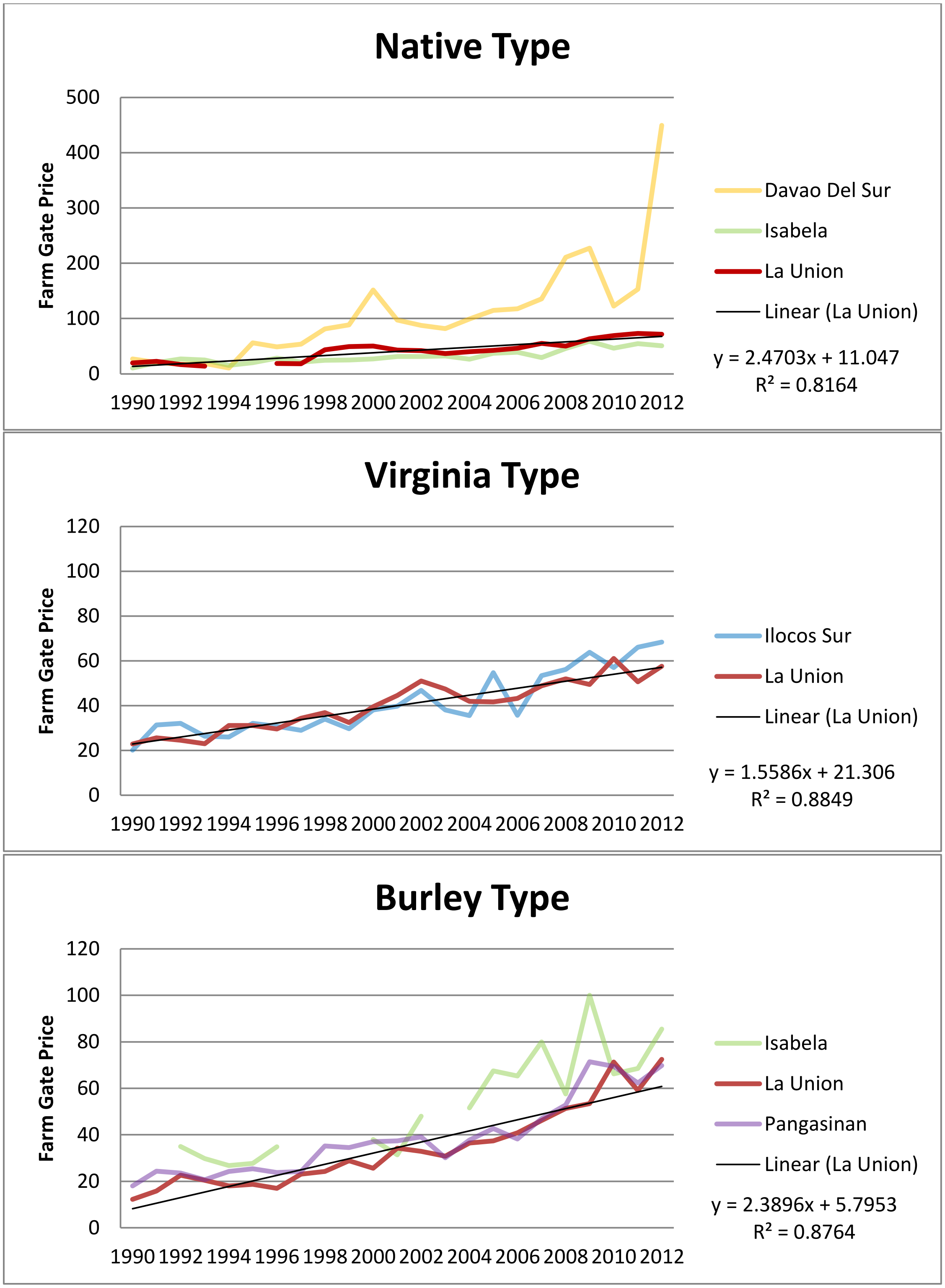

Figure 17 Native, Virginia, and Burley Type Farm Gate Prices for Select Provinces (Pesos per Kilogram)

4.3.2 Comparative Analysis, La Union Province

From 2002 to 2012, it is possible to compare percent area planted data for Native and Virginia tobacco types to corresponding farm gate prices. It is also possible to compare volume of production data to corresponding farm gate prices from 2000 to 2012. La Union is the only province in the Philippines which produced both types of tobacco and reported corresponding farm gate prices for the duration. It is also the only province to report farm gate prices for all three types of tobacco each year since 1990, and was thus used in Figure 18 to show trend lines, slope, and R squared values. This section builds off of Figure 18, and digs deeper into the relatedness of farm gate prices to percent area planted and volume of production.

Figure 18 begins by investigating farm gate prices for each of the three tobacco types. Burley type tobacco is included in Figure 18 even though no data are available for percent area planted and volume of production because Burley tobacco may help to explain the gap between the cumulative tobacco statistics and the sum of Native and Virginia tobacco statistics.

Figure 18 clearly shows that from 2000 to 2012, the farm gate price for Native and Burley tobacco has increased substantially in comparison to Virginia tobacco. The farm gate price of Native tobacco surpassed that of Virginia tobacco around 2005 and the farm gate price of Burley tobacco surpassed that of Virginia tobacco around 2008. Although Virginia tobacco produces approximately a 20 percent higher yield per hectare than Native tobacco, in 2011 and 2012 the farm gate price of Native tobacco was high enough to match this difference entirely. Burley tobacco produces the highest yield per hectare, and the gross income per hectare of Burley tobacco has likely exceeded that of Virginia tobacco for every year since 2006.

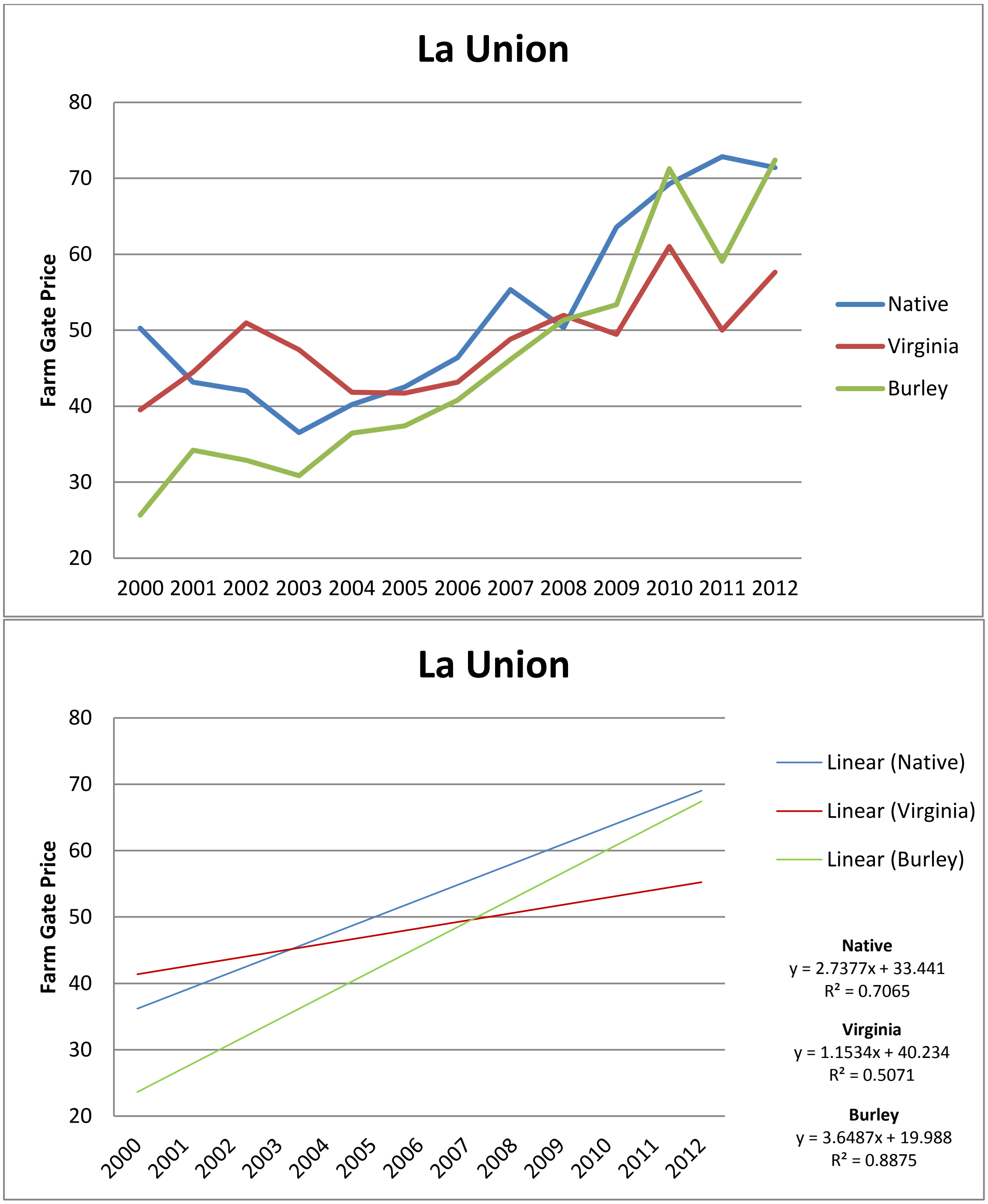

Figure 18 Farm Gate Prices for La Union Province (Pesos per Kilogram)

From a purely economic perspective, tobacco farmers in La Union province should feel natural pressures to increasingly shift from Virginia tobacco to Native or Burley tobacco. It is quite unfortunate that there is no further data available for Burley tobacco, as the combination of high yield per hectare and high farm gate price make it the most economically attractive type going forward.

Figure 19 shows a sharp decrease in percent area farmed after 2003 before evening out again at a lower level in 2007. From 2002 to 2012, Virginia type tobacco went from nearly three percent of total provincial area to just above one percent. Native type tobacco also experienced a decrease in area farmed after 2003; however the decrease was not nearly as sharp. Percent area planted for Native tobacco has been increasing slightly since 2008 and by 2012, recovered to nearly 80 percent of 2003 levels.

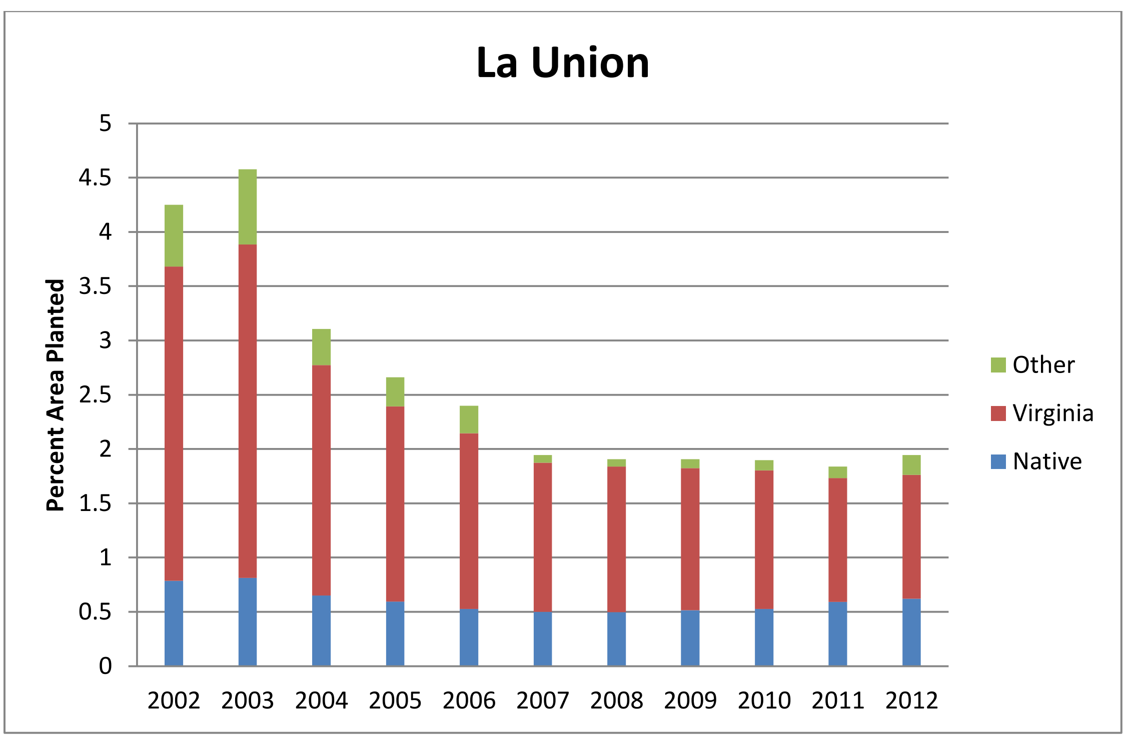

Figure 19 Percent of La Union province total area devoted to tobacco farming
Source: Data from the Bureau of Agricultural Statistics

Figure 20 shows a similar graph to Figure 19; replacing percent total area with volume of production. Although most of the same trends are visible in this graph, the years 2000 and 2001 are additionally visible. Production for both Native and Virginia tobacco appears relatively steady from 2000 to 2003, decreases substantially from 2003 to 2007, and becomes steady again until 2012. The decrease largely mirrors rates in Figure 19, indicating that no substantial increases in yield per hectare offset the decrease in tobacco farming area.

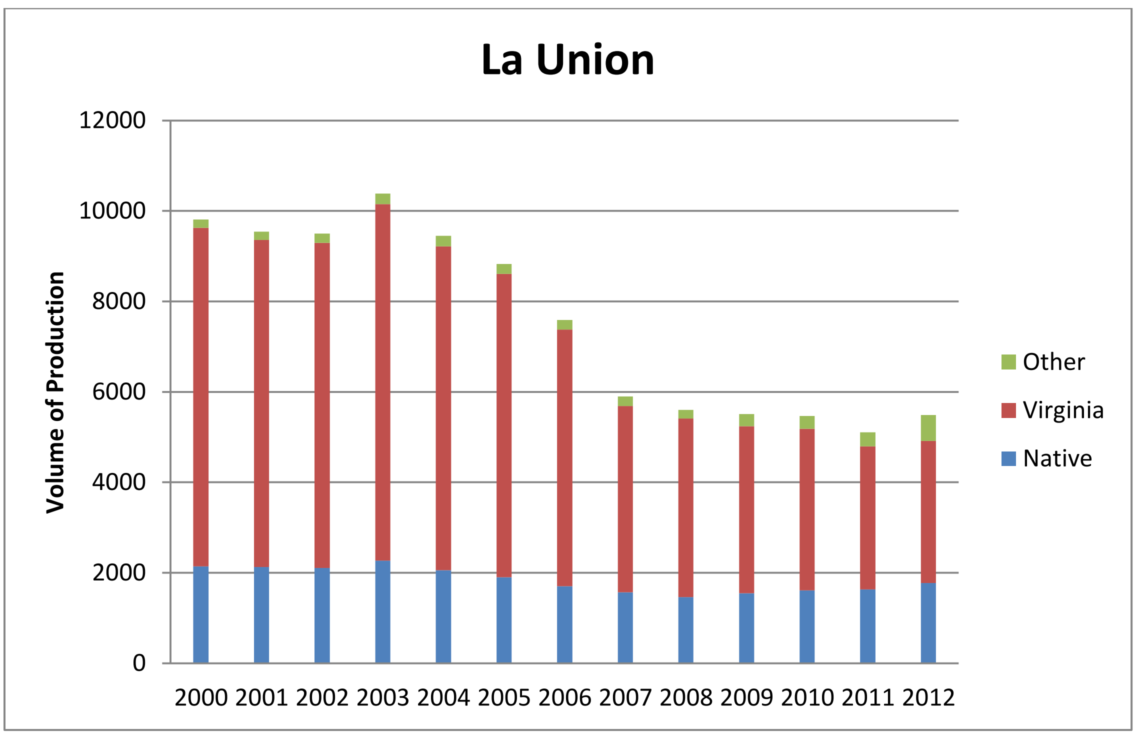

Figure 20 Total Volume of Production for La Union Province (Metric Tons)
Source: Data from the Bureau of Agricultural Statistics

Although the trend is clear that tobacco farming in La Union province is decreasing, Native tobacco has endured better than Virginia tobacco, perhaps partially due to observations regarding farm gate price noted above. Although Burley data would be an insightful addition, there is no official indication that the “Other” type tobacco listed in Figures 20 and 21 represents Burley tobacco. The “Other” type data were simply calculated by subtracting Virginia and Native data from the available cumulative figures.

CHAPTER 5: DISCUSSION

Although tobacco area planted and volume of production decreased dramatically in the Philippines from 1990 to 2012, many nuanced and localized trends emerged from analysis performed using both stationary and dynamic visualization techniques that provide much deeper, more contextualized insight into the industry. Tobacco farming remains an incredibly pertinent and controversial issue, particularly in the ASEAN region where tobacco regulation is being continuously updated and expanded.

5.1 Potential Causes

One of the first observations noted while analyzing the percent area planted and volume of production data was the two large downturns that occurred from 1992 to 1994 and from 2003 to 2007. Although not insinuating causation, it appears as if two very separate occurrences may have played roles in each of these downturns.

The Mount Pinatubo eruption began in the summer of 1991 and continued through 1992, causing nearly USD 500 million in damage and completely disrupting the economy of Luzon. Much of the damage locally came from lahars, rain induced torrents of volcanic debris, in the months following the eruptions. Mount Pinatubo is located on the border between Zambales, Tarlac, and Pampanga provinces on Luzon Island. This would explain why tobacco growing provinces closer to Mount Pinatubo, such as Pangasinan and La Union, experienced the sharpest drop in production while provinces further away, such as Ilocos Sur and Isabela, experienced less severe drops.

Prior to the eruption, nearly 10 percent of the total area of La Union province was devoted to tobacco farming. Within two years, the number dropped to under five percent.

In Pangasinan, production dropped from a high of 31,168 metric tons in 1992, to 8,122 metric tons in 1994. As further confirmation, the southern province of Davao Del Sur, over 1,500 kilometers away, actually increased tobacco production from 654 metric tons in 1993 to 1,639 metric tons in 1994.

The downturn in production from 2003 to 2007 appears to be less of a dramatic, geographically variable shock, and more of an all-encompassing, increasing rate of decline. The sustained decline in tobacco farming more or less corresponds to the passage of the Tobacco Regulation Act of 2003, and the ensuing five year program aimed at transitioning tobacco farmers into alternative farming systems and livelihoods.

The Act established the Tobacco Growers' Assistance Program and the Tobacco Growers' Cooperative. The Tobacco Growers' Assistance Program provided financial support both to farmers displaced due to the implementation of the Act, and those who voluntarily gave up tobacco farming. The Tobacco Growers' Cooperative assisted tobacco farmers in developing alternative farming systems and encouraged tobacco farmers to plant alternative crops.

Because the trend is less sharp and less geographically distinct, it is not possible to say with complete confidence that the two are related, however it remains likely. It should also be noted that there is an increase in tobacco production between 2008 and 2012 directly following the expiry of the five year program implemented under the Tobacco Regulation Act of 2003. It would be an interesting study to determine how much of the increase is from former tobacco farmers switching back again as a result of the expiry of funded programs under the Act.

Further localized disrupters such as typhoons or droughts, along with natural economic pressure to shift production to more productive crops, may contribute towards national trends and regional anomalies, leaving many questions unanswered and in need of further research. Why does Native tobacco production reduce by nearly 50 percent from 2005 to 2006? Why did La Union not experience the same increase in production from 2008 to 2012 that its northern neighbor, Ilocos Sur, experienced?

Although this study exposes trends evident in available spatial data, it does not provide all of the necessary answers regarding causation. To more confidently correlate causation and pick up on smaller trends, it would be helpful to have a longer track record of tobacco farming data, inclusive of all three types: Native, Virginia, and Burley. It would also be helpful to obtain more detailed tobacco farming data at the *barangay* level to open up the possibility of spatiotemporal analysis methods beyond visualization. Lastly, a comparative investigation to other crops, particularly those which can be grown in lieu of tobacco, could provide valuable information for policy decision-makers.

5.2 Key Takeaways

Although farm gate prices for all tobacco types have risen at a relatively linear rate since 1990, the rate of increase in relative farm gate price for Native and Burley type tobacco has readily outpaced that of Virginia type tobacco, yet Virginia tobacco still accounts for over half of all tobacco produced in the Philippines. This would seem to indicate that more tobacco farmers will increasingly feel pressure to change the type of tobacco grown, particularly in the four largest Virginia tobacco producing provinces. Additionally, 2008 to 2012 marked the first time in the entire 23 year study period with four years of consecutive growth in total tobacco production, and could be a sign that tobacco farming is making a comeback.

In general, Native tobacco farming was more widespread geographically, while Virginia tobacco was largely limited to only four provinces in northwestern Luzon. All of the major tobacco growing provinces in northern Luzon share a similar history of tobacco growing, remnants of the Spanish tobacco monopoly. The center of tobacco production in the Philippines is squarely located in Luzon for all types, and any policy measures should be focused on northern Luzon, particularly the Virginia tobacco growing provinces. Any tobacco farming policy measure would be felt at a proportionally higher rate for the northeastern Luzon provinces as well.

Of the methods used, I believe that dynamic visualization would be the most useful for policy makers. The most important difference between stationary and dynamic visualization is that for dynamic visualization, data are presented easily on a single output map, whereas stationary visualization requires an animation or static time series. In this case, dynamic visualization clearly shows the skewed importance of tobacco farming in Northern Luzon, and the relative magnitude and direction of change by year.

Stationary visualization techniques did, however, provide deeper insight into provincial level changes that could be further investigated through supplemental graphs and statistics. For example, it would have been difficult to attribute the downturn from 1992 to 1994 to the Mount Pinatubo eruption, without first visualizing the production dip in surrounding provinces.

CHAPTER 6: CONCLUSIONS

This thesis set out to demonstrate the efficacy of spatiotemporal visualization and analysis as a policy support tool by performing a case study on tobacco farming in the Philippines. The topic of the case study was chosen precisely due to its controversial nature; so that the results could provide novel, spatially driven insights for policy makers to make better informed decisions. Thus, the research was framed to determine how spatial variation in tobacco farming has changed over time in the Philippines.

Five key questions were developed to better address challenges faced from the perspective of a national level policy maker tasked with deciding the future of tobacco farming policy in the Philippines. These questions served as the basis for analysis by means of stationary and dynamic visualization techniques. From these questions, it was hypothesized that clear spatiotemporal trends would emerge and that those trends could be linked to potential causes. The key questions were:

1. What provinces and regions are most dependent on tobacco farming and how has this changed spatially over time?
2. What provinces and regions produce the highest total volume of tobacco production and how has this spatially changed over time?
3. Is there any spatial variation in farm gate prices and, if so, how has this changed spatially over time?
4. Considering the first three key questions, is there any spatial variation between the three types of tobacco grown in the Philippines: Native, Virginia, and Burley? If so, how has this changed over time?
5. If clear spatiotemporal trends are identified, can possible causes also be reasoned?

For question 1, it was found that in 1990, La Union was most dependent on tobacco farming. By 2012 however, Ilocos Sur was the most dependent on tobacco farming. Overall, the Ilocos Region proved to be the most dependent on tobacco farming throughout the timeframe despite substantial declines in tobacco hectares planted since 1990.

Question 2 resulted in similar conclusions to question 1. Because the data were not normalized to provincial area, the Cagayan Valley Region gained more significance in the analysis of tobacco volume of production. Additionally, the increasing dominance of Ilocos Sur over the time period became visible by using dynamic visualization techniques.

For Question 3, farm gate pricing varied by type, but not necessarily by location, with the notable exception of Native type tobacco in the southern provinces. Virginia type prices showed the least volatility, and also the lowest annual rate of growth in average farm gate price. The annual rate of growth in farm gate prices for Native type tobacco was quite a bit higher, likely driving the observed increase in production in northern Luzon.

For question 4, it was found that Native type tobacco production totaled much less than Virginia type yet was grown in many more provinces. Native type tobacco production was spread across many regions however the number of provinces where Native type tobacco was grown decreased over time. Virginia type production was very much centered in only a couple provinces in the Ilocos Region. In the last couple years however, a few other provinces began growing Virginia type tobacco.

For question 5, large trends were picked up and linked to potential causes. Notably, there was a regionalized downturn in production from 1992 to 1994 that may have been attributed to the Mount Pinatubo eruption. Additionally, there was a countrywide downturn from 2003 to 2007 that may have been a result of the Tobacco Regulation Act of 2003 and the ensuing five year program aimed at transitioning tobacco farmers into alternative farming systems and livelihoods.

On all accounts, I believe that this thesis has achieved its goal. The spatiotemporal analysis provides empirical evidence for policy makers to better understand regional and provincial trends in tobacco farming over time. Tobacco farming has drastically reduced in some provinces, yet remained steady or increased in others. Understanding where and why the variability occurs is important for determining the future direction of tobacco farming policy in the Philippines.

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APPENDIX A: PERCENT OF TOTAL PROVINCIAL AREA DEVOTED TO GROWING TOBACCO, BY TYPE AND YEAR

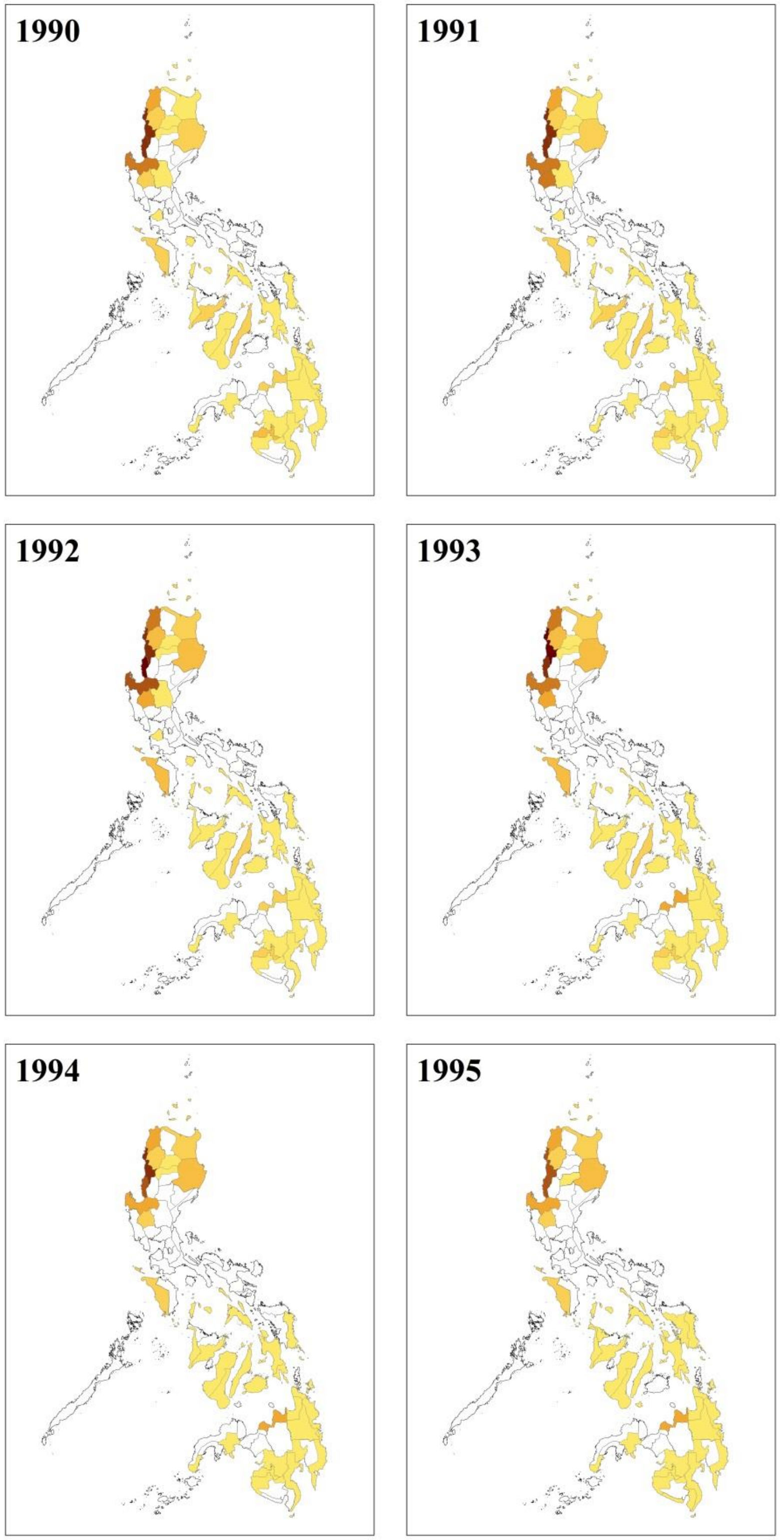

Figure 21 All Tobacco Types

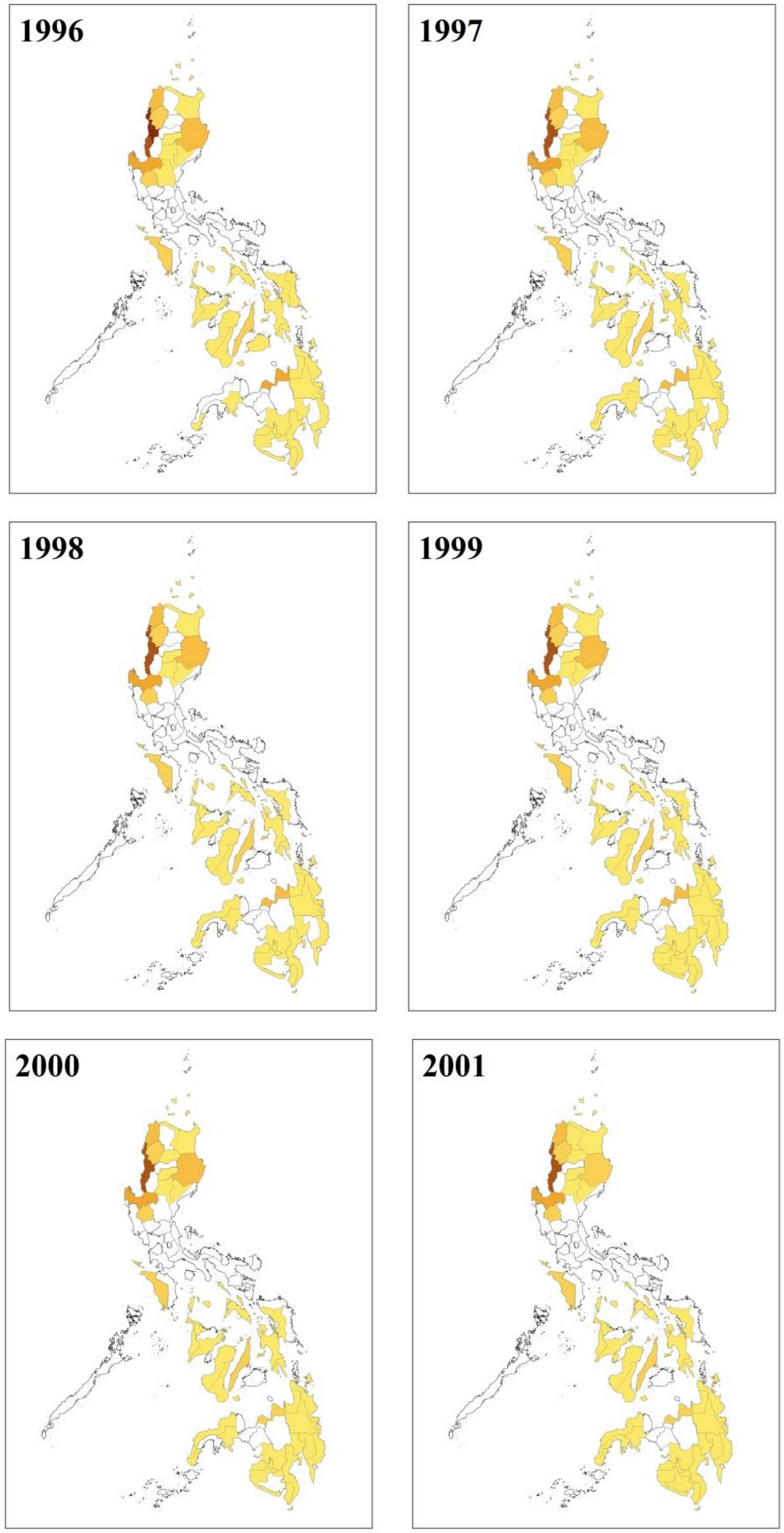

Figure 21 All Tobacco Types (continued)

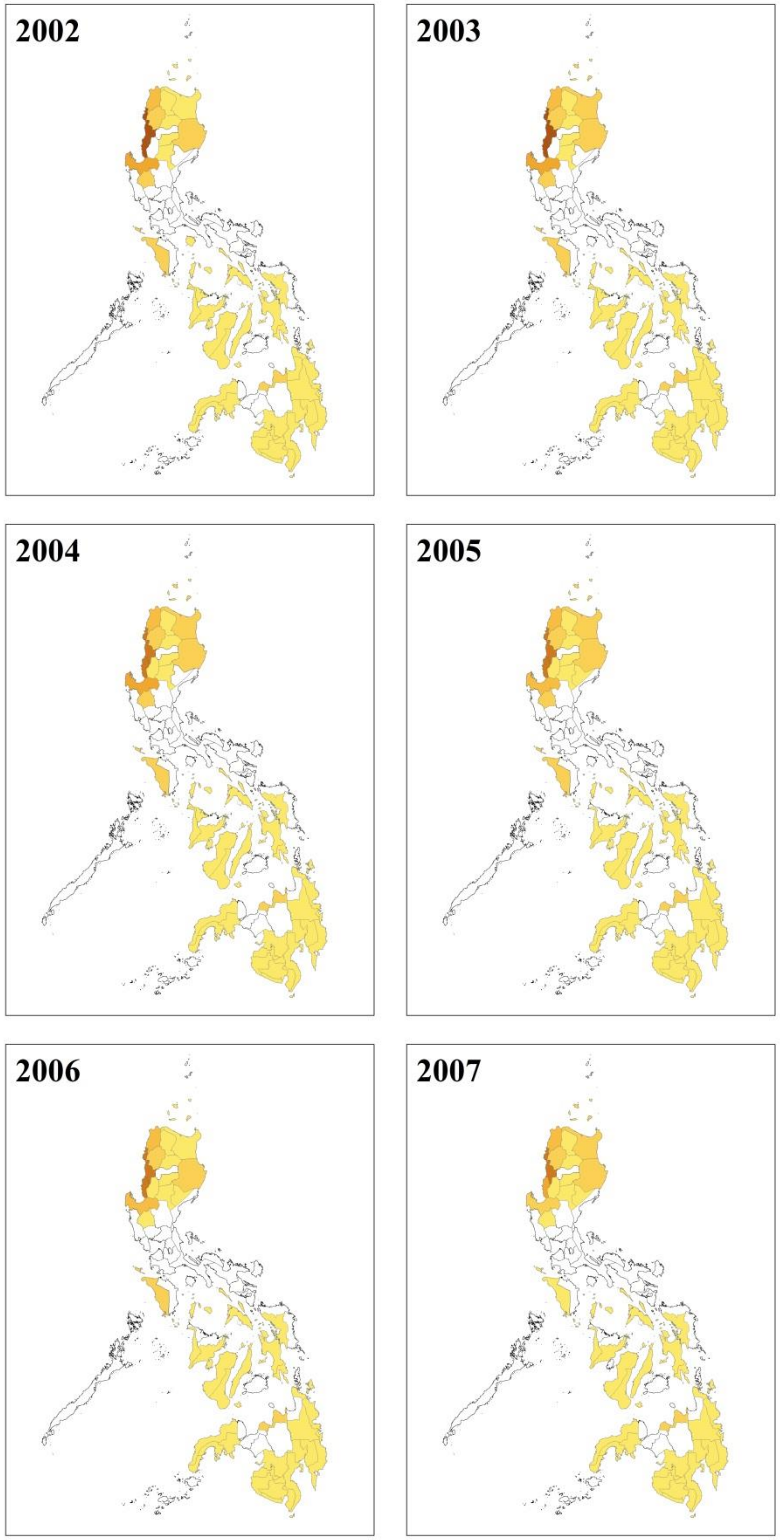

Figure 21 All Tobacco Types (continued)

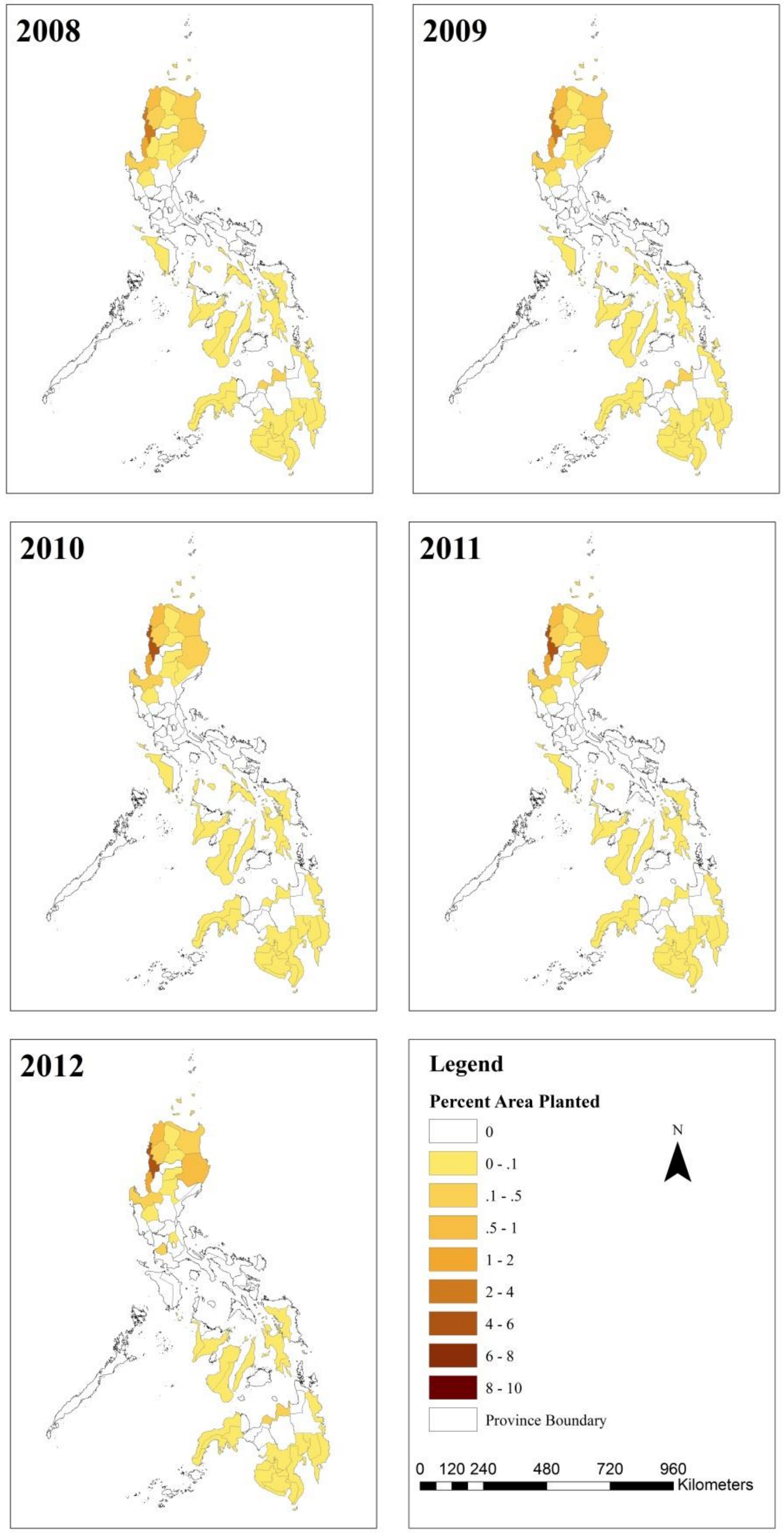

Figure 21 All Tobacco Types (continued)

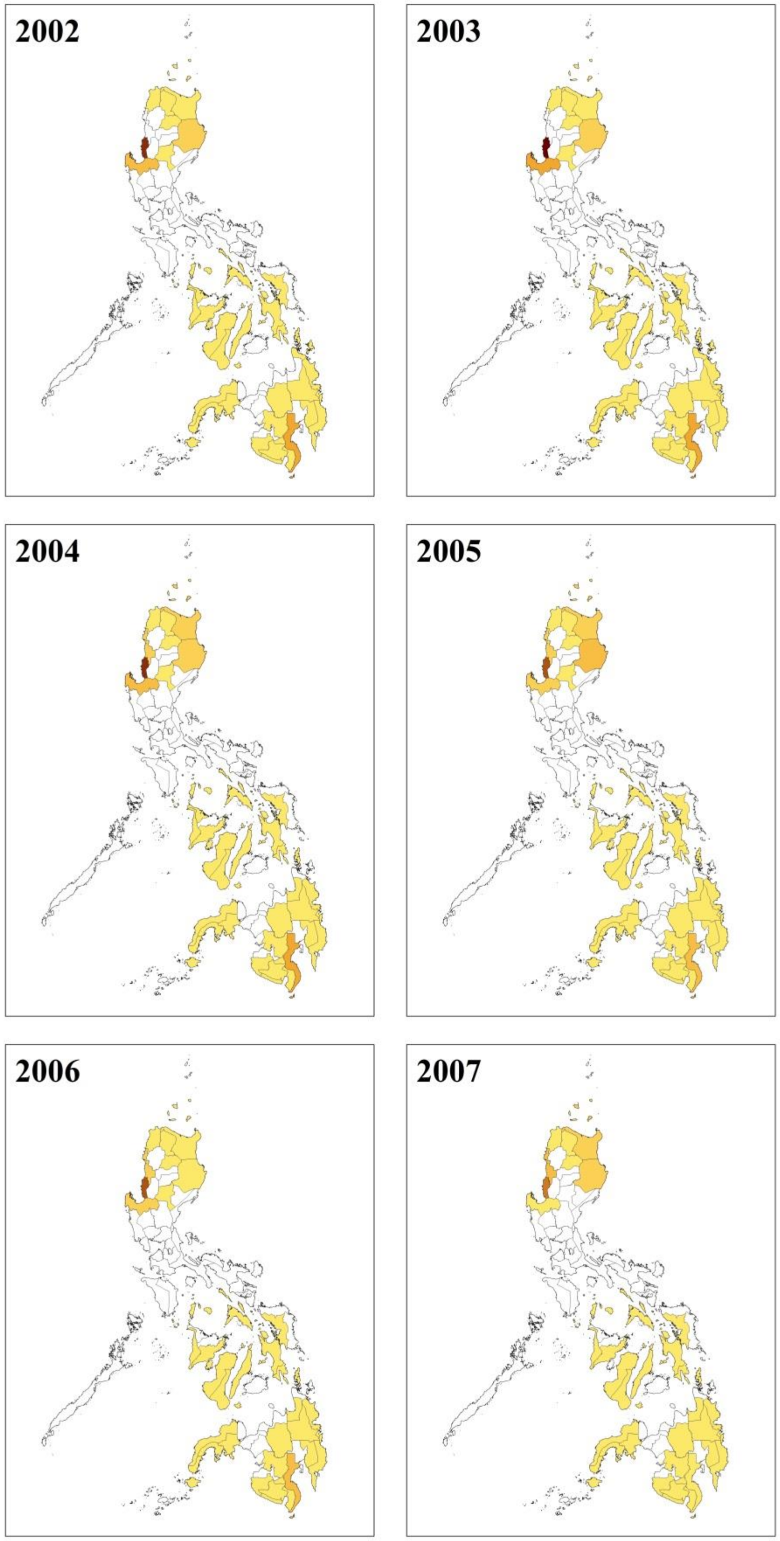

Figure 22 Native Tobacco Type

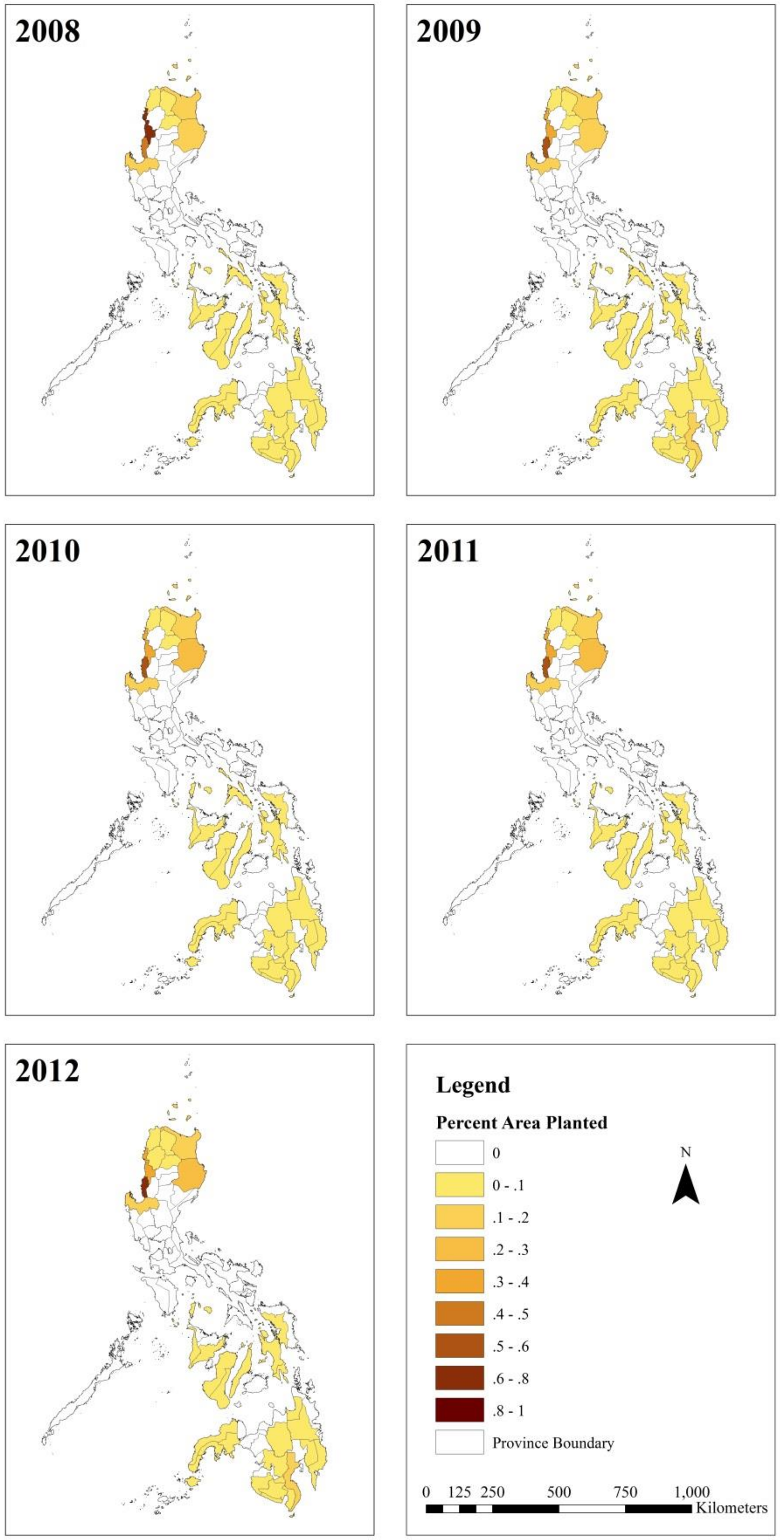

Figure 22 Native Tobacco Type (continued)

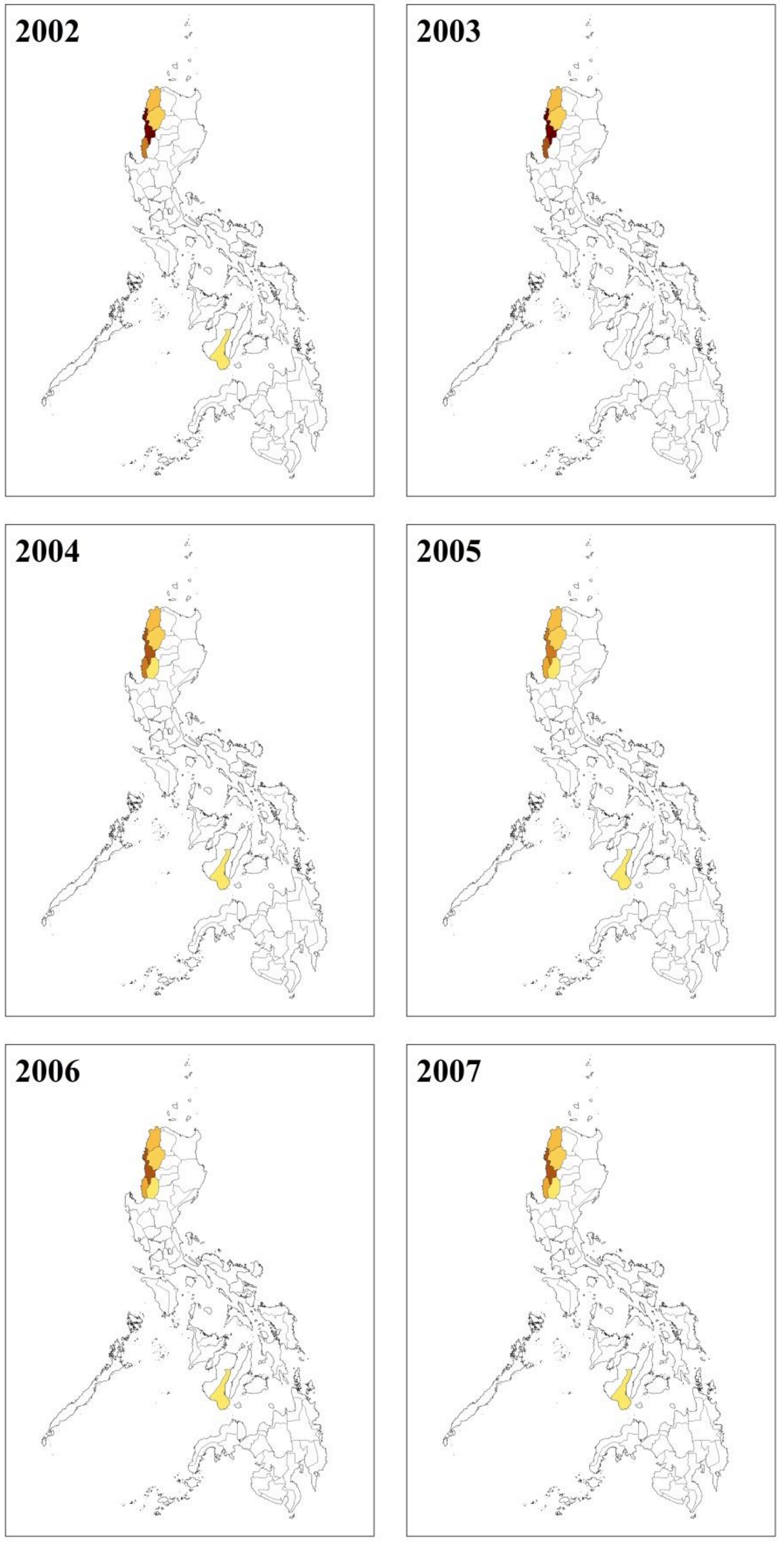

Figure 23 Virginia Tobacco Type

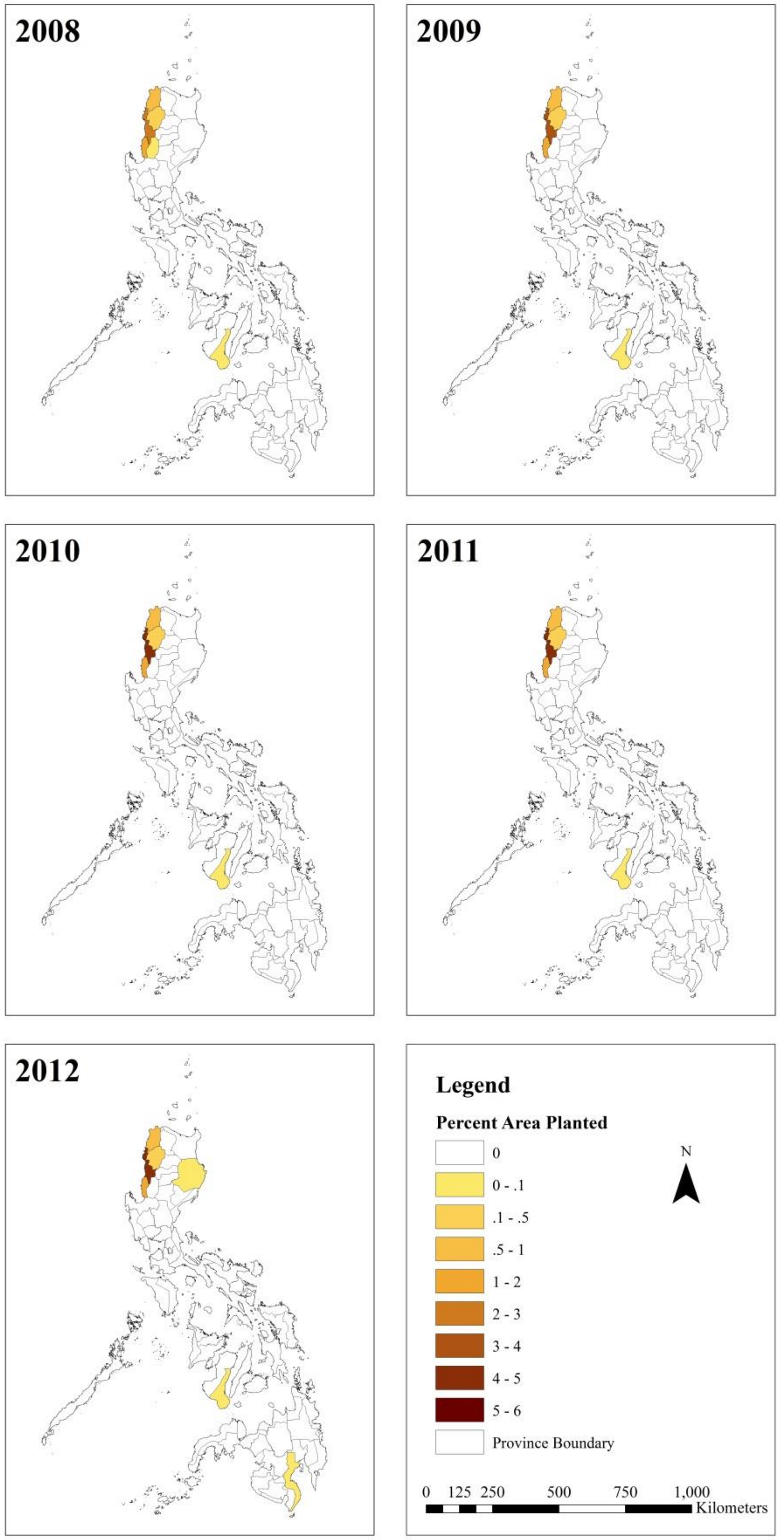

Figure 23 Virginia Tobacco Type (continued)

APPENDIX B: TOTAL VOLUME OF TOBACCO PRODUCTION IN METRIC TONS, BY TYPE AND YEAR

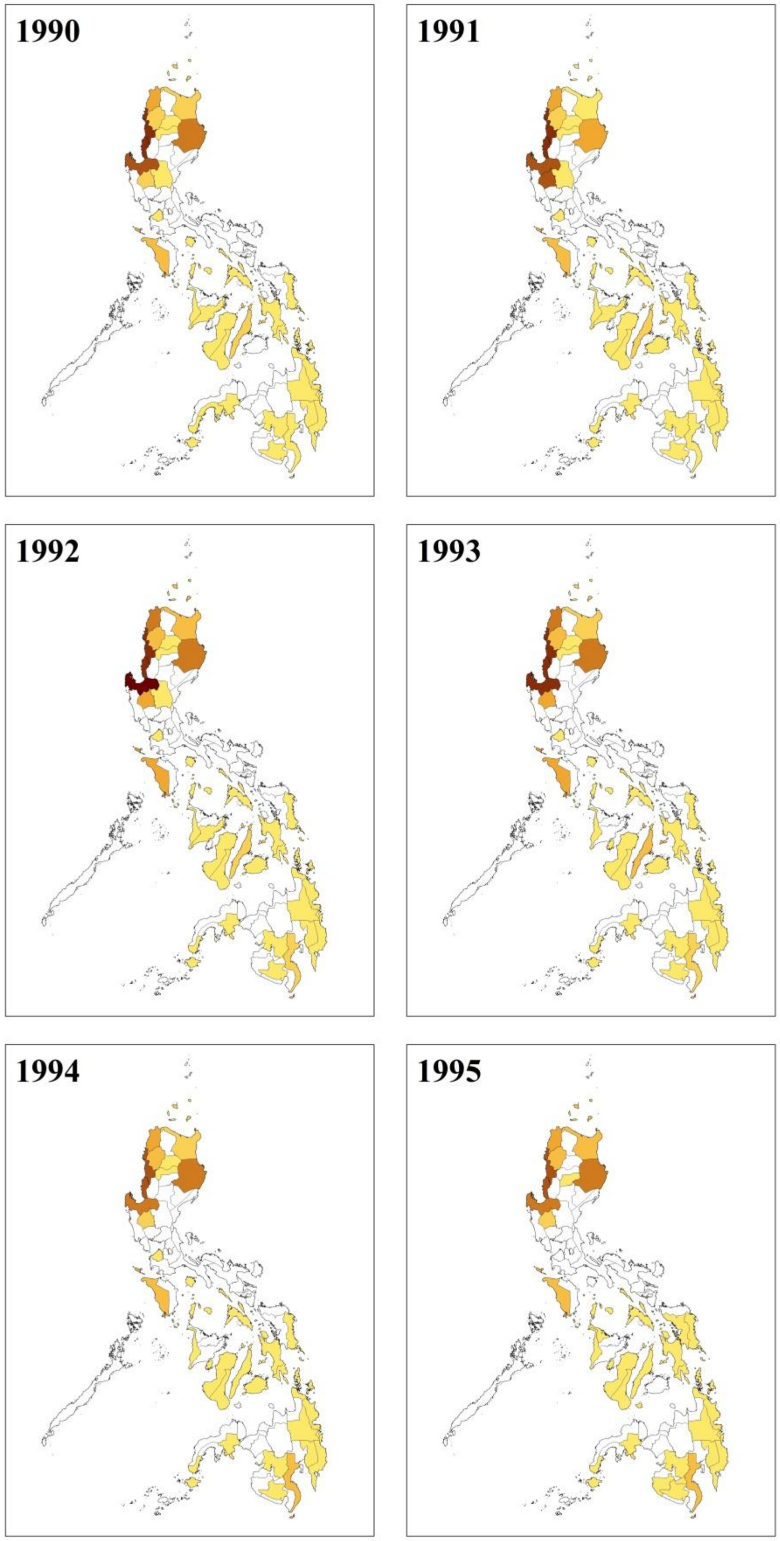

Figure 24 All Tobacco Types

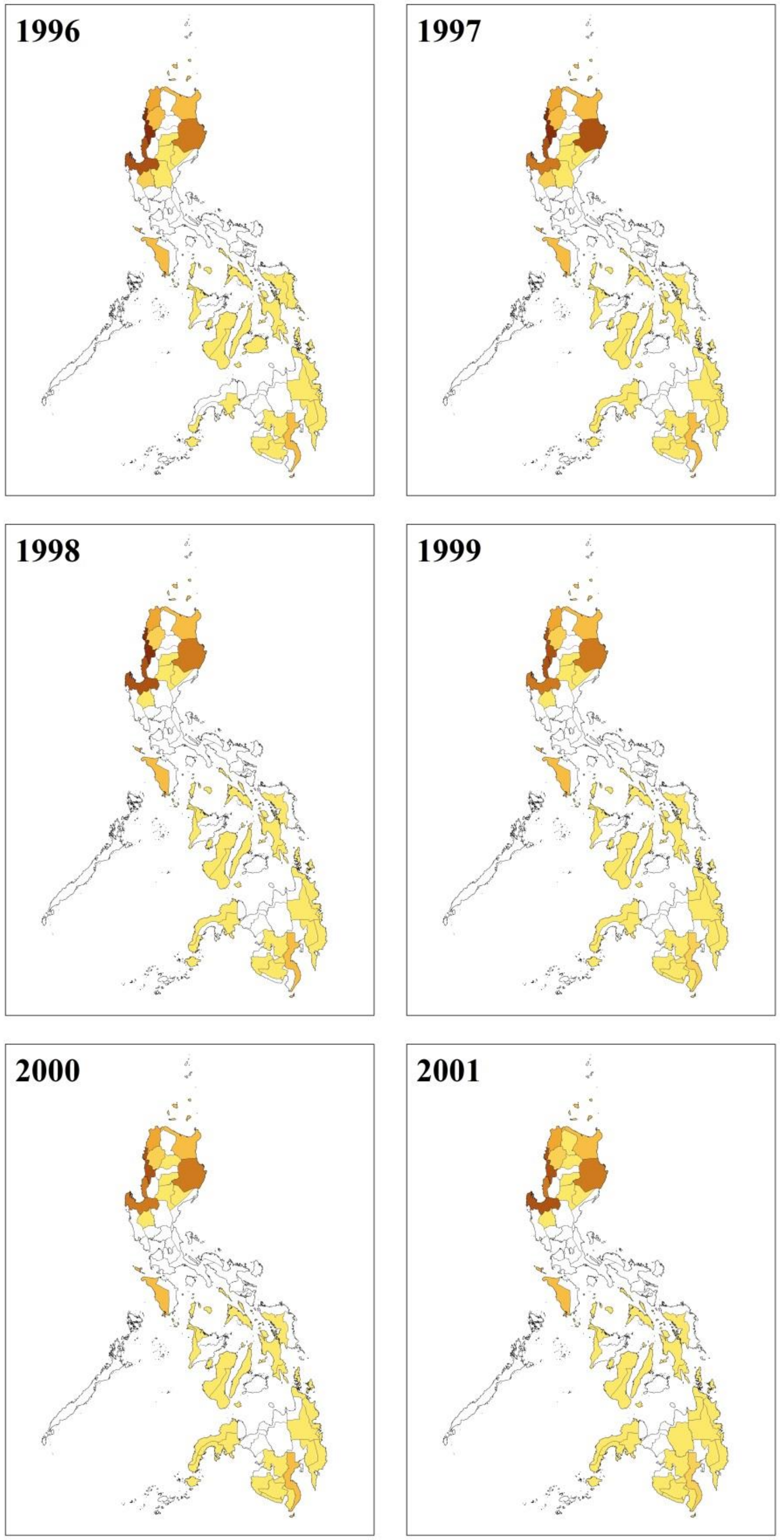

Figure 24 All Tobacco Types (continued)

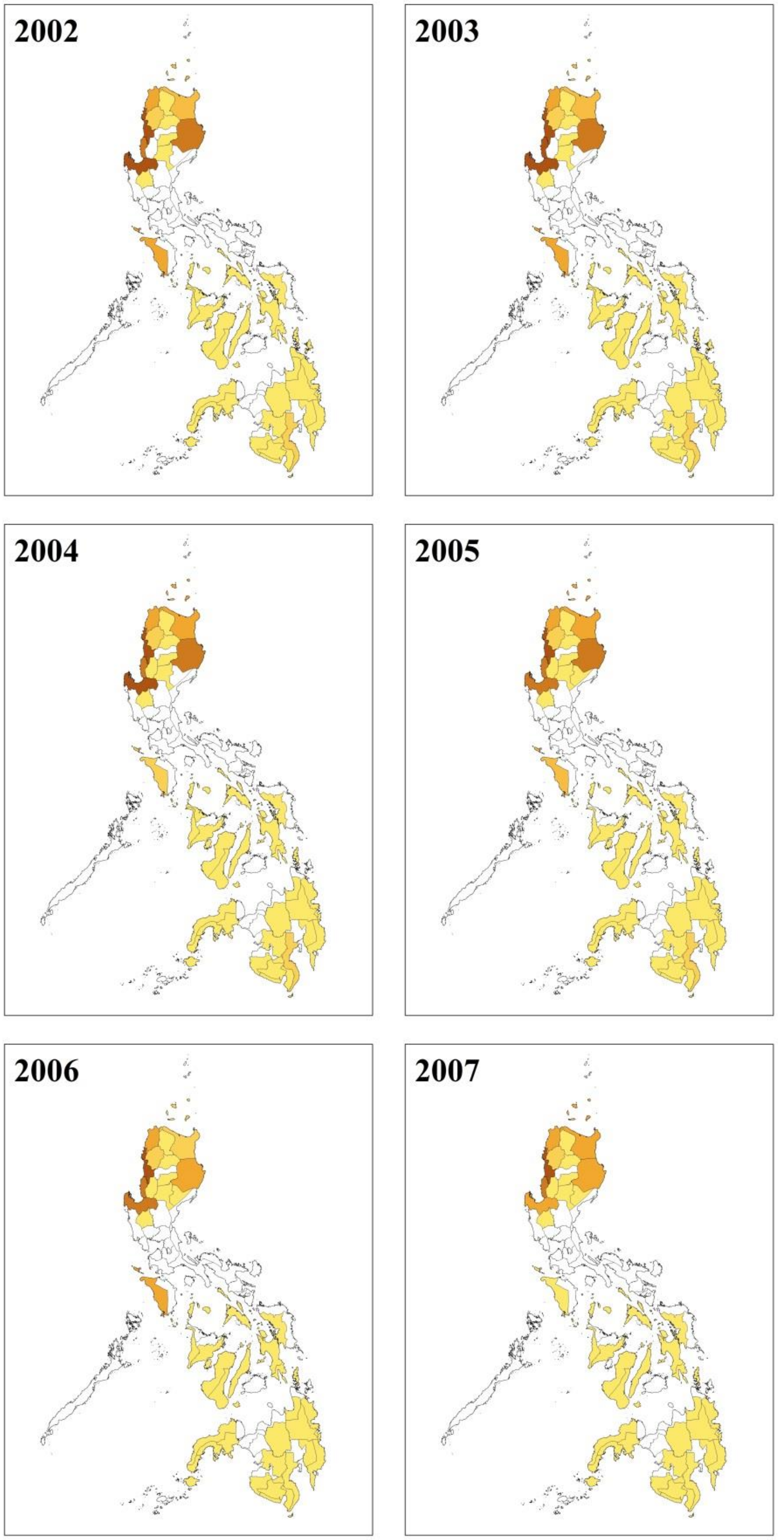

Figure 24 All Tobacco Types (continued)

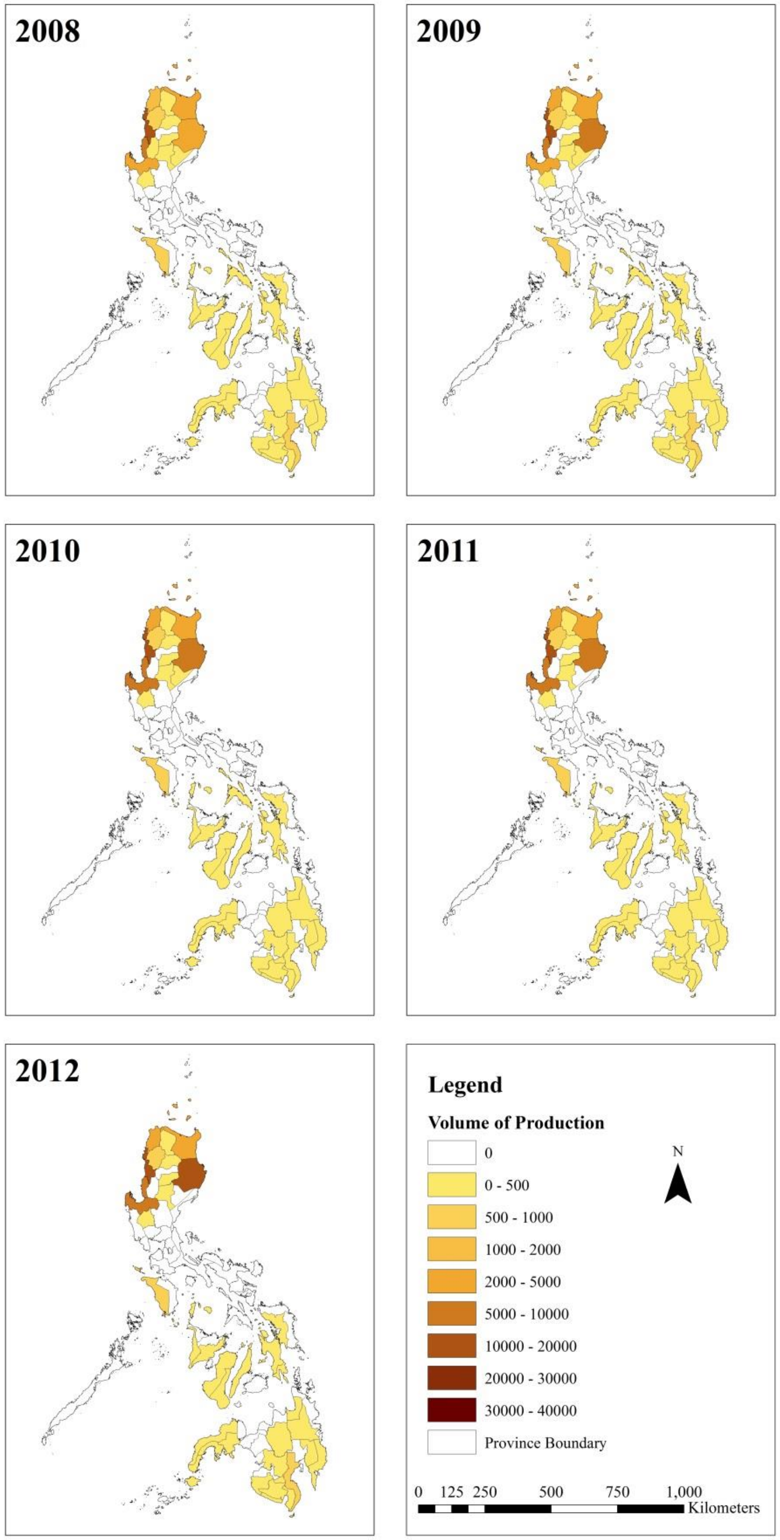

Figure 24 All Tobacco Types (continued)

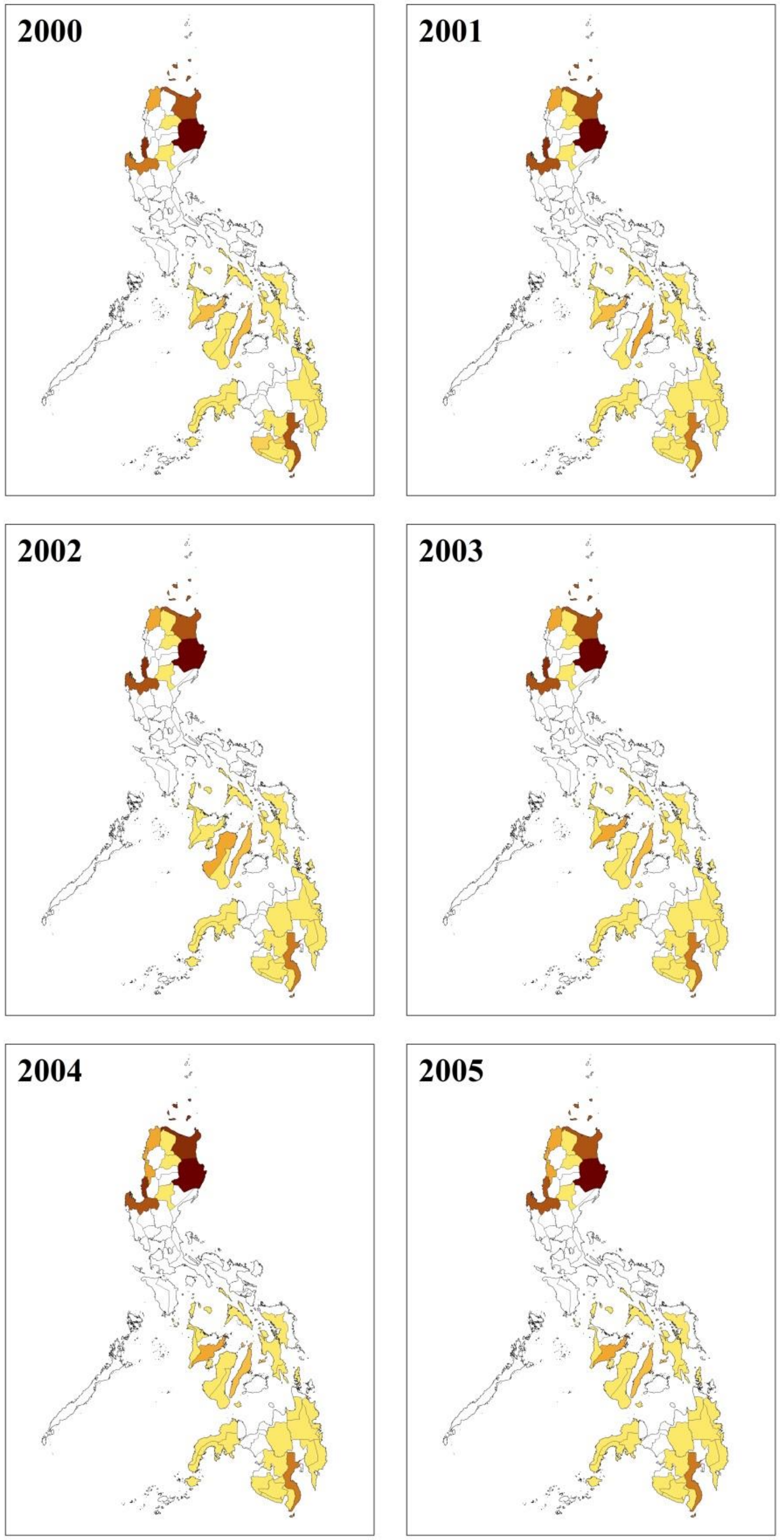

Figure 25 Native Tobacco Type

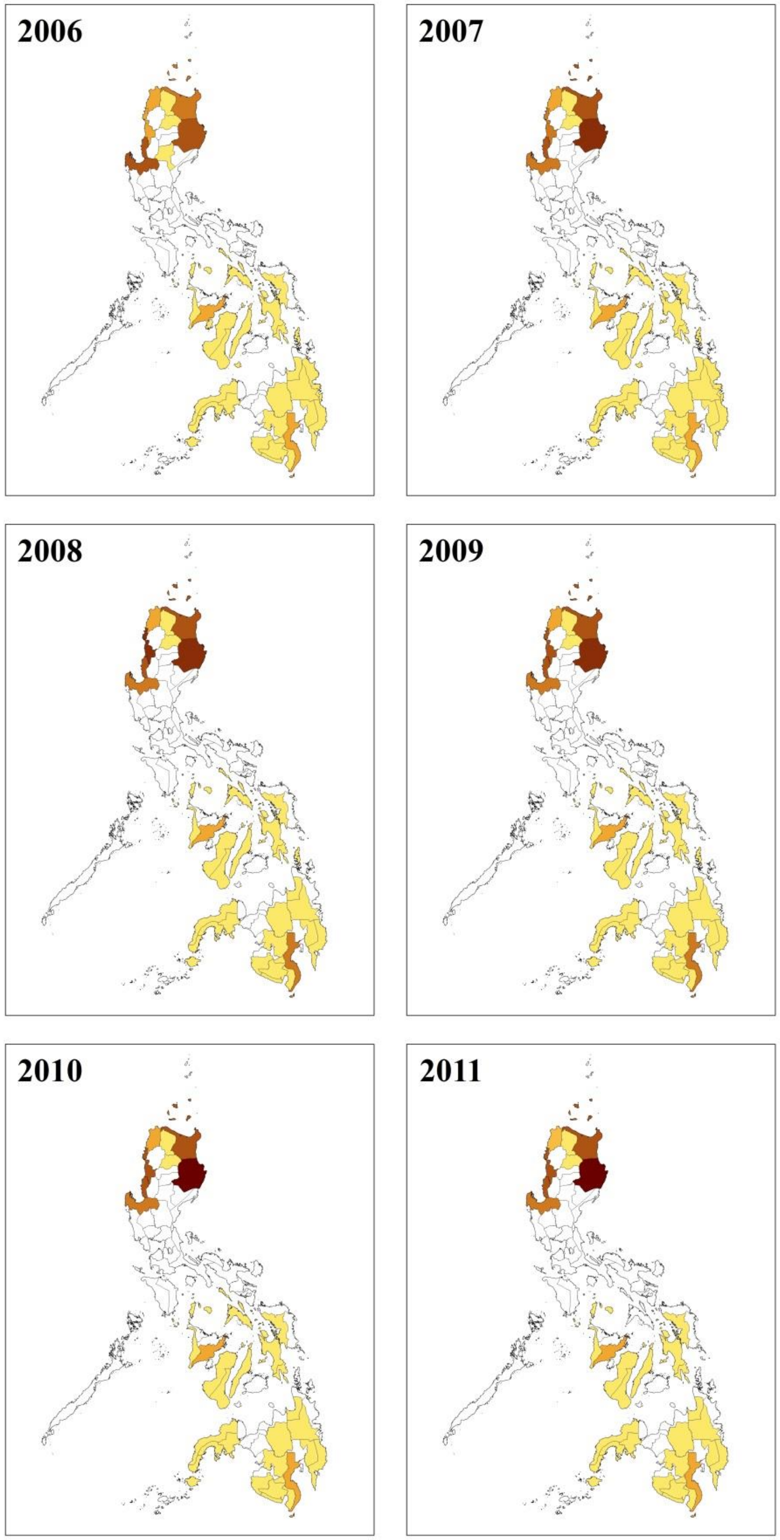

Figure 25 Native Tobacco Type (continued)

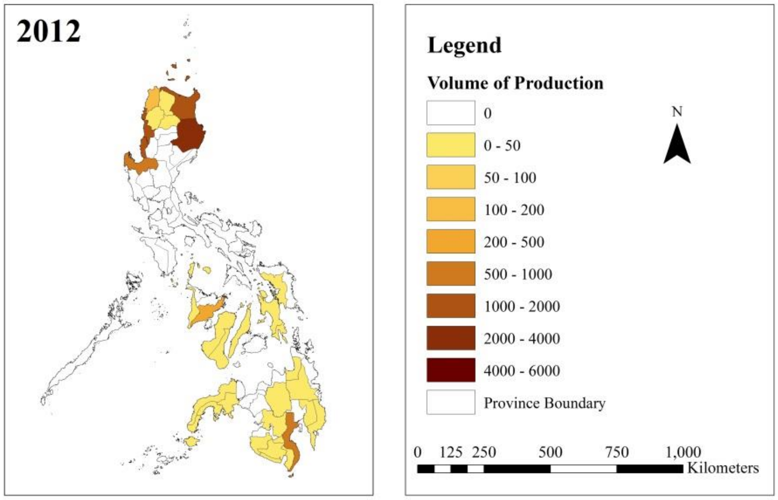

Figure 25 Native Tobacco Type (continued)

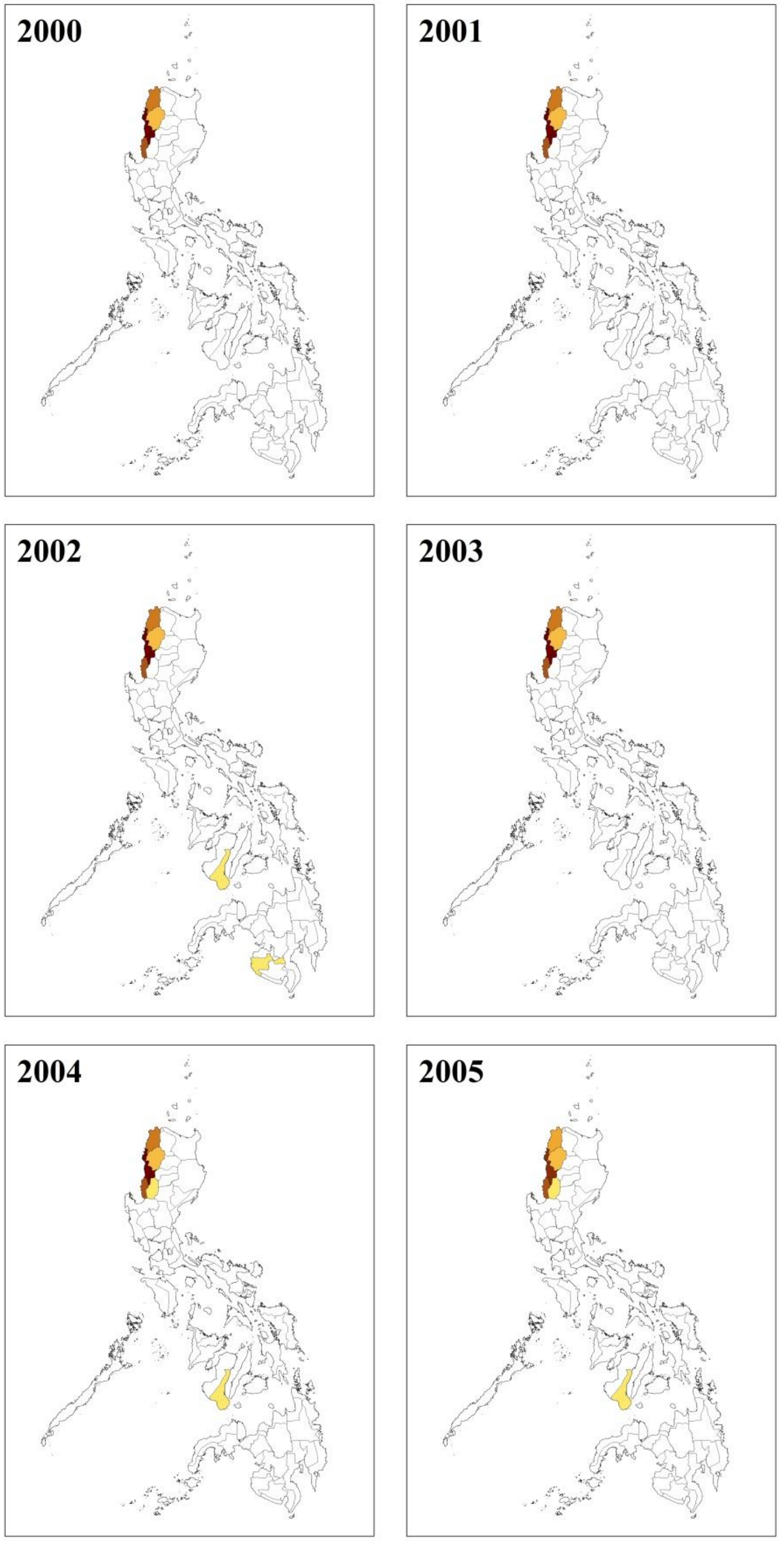

Figure 26 Virginia Tobacco Type

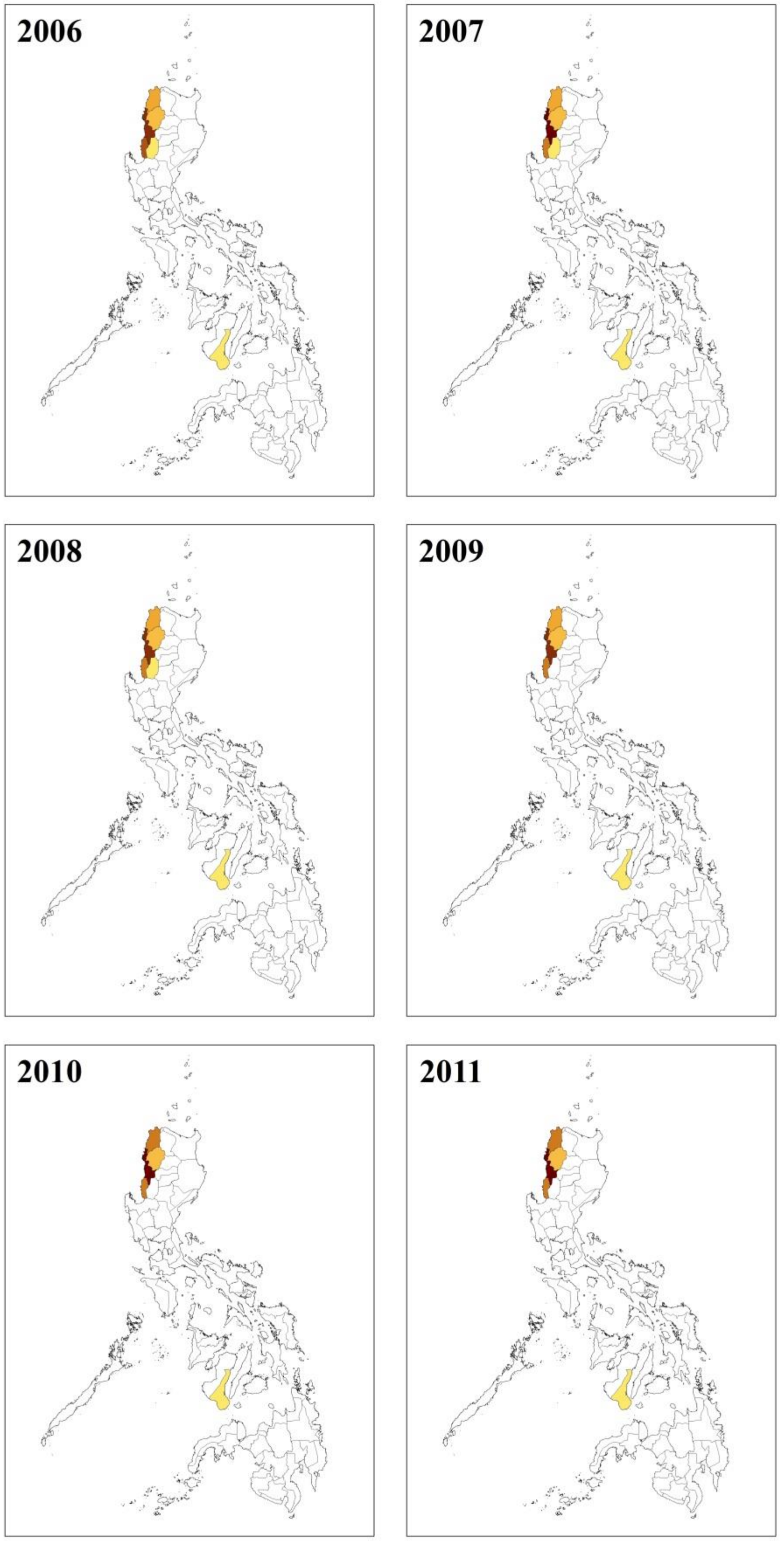

Figure 26 Virginia Tobacco Type (continued)

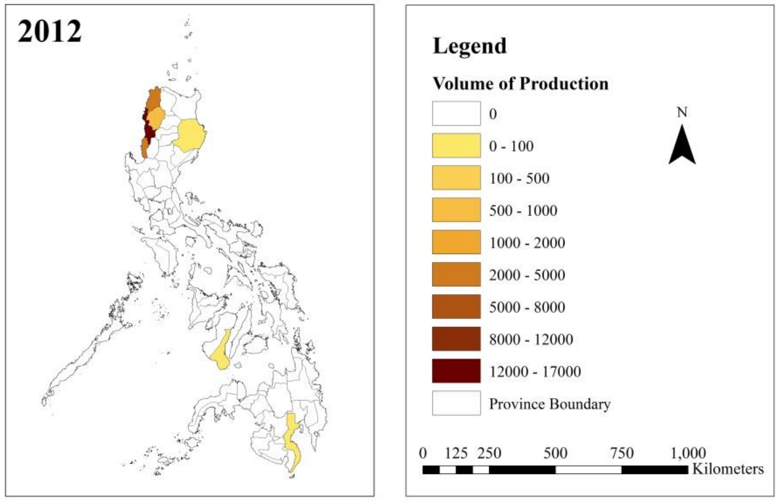

Figure 26 Virginia Tobacco Type (continued)

APPENDIX C: FARM GATE PRICE OF TOBACCO BY PROVINCE, PESOS PER KILOGRAM

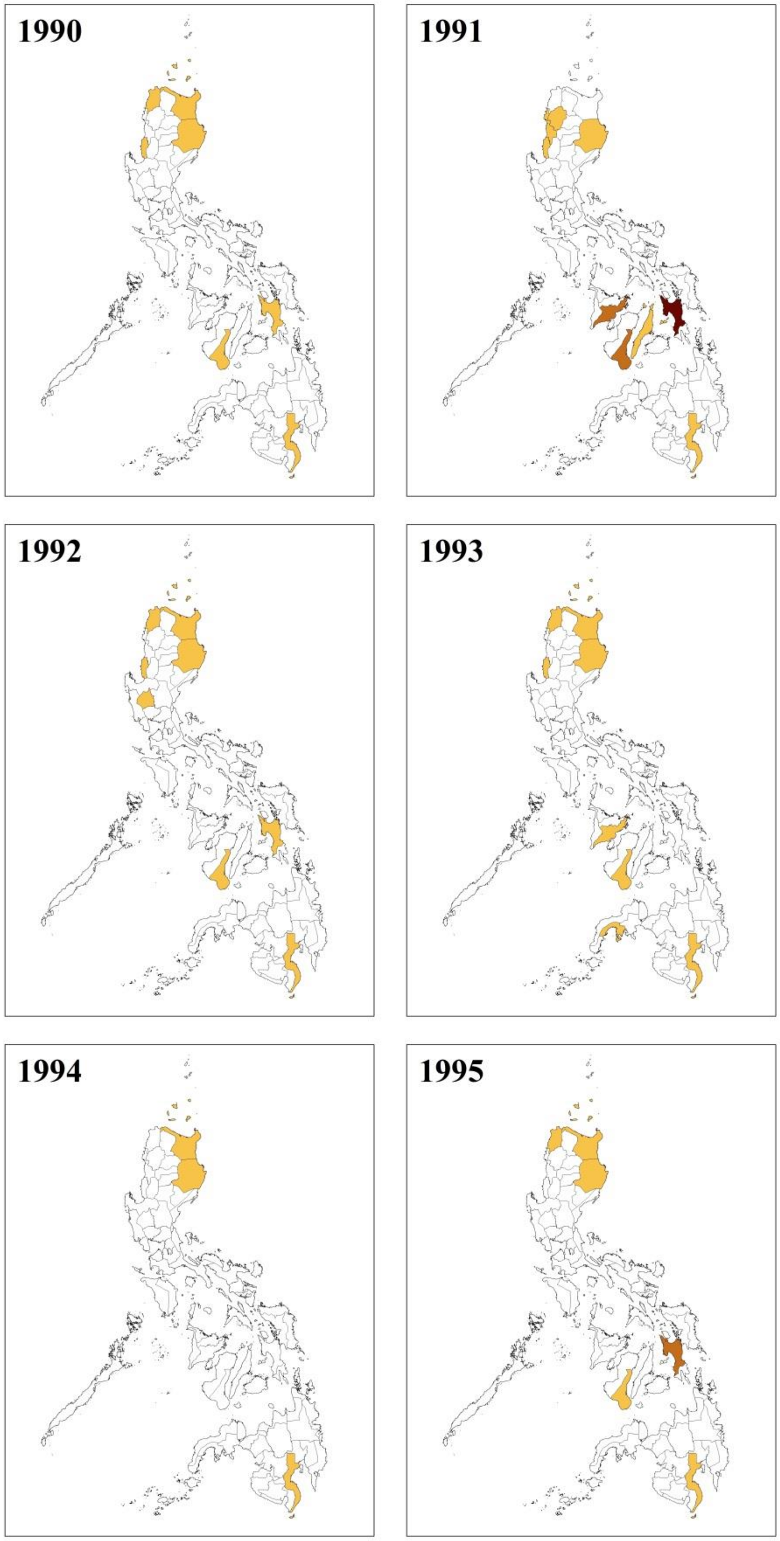

Figure 27 Native Tobacco Type

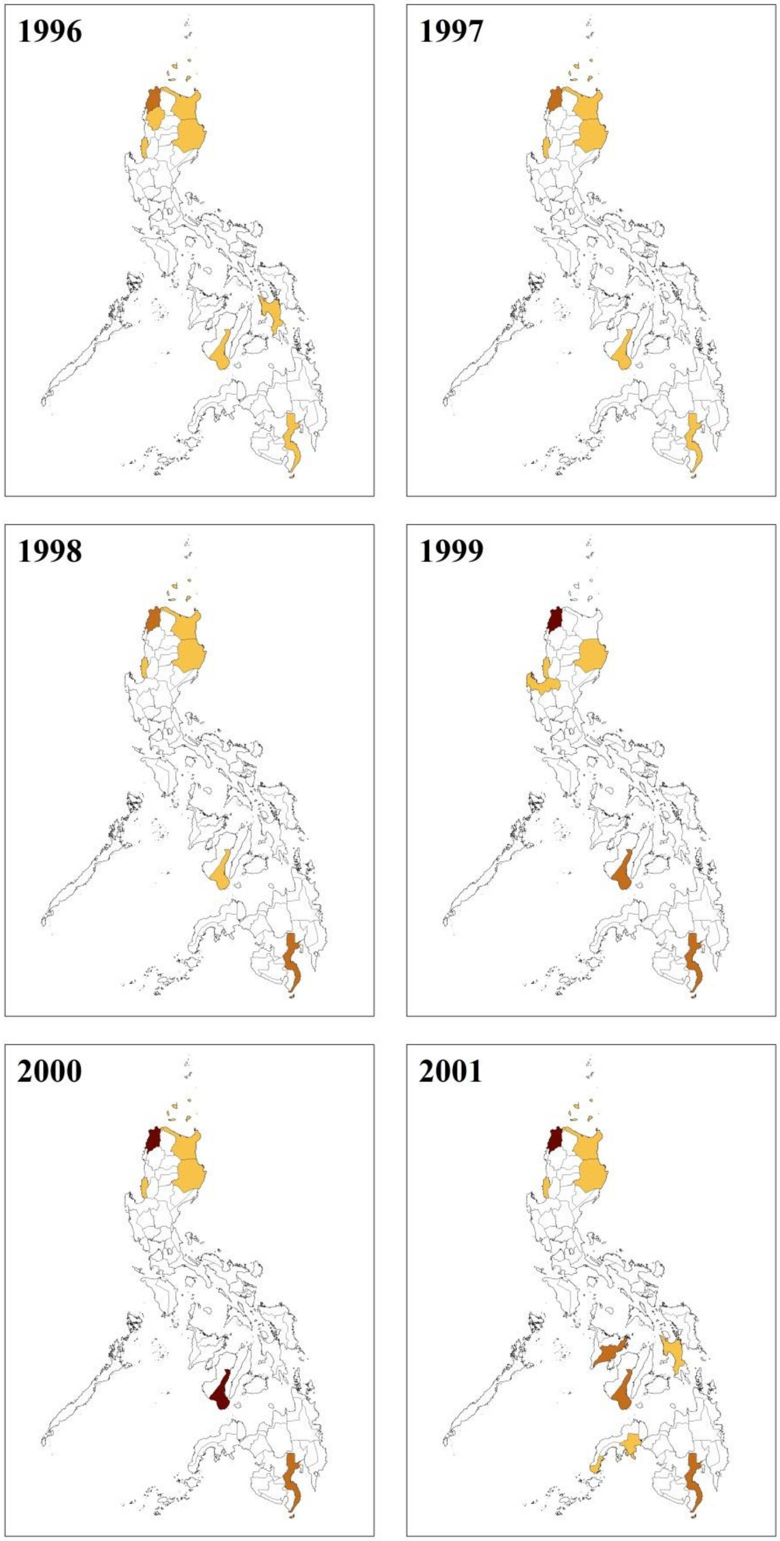

Figure 27 Native Tobacco Type (continued)

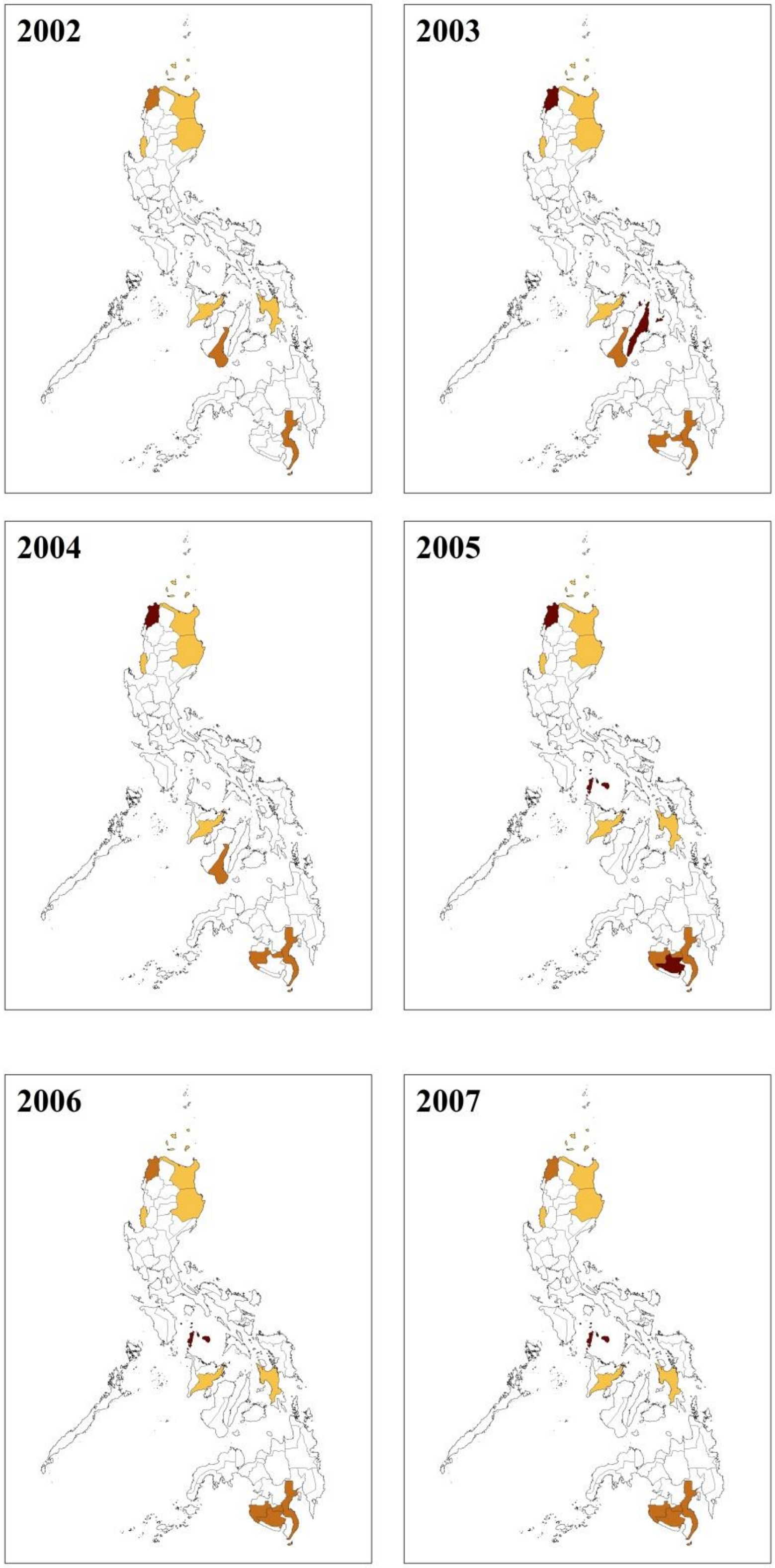

Figure 27 Native Tobacco Type (continued)

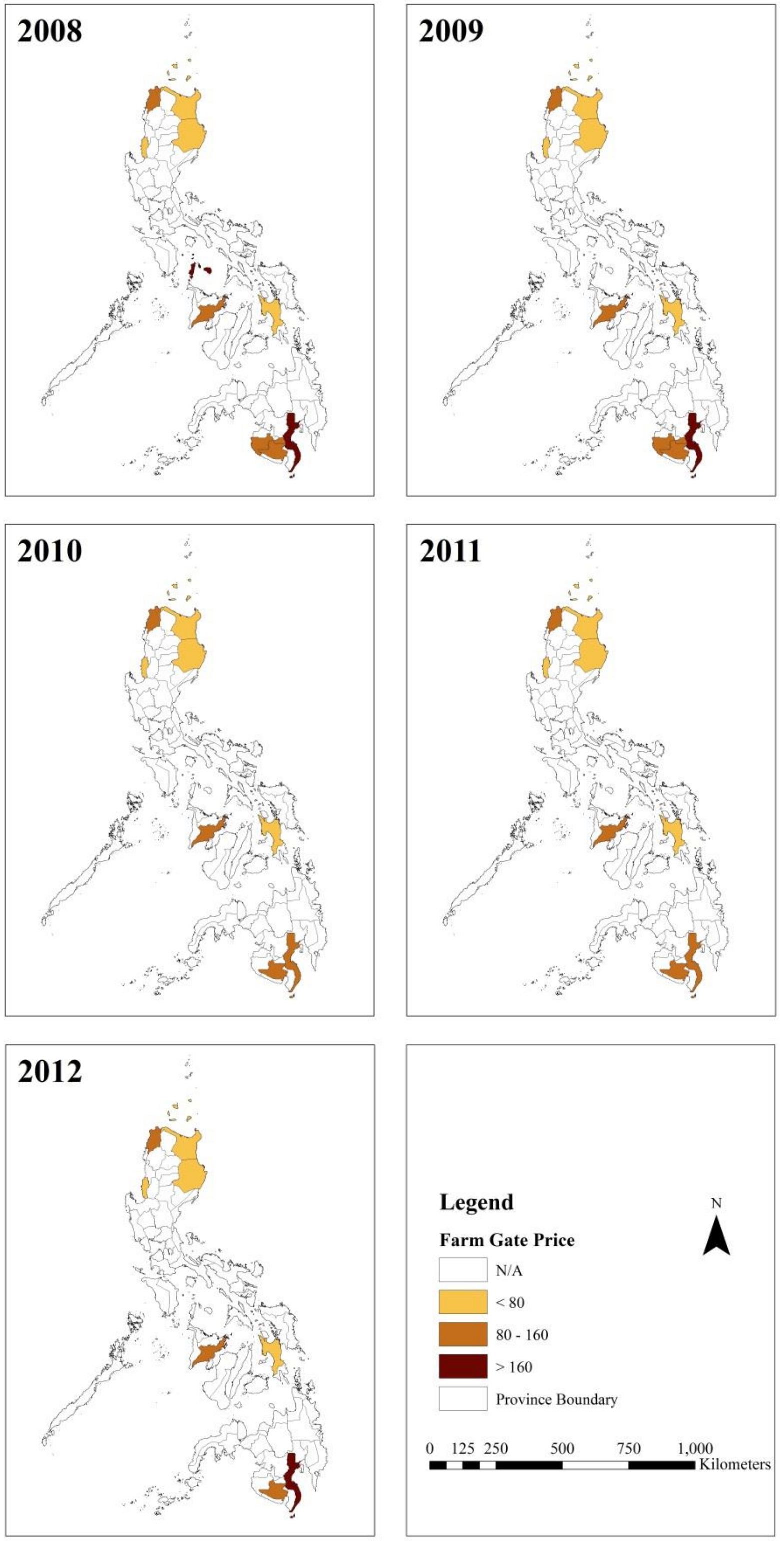

Figure 27 Native Tobacco Type (continued)

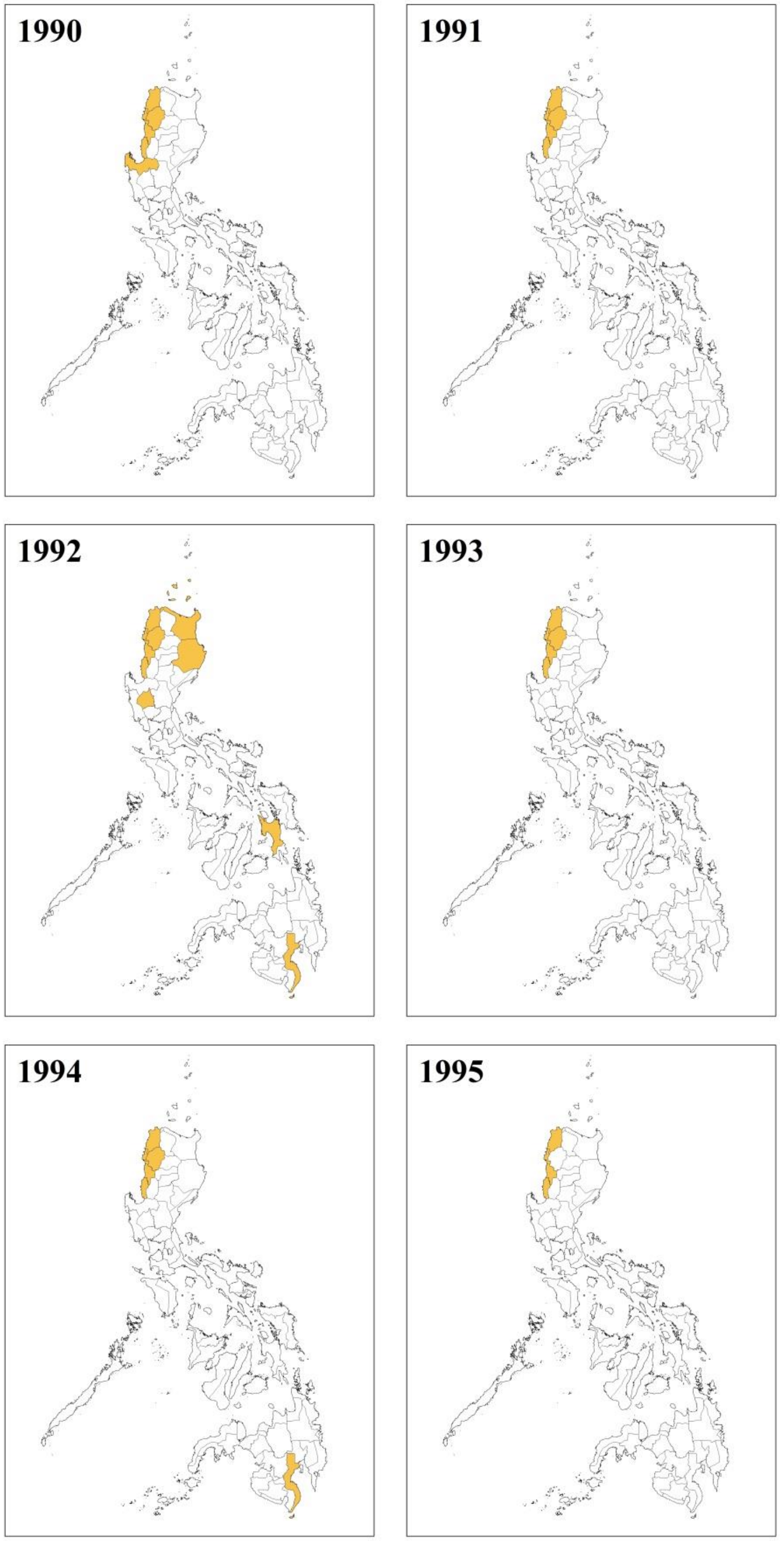

Figure 28 Virginia Tobacco Type

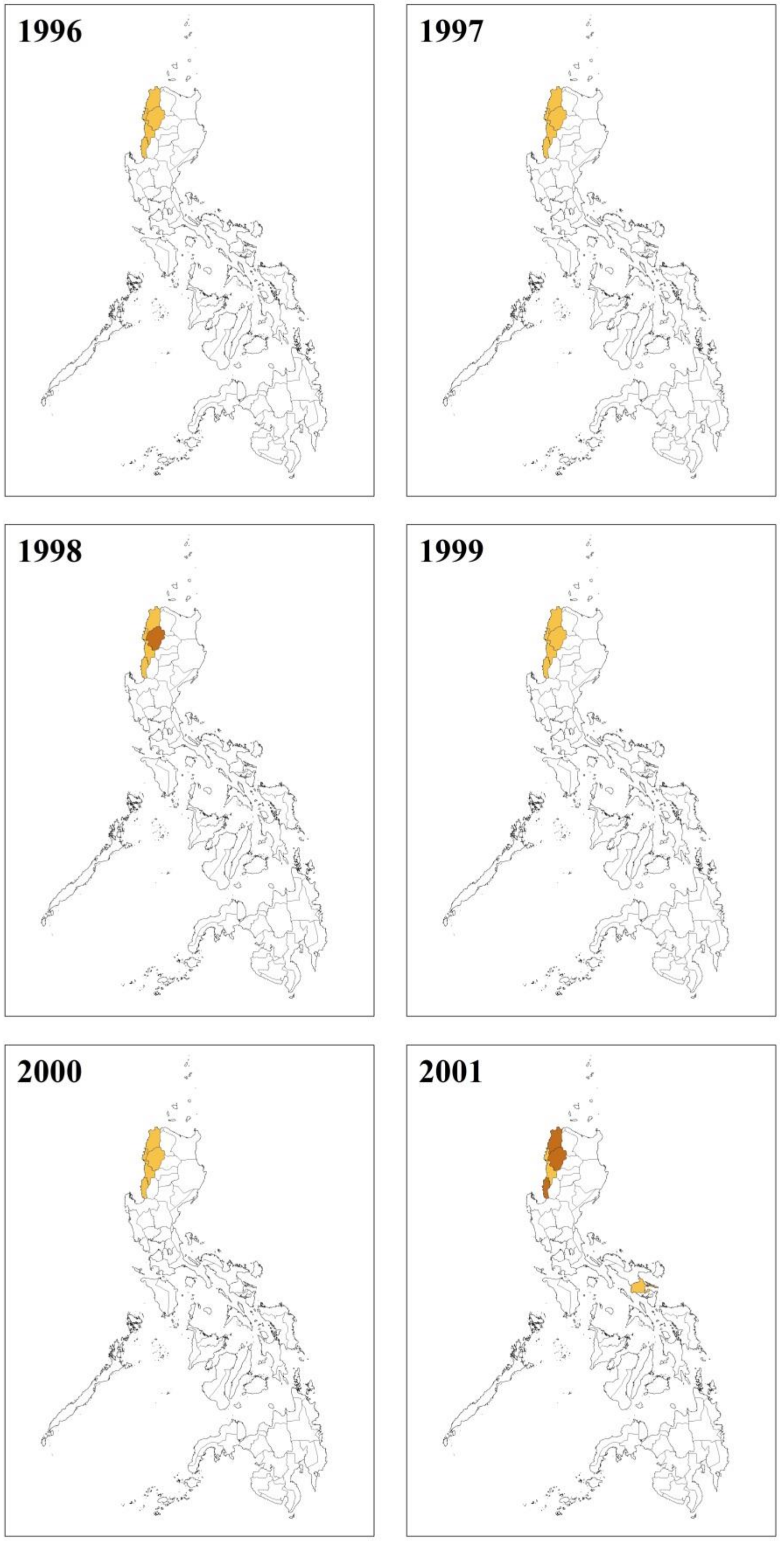

Figure 28 Virginia Tobacco Type (continued)

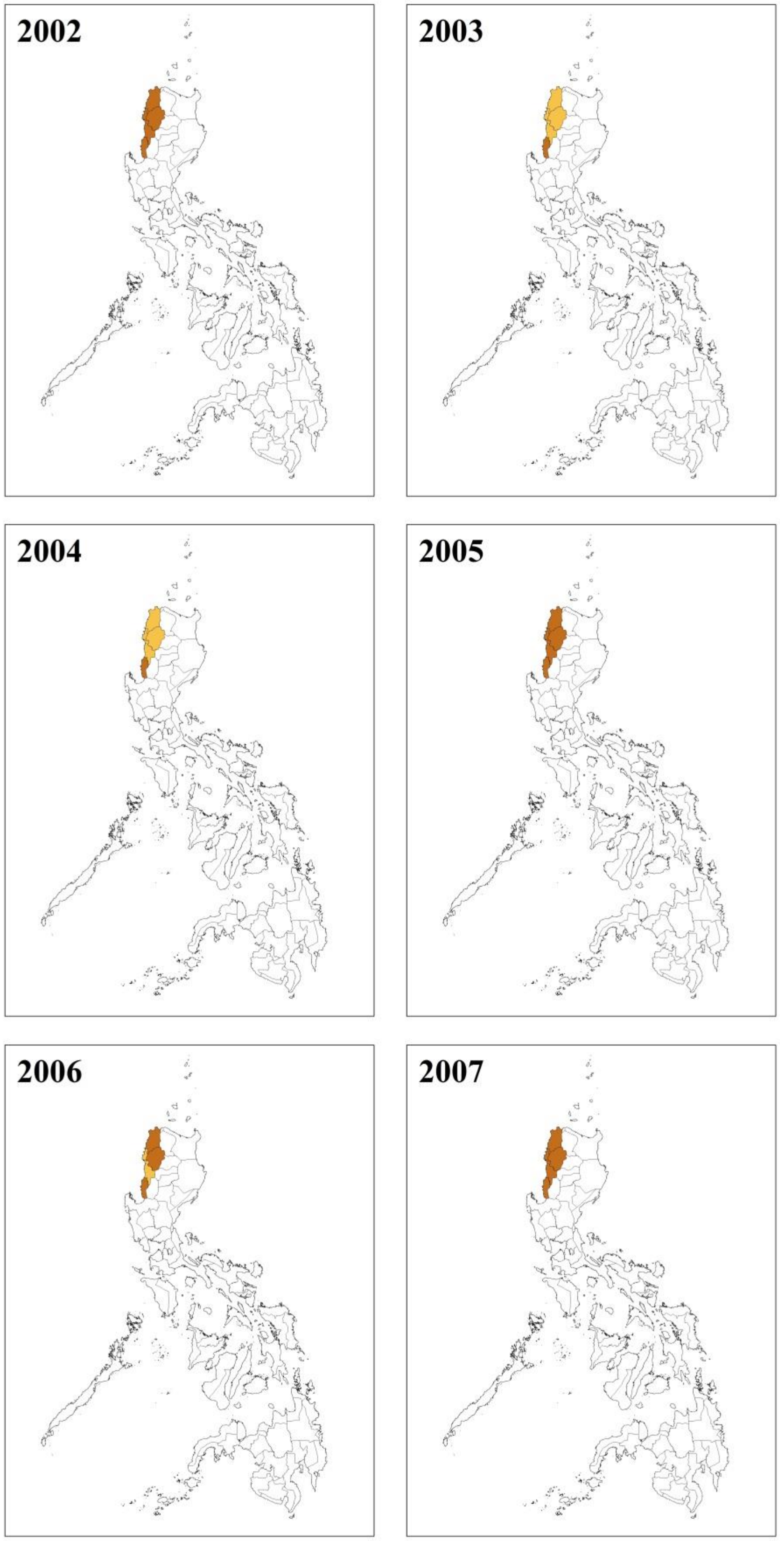

Figure 28 Virginia Tobacco Type (continued)

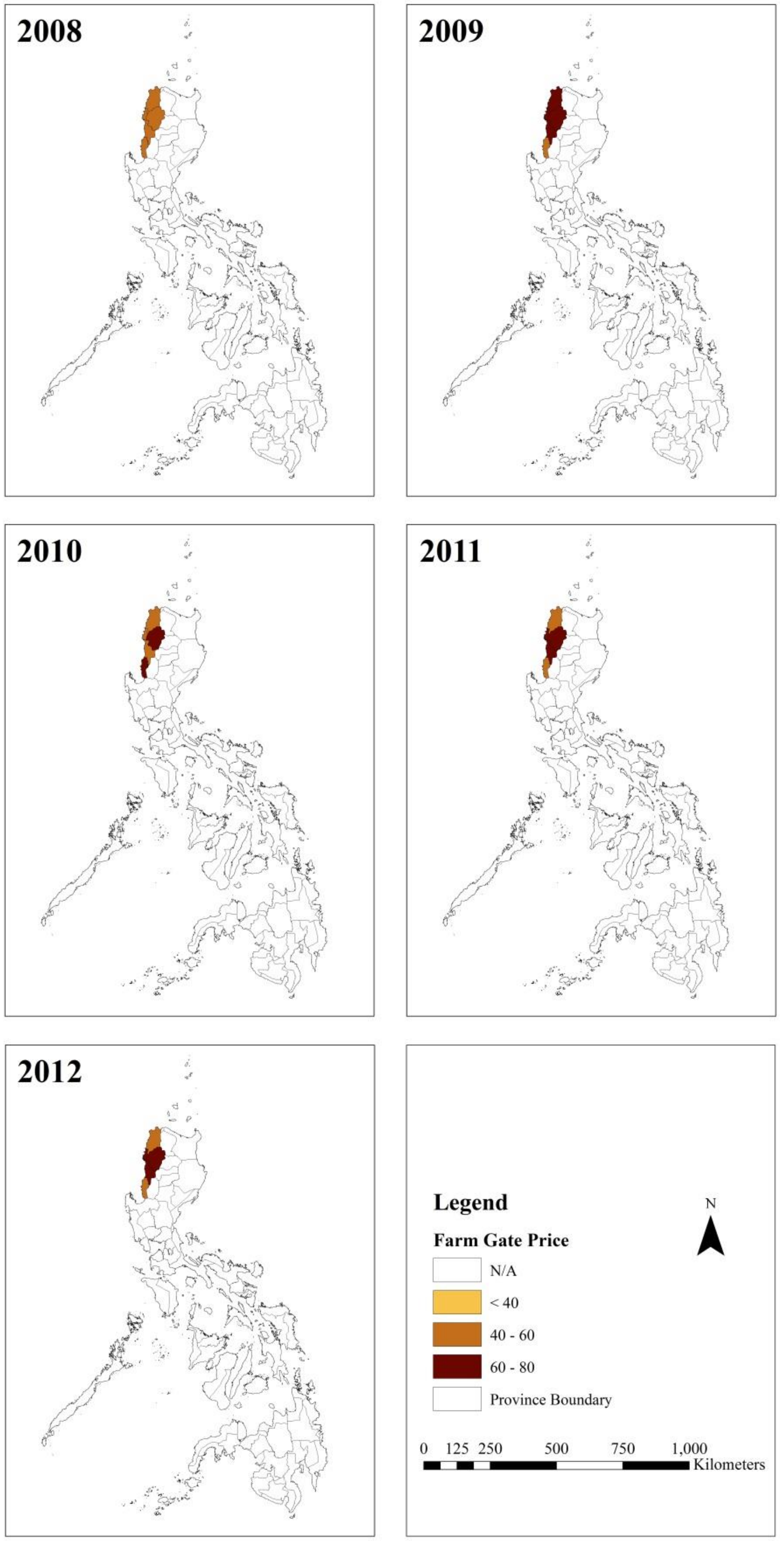

Figure 28 Virginia Tobacco Type (continued)

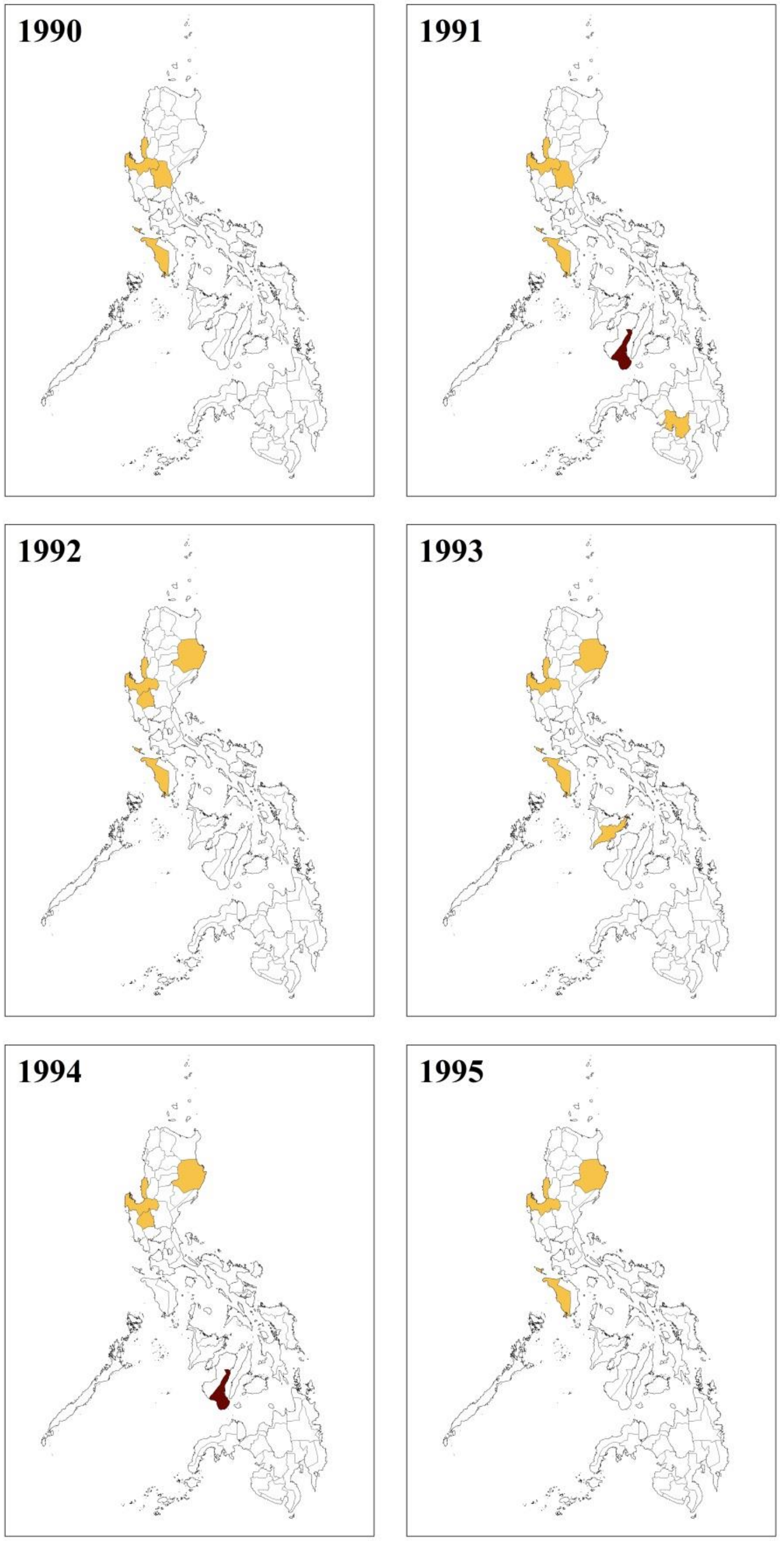

Figure 29 Burley Tobacco Type

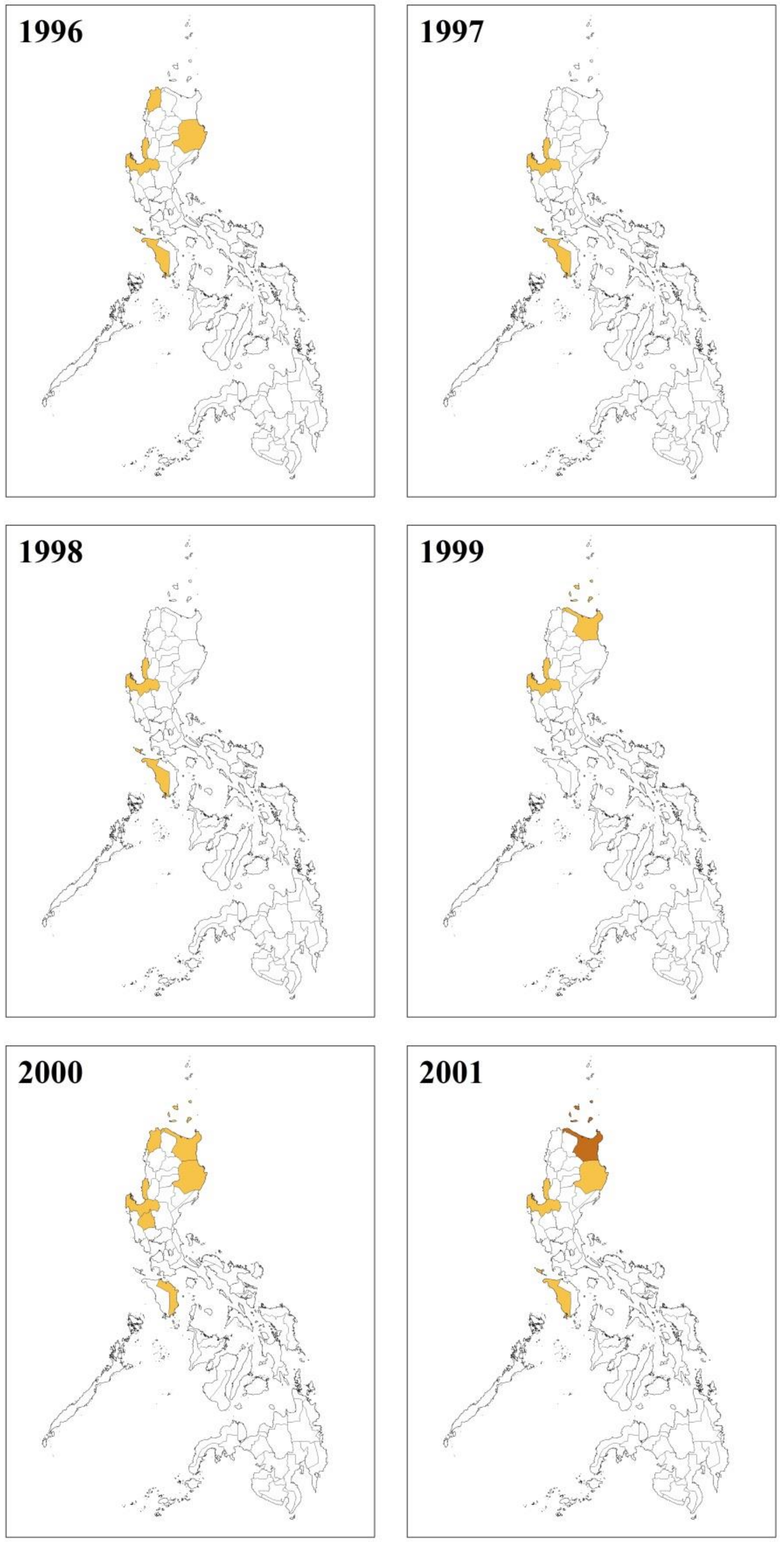

Figure 29 Burley Tobacco Type (continued)

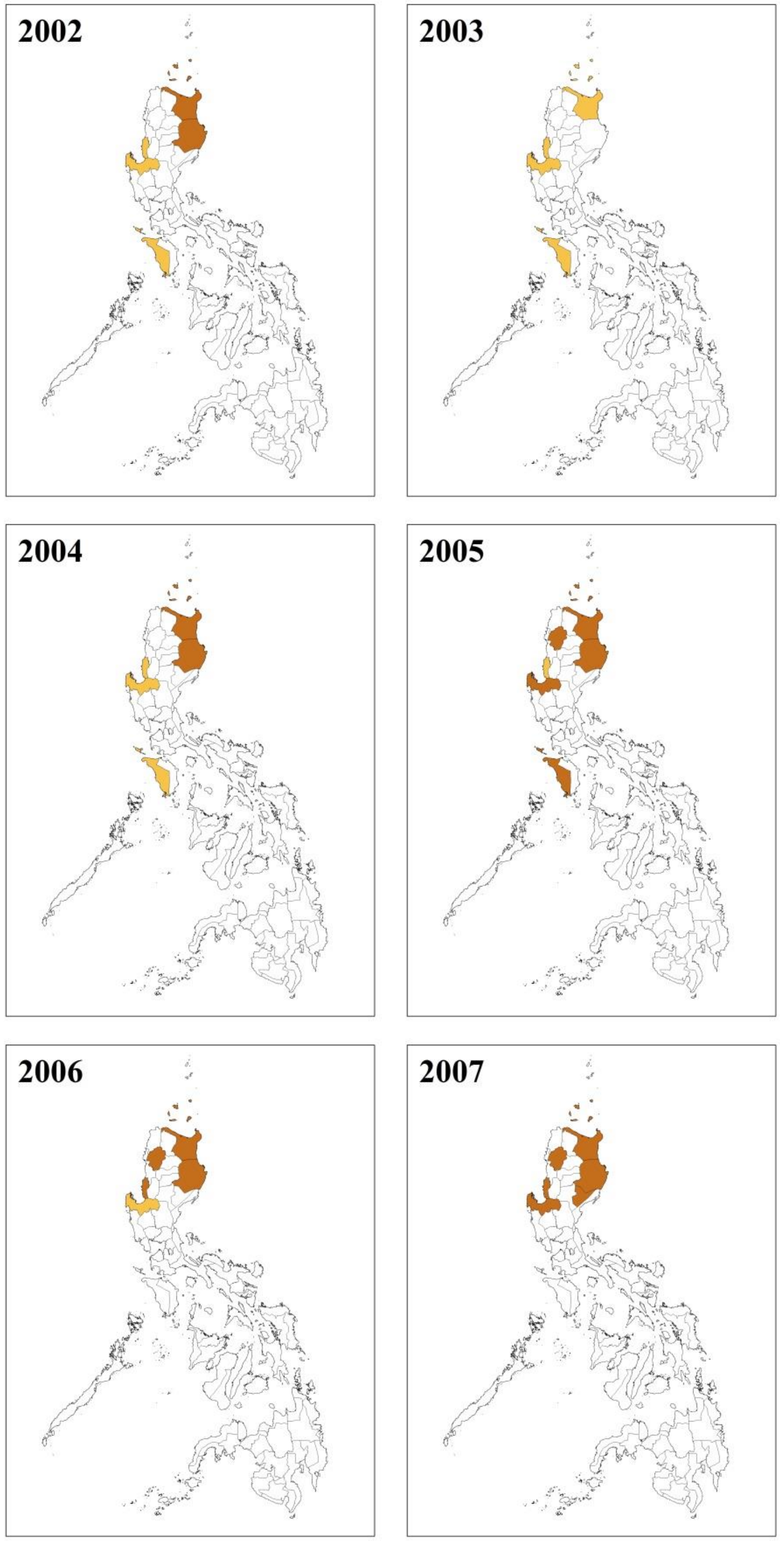

Figure 29 Burley Tobacco Type (continued)

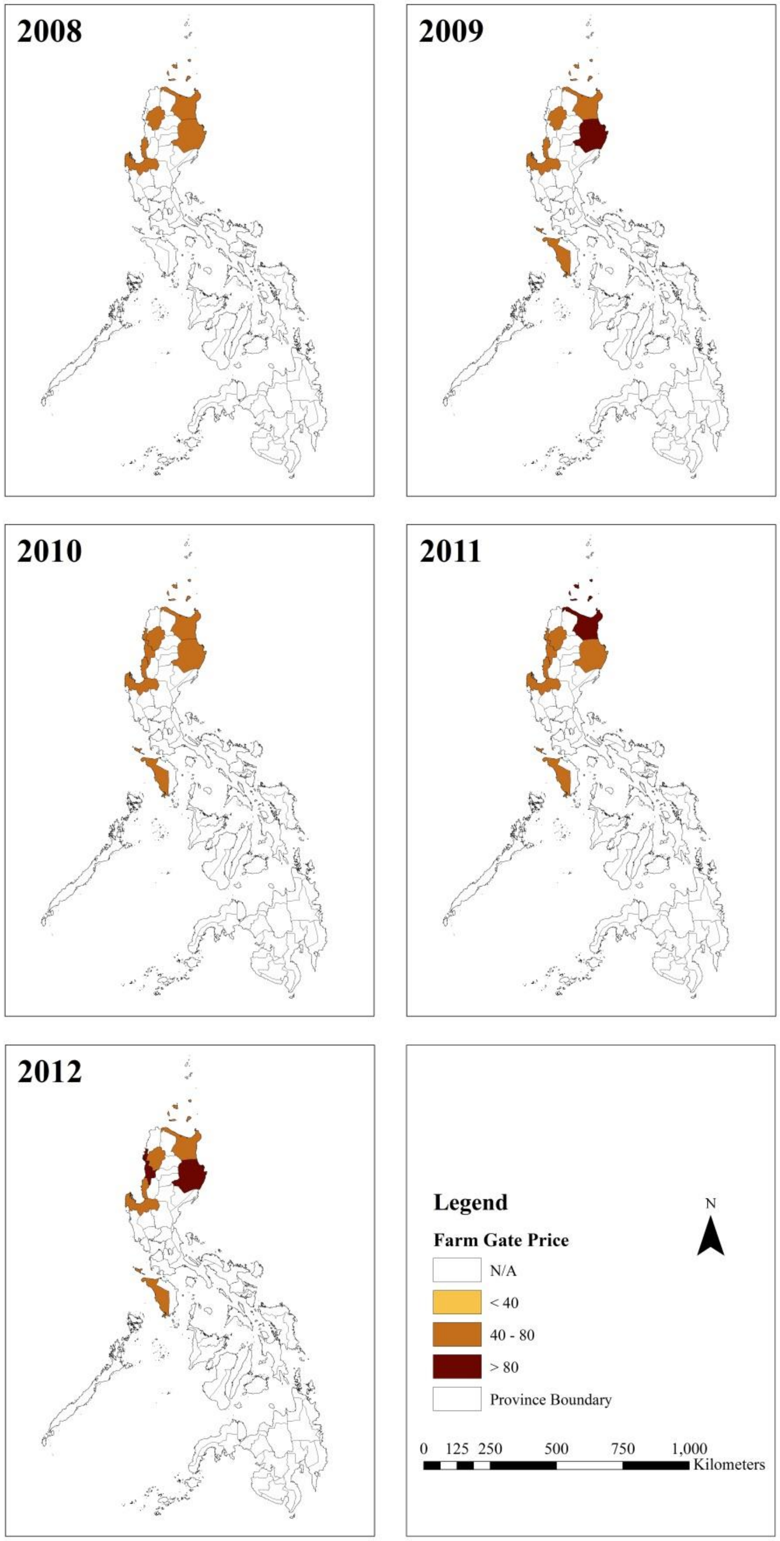

Figure 29 Burley Tobacco Type (continued)