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Socioeconomic Characteristics of Farmers and Agrochemical Use in Grenada

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This is to certify that the doctoral study by

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Abstract

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MSPH, St. George’s University, 2008

DipYDW, University of the West Indies, 2006

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Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Public Health

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Abstract

The World Health Organization classified carbaryl, glyphosate, and paraquat as hazardous to human health. In the Agriculture Health Study in the United States, health problems were associated with the use of these 3 agrochemicals 12 or more times per year. These 3 agrochemicals were commonly used in Grenada. The purpose of this quantitative cross-sectional study was to investigate the relationship between the social and economic characteristics of the farmers who participated in the 2012 agriculture survey and the use of agrochemicals at frequencies that could pose health risks. Five constructs of the social cognitive theory were used as the premise to hypothesize relationships between the variables. Binomial regression analysis was conducted to test the hypotheses of relationships between the characteristics of 8,868 farmers and use of agrochemicals or herbicides ≥12 timers per year. Statistically significant relationships were found between 16 characteristics of the farmers and use of agrochemicals. Significant relationships were also found between 8 characteristics of the farmers and use of herbicides ≥12 timers per year. The findings of this study show that several characteristics of the farmers in Grenada were associated with the use of agrochemicals at frequencies that were hazardous to health. By demonstrating the need to implement preventive measures and adopt the precautionary principle in the use of agrochemicals, positive changes can be made in monitoring agriculture practices, health surveillance, and clinical practice.

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Dedication

This Doctoral Study is dedicated to my husband, Garvin, and my daughter, Gyanni, who gave so much of their time, effort, and resources to make it possible for me to complete this journey. They gave unselfishly and my deepest gratitude is ever extended to them. I also dedicate this Doctoral Study to my extended family who gave unwavering support and motivation along the way.

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I must extend gracious thanks to my colleagues and the staff at Walden University. I recognize Dr. Diana Stark Ekman who provided so much encouragement to me during the first and last courses. Your support was a motivation for me to pursue to the end.

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Section 1: Foundation of the Study and Literature Review

Introduction

According to the World Health Organization (WHO), agrochemical use is widespread and can have negative consequences for public health (WHO, 2018c). Over the past decades, the use of agrochemical —pesticides, herbicides, insecticides, and fungicides used in crop production—became more widespread, particularly in low-income countries, as a modern approach to protect agricultural investments (Lewis, Tzilivakis, Warner, & Green, 2016). In Grenada and in other Caribbean countries, the agriculture sector is an important contributor to the gross domestic product (GDP; Campo, Robinson, Isaac, & Ganpat, 2017; Kinda Campo, Robinson, Patrice Isaac, & Ganpat, 2017). As such, the use of agrochemicals has increased in Grenada to protect agriculture investments (Ministry of Agriculture, 2012).

Agrochemicals containing glyphosate, paraquat, and carbaryl were commonly used in Grenada in 2012 when the agriculture census was conducted and for at least 15 years before and five years after the census period (Ministry of Agriculture, 2012). According to the WHO, these agrochemicals have the potential to cause adverse health effects from occupational and nonoccupational exposures (WHO, 2010, 2014b, 2015). Before this research, studies were not conducted in Grenada to investigate the factors that may predispose local farmers to specific health problems as a consequence of the use of and exposure to agrochemicals. This research was, therefore, conducted to investigate the relationships between the social and economic characteristics of the farmers who participated in the 2012 agricultural census in Grenada and the frequency of use of agrochemicals. The frequency of use of agrochemicals could have been indicative of exposure to the three agrochemicals that were also commonly used in the census period—glyphosate, paraquat, and carbaryl. Considering that this research involved analysis of the first and only population-based data on the frequency of use of agrochemicals by farmers in Grenada, the findings have implications for predicting health outcomes in the farming population. The results also have implications for professional practice and social change to address the risks of health problems associated with the use of hazardous chemicals.

Health planners, policymakers, community members, and other stakeholder groups may reference the findings of this research as a basis to create awareness of the need for policies and interventions to address gaps in the systems to monitor public health. The health status of farmers may be linked to food production and security as well as the benefits of employment, income, and nutrition (McManus et al., 2012; Tirivayi, Knowles, & Davis, 2016). According to the WHO, identifying and addressing the upstream determinants of health were among three critical steps to achieve equality in health and to improve the social conditions of the citizenry (Commission on the Social Determinants of Health, 2008). The findings of this research may also be extrapolated to other countries in the Caribbean region to create similar knowledge about health risk associated with the frequency of use and exposures to agrochemicals. This study may also have critical implications for addressing the current gaps in documenting and recognizing occupational history and practices in clinical settings and in the health surveillance and monitoring programs in Grenada.

In Chapter 1, a statement of the problem that informed the research, purpose of the research, research questions and hypotheses, theoretical framework that underpins the research, nature of the research, literature review, definitions of the variables, assumptions, scope and delimitations, and a summary and conclusion of this chapter are introduced.

Problem Statement

The unsafe use of agrochemicals is a worldwide challenge for public health (Kim, Kabir, & Jahan, 2017; Sarwar, 2015). Risk assessment studies related to this challenge were mostly non-specific to chemicals and few studies focused on investigating what quantitative relationships existed between a wide range of individual characteristics, the level of use and exposure to agrochemicals, and the potential for specific health problems (Ragin et al., 2013). Agrochemicals are commonly used to control pests that affect crops. Human exposure to the chemicals was, however, also found to be associated with several health problems, including the introduction and aggravation of neurological problems, cancer, respiratory problems, and diabetes (Food and Agriculture Organization & WHO, 2016; Kim et al., 2017; Lewis et al., 2016; Sánchez-Santed, Colomina, & Herrero Hernández, 2016).

The population in low-income countries are especially at risk of high exposure to agrochemicals (Grace, 2015; Guha, Guyton, Loomis, & Barupal, 2016). The risk is heightened due to the lack of understanding by farmers about the hazardous nature of the chemicals, lack of resources to address unsafe practices in the agriculture sector, limited capacity to adopt alternative and safer technologies, and the absence of appropriate policies to guide interventions (Jallow, Awadh, Albaho, Devi, & Thomas, 2017; Mamane, Baldi, Tessier, Raherison, & Bouvier, 2015; Remoundou, Brennan, Hart, & Frewer, 2014). Further, the problem of exposure to hazardous agrochemicals was exacerbated by poor agricultural practices in the thrust to increase production to meet the demands of local and export markets (Lewis et al., 2016).

Agrochemical use may be widespread and intensive in the Caribbean region given the agriculture sector remains critical for the economies in the region with contributions from the sector to GDP ranging from 3% in some countries to 35% in other countries (Campo et al., 2017). The contributions to GDP from the agriculture sector in Grenada was about 8% in 2017 (Kinda Campo et al., 2017). Among the agrochemicals that were frequently used in Grenada about the period of the census, the active ingredients included glyphosate, paraquat, and carbaryl (Ministry of Agriculture, 2012). The three chemicals were classified by the WHO as harmful to humans (WHO 2010, 2014b, 2015).

Given the hazardous nature of the chemicals, there was a rationale for investigating the factors that may predispose farmers to health effects from the exposure to the grochemicals. Comprehensive risk assessments related to the use of agrochemicals and their impact on human health were lacking; the impact of agrochemical use on the environment was more widely studied (Lewis et al., 2016). Specific to the Caribbean region, few studies have been conducted on risk related to the use of agrochemical (Henry & Feola, 2013; Ragin et al., 2013). The need for further research and exposure profiling was also emphasized in a publication by Forde and Dewailly (2015) on agrochemical exposure in the Caribbean region. Most of the studies in the Caribbean countries also dated back more than 5 years. No published literature was found on the relationships between the characteristics of farmers in Grenada and exposure to agrochemicals at hazardous levels. This research, therefore, addressed the gap in the literature by providing information on the relationships between several socioeconomic factors and the frequency of use of agrochemicals. Further, this research was the first to generate information from research on the potential for farmers in Grenada to experience specific health problems related to the use of agrochemicals.

Purpose of the Study

The purpose of this quantitative, cross-sectional research was to investigate the relationships between individual social and economic characteristics of farmers who participated in the 2012 agricultural census in Grenada and the frequency of use of agrochemicals at levels that pose risks for specific health problems. For the first research question, the relationships between (a) age, (b) gender, (c) parish of location of the farm, (d) highest level of education completed, (e) markets, (f) receipt of credit, (g) size of household, (h) number of paid workers, (i) status of land ownership, (j) maintenance of farm records, (k) number of nonhousehold members working on the farm, (l) number of parcels of land operated by the farmer, (m) daily number of hours farmer worked on the farm, (n) membership in a farm organization, (o) receipt of technical assistance, (p) production issues, and (q) income from agriculture production (independent variables) and (r) the frequency of use of agrochemicals (dependent variable) were investigated. The agrochemicals were assumed to be glyphosate, paraquat, and carbaryl given that these agrochemicals were among the mostly commonly used in agriculture production in

2012 when the agriculture census was conducted and for at least 15 years before and five years after the census period (Ministry of Agriculture, 2012). The Agriculture Health Study (AHS), a prospective cohort study, was conducted in North Carolina and Iowa in the United States from 1993 and continued to 2017 (Alavanja et al., 1996; National Institute of Environmental Health Sciences, 2017). In the AHS, exposure to carbaryl was found to be associated with sleep apnea (Baumert et al., 2018) and rheumatoid arthritis (Meyer, Sandler, Beane Freeman, Hofmann, & Parks, 2017), exposure to paraquat and carbaryl were found to be associated with decrease in LINE-I DNA methylation (Alexander et al., 2017), exposure to glyphosate was found to be associated with allergic and non-allergic wheezing and exposure to carbaryl was found to be associated with allergic wheezing (Hoppin et al., 2017).

For the second research question, the dependent variable was cumulative intensity-weighted risk exposure score. In the AHS study, the use of herbicides, specifically paraquat, was found to be associated with Parkinson's disease (Tanner et al., 2011) and end-stage renal disease (ESRD; Lebov et al., 2016).

In the AHS, the health problems were found to be associated with lifetime days of use and lifetime intensity-weighted risk exposure days of pesticide applicators (Alavanja et al., 1996; National Institute of Environmental Health Sciences, 2017). In the research in Grenada, the findings of the AHS were referenced to apply algorithms to investigate the possibility of exposure to agrochemicals by Grenada farmers and the implications for public health. The data from the 2012 agricultural census in Grenada included information on the frequency of use of unspecified agrochemicals (Government of

Grenada, 2012a). The reported frequency of use of the agrochemicals was used in calculations to determine the lifetime intensity-weighted risk exposure days score and lapse period over which farmers may experience health problems based on the score. This score was used as a proxy of exposure to the agrochemicals (Alavanja et al., 1996; National Institute of Environmental Health Sciences, 2017).

With a gap in the literature, there was a rationale for the research in Grenada to investigate which demographic characteristics of farmers predisposed them to use agrochemicals that may increase the likelihood of experiencing specific health problems. In other studies, demographic characteristics, such as education, gender, farm size, land tenure, and previous training were found to be associated with the use of agrochemicals (Damalas & Khan, 2016; Mengistie, Mol, & Oosterveer, 2017; Mwatawala & Yeyeye, 2016). Across countries, however, demographic factors may not have equal significance in relation to the use of agrochemicals. As such, this investigation of the relationships between the socioeconomic characteristics of the farmers in the 2012 agricultural census and the frequency of use of agrochemicals was conducted to provide information specific to the Grenadian context. The findings from this research can, however, be extrapolated to other countries in the Caribbean region which have similar demographic profile and level of use of agro-chemicals to Grenada and for which literature on the health implications of use of the chemicals was also absent or scarce.

Research Questions and Hypotheses

The first research question that was answered in this study was: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively?

The null hypothesis for the first research question was: There is no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively.

The alternative hypothesis for the first research question was: There was a relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively.

The second research question that was answered in this study was: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson’s diseases, respectively?

The null hypothesis for the second research question was: There was no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson’s diseases, respectively.

The alternative hypothesis for the first research question was: There was a relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's diseases, respectively.

Theoretical Foundation for the Study

The social cognitive theory (SCT) was proposed by Albert Bandura (1986) to predict how social and cognitive factors influenced health behavior (Tougas, Hayden, McGrath, Huguet, & Rozario, 2015). In principle, Bandura postulated that observations of the social norms had a significant impact on learning and that learning, ultimately, influenced the health behaviors that were practiced by individuals (Marks, Murray, Evans, & Estacio, 2015). The SCT is underscored by a three-dimensional relationship among cognitive, environmental, and supportive behavior factors. These three factors were postulated as determinants of health promotion and disease prevention (National Cancer Institute, 2005), which rendered the SCT as an appropriate theory to support the investigation of the relationship between individual characteristics of farmers, agriculture practices/behaviors, and potential health outcomes. The relationship between the personal cognitive factors, socioeconomic or environmental factors, and supportive behavior were referred to as *reciprocal determinism*, emphasizing the interplay between the components of the theory and the effect on health outcome (Glanz, Rimer, & Viswanath, 2015).

In relation to cognitive influences on behavior, the constructs of the SCT were *self-efficacy* (belief that one can perform a behavior that will lead to a particular outcome), *outcome expectation* (assessment of the consequences of an action), and *knowledge* (information about how to perform an action and the risks and benefits; Glanz et al., 2015). In relation to environmental influences on health, the constructs of the theory were *observational learning* (learning behaviors through cultural norms in a society), *normative belief* (belief about the normalcy and acceptability of a cultural norms), *social support* (support that is provided through interaction with peers, colleagues, family and other members of the society), and *barriers and opportunities* (external factors that facilitate or hinder a behavior; Glanz et al., 2015). With regard to supporting behaviors, the constructs of the SCT were *behavioral skills* (personal capacity to perform a behavior), *intentions* (considerations about adding or modifying behaviors), and *reinforcement and punishment* (providing or removing incentives for performing an action).

Based on the data that were collected in the 2012 agricultural census in Grenada, five constructs of the SCT were applicable in this study in Grenadaa: knowledge, outcome expectations, observational learning, social support, and reinforcement and punishment. These constructs were amenable to operationalization to investigate the relationships between *personal cognitive factors* (for example, highest level of education completed, age, number of hours farmers worked on the farm), *socioeconomic/environmental factors* (for example, number of parcels of land operated by the farmer, membership in a farm association, size of household, number of paid workers on the farm), and *supporting behavioral factors* (for example, receipt of technical assistance, receipt of credit, markets) and health behavior—that is, the frequency of use of agrochemicals at levels that could pose risk for health. The SCT, therefore, was suitably applied to predict the relationship between the reported personal, environmental, and enabling factors and health behavior.

Nature of the Study

In this study, a cross-sectional quantitative design was used. The 2012 agricultural census was a cross-sectional study in which data were collected from farmers on agriculture activities during the past 12-month period (Government of Grenada, 2012a). The census also involved the collection of information on the social and economic characteristics of farmers. The social factors that were identified for inclusion in this study were: (a) age, (b) gender, (c) highest level at which education was completed, (d) size of household, and (e) membership in a farm organization. The economic factors that were identified for inclusion in this study were: (a) parish of location of the farm, (b) markets, (c) receipt of credit, (d) number of paid workers, (e) status of land ownership, (f) maintenance of farm records, (g) number of nonhousehold members working on the farm, (h) number of parcels of land operated by the farmer, (i) daily number of hours farmer worked on the farm, (j) receipt of technical assistance, (k) production issues, and (l) income from agriculture production. The social and economic factors comprised the independent variables in the analyses. The frequency of use of agrochemicals was the dependent variable for the first research question, categorized as *ever used* agrochemicals and *never used* agrochemical. Ever use of any of the agrochemicals was associated with one or more of the health problems stated in the first research question (RQ1).

For the second research question (RQ2), cumulative intensity-weighted exposure days score was categorized as $\geq$ 2087 and $\leq$ 2088 (Lebov et al., 2016; De Roos et al., 2005; Storm et al., 2004a). The score was categorized as "used herbicide ≥ 12 times per year" and "used herbicide ≤ 12 times per year." The used of herbicide ≥ 12 times per year was equivalent to a cumulative intensity-weighted exposure days score achievable over a lapse period. The calculation of cumulative intensity-weighted exposure days and the lapse period are shown in Tables 39-40. The score was calculated taking into consideration field activities, use of protective equipment while mixing and applying agrochemicals, and frequency of application/use of the agrochemicals. The cumulative intensity-weighted exposure days score was, therefore, indicative of the number of days of use and exposure to the chemical over a lapse period.

The 2012 agriculture census was conducted in Grenada to collect information from farmers who had responsibility for selected farms in the country (Government of Grenada, 2012a). The farms were identified through the enumeration of each household in the country as well as through a listing of nonhousehold farms (Government of Grenada, 2012a). A criterion was applied to select the farms for inclusion in the census and one farmer who had responsibility for the farm was interviewed (Government of Grenada, 2012a). The data were collected by surveyors in face-to-face interviews, following which the information was cross-checked and entered manually in SPSS Statistics, v 17.0 (Government of Grenada, 2012a, 2012b). In this study, both descriptive and statistical analyses were conducted. The frequency of outcomes for each category of the variables was reported in the descriptive statistics. Binomial logistic regression analysis was conducted to investigate what quantitative relationships existed between the social and economic characteristics of the farmers and the frequency of use of agrochemicals.

Literature Search Strategy

Peer-reviewed literature was located using the following databases: Google, Google Scholar, Agricola, BioMed Central, Emerald Insight, Directory of Open Access Journals, Thoreau Multi-Database Search, MEDLINE with Full Text, Health and Environmental Research Online (HERO), ProQuest Central, PubMed, and ScienceDirect. The literature review also drew on the findings of the AHS, which was the largest prospective cohort study in the United States on farmers' and spouses' exposures and health outcomes (National Institute of Environmental Health Sciences, 2017). According to the WHO, the AHS was one of the most rigorous studies on the association between exposure to specific agrochemicals and consequent health outcomes (Food and Agriculture Organization and World Health Organization, 2016). In the study in Grenada, reference was made to publications of the findings of the AHS to identify the health outcomes related to exposure to glyphosate, carbaryl, and paraquat.

In the first phase, the terms *glyphosate* OR *carbaryl* OR *paraquat* AND *health* OR *public health* OR *disease* AND *Agricultural Health Study* were used in the search. Studies that were current, i.e., studies that were published between January 2015 and April 2018 were included. As the AHS continued, new findings on health effects were updated in publications. The most recent peer-reviewed publication on the health effect was included in this literature review. To relate the AHS findings to the concept of exposure in this study, publications that explained the algorithm for cumulative intensity-weighted risk exposure-days or days per year of use of the agrochemicals were included. Commentaries, editorials, reviews, publications that were not peer-reviewed, publications that did not include information on exposure to the agrochemicals, and studies primarily based on persons not engaged in farm work and spouses were excluded in the initial search.

In the second phase, the terms *glyphosate* OR *carbaryl* OR *paraquat* combined with the names of the respective health problems stated in the research questions; *pesticides* combined with the names of the respective health problems stated in the research questions; *agro-chemical* combined with the names of the respective health problems stated in the research questions; "*prospective study*" AND "*pesticide*" OR "*agro-chemical;*" and "*prospective study*" combined with the names of the respective health problems stated in the research questions. Studies that were mostly current, that is, published between January 2015 and April 2018, were included in the search. References were reviewed to identify other relevant publications that were not found in the initial search in the databases. Relevant technical reports and working papers from committees affiliated with the WHO, such as the International Agency for Research on Cancer (IARC), which provided additional information related to the findings of the AHS, were reviewed and included. The methodology documents and other publications from the institutions that collaborated in the AHS in the United States and the 2012 agricultural census in Grenada were also referenced in this literature review. Commentaries, editorials, and reviews were excluded in the second phase of the search.

To identify literature related to the constructs in the SCT, in the third phase, the search included literature that provided information on the socioeconomic characteristics of farmers and level of agrochemicals used in agriculture production. The search terms that were used were "*pesticide*" OR "*agro-chemical*" AND "*socioeconomic status*" OR "*age*" OR "*gender*" OR "*parish/place of residence*" OR "*education*" OR "*household size*" OR "*daily hours on the farm*" OR "*type of market*" OR "*income*" AND "*pesticide*" OR "*agro-chemical*."

To calculate lifetime intensity-weighted risk exposure-days, data were required about field activities and the use of personal protective equipment (PPE). Information was not provided in the census on the on the use of PPE by farmers. To include each factor in the algorithm to calculate the exposure score, the fourth phase of the literature review was conducted to locate publications on the use of PPE in agriculture production in Grenada. One study was found that was published in 2005 (Semple, Johnson, & Arjoonsingh, 2005). The search was extended to locate publications on the use of PPE in agriculture production in other Caribbean countries to support assumptions regarding what practices might uphold in Grenada. Commentaries, editorials, reviews, and publications that were not peer-reviewed or published before January 2015 were excluded in the fourth phase of the search.

Literature Review Related to Key Variables and/or Concepts

Prospective Cohort Studies

A limited number of prospective cohort studies were conducted to investigate causal relationships between exposure to agrochemicals and specific health problems

(Food and Agriculture Organization & WHO, 2016). Prospective cohort studies are particularly advantageous for establishing causality for several reasons: the reliability of the evidence is strengthened with the exposure established before the outcome, multiple outcomes can be investigated simultaneously, rare outcomes may be presented in the large sample that is usually used in cohort studies, diseases with long latency periods may be investigated in the long-term studies, and comprehensive data may be collected resulting from upfront planning and identification of the specific variables for measurement in the study and the extended period for data collection (Song & Chung, 2010). High cost and high attrition rates were the main problems associated with prospective cohort studies (Song & Chung, 2010).

In this study, the focus was on investigating the relationships between socioeconomic characteristics of farmers and exposure to agrochemicals to prove or disprove that farmers in Grenada were likely to develop health problems that were found among farmers in the AHS. This study was grounded in the literature and in rigorous methodologies to identify the variables. The results of prospective cohort studies that established causality were also advantageous to support the hypotheses of the relationship between the variables (Song & Chung, 2010; Thiese, 2014).

AGRICOH, a consortium of agricultural cohort studies, was established by the IARC/WHO to promote collaboration between studies to facilitate data sharing and pooled analyses at the international level (Brouwer et al., 2016). In the early part of 2016, the consortium included 29 studies in 12 countries (World Health Organization, 2018b) with four large agriculture-specific studies with 70,791 – 434,000 participants in the United States, France, and Norway (World Health Organization, 2018a). Recent publications were found on the studies in the United States and France. Other studies in the consortium were conducted in the United Kingdom, Australia, Chile, Canada, Costa Rica, Denmark, South Africa, New Zealand, and Republic of Korea (World Health Organization, 2018b) with the number of participants ranging between 270- 20,831 (World Health Organization, 2018a).

Approaches to Cohort Studies

The Agricultural Health Study (AHS), which was conducted in the United States from 1993 (Alavanja et al., 1996; National Institute of Environmental Health Sciences, 2017), was one of a few large prospective epidemiological studies in which the health effects from exposure to specific active ingredients in agrochemicals were assessed. The AHS was conducted in Iowa and North Carolina with more than 89,000 private and commercial agrochemical applicators and their spouses enrolled at the start of the study (Alavanja et al., 1996; National Institute of Environmental Health Sciences, 2017). The study was the largest observational prospective cohort study conducted in the United States to measure exposure to specific agrochemicals and health outcomes, periodically, through the collection and analysis of data on farm work practices and exposures, other environmental exposures, medical information, lifestyle, and DNA samples (Storm et al., 2004). The study was focused on health problems arising from exposure to agrochemicals; Parkinson's disease (Tanner et al., 2011), ESRD (Lebov et al., 2016), sleep apnea (Baumert et al., 2018), rheumatoid arthritis (Meyer et al., 2017), decrease in LINE-I DNA methylation (Alexander et al., 2017), and allergic and non-allergic wheezing (Hoppin et al., 2017). Age- and gender-adjusted data for health outcomes in the cohort and the general population in Iowa and North Carolina, case-control studies, and cross-sectional studies were also used to investigate the differences in the health risk for the participants who had higher exposure to the agrochemicals and the general population (Storm et al., 2004a). The AHS was a comprehensive study with the three primary designs for conducting observational studies, that is, cohort, cross-sectional, and case-control, used in the investigations (von Elm et al., 2014). The relationships between socioeconomic variables, exposure levels, and health outcomes were also reported in the literature.

A large prospective cohort study was conducted in France to investigate the relationship between general exposure to agrochemicals and cancer among 181,842 persons who were associated with agricultural work in the country between 2005-2011 (Lemarchand et al., 2017). The data collection period for the AGRICAN (AGRIculture and CANcer) study was 2005 – December 2011. A wide group of workers including people working on farms and in forests, beekeepers, oyster farmers, people working in the agricultural service sector and cooperatives, and retired people were included in the study. The health outcomes from general exposure to agrochemicals were reported without specific information on exposure to glyphosate, carbaryl, and paraquat (Lemarchand et al., 2017). The lack of information on the specific agrochemicals used by the farmers was a limitation in referencing the study to support hypotheses about the relationship between exposure to specific agrochemicals and cancer incidence. The relationships between socioeconomic characteristics, exposure, and outcomes were, however, reported. The reports on the relationship between socioeconomic factors and agrochemical related health outcomes provided some support for further investigation of the variables in other contexts.

A prospective cohort study was conducted in Norway, involving 318, 628 male and female participants who were followed from 1972 – 2013 (Langseth, Gislefoss, Martinsen, Dillner, & Ursin, 2016) The participants were originally recruited for the cardiovascular disease survey. The study involved measuring biochemical and immunological changes in blood serum on an annual basis as well as lifestyle practice, vital health status, and exposure to polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDE)] until the participant was diagnosed with cancer. A weakness of the study was the use of baseline data from a previous study which may be a cause of inconsistency in the definitions used in the current study (Langseth et al., 2016). The use of baseline data from a previous study can limit making comparisons with other studies, including, in identifying individual factors that may have a significant impact on health outcomes mediated by exposure to agrochemicals. Using blood serum from the previous study for baseline reference may have also compromised the quality of the samples (Langseth et al., 2016). Gender was the primary dependent variable that was examined in the study (Langseth et al., 2016). A strength of the study was the large number of cases identified due to the efficiency of the protocol for testing samples (Langseth et al., 2016). The protocol on analysis of blood serum was not a suitable reference for the research question in the study in Grenada.

The CanCHEC (Canadian Census Health and Environment Cohort) study is the largest prospective cohort study with 70,570 agricultural workers in Canada (Kachuri et al., 2017). The study involved following up participants from 1991-2010. Demographic, socio-economic, and lifestyle-related data were collected for analysis to investigate the relationship between the participants' characteristics and incidence of cancer. Exposure to sunlight may have been a confounding factor for the incidence of two types of cancer that were found in the study. Similar to the study that was published by Lemarchand et al. (2017), exposure to specific pesticides were not reported which is a limitation for duplication of the study in other populations. Another limitation was the use of baseline data that were collected from the parent study on cancer surveillance. Detail and specificity of the variables may have been limited for the purpose of the original study and may not be defined for the follow-up study. The inclusion of a nationally representative sample was a strength in the study (Kachuri et al., 2017).

Rationale for Selection of the Variables or Concepts

The AHS was regarded by the Food and Agriculture Organization (FAO) and WHO as one of the most rigorous studies that was conducted to investigate the relationships between exposure to agrochemicals and health problems (FAO & WHO, 2016). Apart from including results on the socioeconomic and demographic characteristics of participants, results on the specific type of agrochemical to which participants were exposed, level of exposure, and the specific health outcomes that were associated with exposure were also reported (Storm et al., 2004a; Storm, Cope, Buhler, & McGinnis, 2004b). The methodology of the AHS can, therefore, be duplicated in other settings to investigate the potential for the health outcomes from exposure to the specific chemicals. The publications on the results of the AHS also included three critical constructs that are necessary to assess causality: exposure, individual differences, and health outcome. Additionally, there was homogeneity in the participants in the AHS, unlike the AGRICAN study that included participants with varied characteristic (Lemarchand et al., 2017). Therefore, in this research, the findings of the AHS were used as the primary reference to investigate exposure to specific agrochemicals that constitute a risk for specific diseases. Recent literature, published in 2015 and more recently, were also available on the results from the AHS. The most recent studies on exposures, socioeconomic status, and health outcomes in the AHS study were used to guide in designing this research.

Review and Synthesis of the Literature Related to the Variables

Sleep apnea. Very few recent studies were published on the relationships between sleep apnea, social-economic characteristic, and exposure to agrochemicals. Most of the studies were focused on the relationships between sleep apnea and environmental factors such as temperature, ozone concentration, humidity, particulate matter (Glaser et al., 2014; Weinreich et al., 2015; Zanobetti et al., 2010). The only recent published study that was found was from the AHS in which the relationship between exposure to carbaryl and sleep apnea was investigated. The study was conducted with 1569 male pesticide applicators (Baumert et al., 2018). Measurements of exposure were conducted in the periods 1993-1997, 1999-2003, and 2000-2010. The odds ratio for exposure to carbaryl (OR 1.11, 95% CI 0.81-1.54), was > 1, mostly among males with a mean age of 65 years, compared to non-cases with a mean age of 63 years. Carbamates inhibit acetylcholinesterase which hydrolyzes acetylcholine that affects neurotransmission. The inhibition of the enzyme disrupts the neurological function resulting in irregular breathing pattern during sleep, referred to as sleep apnea. Although the study reported by Baumert et al. (2018) was the only one found on exposure-outcome related to sleep apnea and carbaryl, the prospective cohort study used a sound methodology (FAO &WHO, 2016) in which a potentially higher risk of sleep apnea was found among older farmers who applied carbaryl. Age was, therefore, selected as a socioeconomic characteristic to be investigated as a potential factor that may be associated with exposure to agrochemicals and risk for sleep apnea.

Rheumatoid arthritis. One study was found that included a report on the relationship between rheumatoid arthritis and the use of carbaryl. Following a study, in which a high incidence of rheumatoid arthritis was found among female spouses of pesticide applicators (Lee, Steffes, Jacobs, & Jr., 2007; Parks et al., 2011), a further study was conducted among 26,134 applicators, predominantly male, with measurements of exposure in 1999–2003, 2005–2010, and 2013–2015 (Meyer et al., 2017). Rheumatoid arthritis was associated with an odds ratio > 1 for ever use of carbaryl, particularly among applicators above 40 years, and those who smoked five or more packs of cigarettes in a year. The findings of the AHS study were, generally, consistent with the results of a study in Greece, published by Koureas, Rachiotis, Tsakalof, & Hadjichristodoulou (2017), in which a higher frequency of rheumatoid arthritis was found among 80 applicators of organophosphate, guanidine, and quinone pesticides than in the control group of 90 individuals. The risk was also increased with higher lifetime exposure although age, smoking, and alcohol use may have been confounding factors. The findings from the AHS was the basis to investigate the potential risk for RA among older farmers in Grenada who may apply carbaryl. Although the health effects from exposure to carbaryl was not investigated in the study by Koureas et al. (2017), the findings of the studies by both Koureas et al. (2017) and Meyer et al. (2017) show age and number of hours of work on farms were important factors in the relationship between exposure to agrochemicals and rheumatoid arthritis.

Allergic and nonallergic wheeze. Results of studies were only found on the relationship between wheezing and exposure to agrochemicals among participants in the AHS. Among 22,134 male pesticide applicators who reported on exposure to agrochemicals in 2005-2010, an exposure-relationship was found in the association between use of glyphosate and allergic and non-allergic wheeze and between ever use of carbaryl and allergic wheeze with younger farmers, under 50 years, more likely to wheeze (Hoppin et al., 2017). Age was, therefore, selected as a factor for inclusion in the investigation in Grenada to determine whether there was an association between the socioeconomic characteristics of the farmers and the frequency of use of agrochemicals, indicative of risk of allergic and non-allergic wheeze.

Parkinson's disease. Parkinson's disease was among the most studied diseases from exposure to agrochemicals, in particular, paraquat. More than 26 studies were available on the topic, including case-control, cohort and cross-sectional studies (Mostafalou & Abdollahi, 2017). Nonetheless, the majority of the studies were published over 5 years, mostly over 10 years, and some studies did not specify the chemical ingredient but focused on exposure to a general group of chemicals, such as herbicides or insecticides (Mostafalou & Abdollahi, 2017). Albeit, in a large study cohort study in the Netherlands focusing on diet and cancer with approximate 42,298 participants with exposure measurement taken between 1986 to 31 December 2003, elevated risks for Parkinson's disease were observed for men who were exposed to any agrochemicals (Van Maele-Fabry, Hoet, Vilain, & Lison, 2012). Generally, women had shorter occupational time and low exposure to the agrochemicals, hence, the prevalence of the disease from exposure to the chemicals was also lower among females. A weakness of the study in the Netherlands was that most of the participants were recruited while retired (55-69 years) and exposure was measured for general exposure to agrochemicals and not specific ingredients.

On the other hand, Goldman et al. (2012) examined exposure to agrochemicals for different time frames; never used, used less than or equal to the median four years, or used more than the median four years by 87 cases and 343 controls, primarily men of non-Hispanic White race (97%). Although the difference between the groups was not significant, men who were exposed to paraquat were diagnosed with Parkinson's disease at younger ages (58.7 years) as compared to men who were not exposed to the chemical (62.2 years). Generally, there was a strong direct association between the lifetime exposure to paraquat and Parkinson's disease (Goldman et al., 2012). Genetic factors were found to be an important mediator of Parkinson's disease from exposure to agrochemicals (Goldman et al., 2012). Chinta et al. (2018) also found exposure to paraquat was associated with Parkinson's disease through induced cessation of growth and division of cells in the central nervous system.

In a cross-sectional study among 498 participants in the AHS that used paraquat in the late 1980s and early 1990s, Parkinson's disease was also found to be associated with exposure and less than 50% of protective glove use (OR of 3.9 (95% CI 1.5, 10.2)) (Furlong et al., 2015). Tanner et al. (2011) also found the incidence of Parkinson's disease was more frequent among pesticide applicators that used paraquat between 2002 and 2008 for more than 25 lifetime days. A weakness of Tanner's study was, despite a large cohort from which the cases and controls were selected, the small number of voluntary exposed cases and controls posed challenges in assessing the possible influence of confounding factors such as demographics and socioeconomic differences. The threat to internal validity may have been reduced, however, through personal examination and diagnostic confirmation by two experts. Based on the studies published by (Furlong et al., 2015; Goldman et al., 2012; Mostafalou & Abdollahi, 2017; Tanner et al., 2011; Van Maele-Fabry et al., 2012), it was prudent to investigate the relationship between factors such as age and gender as possible risk factors for Parkinson's disease from exposure to paraquat.

ESRD. Few studies were conducted to investigate the relationship between ESRD and exposure to paraquat. The AHS is the largest prospective study on the relationship between exposure to agrochemicals and ESRD. In the AHS follow-up study, with 55,580 male pesticide applicators from enrollment between 1993–1997 to the end of the follow up period in December 2011, a relationship was found between the number of visits to the doctor for complaints related to any pesticide use as well as a relationship between highest exposure to paraquat and ESRD diagnosis (Lebov et al., 2016). Completion of education at levels higher than high school, obesity at enrollment, diabetes, high blood pressure, and kidney disease were significantly associated with increased risk for ESRD. Threats to internal validity were reduced through the collection of baseline data before the onset of the disease and data on the incidence of the disease from population-based kidney disease registries, thereby, eliminating the potential for recall bias and misclassification in self-reporting surveys (Lebov et al., 2016). A threat to reliability in the study was the extended latency period of the disease, which increased the possibility that individuals were recruited in the asymptomatic stage although already infected by the disease (Lebov et al., 2016). Nonetheless, the study supported the need to also investigate the potential relationship between education and exposure to agrochemicals at levels that pose a risk for ESRD.

The findings of Lebov et al. (2016) were generally consistent with findings by Sanoff et al. (2010) in which an association was found between exposure to agrochemicals and ESRD in a cross-sectional study in Nicaragua. The study was conducted with 1002 participants in which it was found that the frequency of ESRD was higher among the participants that were also to more frequently exposed to agrochemicals (Sanoff et al., 2010). Although the specific agrochemicals were not identified, type of employment–full time versus part time–was found to influence the level of exposure to agrochemicals and the potential for health problems (Sanoff et al., 2010). Part-time versus full-time employment was, therefore, selected as a factor for investigation in the study in Grenada to determine whether there was a relationship between socioeconomic differences and the level of exposure to agrochemicals that may pose a risk for ESRD.

The results of another study were published a year later by O'Donnell et al. (2011). The case-control study, with 771 participants in Nicaragua, was conducted to investigate the relationships between socioeconomic factors, environmental exposure, and laboratory-diagnosed renal disease. Education, exposure to agrochemicals, agriculture work history, alcohol and cigarette use, and personal and family medical histories were the socioeconomic factors that were included in the study (O'Donnell et al., 2011). Hypertension, high altitude residence, agrochemicals exposure, and current or former alcohol consumption were associated with chronic kidney disease. Similar to the study by Sanoff et al. (2010), O'Donnell et al. (2011) did not explore the relationship between specific agrochemicals and the health outcome. Nonetheless, the studies in Nicaragua highlighted the importance of investigating the relationships between education level, number of years in farming, and the use of agrochemicals at levels that pose a risk for ESRD.

Decreased DNA methylation. Studies have been conducted to explore the relationship between exposure to environmental factors, including agrochemicals, and alternations in genetic expressions, known as DNA methylation. Few studies were conducted, however, to demonstrate the pathological pathway between exposure and outcomes. The AHS was one study that was conducted with 596, predominantly, white males from 1993-2010 to assess exposure to agrochemicals and DNA methylation (Alexander et al., 2017). The findings show that exposure to paraquat and carbaryl were significantly associated with decreasing LINE-1 DNA methylation among participants with the highest lifetime exposure (Alexander et al., 2017).

A study was also conducted with 1656 participants from a larger cohort in the Dutch national study from 2006–2011 to investigate the relationship between DNA methylation and general exposure to pesticides van der Plaat et al. (2018). Van der Plaat et al. (2018) did not investigate the relationship between the health problem and specific agrochemicals but also found that, generally, higher levels of exposure was associated with DNA methylation, particularly in participants with airway obstruction. A higher risk of cancer was found from hypomethylation than hypermethylation (Woo & Kim, 2012). The studies by Alexander et al. (2017) and van der Plaat et al. (2018) highlighted number of hours of farm work and full-time versus part-time employment in agriculture as important socioeconomic factors for investigation in a study to identify risk for hypomethylation related health problems, including cancers.

Use of Agrochemicals in Grenada and in the Caribbean Region

There was limited evidence of the scope of the problem related to the use and exposure to agrochemicals in the Caribbean region. Few studies were published relating to the use of agrochemicals and effects/potential effects on population health (Ragin et al., 2013). One study was conducted by Forde et al. (2015) to assess the level of organophosphates (OPs), carbamates, phenoxy acids, and chlorophenols metabolites in the urine of pregnant women in 10 Caribbean countries between 2008 – 2011. The findings were mostly moderate to high levels of the metabolites in the urine samples, indicating that the population in the region, including pregnant women, was exposed to agrochemicals (Forde et al., 2015).

Single publications were found on the knowledge, attitudes, and practices related to the use of agrochemicals use among coffee producers in Jamaica (Henry & Feola, 2013) and the general use of agrochemicals and protective clothing among farmers in Jamaica and Grenada (Semple et al., 2005). More than three-quarters of participants in the study in Jamaica reported they experienced adverse health effects from direct contact with agrochemicals, although most of the farmers worked with the agrochemicals for less than five days in the reporting year and for 2-5 hours per day (Henry & Feola, 2013). There was low knowledge about agrochemical toxicity pathways which may have contributed to the limited use of PPE by the participants; rubber boots were most frequently used during handling of agrochemicals, gloves were occasionally worn, and other protective equipment was virtually absent in the field (Henry & Feola, 2013). Social norms and culture were not found to support the use of PPE and education level was not associated with protection from exposure (Henry & Feola, 2013). Similarly, Semple et al. (2005) found that PPE was not commonly used by farmers in Grenada and education was not associated with taking measures to protect farmers. Farmers who worked more days with agrochemicals in Jamaica were also more likely to use protective equipment, however, cost appeared to be a factor that influenced the use of PPE (Henry & Feola, 2013). In both countries, the participants reported that information on the potential negative health effect from exposure to agrochemicals was mostly imparted through training programs and most of the farmers were aware of the issue, despite the low use of PPE.

Specific to diseases, one study was found on the assessment of the risk for prostate cancer among farmers in Trinidad, Jamaica and other countries from occupational exposure to agrochemicals (Ragin et al., 2013). Unpublished data from the Genetic Susceptibility to Environmental Carcinogens study and the African-Caribbean Cancer Consortium show a relationship between exposure to agrochemicals, in general, and prostate cancer (Ragin et al., 2013). The socioeconomic characteristics of the farmers and confounding variables were not investigated to investigate the effects on health outcomes in the countries (Ragin et al., 2013).

Review and Synthesis of Studies Related to the Research Questions

The majority of publications that were found in the literaturre did not include investigations of a wide range of socioeconomic characteristics of participants and disease outcomes. Information was not provided for several variables for which data were collected in the 2012 agricultural census in Grenada, such as membership in farm associations, market presence, receipt of technical support, and size of households. In other studies, information was not provided on the specific chemicals to which participants were exposed, neither the specific diseases that resulted from the exposure.

One study was focused on gender, exposure to carbaryl, and sleep apnea (Baumert et al., 2018). Studies were not found on investigations of other socioeconomic factors relating to the disease. With regard to rheumatoid arthritis, Meyer et al. (2017) focused on gender and exposures while Koureas et al. (2017) focused on number of hours of work with carbaryl. Both authors focused on age, exposure to carbaryl, and rheumatoid arthritis. Van Maele-Fabry et al. (2012) focused on gender in relation to exposure to paraquat and Parkinson's disease while Tanner et al. (2011) only focused on age, and Goldman et al. (2012) focused on gender, age, and number of hours of work with paraquat. Although Furlong et al. (2015) found a relationship between the use of glove, paraquat and Parkinson's disease, other socioeconomic factors that may influence the use of gloves, such as education and income, were not investigated. Hoppin et al. (2017) only investigated the relationship between age and gender, exposure to glyphosate and carbaryl, and allergic and non-allergic wheeze. O'Donnell et al. (2011) focused on the most socioeconomic factors, pertinent to the study in Grenada, in relation to end-stage kidney disease. O'Donnell et al. (2011) focused on relationships between education, number of hours of work with paraquat, and years of work while Lebov et al. (2016) only focused on education. Alexander et al. (2017) only focused on the number of hours of work, exposure to paraquat, and DNA methylation. The findings were also indicative of differences in the relationships between practices and health outcomes across the countries. For example, while education was associated with a risk of ESRD in the AHS in the United States (Lebov et al., 2016), there was no association between education and the use of PPE to protect against occupational diseases in Jamaica (Henry & Feola, 2013).

Overall, very limited information was available on socioeconomic factors, exposure, and disease outcome to provide a broader foundation for this research, particularly from the Caribbean region. A wider range of factors were included in the research in Grenada. Further, a unique approach was used, drawing on the algorithms in the AHS to design a study for Grenada that can generate information for comparison. In addition,through identifying the characteristics of farmers that relate to the use of agrochemicals at levels that were determined to be associated with specific diseases, conclusions can be drawn about the potential for incidences of the diseases in the farming popualtion in Grenada.

WHO/IARC Classification of the Agrochemicals

The WHO/IARC classified agrochemicals according to the potential hazard to human and animal health as *extremely hazardous*, *highly hazardous, moderately hazardous*, and *slightly hazardous* (WHO, 2016). The classifications were based on the findings of studies that were conducted by the IARC and review of other studies (FAO and WHO, 2016). Paraquat was classified by the WHO as *moderately hazardous* (WHO, 2010). Based on the findings of the International Agency for Research on Cancer (IARC), glyphosate was classified by the WHO as *probably carcinogenic* to humans (WHO, 2015). Although carbaryl was not classified as carcinogenic by the IARC, the chemical was reported to be associated with several health problems and recommended for priority review (WHO, 2014a). The hazardous nature of the three agrochemicals warrants epidemiological studies to determine how public health may be impacted by exposures in specific contexts.

Definitions

Agriculture census: Enumeration of all farming households and farm enterprises in the

State of Grenada (including the mainland Grenada and the dependencies, Carriacou and Petite Martinique) on census day without duplication of entities (Government of Grenada, 2012a).

Agriculture census frame: All households in each enumeration district in the State of Grenada (Government of Grenada, 2012a).

Agrochemical: Pesticides, herbicides, insecticides, and fungicides used in crop production (Encyclopaedia Britannica, 2018).

Allergic wheezing: Inflammation and narrowing of the airway in any location, from the throat to the lungs can result in wheezing (Merck Sharp & Dohme Corp., 2018). The most common causes of recurrent wheezing are asthma and chronic obstructive pulmonary disease (COPD), which both cause narrowing and spasms (bronchospasms) in the small airway in the lungs (Merck Sharp & Dohme Corp., 2018). Allergic wheeze, also referred to as allergic asthma, occurs as a consequence of exposure to allergens in the environment that cause the production of allergen antibodies (Leynaert et al., 2012). Allergic wheeze is characterized as wheeze with other symptoms of allergy (Hoppin et al., 2017).

Census day: The day on which the survey was conducted with the farmer (Government of Grenada, 2012a).

Census year: The census year is January 1, 2012 – December 31, 2012. Albeit, the data were collected for the "past 12 months" from census day (Government of Grenada, 2012a).

Cumulative intensity-weighted risk exposure Score: Cumulative intensity risk exposure was a quantitative measure of exposure to agrochemicals considering exposure to the agrochemical on a daily basis, frequency of daily exposure over one year, and the total number of years of exposure to the agrochemicals (Dosemeci et al., 2002; Storm et al., 2004a).

*DNA methylation***:** DNA methylation is the inhibition or promotion of gene transcription as a result of depletion and reduction of enzymatic activities to facilitate bonding of genetic components (Ruiz-Hernandez et al., 2015). Hypermethylation is the promotion of certain genetic expressions while hypomethylation is the inhibition of or decrease in the genetic expressions (Ruiz-Hernandez et al., 2015).

*End stage renal disease***:** A chronic condition in which the kidney becomes non-functional slowly and progressively over a long period (Merck Sharp & Dohme Corp., 2018). Stage 5 is typically associated with ESRD where waste builds up to unhealthy levels in the body. The disease is life-threatening to the extent that dialysis or a kidney transplant is usually required, otherwise, death will occur(Merck Sharp & Dohme Corp., 2018).

Enumeration district: **A**n enumeration district is a stable area of approximately 100 households that is demarcated on a map (Government of Grenada, 2012a).

Farmer: The member of the household or an institution that has the technical or economic responsibility of a farm. When more than one person has such responsibilities, the farmer is regarded as the person who spends the most time working on the farm whether the land is owned, leased, or without legal title. If two or more persons spend equal time working on the farm, then the eldest person is considered as the farmer to answer the questions (Government of Grenada, 2012a).

Farm/holding: **T**he cutoff limit for a farm/holding is technical or economic responsibility for at least one of the following one:

1 or more cattle
5 or more sheep, goats, and pigs (combined)
Breeding sheep, goats or pigs
25 or more poultry
25 or more fruit, nut or spice trees (combined)
¼ acre (10,000 sq.ft) of land used for garden crops (temporary vegetables, root crops, herbs, melons, pineapples, flowers, etc.)
Annual sales of agricultural produce of EC$2,500 or more (Ministry of Agriculture, 2012a, p. 12)**.**

Household farm: An economic unit under agricultural production, owned or managed by a member or members of households that were enumerated in the census (Government of Grenada, 2012a).

Non-allergic wheezing: Non-allergic wheeze is present alone and without other symptoms of allergy (Hoppin et al., 2017).

Nonhousehold Farm: An economic unit under agricultural production that is not owned or managed by a member or members of households that were enumerated in the census (Government of Grenada, 2012a).

Parkinson's disease: A slowly progressive, degenerative disorder characterized by resting tremor, stiffness, slow and decreased movement, and postural instability (Merck Sharp & Dohme Corp., 2018). Motor dysfunction is the most common symptom of the disease (Chin-Chan, Navarro-Yepes, & Quintanilla-Vega, 2015). The mean age at onset is about 57 years (Merck Sharp & Dohme Corp., 2018).

*Private household***:** Part of all of a building, such as an apartment, flat, single house, part of a commercial building, out room, or a room that serves as a residence for six or fewer persons (Government of Grenada, 2012a).

Respondent: The person, usually the farmer, who answered the questions about the farm. In a few cases, other persons who were employed on the farm or very knowledgeable about the farm operations answered the questions (Government of Grenada, 2012a).

Rheumatoid arthritis: A chronic disease characterized by inflammation of the joints from an autoimmune response of the body (Merck Sharp & Dohme Corp., 2018). Rheumatoid arthritis affects about 1% of the population and primarily women. Onset may be at any age, most often between 35-50 years, but the disease can also develop during childhood. Rheumatoid arthritis usually causes inflamed and painful joints, leading to progressive retardation of movement (Merck Sharp & Dohme Corp., 2018).

Sleep apnea: Sleep apnea occurs when a person experiences short episodes of complete or partial closure of the airway during sleep that causes breathing to stop (Merck Sharp & Dohme Corp., 2018). Individuals suffering from the condition may experience excessive daytime sleepiness, restlessness, snoring, recurrent awakening, and morning headache. If untreated the condition is often related to hypertension, heart failure, and fatal accidents (Merck Sharp & Dohme Corp., 2018).

Assumptions

Two major assumptions were made in this research. First, questions were not included in the 2012 agricultural census in Grenada to identify the name of the agrochemicals that were used and the number of hours of use per day by farmers. Instead, a general question was asked about the number of days per year that a category of agrochemical, herbicide and insecticide, was used. In the absence of data on specific agrochemicals that were used in the reporting period, this study in Grenada was premised on the assumption that at least one of the agrochemicals that were regularly used in Grenada – glyphosate, carbaryl, paraquat—was also used by the farmers and reflected in the number of days per use in the 12-month reporting period. As such, this research was an investigation of the potential or possibility for health problems due to the use and exposure to the respective agrochemical at the reported frequency.

Second, in order to calculate cumulative intensity-weighted risk exposure-days, data were required on (a) field tasks performed by farmers with agrochemicals and equipment, that is, the percentage of time mixing chemicals, application method, ever/never repair application equipment, (b) number of PPE used during application of agrochemicals, (c) days per year of use of agrochemicals, and (d) duration (years) of use of agrochemicals. The 2012 agricultural census in Grenada included questions to provide information on (c) (days per year of use of agrochemicals) and (d) (12 months/1 year period) as well as part of (a) - type of sprayer used to apply agrochemicals.

In this research, assumptions were made about missing information for a and b (see assumptions in Tables 39-40 with regard to mixing, application, and repair of equipment in the field). The assumption about the percentage of time mixing was deduced from the work system in Grenada that subscribed to an 8-hour per day shift. Full-time farmers normally followed an 8-hour work shift from about 6:00 a.m. – 2:00

p.m. while part-time farmers may complete tasks in the field by 8:00 a.m. to attend other types of employment. An assumption was also made that equipment were loaded and serviced in the field.

Assumptions about PPE were made on the basis of the literature describing the trend of use of protective equipment while handling agrochemicals. Rubber boots were the most commonly used PPE, gloves were used occasionally, and other equipment was not generally used (Henry & Feola, 2013; Semple et al., 2005). The findings from studies in other low-income countries, such as in Ethiopia, Kuwait, Sierra Leone, also show that PPE was not commonly used by farmers (Jallow et al., 2017; Negatu, Kromhout, Mekonnen, & Vermeulen, 2016; Sankoh, Whittle, Semple, Jones, & Sweetman, 2016). In the study by Semple et al. (2005), it was found that the use of PPE, apart from rubber boots, was not a regular practice in Grenada. Semple (2005) did not report on the use of other protective equipment by farmers in Grenada.

Scope and Delimitations

The research was undertaken to contribute to knowledge about the socioeconomic characteristics of farmers in Grenada that may have been risk factors for agriculture-related occupational diseases. Two areas in the research problem were addressed. First, this study contributed to close the gap in the literature with regard to the risk associated with the frequency of use of three agrochemicals that were also commonly used in Grenada. Grace, (2015) and Guha, Guyton, Loomis, and Barupal (2016) highlighted the low level of knowledge about hazardous chemicals in low-income countries. The potential to experience health problems as a consequence of the frequency of use of specific agrochemicals was investigated. As such, the findings of this study may be used as evidence to support the development of measures to address public health problems.

Second, apart from contributing information on the health hazards associated with exposure to commonly used agrochemicals, information was provided about personal factors that predisposed farmers to health problems. The socioeconomic characteristics of the farmers and the frequency of use of agrochemicals were investigated. Socioeconomic factors were not investigated in many studies and, as such, there was a gap in the literature with regard to the relationships between the characteristics of farmers and potential health outcomes. It was, therefore, vital to understand these characteristics as a first step to manage the health problems (Fertman & Allensworth, 2017; Harris, 2017).

The Ministry of Agriculture's report on the 2012 agriculture census contained descriptive information. Statistical analysis was not conducted to investigate relationships between variables. Data were collected in the census on the frequency of use of agrochemicals. These data were, therefore, used in the analyses to examine the relationships between agricultural practices and the potential to experience health problems. Medical diagnosis was beyond the scope of this study.

The study included all farming households and farm enterprises that met the criteria for inclusion in the in the 2012 agricultural census in Grenada (Government of Grenada, 2012a). The selected households were a subset of the households that were enumerated in the Population and Housing Census (Government of Grenada, 2012a). The census data allowed for identifying all possible relationships in the characteristics of the population given that the data were collected from a frame that included all households in the country and contained the responses of a large sample. Random sampling was however, done at the level of the household, which also reduced the potential for bias in the study. The results of the study in Grenada can, therefore, be generalized to the wider population.

Application of the tenets of the health belief model (HBM) in studies usually helped to capture life experiences to explain health behaviors and, to a certain extent, inform behavior change (Glanz et al., 2015). The HBM was commonly used in studies to examine the influence of personal differences on the use of agrochemicals (Bay & Heshmati, 2016; Jin, Wang, He, & Gong, 2016; Khan, Husnain, Mahmood, & Akram, 2013). The theory is intuitive and, therefore, health behaviors were predicted based on perceptions about the likelihood and severity of a health outcome, rather than mental processing of the consequences of actions (Glanz et al., 2015). In the HBM, the perception of health impact is also determined by value and expectation of the outcome (Glanz et al., 2015). The applicability of the theory was, nonetheless, limited in this study given that data were not collected on perceptions and personal preferences that may have informed value and expectations of the outcomes of exposure to agrochemicals. As such, the HBM was not suitable for application in this research.

Significance, Summary, and Conclusions

In this research, the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and exposure to agrochemicals—glyphosate, paraquat, and carbaryl—at levels that were hazardous for human health was investigated.

The chemicals have been found to be associated with Parkinson's disease (Tanner et al., 2011), ESRD (Lebov et al., 2016), sleep apnea (Baumert et al., 2018), rheumatoid arthritis (Meyer et al., 2017), decrease in LINE-I DNA methylation (Alexander et al., 2017), and allergic and nonallergic wheezing (Hoppin et al., 2017).

The originality and implications of the study were demonstrated in four ways. First, this study involved the application of a unique approach to investigating the relationship between socioeconomic characteristics of farmers and health outcomes. The AHS was the largest prospective cohort study in the United States on farmers' exposure and health outcomes (National Institute of Environmental Health Sciences, 2017) and regarded by the WHO as a rigorous study (Food and Agriculture Organization and WHO, 2016). Algorithms were applied from the AHS to calculate intensity-weighted risk exposure of farmers with different profiles. Thereafter, a determination was made of the potential for specific diseases to develop as a consequence of the levels of exposure. Additionally, based on the practices that were reported in the 2012 census, the period over which, potentially, diseases may develop due to exposure, was calculated.

Second, the information from this research can contribute to filling a gap in knowledge related to agriculture-related occupational diseases. Few socioeconomic factors were investigated in studies in other countries. In this research, several other variables that were not considered in other studies were investigated—including, location of the farm, size of farmers' household, main occupation, receipt of credit, markets, membership in farmers association, and income from agriculture production. Apart from the AHS, multiple practices of farmers were considered only in a few studies to calculate risk exposure. Given that this was the first study of its kind in Grenada, its findings may be used as baseline; the findings also filled a gap in the literature on identifying the relationships between a wide range of social and economic factors and exposures in the Grenadian context, both generally and specifically.

Third, conducting a census is costly because of the large sample that may be involved. Nonetheless, censuses produce a highly representative sample (Brant, Haas-Haseman, Wei, Wickham, & Ponto, 2015) that can contribute to strengthening the reliability of a study (Babbie, 2017). The pattern of conducting agriculture censuses show that a study is conducted about every 14-17 years in Grenada (Government of Grenada, 2012a). This means that the next census is likely to be conducted around 2026-2029. As such, the dataset for the 2012 agricultural census contained the most recently available data that could provide some indication of risk factors related to the use of agrochemicals in Grenada, at least for the next 8 years.

Fourth, based on the global pattern, it is also likely that the use of agrochemicals will increase in Grenada and in other countries (Lewis et al., 2016) and, thus, there may be a heightened risk for public health problems. If such health problems exist, they may not be properly assessed and addressed while gaps exist in understanding the relationship between socioeconomic factors and health problems that could arise from the use of agrochemicals. Further, the findings from the study could be used to guide in the development of the questionnaire for the next census to increase data collection related to the use of agrochemicals and health in Grenada.

The approach to this study was appropriate to generate information to inform positive social change with regard to the use of agro-chemicals and resulting diseases after considering three factors:

1. Whether there is a need to address the type of agrochemicals that are used in Grenada;
2. Whether there is a need to address agricultural practices related to personal protection, and
3. Whether there is a need to modify the surveillance system to monitor occupational-related diseases.

Consequently, the information from this research may be used as evidence to inform changes in the systems for management and monitoring of agrochemicals use as well as disease surveillance in the Grenadian population. Through appropriate enhancement of these systems, there is also a greater potential to protect the health of the Grenadian public.

Chapter 2 will include details about the methodology for data collection, and the plan for analysis and interpretation of the data. The main outputs of the study are calculations of risk exposure scores, determination of the relationship between variables, and determination of the period over which diseases may develop, based on reported practice in the 2012 census.

Section 2: Research Design and Data Collection

Introduction

The purpose of this quantitative cross-sectional study was to investigate the relationships between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and their use of agrochemicals at levels that pose health risks. In this study, the relationships between socioeconomic characteristics of the farmers and exposure to three agrochemicals was investigated to determine potential for the development of Parkinson's disease (Tanner et al., 2011), ESRD (Lebov et al., 2016), sleep apnea (Baumert et al., 2018), rheumatoid arthritis (Meyer et al., 2017), decrease in LINE-I DNA methylation (Alexander et al., 2017), and allergic and non-allergic wheezing (Hoppin et al., 2017). In the AHS study, the health problems were associated with specific frequency of exposure. The findings of the AHS were used as the basis to develop this research to investigate factors that have the potential to cause farmers in Grenada to expereince specific health problems. It was vital to understand individual differences that may predispose the farmers to the health problems in the Grenadian context.

Chapter 2 includes the details of the research design, study population, sampling procedures, operationalization of the constructs, data analysis plan, and ethical procedures in the study.

Research Design and Rationale

A quantitative, cross-sectional, correlation design was used in the research in Grenada. This design was aligned with a correlation study in which the relationships between variables were analyzed (Creswell, 2014). The annual frequency of use of agrochemicals was the dependent variable for the first research question. The dependent variable was categorized as "ever used" and "never used" agrochemicals. For the second research question, the dependent variable was cumulative intensity-weighted risk exposure-days score and categorized in as: " ≤ 2087" and " ≥ 2088" (Lebov et al., 2016; De Roos et al., 2005; Storm et al., 2004a) and reflected as "used herbicide ≥12 times per year" and "used herbicide ≤ 12 times per year." The selected socioeconomic characteristics of the farmers in the 2012 agricultural census were the independent variables: age, gender, highest level of education completed, size of household, and membership in a farm organization. The economic factors included in this study were parish of location of the farm, markets, receipt of credit, number of paid workers, status of land ownership, maintenance of farm records, number of nonhousehold members working on the farm, number of parcels of land operated by the farmer, daily number of hours farmer worked on the farm, receipt of technical assistance, production issues, and income from agriculture production.

Cross-sectional studies involve observation of a situation in a segment of the population at a point in time (Burkholder, Cox, & Crawford, 2016). In this study, the data were collected for a reporting period of 1 year and will be analyzed to provide information on social economic factors that relate to the frequency of use of the agrochemicals during the period. The study did not include a trial or intervention. Cross-sectional studies can be exploratory or explanatory, depending on the purpose of the study. In an explanatory cross-sectional study, the focus is on conducting examinations or investigations to determine what exists and to what extent (Babbie, 2017). On the other hand, an exploratory cross-sectional study is focused on observing an existing problem at a point in time to explain the nature of the problem (Babbie, 2017). In this study, the research question led to an investigation to determine whether a relationship exists between variables during a specific reporting period. As such, the design of this study was explanatory cross-sectional.

A nomothetic approach was also used in the study with the research question leading to an investigation of the relationship between variables. The nomothetic approach investigated causality, that is, how much one variable influenced a situation or outcome. The nomothetic approach is different to the idiographic approach; in the latter approach, the focus is to provide details about the dynamics of the relationship between the variables (Babbie, 2017). The nomothetic approach is, therefore, oriented to the application of theories that predict why a particular behavior occurred (Babbie, 2017). The nomothetic approach underpinned the design of the study in which the SCT was applied to investigate the strength of the association between variables or the effect of one variable on another. As such, the proposed hypotheses about the relationships between the variables were tested to determine whether they should be rejected or fail to be rejected. The causal relationship between variables may be proven by statistical correlation—such as regression analysis that was used in this study; time order – that is demonstrating that the independent variables preceded the dependent variables; and nonspruriousness – that is, the effect cannot be explained by other factors (Babbie, 2017). In relation to the latter condition, the SCT theory was applied to establish the most plausible explanation for the outcomes. Regression analysis is a measure of association, using numerical values (Frankfort-Nachmias & Leon-Guerrero, 2015). In applying these measures, a quantitative design was used in the study.

The positivist orientation is premised on understanding how variables are related by applying methodological approaches to observe, explain, and control events (Burkholder et al., 2016). This research was generally aligned with this orientation as the study investigated how the socioeconomic characteristics of individuals were related to specific outcomes, mediated by the constructs of the SCT– personal cognitive factors, socioeconomic or environmental factors, and supportive behavior. Construct validity was established by applying evidence from other studies (AHS) that supported the application of the SCT (cognitive, environmental, and behavioral factors), to predict health behaviors (Babbie, 2017). The post-positivist approach was applicable in the research in Grenada, given that application of the algorithm was unique in the settings of a Caribbean country and, therefore, there was an opportunity to explore the relationships between various factors that may not have been previously considered or include in studies premised on the HBM.

Few studies have been conducted to investigate the relationship between a wide range of socioeconomic variables, frequency of use of agrochemicals, and potential health outcomes. The study, therefore, contributed to addressing this gap in the literature. More specifically, studies were virtually non-existent on the issue in the Caribbean region. This study was the first to provide information about the relationship between individual characteristics and agriculture-related health outcomes in Grenada. The findings can be used as baseline. The results may also be applicable to other countries in the region that have similar demographic profiles and agricultural practices.

Methodology

Target Population

The 2012 agricultural census was conducted with each person in the State of Grenada that met the criteria of having technical or economic responsibility for farm holdings, that is, 1 or more cattle, 5 or more sheep, goats and pigs (combined), breeding sheep, goats or pigs, 25 or more poultry, 25 or more fruit, nut or spice trees (combined), ¼ acre (10,000 square feet) of land used for garden crops (temporary vegetables, root crops, herbs, melons, pineapples, flowers, etc.), annual sales of agricultural produce of EC$2,500 or more (Ministry of Agriculture, 2012a, p. 12). The dataset of the Grenada 2012 Agriculture Census contained the responses of 9295 farmers. Of the 9295 farmers in the dataset, 95.4% (N = 8868) were involved either in crop production only or in both crop production and animal husbandry. These farmers were included in the analysis.

Sampling and Sampling Procedures

The Government of Grenada has legal responsibility for the conduct of censuses. In conducting censuses, data are collected from each household in the jurisdiction in which the census is conducted. As such, the agriculture census frame also involved each private household in the State of Grenada that is identified in the Housing and Population census (Government of Grenada, 2012b). The census was conducted from October–November, 2012 (Government of Grenada, 2012b). In each household in the enumeration district (287), a short farm questionnaire was administered to identify the households that met the criteria of operating an agricultural holding above the cut-off limit, that is, having responsibility for at one or more of the following -at least 1/4 acre of garden crops; or 25 or more permanent fruit, nut, or spice trees; or 1 or more cattle; or 5 or more sheep, goats or pigs; or 25 or more poultry; or annual sales of agricultural produce of at least EC$2,500 (Government of Grenada, 2012a)**.** A list of nonhousehold farms was also identified for inclusion in the census (Government of Grenada, 2012b). The long questionnaire was administered to the selected farmer – that the persons with decision-making responsibility for the farm. In the case of joint responsibility, the person that worked the longest hours on the farm was selected. If each person either worked the longest hours on the farm or the oldest farmer (Government of Grenada, 2012b). The dataset contained the responses of the farmers to the long farm questionnaire.

To collect the data, the enumerators canvassed the assigned ED (Government of Grenada, 2012b). Each household was identifying and the short farm questionnaire was administered to identify the households that had holding that was above the cut-off limit. The long farm questionnaire was applied to all holdings above the threshold. All data were collected through face-to-face interviews. Responses were filled on the questionnaire. The responses were cross-checked by field supervisors for clarifications to ensure completeness of the survey. The data were manually entered into SPSS, cleaned and coded. The accuracy of the data were checked by comparing the data in the census with external data (Government of Grenada, 2012b).

The dataset was held in the Ministry of Agriculture in Grenada. A written request is usually required to gain access to government documents. As such, a letter, dated

October 12, 2017 (attached) was sent via email to the Permanent Secretary in the Ministry of Agriculture to request permission to use the data. A letter, dated June 4, 2018, was sent by the Permanent Secretary confirming the approval to use the data.

The data set from the 2012 agricultural census in Grenada was used in this study. The data were collected in the most recent agricultural census in the country. Agricultural censuses are conducted every 15-17 years in Grenada (Government of Grenada, 2012a). The next agricultural study was, therefore, likely to be conducted in the next 8-11 years. The 2012 agricultural census was commissioned to collect data from farming households and enterprises on farming practices in Grenada. The dataset, from the most recent census, was held by the Ministry of Agriculture in Grenada. The 2012 agricultural census is the first one in which data were collected on the level of use of agrochemicals in Grenada. Therefore, the dataset was the only source of information to conduct this study.

Instrumentation and Operationalization of Constructs

The instrument for collection of data in the 2012 census was developed by local representatives in consultation with FAO experts (Government of Grenada, 2012b). The instruments were published online by FAO (Government of Grenada, 2012a, 2012b). The instrument was appropriate for this study for three reasons: First, although agriculture censuses were conducted in 1961, 1975, 1981, and 1995 (Government of Grenada, 2012a), the 2012 census was unique, being the first study in which data were collected on the frequency of use of agrochemicals. As such, prior to 2012, it was virtually impossible to conduct any credible study to establish baseline information on the risk for specific diseases from exposure to agrochemicals in the Grenada context.

Second, the instruments show that data were collected on demographics and other economic factors such as farm labor, land tenure, land use, cultivation, irrigation, livestock, fertilizer and agrochemicals use, farm machinery, production issues, participation in organizations, credit, and receipt of technical assistance (Government of Grenada, 2012a) which allowed for investigation of the relationships between a wide range of socioeconomic factors and frequency of use of agrochemicals to answer the research questions. Third, the question on the time period over which the chemicals were used in the census year was relevant to facilitate the calculation of cumulative intensity weighted risk exposure score for selected periods for which the farmers may possibly experience the health problems.

In a letter dated October 12, 2018, the Ministry of Agriculture granted permission to use the instrument in the development of the research. Previously, verbal consent was given by the Permanent Secretary in the Ministry of Agriculture in response to the letter, dated June 4, 2018. Although published, there were no assessments of reliability and validity of the instruments.

The 2012 agricultural census was the fifth that was conducted in Grenada (Government of Grenada, 2012a). Although the instruments may have contained some standard question, consultation was held with the FAO representatives to refine the instruments. In refining the instruments, lessons that were learned from previous administration were incorporated in the revisions. For example, in the 1995 census, one question was included for farmers to indicate whether they used agrochemicals. In the 2012 census, this question was revised to collect information on the frequency of use of the agrochemicals as well as the type of agro-chemical used in practice. This question in the 2012 census was more appropriate for inclusion in risk assessment studies.

Basis for Development of the Research Tool

The Statistics Act of December 1960 mandated the statistical office in Grenada to conduct censuses (Government of Grenada, 2012b). The agricultural census was also conducted as a mandate by this Act. The instruments were developed by the Central Statistics Office in collaboration with the Ministry of Agriculture and consultants of the Food and Agriculture Organization (FAO). The 2012 agriculture census was approved by the Government of Grenada and was funded by the European Union and the Government (Government of Grenada, 2012b).

Operationalization of the Variables

Allergic wheeze

Glyphosate use was found to be associated with allergic and non-allergic wheeze with any level of use – that is, 1–10 days and 11–365 days of use per year compared to never used (Hoppin et al., 2017).

ESRD

Paraquat was found to be associated with ESRD for the highest category of exposure- that is, ≥ 2088 intensity-weighted risk exposure score as compared with never used the agrochemical (Lebov et al., 2016).

LINE-I DNA methylation

Paraquat use was found to be associated with significant decrease in LINE-I DNA methylation for ever used and the highest level of lifetime days of application compared to never used (Alexander et al., 2017). Carbaryl was found to be associated with a decrease in LINE-I DNA methylation for ever used and the highest level of lifetime days of application compared to never used (Alexander et al., 2017).

Non-allergic wheeze

Carbaryl was found to be associated with allergic wheeze with any level of use – that is, 1–10 days and 11–365 days of use per year compared to never used (Hoppin et al., 2017).

Parkinson's disease

Paraquat use was associated with Parkinson's disease for > 25 lifetime days of use as compared to < 25 days of lifetime days of use (Tanner et al., 2011);

Rheumatoid arthritis

Carbaryl was found to be associated with rheumatoid arthritis for ever used compared with never used (Meyer et al., 2017);

Sleep apnea

Carbaryl was found to be associated with associated with sleep apnea for ever used compared to never used (Baumert et al., 2018).

Dependent Variables

For the first research question, frequency of use of agrochemicals (dependent variable) was classified as "ever used" or "never used" agrochemicals. Farmers who reported light use: that is, the application of the chemicals 1-5 times per year; medium use: that is, 6-11 times per year; and heavy use: that is, 12 or more times per year (Government of Grenada, 2012a), were considered as ever used agrochemicals.

For the second research question, the dependent variable was cumulative intensity-weighted risk exposure-days score, categorized as ≤ 2087 and ≥ 2088 (Lebov et al., 2016; De Roos et al., 2005; Storm et al., 2004a) and reflected as frequency of use of herbicides ≥ 12 times per year and ≤ 12 times per year. The cumulative intensity-weighted risk exposure-days score is calculated by exposure intensity × lifetime exposure-days (that is, number of days X years of exposure) (Storm et al., 2004a). The calculation of cumulative intensity-weighted exposure days and the lapse period are shown in Tables 39-40. The used of herbicide ≥ 12 times per year was equivalent to a cumulative intensity-weighted exposure days score achievable over a lapse period.

Independent Variables

The independent variables in the study were: (a) age, (b) gender, (c) highest level at which education was completed, (d) size of household, and (e) membership in a farm organization. The economic factors that were identified for inclusion in this study were: (a) parish of location of the farm, (b) markets, (c) receipt of credit, (d) number of paid workers, (e) status of land ownership, (f) maintenance of farm records, (g) number of nonhousehold members working on the farm, (h) number of parcels of land operated by the farmer, (i) daily number of hours farmer worked on the farm, (j) receipt of technical assistance, (k) production issues, and (l) income from agriculture production. The social and economic factors comprised the independent variables in the analyses. The frequency of use of agrochemicals was the dependent variable for the first research question, categorized as *ever used* agrochemicals and *never used* agrochemical. Ever use of any of the agrochemicals was associated with one or more of the health problems stated in the first research question (RQ1).

Age. Age was categorized as: 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, ≥75 years.

Experienced production issues. Experienced production issue was categorized as: yes, no.

Gender. Gender was categorized as: male, female.

Highest level of completing education. Highest level of completion of education was categorized as: primary, secondary, vocational, university, tertiary.

Income from agriculture production in the last 12 months. Income from agriculture production in the last 12 months was categorized as: all income, no income, half of income, quarter of income, ≤ quarter of income.

Maintenance of farm records. Maintenance of farm records was categorized as: yes, no

Membership in a farm organization. Membership in a farm organization was categorized as: yes, no.

Presence in markets. Presence in markets was categorized as: Do not sell to markets, Sell to markets.

Parish of location of the farm. Parish of location of the farm was categorized as:

St. George

St. John

St. Mark

St. Patrick

St. Andrew

St. David

Carriacou

Petite Martinique

Number of paid workers on the farm in the last week. Number of paid workers on the farm in the last week was categorized as: 0, 1-2, 3-4, 5-6, ≥7.

Parcels of land operated. Parcels of land operated by the farmer were categorized as: 1-2, 3-5, 6-10, and ≥11.

Receipt of credit in the last 12 months. Receipt of credit in the last 12 months was categorized as: yes, no.

Receipt of technical assistance in the last 12 months. Receipt of any technical assistance in the last 12 months was categorized as: yes, no

Status of land ownership. Status of and ownership was categorized as: individual ownership, joint ownership with members in the same household, joint ownership with nonhousehold members.

Size of farmers' household. The size of farmers' household was categorized as: 1-4, 5-9, ≥10 persons.

Unpaid nonhousehold workers on the farm in the last week. Unpaid workers on the farm in the last week were categorized as: 0, 1-2, 3-4, 5-6, ≥7.

Weekly hours of farmer's work on the farm. The categories of weekly hours of work on the farm was based on the assumption that farmers whose main occupation is farmers were involved in farming ≥36 hours (full time). Farmers who worked ≤35 hours were considered as part time workers.

Data Screening

In the data screening process, I reviewed the dataset to ensure all the variables for investigation were included in the dataset. Next, the categories of each variable were examined to check that labeled of the groups were in accordance with the required responses and codes in the questionnaire. In cases where the code or category was not aligned with the questionnaire, the variable was re-categorized to ensure the best fit with the questionnaire. For each question the number of missing responses was less than 1%. Continuous variables were also categorized to minimize errors from small number of counts in cells in the binomial regression analysis. The distribution of the data were checked in frequency analyses and cross-tabulation tables to ensure that each cell contained >10 counts to achieve valid results in the binomial logistic regression. A minimum of 10 counts per cell is generally accepted as the standard for logistic regression analysis (Vittinghoff & McCulloch, 2007). Variables that contained cells with small number of counts were re-categorized with the cells combined to ensure that each cell contained at least 10 cases.

The first research question that was answered in this research was: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively?

The null hypothesis for the first research question was: There is no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively.

The alternative hypothesis for the first research question was: There was a relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively.

The second research question that was answered in this research was: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's diseases, respectively?

The null hypothesis for the second research question was: There was no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's diseases, respectively.

The alternative hypothesis for the first research question was: There was a relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's diseases, respectively.

Data Analysis Plan

Descriptive Analysis

The descriptive and inferential analyses in this research were conducted using IBM SPSS Statistics Software (version 24). Descriptive statistics is the organization or the description of quantitative information but does not lead to making inferences or predictions about a population (Frankfort-Nachmias & Leon-Guerrero, 2015). The descriptive analysis included counts of outcomes in each category of the dependent and independent variables. Cross-tabulation tables were also created to observe counts. The cross-tabulation tables were used in the decisions to re-categorize variables for conducting the binomial logistic regression analysis. Cells with small counts in the tables were combined to create larger counts that were appropriate for conducting regression analysis (Vittinghoff & McCulloch, 2007; Plonsky, 2015).

Logistic Regression

Regression analysis was conducted to investigate the relationship between one independent variable and the dependent variable of between a group of independent variable and the dependent variable. The codes were screened and, where necessary, the data were categorized and/or re-coded for the analyses.

Analysis and Interpretation of the Results

Two types of analysis were conducted in this study – descriptive analysis and statistical analysis.

The statistical significance of the effect of each independent variable on the dependent variable was interpreted. Alpha was set at .05 (5%), that is the cut-off point at which the results will be considered as statistically significant and the null hypothesis is rejected. The alpha level of .05 (5%) is a generally acceptable level of risk in rejecting the null hypothesis (Frankfort-Nachmias & Leon-Guerrero, 2015). The results of odds ratio was also interpreted with 95% confidence level. This level of confidence is commonly used to indicate the likelihood that the population parameter is within the specified range (Frankfort-Nachmias & Leon-Guerrero, 2015).

Threats to Validity

Validity is accuracy in measuring the intended outcomes in a study (Creswell, 2014). There may be threats to internal and external validity arising from the use of secondary data (Brakewood & Poldrack, 2013). The use of different instrumentation in a study in one factor that can pose a threat to internal validity (Fink, 2013; Thiese, 2014). In this study, algorithms from the AHS were applied to the Grenadian context. This approach may pose a challenge for internal validity of the study for two main reasons. First, the data selected in the AHS prospective study were more comprehensive than the data collected in the 2012 agriculture census. Hence, assumptions were made to satisfy some conditions in the calculations as data were not collected or partially collected on the item. This issue was particular to use of PPE by farmers in Grenada. One study was found that provided some indication about the use of PPE in Grenada. To ensure that the most appropriate assumptions were made, however, the literature was reviewed to identify the general pattern of use of PPE in other countries which may have similar demographics and practices as Grenada.

The second reason for threats to the validity of this research was owing to the lack of information on the specific agrochemicals used by farmers in the 2012 agriculture census. The assumption was made that farmers used at least one of the specified agrochemicals at the reported level. Nonetheless, to reduce bias in the study, the results were presented as a potential or possibility for farmers to experience the health outcomes rather than establishing causality of the health outcomes. Further studies are encouraged to collect additional information to increase understanding about the use of agrochemicals and public health implications in Grenada.

Prospective cohort studies are more adept to establish causality while cross-sectional studies provide a snapshot of the situation in a population at a particular time (Fink, 2013). As such, causality was established in the AHS study. Though the algorithms from the AHS were applied in the study in Grenada, sufficient information was not produced to establish causality between the independent variables and the dependent variables. The AHS was also conducted mostly with white male applicators in two states in the United States. Demographic and geographical factors can have significant influence on behaviors. The demographic differences in the population in the AHS and in the study in Grenada were limitations in comparing the results of the studies.

The use of instrumentation from other studies can result is a threat to internal validity (Fink, 2013). One of the challenges in using secondary data is defining the variables and scales of measurement (Shi & Johnson, 2014). Several different approaches were used in agrochemical risk assessment studies (Food and Agriculture Organization and World Health Organization, 2016). For example, while lifetime intensity weighted-risk score was used to measure exposure in the AHS (Storm et al., 2004a), days of use per year was the most common method used in other studies (Food and Agriculture Organization and WHO, 2016). The latter approach was also used in the 2012 agriculture census, categorized as high, low, and medium use of the agrochemicals (Government of Grenada, 2012a). Additionally, due to the differences in the size of the farms in the United States and in Grenada, there may also be vast differences in the constructs of high, low, and medium use of the chemicals. This difference may also affect how results are interpreted. For example, in the 2012 census, low use of agrochemicals was classified as 1-5 days of application per year (Government of Grenada, 2012a) while 1-10 days represented low use in the AHS study (Hoppin et al., 2017). To minimize this challenge, the focus of the research in Grenada was limited to an investigation of the relationship between social and economic characteristics of the farmers and the frequency of use of agrochemicals rather than a comparison of the frequency of use of agrochemicals in the United States and Grenada. The approach that was used in the study in Grenada was also beneficial to improve understanding about risk factors of diseases in the local context.

A study was conducted to evaluate the consistency of the methods that were used to assess occupational exposure to active ingredients in pesticides and chemical groups in a pooled analysis of agricultural cohorts within the AGRICOH consortium—the AHS in the United States, the French Agriculture and Cancer Study (AGRICAN) and Cancer in the Norwegian Agricultural Population study (Brouwer et al., 2016). The participants in the AHS were required to self-report pesticide use, whereas crop-exposure matrices were used in the AGRICAN and in Cancer in the Norwegian Agricultural Population study.

There was a higher correlation in exposure measures in the study in Norway and AGRICAN, but not between these studies and the AHS. The authors concluded that, while exposure measures were not standardized, the method used in the AHS may be more reliable in providing scientific evidence about the association between exposure and health outcomes (Brouwer et al., 2016). A limitation in the AHS, however, was the lack of consideration of the effect of other additives in the agrochemicals, hygiene, and temperature that may also affect exposure and the rate of absorption of agrochemicals in the body. This limitation was also transferred to the research in Grenada and posed a threat to the external validity of the study. Further studies are recommended to investigate additional factors that were not included in this baseline study.

Ethics

Ethics relate to the practices of researchers that may be considered as right or wrong based on the effect of the practice on the research population (Avasthi, Ghosh, Sarkar, & Grover, 2013). Owing to the onerous burden that was placed on research populations by virtue of participation in risky studies, code of ethics were developed to ensure that proposals were morally and ethically sound to avert ethical issues (Brakewood & Poldrack, 2013). The Tuskegee Syphilis Study, which was conducted in the United States, is a well-known example of such disregard for human welfare in research (Kim, 2012).

Although the conduct of census is a legal responsibility of the government of Grenada, research ethics was followed in the use of the 2012 agricultural census data. Application for the study was made both to Walden University Institutional Review

Board (IRB) and St. George's University IRB. Additionally, a letter of approval was provided by the Ministry of Agriculture with conditions for the use of the dataset and protection of the respondents. The study was approved by Walden University (IRB Approval No.: 09-06-18-0720748) and exempted from approval by St. George's University IRB (IRB Reference: 18061). The data were analyzed following approval from the IRB at both institutions.

According to El Emam, Rodgers, and Malin (2015), there are two critical ethical considerations in using secondary data: consent and anonymity. Because secondary data from 2012 was used in this research, it was not practical to secure informed consent from the participants. In conducting this research, the participants should, however, also be protected through anonymity. Participants' names were not provided by the Ministry of Agriculture in the dataset. Further, the data were categorized and analyzed and reported as a pool. The dataset was stored on a password-protected computer. As part of the conditions by the Ministry of Agriculture to use the dataset, the letter of approval from the Ministry also stipulated that the dataset should only be used for this research and not distributed or shared with other parties.

Summary and Transition

This quantitative cross-sectional study was conducted to investigate the relationships between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and the use of agrochemicals at levels that pose risks for health. The relationships between socioeconomic characteristics of the farmers—(a) age, (b) gender, (c) highest level at which education was completed, (d) size of household, and (e) membership in a farm organization. The economic factors that were identified for inclusion in this study were: (a) parish of location of the farm, (b) markets, (c) receipt of credit, (d) number of paid workers, (e) status of land ownership, (f) maintenance of farm records, (g) number of nonhousehold members working on the farm, (h) number of parcels of land operated by the farmer, (i) daily number of hours farmer worked on the farm, (j) receipt of technical assistance, (k) production issues, and (l) income from agriculture production — and exposure to agrochemicals, presumably, glyphosate, carbaryl, and paraquat—were investigated to determine whether there was a potential for farmers to experience Parkinson's disease, ESRD, sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheezing as a consequence of the level of use of agrochemicals, in general, and herbicides, specifically. The algorithms used in the AHS were applied in the Grenadian context to identify hazardous levels of use of agrochemicals and exposure.

Section 3 includes the results of the quantitative analysis. Tables were included with the findings of the descriptive and statistical analyses. The relationships between the independent and dependent variables were also reported in the chapter. These results of the analyses provided information that was used to support the decision to accept or reject the null hypotheses.

Section 3: Presentation of the Results and Findings

Introduction

The purpose of this quantitative cross-sectional research was to investigate the relationships between the social and economic characteristics of farmers who participated in the 2012 agricultural census in Grenada and the use of agrochemicals at levels that pose risks for specific health problems. Exposure to the chemicals have been found to be associated with Parkinson's disease (Tanner et al., 2011), ESRD () (Lebov et al., 2016), sleep apnea (Baumert et al., 2018), rheumatoid arthritis (Meyer et al., 2017), decrease in LINE-I DNA methylation (Alexander et al., 2017), and allergic and non-allergic wheezing (Hoppin et al., 2017). This research examimined the potential for farmers in Grenada to experience these health problems.

The first research question that was answered in this study was: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively?

The null hypothesis for the first research question was: There is no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, respectively.

The second research question that was answered in this study was: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's diseases, respectively?

The null hypothesis for the second research question was: There was no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's diseases, respectively.

The following socioeconomic characteristics (independent variables) were included in the study: (a) age, (b) gender, (c) highest level at which education was completed, (d) size of household, and (e) membership in a farm organization. The economic factors that were identified for inclusion in this study were: (a) parish of location of the farm, (b) markets, (c) receipt of credit, (d) number of paid workers, (e) status of land ownership, (f) maintenance of farm records, (g) number of nonhousehold members working on the farm, (h) number of parcels of land operated by the farmer, (i) daily number of hours farmer worked on the farm, (j) receipt of technical assistance, (k) production issues, and (l) income from agriculture production. The frequency of use of agrochemicals was the dependent variable.

For the first research question, frequency of exposure was the dependent variable, classified as ever used or never used agrochemicals. For the second research question, the dependent variable was cumulative risk exposure score, classified in two groups: ≤ 2087 and ≥ 2088.

Data Collection of Secondary Data Set

Timeframe for Data Collection, Recruitment, and Response Rate

The 2012 agriculture census was conducted from October–November, 2012 in all parishes on the mainland in Grenada and in the two dependency islands, Carriacou and Petite Martinique (Government of Grenada, 2012b). The census was conducted with each household in the State of Grenada in the 287 enumeration districts. To collect the data, trained enumerators canvassed the assigned ED (Government of Grenada, 2012b). A short questionnaire was administered to identify the households that met the criteria of operating an agricultural holding above the cut-off limit of having at least one household member with technical or economic responsibility for a farm holding, that is, (a) 1 or more cattle; (b) 5 or more sheep, goats and pigs (combined), breeding sheep, goats or pigs, (c) 25 or more poultry; (d) 25 or more fruit, nut or spice trees (combined); (e) ¼ acre (10,000 sq.ft.) of land used for garden crops (temporary vegetables, root crops, herbs, melons, pineapples, flowers, etc.); or (e) annual sales of agricultural produce of EC$2,500 or more were included in the sample (Ministry of Agriculture, 2012a). A list of nonhousehold farms was also produced for inclusion in the census (Government of Grenada, 2012b).

The long farm questionnaire was applied to all holdings that were above the cut-off limit. The long questionnaire was administered to the selected farmer – that is, the person with decision-making responsibility for the farm (Government of Grenada, 2012b). All data were collected through face-to-face interviews. Responses were filled on the questionnaire. A total of 9295 farmers were included in the census.

Discrepancies in the Use of the Data Set from the Planned Methodology

The research proposal was developed to investigate the relationship between twelve independent variables and two dependent variables. The independent variables that were included in the initial proposal were age, gender, parish of location of the farm, education level, household size, main occupation of the farmer, farmers daily number of unpaid hours working on the farm, membership in an organization, type of market, receipt of technical assistance, experienced production issues, and income from agricultural production. The dependent variable was frequency of use of the agrochemical.

The dataset was examined and other social and economic variables were identified and included in the analyses. The additional independent variables were: (a) receipt of credit, (b) number of paid workers on the farm in the past week, (c) status of land ownership, (d) maintenance of farm records, (e) number of nonhousehold members working on the farm in the past week, and (f) number of parcels of land operated by the farmer. The inclusion of these additional variables served to enhance the research through providing insights about other socioeconomic factors that also had the potential to influence the use of agrochemicals at levels that can have implications for health. Inclusion of the new variables also contributed to expanding the body of knowledge about factors that should be considered in future research or that may have also had impact on the findings of previous studies. The main occupation of farmers was excluded as the responses in the dataset were widely varied and difficult to categorize.

Baseline Descriptive and Demographic Characteristics of the Sample

The long questionnaire was administered to one farmer in each household that met the cutoff limit. The selected farmers were persons with decision-making responsibility for the farm. In the case of joint responsibility, the person that worked the longest hours on the farm was selected. If the farmers worked equal amount of hours on the farm, then the oldest farmer was selected (Government of Grenada, 2012b). The dataset contained the responses to the selected farmers.

Representativeness of the Sample

The data were collected in the 2012 agriculture census. The census was population- based with each household in the State of Grenada included in the sampling frame. The households that met the cut-off point were included in the data collection survey. One representative in each household that met the criteria was interviewed and the data were included in the dataset. The sample was, therefore, representative of the general farming population in Grenada.

Univariate Analyses to Justify Covariates in the Study

Cross-tabulation tables were produced and analyzed to determine the counts in each cell to ascertain that the variable can be included in binomial logistic regression analyses. Variables with 10 or more counts in each cell were not included in this section. Variables with smaller counts in the cells were shown in this section. Further, an explanation was provided of the measures taken to increase the count in the cells for the binomial regression analysis.

Number of parcels of land operated. Table 1 shows the cross-tabulation for the independent variable number of parcels of land operating and the dependent variable, ever use of agrochemical. The counts in the cells for farmers who reported ever use of agrochemicals ranged from 0-818. The cells with 0, 21, and 219 counts were combined for the binomial regression analysis.

Table 1

Cross-tabulation of Frequency of Parcels of Land Operated by Farmers and Frequency of Use of Agro-chemicals

		Frequency of use of agrochemicals		
		Ever used agrochemicals	Never used agrochemicals	Total
1-2 parcels	Frequency (n)	818	7073	7891
	Percentage (%)	77.3%	90.7%	89.1%
3-5 parcels	Frequency (n)	219	695	914
	Percentage (%)	20.7%	8.9%	10.3%
6-10 parcels	Frequency (n)	21	31	52
	Percentage (%)	2.0%	0.4%	0.6%
≥11	Frequency (n)	0	1	1
	Percentage (%)	0.0%	0.0%	0.0%
Total	Frequency (n)	1058	7800	8858
	Percentage (%)	100.0%	100.0%	100.0%

Parish. Table 2 shows the cross-tabulation for the independent variable parish and the dependent variable, use of herbicide ≥12 times per year. The counts in the cells for farmers who used herbicide ≥12 times per year ranged from 0-16. The results show a small numbers of farmers used herbicide ≥12 times per year in each parish in which the farm was located. Owing to the small number of counts in the cells, binomial regression analysis was not practical to assess the relationship between the independent and dependent variables.

Table 2

Cross-tabulation of Frequencies for Parish of Location of Farm and Frequency of Use of Herbicides

		Frequency of use of agrochemicals		
		<12times per year	≥12 times per year	Total
St George	Frequency (n)	34	1	35
	Percentage (%)	5.7%	3.6%	5.6%
St John	Frequency (n)	117	2	119
	Percentage (%)	19.8%	7.1%	19.2%
St Mark	Frequency (n)	20	1	21
	Percentage (%)	3.4%	3.6%	3.4%
St Patrick	Frequency (n)	82	5	87
	Percentage (%)	13.9%	17.9%	14.0%
St Andrew	Frequency (n)	254	16	270
	Percentage (%)	42.9%	57.1%	43.5%
St David	Frequency (n)	80	3	83
	Percentage (%)	13.5%	10.7%	13.4%
Carriacou	Frequency (n)	5	0	5
	Percentage (%)	0.8%	0.0%	0.8%
	Frequency (n)	592	28	620
Total	Percentage (%)	100.0%	100.0%	100.0%

Education. Table 3 shows the cross-tabulation for the independent variable education and the dependent variable, use of herbicide ≥12 times per year. The counts in cells of farmers who used herbicide ≥12 times per year ranged from 0-20. The results show none of the farmers who used herbicide ≥12 times per year completed school at primary and university levels. Owing to the small number of counts, the categories of primary and secondary levels were combined and all other categories were combined, respectively, to increase the counts in the cells for binomial regression analysis.

Table 3

Cross-tabulation of Frequencies for Highest Level of Education Completed and Frequency of Use of Herbicides

		Frequency of use of agrochemicals		
		<12times per year	≥12 times per year	Total
Primary	Frequency (n)	10	0	10
	Percentage (%)	1.7%	0.0%	1.6%
Secondary	Frequency (n)	332	20	352
	Percentage (%)	56.1%	71.4%	56.8%
Vocational	Frequency (n)	112	4	116
	Percentage (%)	18.9%	14.3%	18.7%
University	Frequency (n)	20	0	20
	Percentage (%)	3.4%	0.0%	3.2%
Tertiary	Frequency (n)	118	4	122
	Percentage (%)	19.9%	14.3%	19.7%
Total	Frequency (n)	592	28	620
	Percentage (%)	100.0%	100.0%	100.0%

Experienced production issue. Table 4 shows the cross-tabulation for the independent variable presence of production issue and the dependent variable, use of herbicide ≥12 times per year. The counts in cells for farmers who used herbicide ≥12 times per year ranged from 0-28. None of the farmers without production issues indicated use of herbicide ≥12 times per year. Owing to zero count in one category of farmers experiencing production issue, binomial regression analysis was not practical to assess the relationship between the independent and dependent variables.

Table 4

Cross-tabulation of Frequencies for Experienced Production Issue and Frequency of Use of Herbicides

		Frequency of use of agrochemicals		
		<12times per year	≥12 times per year	Total
No production issue experienced	Frequency (n)	65	0	65
	Percentage (%)	11.0%	0.0%	10.5%
Experienced production issue	Frequency (n)	527	28	555
	Percentage (%)	89.0%	100.0%	89.5%
Total	Frequency (n)	592	28	620
	Percentage (%)	100.0%	100.0%	100.0%

Size of household. Table 5 shows the cross-tabulation for the independent variable size of household and the dependent variable, use of herbicide ≥12 times per year. The counts in cells for farmers who used herbicide ≥12 times per year ranged from 0-18. The cells with 10 and 0 counts were combined for the binomial regression analysis.

Table 5

Cross-tabulation of Frequencies for Size of Farmers Households and Frequency of Use of Herbicides

		Frequency of use of agrochemicals		
		<12times per year	≥12 times per year	Total
0-4 household members	Frequency (n)	437	18	455
	Percentage (%)	73.8%	64.3%	73.4%
5-9 household members	Frequency (n)	145	10	155
	Percentage (%)	24.5%	35.7%	25.0%
≥10 household members	Frequency (n)	10	0	10
	Percentage (%)	1.7%	0.0%	1.6%
Total	Frequency (n)	592	28	620
	Percentage (%)	100.0%	100.0%	100.0%

Number of parcels of land operated. Table 6 shows the cross-tabulation for the independent variable number of parcels of land operating and the dependent variable, use of herbicide ≥12 times per year. The counts for farmers who used herbicide ≥12 times per year ranged from 3-15. The results show the categories with 15, 10, and 3 counts, respectively. The cells with 10 and 3 counts were combined for the binomial regression analysis.

Table 6

Cross-tabulation of Frequencies for Number of Parcels of Land Operated by Farmers and Frequency of Use of Herbicides

		Frequency of use of agrochemicals		
		<12times per year	≥12 times per year	Total
1-2 parcels	Frequency (n)	440	15	455
	Percentage (%)	74.3%	53.6%	73.4%
3-5 parcels	Frequency (n)	141	10	151
	Percentage (%)	23.8%	35.7%	24.4%
≥6 parcels	Frequency (n)	11	3	14
	Percentage (%)	1.9%	10.7%	2.3%
Total	Frequency (n)	592	28	620
	Percentage (%)	100.0%	100.0%	100.0%

Number of unpaid nonhousehold members working on the farm - Table 7 shows the cross-tabulation for the independent variable number of unpaid workers on the farm and the dependent variable, use of herbicide ≥12 times per year. The counts in the cells ranged from 0-26. Owing to the small counts in 3 cells, binomial regression analysis was not practical to assess the relationship between the independent and dependent variables.

Table 7

Cross-tabulation of Number of Nonhousehold Members Working on the Farm in the Last Week and Frequency of Use of Herbicides

		Frequency of use of agrochemicals		
		<12times per year	≥12 times per year	Total
No members	Frequency (n)	537	26	563
	Percentage (%)	90.7%	92.9%	90.8%
1-2 members	Frequency (n)	47	2	49
	Percentage (%)	7.9%	7.1%	7.9%
3-4 members	Frequency (n)	7	0	7
	Percentage (%)	1.2%	0.0%	1.1%
≥5 members	Frequency (n)	1	0	1
	Percentage (%)	0.2%	0.0%	0.2%
Total	Frequency (n)	592	28	620
	Percentage (%)	100.0%	100.0%	100.0%

Number of paid workers on the farm in the past 2 weeks. Table 8 shows the cross-tabulation for the independent variable number of paid workers on the farm in the past 2 weeks and the dependent variable, use of herbicide ≥12 times per year. The counts in the cells for farmers who used herbicide ≥12 times per year ranged from 1-17. The cells with 7, 3, and 1count were combined for the binomial regression analysis.

Table 8

Cross-tabulation of Number of paid Workers on the Farm in the Last Week and Frequency of Use of Herbicides

		Frequency of use of agrochemicals		
		<12times per year	≥12 times per year	Total
No workers	Frequency (n)	387	17	404
	Percentage (%)	78.8%	60.7%	77.8%
1-3 workers	Frequency (n)	81	7	88
	Percentage (%)	16.5%	25.0%	17.0%
4-6 workers	Frequency (n)	19	3	22
	Percentage (%)	3.9%	10.7%	4.2%
≥7 workers	Frequency (n)	4	1	5
	Percentage (%)	0.8%	3.6%	1.0%
Total	Frequency (n)	491	28	519
	Percentage (%)	100.0%	100.0%	100.0%

Results

Descriptive Statistics

The descriptive statistics shows the frequency of responses of the categorical independent and dependent variables.

Response rate. The dataset of the Grenada 2012 Agriculture Census contained the responses of 9295 farmers. Of the 9295 farmers in the dataset, 95.4% (N = 8868) were involved either in crop production only or in both crop production and animal husbandry. These farmers were included in the analysis. A total of 427 farmers were only involved in animal husbandry and were excluded in the analysis as they were not expected to use the agrochemicals specified in this study.

Social characteristics of farmers. The social characteristics of the farmers that were investigated in this study were: gender, age, education, size of household, and membership in a farm organization.

Gender, age, education. A total of 71.5% of the farmers were males (n = 6343) and 28.5% were females (n = 2525). The majority of farmers were in the middle to older age groups, 45-54 (26.2%, n = 2324), 55-64 (19.1%, n = 1694), 35-44 (18.1%, n = 1608), and 65-74 (12.7%, n = 1127). More than half of the farmers completed education at the secondary school level (56.9%, n = 5044) while a quarter completed a vocational school at the highest level of education (25.1%, n = 2226). The smallest number of farmers completed their education at primary school (0.8%, n = 70) and university (2.6%, n = 230). Table 9 shows the frequency and percent statistics of gender, age, and education of the farmers.

Table 9

Frequency and Percent Statistics of Participants Gender, Age, and Education

Demographic	Frequency (n)	Percentage (%)
Gender		
Male	6343	71.5
Female	2525	28.5
Total	8868	100.0
Age		
15-24	242	2.7
25-34	917	10.3
35-44	1608	18.1
45-54	2324	26.2
55-64	1694	19.1
65-74	1127	12.7
≥75	701	7.9
No response	255	2.9
Total	8868	100.0
Education		
Primary	70	.8
Secondary	5044	56.9
Vocational	2226	25.1
University	230	2.6
Tertiary	1272	14.3
No response	26	.3
Total	8868	100.0

Size of household. The farmers were asked the total number of persons that lived in the household at the time of the interview. The majority of farmers had household size in the smallest category with 1-4 members (74.8%, n = 6633). Almost one quarter of the farmers had larger households with 5-9 members (23.7%, n = 2101). Less than 2% of farmers had 10 or more members in the household. Table 10 shows the frequency and percent statistics of members in the farmers' households.

Table 10

Frequency and Percent Statistics of Number of Members in Farmers Household

Demographic	Frequency (n)	Percentage (%)
Size of Household		
1-4 members	6633	74.8
5-9 members	2102	23.7
≥ 10 members	123	1.4
No response	10	.1
Total	8868	100.0

Membership in a farm organization. The farmers were asked whether they belonged to any farm organization, including Fair Trade, Grenada Cocoa Association (GCA), Grenada Cooperative Nutmeg Association (GCNA), Farm Watch, Carriacou Farmers Associations, or other farm organizations. The majority of farmers did not have membership in a farm organization (67.8%, n = 6013). Table 11 shows the frequency and percent statistics of number of members in famers' household.

Table 11

Frequency and Percent Statistics of Farmers with Membership in Farm Organizations

Demographic	Frequency (n)	Percentage (%)
Membership in a Farm Organization		
Yes	2845	32.1
No	6013	67.8
No response	10	.1
Total	8868	100.0

Economic characteristics of farmers. The economic characteristics of the farmers that were investigated in this study were: location of the farm, weekly hours of work, income, access to credit, status of land ownership, parcels of land operated, number of paid and unpaid workers on the farm, production issues, maintenance of farm records, use of agro-chemicals, receipt of technical assistance, and markets.

Location of farm. The farmers were asked to state the parish in which the farm was located on the mainland or whether in Carriacou or Petite Martinique. About one-third of the farms were located in the parish of St. Andrew which is the largest parish on the mainland and in the State of Grenada (34.1%, n = 3022). Further, about equal percentages of farms were located in the parishes of St. George (18.9%, n = 1678) and St. David (18.1%, n = 1602). On the mainland, the smallest number of farms was located in St. John and St. Mark which are the smallest parishes on the mainland. Overall, the smallest number of farms was located in Carriacou and Petite Martinique which are small dependency islands in the jurisdiction of the State of Grenada. Table 12 shows the frequency and percent statistics of the location of the farm.

Table 12

Frequency and Percent Statistics of the Location of the Farm

Demographic	Frequency (n)	Percentage (%)
Location of the Farm		
St. George	1678	18.9
St. John	640	7.2
St. Mark	302	3.4
St. Patrick	1333	15.0
St. Andrew	3022	34.1
St. David	1602	18.1
Carriacou	270	3.0
Petite Martinique	11	.1
No response	10	.1
Total	8868	100.0

Weekly hours of work, income, and access to credit. The farmers were asked about weekly hours of work on the farm, only 7.1% farmers worked ≤36 hours on the farm during a one week period (n = 628). Over two-thirds of farmers worked ≥ 36 hours. Table 7 shows the frequency and percent statistics of main occupation of the farmers in the last 13 months before the interview.

When asked about the proportion of income received from farming in the last 12 months, the majority of farmers reported they did not earn income from farming (43.4%, n = 3850). Further, 22.1% earned less than a quarter of their total income (n = 1956) and only 7.0% earned all income from farming (n = 624). Table 13 shows the frequency and percent statistics of and income from farming in the last 12 months before the interview.

The farmers were also asked whether they accessed credit from a development bank, commercial bank, farm organization, Ministry of Agriculture, non-government organization, credit union, Marketing and National Importing Board (MNIB), or other institution in the last 12 months before the interview. The overwhelming majority of farmers did not access credit during the 12-month period (98.3%, n = 8719). Only a very small percentage of farmers had accessed credit from one or more of the institutions. Table 13 shows the frequency and percent statistics of access to credit by farmers in the last 12 months before the interview.

Table 13

Frequency and Percent Statistics of Weekly Hours of Work, Income from Crop Production, Access to Credit

Demographic	Frequency (n)	Percentage (%)
Weekly Hours of Work on Farm		
No hours	7	.1
≤35 hours (part time)	6658	75.1
≥ 36 hours (full time)	628	7.1
No response	1575	17.8
Total	8868	100.0
Income in the Last 12 Months		
All income	624	7.0
None income	3850	43.4
Half of income	924	10.4
About 1/4 of income	1443	16.3
Less than 1/4 income	1956	22.1
No response	71	.8
Total	8868	100.0
Access to Credit in the Last 12 Months		
Yes	139	1.6
No	8719	98.3
No response	10	.1
Total	8868	100.0

Legal status and parcels of land operated by the farmer. The farmers were asked whether the farm was legally owned by an individual, two or more members of the same household or joint ownership with two or more members from different households. Joint ownership included company, cooperative, government farm, or other. The overwhelming majority of farmers were individual owners of the farm (83.6%, n = 7410) while 12.9% of farmers jointly owned farms with other members of the household (n =

1147) and less than 5% of farmers had joint ownership with nonhousehold members. Table 14 shows the frequency and percent statistics of legal status of ownership of the farms.

The farmers were also asked the number of parcels of land they operated on the day of the interview. A parcel of land was defined as any piece of land under a single form of tenure, surrounded by other land, water, road, forest, etc. that is not part of the piece of land (Government of Grenada, 2012b). The majority of farmers operated 1-2 parcels of land (89.0%, n = 7891). Further, 10.3% of farmers operated two parcels of land (n = 914). Less than 1% of farmers operated more than 5 parcels of land. Table 14 shows the frequency and percent statistics of the number of parcels of land operated by the farmers.

Table 14

Frequency and Percent Statistics of Legal Status of the Farms and Parcels of Land Operated by the Farmer

Demographic	Frequency (n)	Percentage (%)
Legal Status of the Farm		
Individual	7410	83.6
2 or more persons from same household	1147	12.9
2 or more persons from different households, including government owned farms	301	3.4
No response	10	.1
Total	8868	100.0
Parcels of Land Operated by the Farmer		
1-2	7891	89.0
3-5	914	10.3
6-10	52	.6
≥11	1	.0
No response	10	0.1
Total	8868	100.0

Paid and unpaid workers on the farm. The farmers were asked about paid workers and unpaid nonhousehold members working on the farm in the last week before the interview. The majority of farmers did not employ paid workers on the farm in the week before the interview. A total of 79.9% of the farmers reported there were no paid workers on the farm during the period (n = 7082). In cases where there were paid workers on the farm, 16.8% had 1-2 paid workers on the farm (n = 1487). Less than 1% farmers had more than 5 paid workers on the farm in the week before the interview.

Further, 93.1% of farmers also reported there were no unpaid nonhousehold workers on the farm in the week before the interview (n = 8253). Of the farmers that had unpaid nonhousehold members working on the farm, 6% reported they had 1-2 persons (n = 533). Table 15 shows the frequency and percent statistics of paid and un-paid workers on the farm in the week before the interview.

Table 15

Frequency and Percent Statistics of Paid and Unpaid Workers on the Farm in the Previous Week

Demographic	Frequency (n)	Percentage (%)
Paid Workers on the Farm in the Previous Week		
0	7082	79.9
1-2	1487	16.8
3-4	230	2.6
5-6	44	.5
≥7	15	.2
No response	10	.1
Total	8868	100.0
Unpaid Nonhousehold Workers on the Farm in the Previous Week		
0	8253	93.1
1-2	533	6.0
3-4	65	.7
≥7	7	.1
No response	10	0.1
Total	8868	100.0

Production issues and farm records. The farmers were asked whether they experienced issues in production including pest and diseases, access to technical support, storage, availability of inputs, marketing, and access to land. The majority of farmers stated they experienced issues (62.5%, n = 5544). Praedial larceny (stealing), pest, lack of accessible roads, and diseases were most commonly reported issues in production. Additionally, the overwhelming majority of farmers did not maintain farm records (91.7%, n = 8134). Table 16 shows the frequency and percent statistics of farmers that reported experience with production issues and maintenance of farm records.

Table 16

Frequency and Percent Statistics of Farmers Experience With Issues in Production and Maintenance of Farm Records

Demographic	Frequency (n)	Percentage (%)
Experienced Production Issue		
No Farming Issue	3324	37.5
Farming Issue	5544	62.5
Total	8868	100.0
Type of Production Issue Experienced[a]		
Access Roads	892	16.1
Access to Credit	41	0.7
Access to Land	34	0.6
Availability of Inputs	93	1.7
Disease	387	7.0
Dog Predation	148	2.7
Marketing	163	2.9
Pest	1155	20.8
Praedial Larceny	2302	41.5
Storage	24	0.4
Technical Support	305	5.5
Farm Record Maintenance		
Yes	724	8.2
No	8134	91.7
No response	10	.1
Total	8868	100.0

[a]Farmers were requested to report all production issues.

Use of agrochemicals and receipt of technical assistance. The farmers were asked about the type of agrochemicals used in the past 12months before the interview and the frequency of use. Overall, 11.9 % farmers reported they used at least one herbicide, insecticide, or fungicide (n = 1059). The farmers were also asked about receipt of technical assistance from the Ministry of Agriculture, farm organizations, media, non-government organizations, Chinese mission, Caribbean Agricultural Research and Development Institute (CARDI), Inter-American Institute for Cooperation *Agriculture* (*IICA*), and other institutions in the last 12 months before the interview. Only 6.4% farmers reported they received technical assistance from one or more of the institutions (n = 570). Table 17 shows the frequency and percent statistics of use of agrochemical by farmers and receipt of technical assistance.

Table 17

Frequency and Percent Statistics of Agrochemical Use by Farmers and Receipt of Technical Assistance

Demographic	Frequency (n)	Percentage (%)
Use of Agrochemical in the Last 12 Months		
Used agrochemical	1059	11.9
Did not use agrochemical	7809	88.1
Total	8868	100.0
Receipt of Technical Assistance in the Past 12 Months		
Yes	570	6.4
No	8288	93.5
No response	10	.1
Total	8868	100.0

Market. The farmers were asked to identify the markets to which they sold products. The largest number of farmers reported they did not sell to markets (62.1%, n = 5509). Further, 28.3% farmers sold products to associations (n = 2511), and 17.5% sold at roadside (n = 1554), 13.9% sold on the farm (n = 1230) and 12% sold to supermarkets (n = 1260). Table 18 shows the frequency and percent statistics of the markets accessed by the farmers.

Table 18

Frequency and Percent Statistics of Markets Accessed by the Farmers

Demographic	Frequency (n)	Percentage (%)
Access for Markets		
Do not sell to markets	5509	62.1
Sell to markets	3349	37.8
No response	10	.1
Total	8868	100.00
Type of Market Accessed [b]		
Hotel/restaurant	423	4.8
Municipal market	607	6.8
Roadside vending	1554	17.5
On farm	1230	13.9
Supermarkets	1066	12.0
Traffickers/exporters	879	9.9
Agro-processors	117	1.3
Associations	2511	28.3
Marketing Board	806	9.1
Farmers market	271	3.1
Schools	147	1.7
Other markets	995	11.2

[b]Farmers were requested to report all markets

Summary of Results of the Descriptive Statistics

The results of the descriptive analysis show the social and economic characteristics of the framers who participated in the in the 2012 agriculture census in

Grenada. The results on the social characteristics of the farmers indicated: almost three-quarters of the farmers were males, about one quarter of the farmers were middle-aged between 45-54 years, more than half of the farmers completed secondary school at the highest level of education, about three-quarters of the farmers had households with 1-4 members, and more than half of the farmers did not have membership in farm organizations.

The results on the economic characteristics of the farmers indicated: about one-third of the farms were located in St. Andrew and St. George which were the largest and second largest parishes, respectively, on the mainland. On the mainland, the smallest number of farms was located in St. John and St. Mark which were also the smallest parishes on the mainland. Overall, the smallest number of farms was located in Carriacou and Petite Martinique which were small dependency islands in the jurisdiction of the State of Grenada. Further, the results on the economic characteristics of the farmers indicated: two-thirds of the farmers worked on the farm on a part time basis; cumulatively, more than half of the farmers earned no income and up to quarter of income from agriculture; almost none of the farmers accessed credit in the census year; more than three-quarters of the farmers operated 1-2 parcels of land; more than three-quarters of the farmers had individual ownership of the land; more than three-quarters of the farmers did not have paid workers on the farm in the past week before the interview; almost none of the farmers had unpaid household workers on the farm in the past week; more than half of the farmers experienced issues in production; almost none of the farmers maintained farm records; about 12% of the farmers used agrochemicals in the census year; almost none of the farmers received technical assistance in the census year; and more than half of the farmers did not sell to markets.

Assumptions for Binomial Regression Analysis

Logistic regression analysis was conducted to investigate the relationship between the independent variables and the dependent variable. Logistic regression is an inferential analysis performed to predict the probability of an outcome in a dependent variable based on a relationship with an independent variable) (Laerd Statistics, 2018). The type of regression analysis differ, however, base on the level of measurement and type of dependent variable, such as continuous, dichotomous, or categorical (Frankfort-Nachmias & Leon-Guerrero, 2015). Binomial regression analysis was used to test the hypothesis for both RQ1 and RQ 2. Three assumptions were critical to conduct binomial logistic regression.

First, the dependent variable should be measured on a dichotomous scale. A variable is measured on a dichotomous scale when there are two outcome values for the dependent variable (Laerd Statistics, 2018). For RQ1, the values of the dependent variable (frequency of use of agro chemical) was ever used agrochemical and never used agrochemical to determine potential for experiencing sleep apnea, rheumatoid arthritis, decrease in LINE-1 DNA methylation, allergic and non-allergic wheeze. The dependent variable was, therefore, measured on a dichotomous scale. Therefore, this first assumption was met in the analysis. For RQ2, the values of the dependent variable were $\leq$ 2088 and $\geq$2088. The variable was, therefore, measured on a dichotomous scale.

The second assumption for conducting binomial regression is that one or more independent variables are included in the analysis and that the independent variables are either continuous or categorical (Laerd Statistics, 2018). All variables used in the analysis were categorical. A categorical variable has two or more categories that are labeled or named for the purpose of classifying or grouping observations (Frankfort-Nachmias & Leon-Guerrero, 2015). The categories of the variables are shown above.

The third assumption for binomial regression analysis is independence of observations between the independent variables and the categories of the dependent variable (Laerd Statistics, 2018). As such, the dependent variable should have mutually exclusive categories (Laerd Statistics, 2018). This assumption is met, as the values of the dependent variable for RQ1 are exclusive of each other: ever used agrochemical and never used agrochemical. The values of the dependent variable for RQ2 were < 2088 and ≥ 2088.

Results for RQ1

RQ1: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause the specified pathologies?

Null Hypothesis: There was no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and frequency of use per year of agrochemicals at levels that can potentially cause the specified pathologies. The specified pathologies in the research question were sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze. The socioeconomic characteristic (independent variables) were age, gender, parish of location of the farm, highest level of education completed, markets, receipt of credit, size of household, number of paid workers, status of land ownership, maintenance of farm records, number of nonhousehold members working on the farm, number of parcels of land operated by the farmer, daily number of hours farmer worked on the farm, membership in a farm organization, receipt of technical assistance, production issues, and income from agriculture production. The dependent variable was frequency of use of agrochemical (ever used and never used). The relationship between each individual independent variable and the dependent variable was investigated. The B value also indicated the direction of the relationship with the dependent variable (B). The table also shows the standard errors (S.E.), the ratio of the regression weight to the standard error (Wald), significance level (sig.), odds ratio (exp B), and the 95%CI of the odds ratio. Odds ratio indicated how much more or less a case is likely to be in the affirmative category as compared to the reference group.

Gender. The logistic regression chi square result show the model was statistically significant, $\chi^2(1, N = 8868) = 58.30, p < .01$) for predicting the impact of gender on frequency of use of agrochemical. The model explained 1.3% (Nagelkerke R^2) of the variance in frequency of use of agrochemical by gender. The model correctly classified 88.1% of cases. Male was used as the reference group. The odds of females’ ever use of agrochemical was lower than 1 and statistically significant (OR .549, 95% CI: .467-.645, $p < .001$). Females were, therefore, less likely to have ever used agrochemical and experienced the health problems stated in RQ1. We, therefore, reject the null hypothesis that there was no relationship between gender and ever use of agrochemical. Table 19 shows the variables in the equation for logistic regression analysis with gender and frequency of use of agrochemical.

Table 19

Logistic Regression Analysis with Frequency of Use of Agrochemical and Gender

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Gender (F)	-.599	.082	53.007	1	.000	.549	.467	.645
Constant	2.453	.074	1108.262	1	.000	11.625		

Age. The logistic regression model was statistically significant, $\chi^2(6, N = 8613) = 34.14, p < .01)$. The model explained about 1.00% (Nagelkerke R^2) of the variance in frequency of use of agrochemical by age. The model correctly classified 87.9% of cases. The youngest age category, 15-24 years, was used as the reference group to compare the relationship between age-groups and the frequency of use of agrochemical. Compared to the reference group, the odds ratio for ever use of agrochemical by farmers aged 25-34 years was higher than 1 (OR 1.56, 95% CI: .865- 2.82) but not statistically significant (p = .140). Further, compared to the reference group, the odds ratio was lower than 1 for farmers in all age groups ≥35 years for ever use of agrochemical. The difference in the odds ratio for ever use of agrochemical was statistically significant between farmers aged 15-24 years and farmers aged 55-64 years (OR .725, 95% CI: .51- .989, $p = .042$) and 65-74 years (OR 1.56, 95% CI: .865- 2.82). The results indicated that older farmers were less likely to have ever used agrochemical at levels that can potentially cause the diseases stated in RQ1, compared to younger farmers. The overall difference between the reference group the other age groups was statistically significant ($p<.001$). We, therefore, reject the null hypothesis that there was no relationship between age and ever use of agrochemical. Table 20 shows the variables in the equation for logistic regression analysis with age and frequency of use of agrochemical

Table 20

Logistic Regression Analysis with Frequency of Use of Agrochemical and Age

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
15-24			32.471	6	.000			
25-34	.445	.301	2.183	1	.140	1.561	.865	2.817
35 -44	-.160	.176	.825	1	.364	.852	.603	1.203
45-54	-.238	.161	2.192	1	.139	.788	.576	1.080
55-64	-.518	.152	11.612	1	.001	.596	.442	.802
65-75	-.322	.158	4.123	1	.042	.725	.531	.989
≥75	-.120	.169	.505	1	.477	.887	.637	1.234
Constant	2.272	.140	261.990	1	.000	9.696		

Parish of location of the farm. The logistic regression model was statistically significant, $\chi^2(7, N = 8858) = 232.38, p < .01$). The model explained about 5.00% (Nagelkerke R^2) of the variance in parish of location of the farm and frequency of use of agrochemical. The model correctly classified 88.1% of cases. The most urbanized parish, St. George was used as the reference considering most of the agrochemical supply shops were also located in the area and, therefore, farmers in close proximity may have ready access to the chemicals compared to farmers in the other parishes.

Compared to St. George, the odds of ever used agrochemical by farmers with farms in the parishes on the mainland was lower than 1– St. Andrew (OR .370, 95% CI: .294- .467), St. David (OR .517, 95% CI: .399- .670), St. Mark (OR .600, 95% CI: .387- .932), St. John (OR .159, 95% CI: .122- .208), and St. Patrick (OR .511, 95% CI: .390- .668) – but statistically significant (p<.05). The odds of ever used agrochemical by farmers with farms in Petite Martinique was lower than 1 (OR .614, 95 CI .78 – 4.842, p = .643) compared to ever used agrochemical by farmers in St. George. On the other hand, the odds of ever used agrochemical by farmers with farms in Carriacou was higher than 1 (OR 1.445, 95 CI .762 – 2.732) but not statistically significant (p = .258).

The results indicated that farmers with farms in the rural parishes on the mainland and in petite Martinique were less likely to have ever used agrochemical and potentially less likely to experience the health problems stated in RQ1 as compared to farmers with farms in St. George. Overall, the differences in the odds of ever used agrochemical by the farmers with farms in St. George and farmers in the other parishes was statistically significant (*p*<.001). We, therefore, reject the null hypothesis that there was no relationship between the parish in which he farm was located and ever used agrochemical. Table 21 shows the variables in the equation for logistic regression analysis with parish in which the farm was located and frequency of use of agrochemical.

Table 21

Logistic Regression Analysis with Frequency of Use of Agrochemical and Parish of Farm Location

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
St. George			226.286	7	.000			
St. John	-1.837	.137	180.287	1	.000	.159	.122	.208
St. Mark	-.510	.224	5.174	1	.023	.600	.387	.932
St. Patrick	-.672	.137	24.069	1	.000	.511	.390	.668
St. Andrew	-.995	.117	72.469	1	.000	.370	.294	.465
St. David	-.660	.132	24.865	1	.000	.517	.399	.670
Carriacou	.368	.325	1.280	1	.258	1.445	.764	2.732
Petite Martinique	-.489	1.054	.215	1	.643	.614	.078	4.842
Constant	2.791	.105	711.972	1	.000	16.299		

Education. The logistic regression model was statistically significant, $\chi^2(4, N = 8842) = 22.70, p < .01$). The model explained about 1.00% (Nagelkerke R^2) of the variance in education and frequency of use of agrochemical. The model correctly classified 88.0% of cases. The lowest level at which education was completed—primary school—was used as the reference group. Compared to the farmers who completed education the lowest level, the odds of ever used agrochemical was higher than 1 for all other levels at which education was completed. The difference in the odds ratio for ever used agrochemical between farmers who completed school at the primary level and farmers who completed school at the vocational level was statistically significant (OR 1.945, 95 CI 1.026 – 3.679, p = .041).

The results indicated that farmrs who completed education at levels higher than primary school were more likely to have ever used agrochemicals and potentially experience the health problems stated in RQ1. Overall, the differences in the odds of ever used agrochemical by the farmers who completed education at the primary or lower level of school and farmers who completed their education at a level higher than primary school was statistically significant ($p<.001$). We, therefore, reject the null hypothesis that there was no relationship between education and ever used agrochemical. Table 22 shows the variables in the equation for logistic regression analysis with level of completion of education and frequency of use of agrochemical.

Table 22

Logistic Regression Analysis with Frequency of Use of Agrochemical and Level of Completion of Education

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Primary			22.450	4	.000			
Secondary	.399	.320	1.553	1	.213	1.490	.796	2.790
Vocational	.665	.325	4.187	1	.041	1.945	1.028	3.679
University	.142	.366	.150	1	.698	1.153	.562	2.364
Tertiary	.214	.327	.430	1	.512	1.239	.653	2.352
Constant	1.576	.317	24.681	1	.000	4.833		

Market presence. The logistic regression model was statistically significant, $\chi^2(1, N = 8858) = 356.52, p < .01$). The model explained about 8.00% (Nagelkerke R^2) of the variance in market presence and frequency of use of agrochemical. The model correctly classified 88.1% of cases. No market presence was used as the reference group in further examination of the effect of market presence on ever used agrochemical. Compared to farmers who did not sell to market, farmers who had market presence were at least 3 times more likely to have ever used agrochemical (OR 3.54, 95% CI: 3.088 – 4.047) and to also experience the health problems stated in RQ1. The difference in the odds ratio for ever use of agrochemical between farmers without market presence and farmers with market presence was statistically significant (p<.001). We, therefore, reject the null hypothesis that there was no relationship between the parish in which he farm was located and ever used agrochemical. Table 23 shows the variables in the equation for logistic regression analysis with market presence and frequency of use of agrochemical.

Table 23

Variables in the Equation for Logistic Regression Analysis with Frequency of Use of Agrochemical and Market Presence

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Sell to markets	1.263	.069	334.768	1	.000	3.535	3.088	4.047
Constant	1.375	.042	1053.557	1	.000	3.956		

Income from agriculture production. The logistic regression model was statistically significant, $\chi^2(4, N = 8797) = 278.27, p < .01$). The model explained about 6.00% (Nagelkerke R^2) of the variance in income from agriculture production and frequency of use of agrochemical. The model correctly classified 88.0% of cases. The highest category of earning from agriculture, all income, was used as the reference group. Compared to the farmers who earned all income from agriculture, the odds of using agrochemical was higher than 1 and statistically significant for farmers who earned half of their income from farming (OR 1.578, 95 CI1.305 – 1.907, p<.01) and lower than 1, but statistically significant, for all the other categories of income earned from agriculture production. The results indicated farmers who earned half of their income from agriculture were also more likely to experience the health problems stated in RQ1. The difference in the odds ratio for ever use of agrochemical between farmers who earned all income and farmers who earned a percentage of income of income from agriculture was statistically significant (p<.001). We, therefore, reject the null hypothesis that there was no relationship between income from agriculture and ever used agrochemicals. Table 24 shows the variables in the equation for logistic regression analysis with income from agriculture production and frequency of use of agrochemical.

Table 24

Logistic Regression Analysis with Frequency of Use of Agrochemical and Income from Agriculture Production

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
All income			278.005	4	.000			
No income	-.870	.121	51.515	1	.000	.419	.330	.531
Half of income	.456	.097	22.209	1	.000	1.578	1.305	1.907
¼ of income	-1.001	.106	89.169	1	.000	.368	.299	.452
≤1/4 of income	-.392	.104	14.170	1	.000	.676	.551	.829
Constant	2.129	.073	842.288	1	.000	8.404		

Presence of agriculture issue. The logistic regression model was statistically significant, $\chi^2(1, N = 8868) = 393.91, p < .01$). The model explained 8.4% (Nagelkerke R^2) of the variance in presence of agriculture issue and the frequency of use of agrochemical. The model correctly classified 88.1% of cases. Absence of production issue was used as the reference category to investigate the relationship between production issue and ever used agrochemical. Compared to the farmers who did not experience production issues, the odds ratio for ever use of agrochemical was lower than 1 for farmers who reported production issue (OR .193, 95%CI: .159-.234). The results indicated that farmers who reported production issues were also less likely to ever use agrochemical and potentially experience the health problems stated in RQ1. The difference in the odds ratio for ever use of agrochemical between farmers who experienced production issue and farmers who did not experience production issue was statistically significant (p<.001). We, therefore, reject the null hypothesis that there was no relationship between presence of production issue and ever used agrochemical. Table 25 shows the variables in the equation for logistic regression analysis with experienced production issue and frequency of use of agrochemicals.

Table 25

Logistic Regression Analysis with Frequency of Use of Agrochemical and Experienced Production Issue

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Experienced production issue	-1.646	.098	282.137	1	.000	.193	.159	.234
Constant	3.242	.091	1264.632	1	.000	25.592		

Membership in a farm organization. The logistic regression model was statistically significant, $\chi^2(1, N = 8858) = 131.87$, $p < .01$). The model explained 2.8%

(Nagelkerke R^2) of the variance in membership in a farm organization and frequency of use of agrochemical. The model correctly classified 88.1% of cases. Belonging to a farm organization was used as the reference category to investigate the relationship between membership in a farm organization and frequency of use of agrochemical. Compared to farmers who had membership in a farm organization, the odds ratio was lower than 1 for farmers who did not belong to a farm organization (OR .463, 95%CI: .407- .527), indicating that the latter group of farmers were less likely to have ever used agrochemical and to experience health problems stated in RQ1. The difference in the odds ratio for ever use of agrochemical between farmers who had and did not have membership in a farm organization was statistically significant ($p<.001$). We, therefore, reject the null hypothesis that there was no relationship between membership in a farm organization and ever used agrochemical. Table 26 shows the variables in the equation for logistic regression analysis with membership in farm organization and frequency of use of agrochemical.

Table 26

Logistic Regression Analysis with Frequency of Use of Agrochemical and Membership in Farm Organization

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Does not belong to farm organization	-.770	.066	134.715	1	.000	.463	.407	.527
Constant	2.296	.045	2633.808	1	.000	9.933		

Receipt of technical assistance. The logistic regression model was statistically significant, $\chi^2(1, N = 8858) = 181.92, p < .01$). The model explained 4% (Nagelkerke R^2) of the variance in receipt of technical assistance by farmers and frequency of use of agrochemical. The model correctly classified 88.1% of cases. Receiving technical assistance was used as the reference category in the analysis to investigate the relationship between farmers' receipt of technical assistance and frequency of use of agrochemical. Compared to farmers who received technical assistance, the odds ratio for ever use of agrochemical was lower than 1 for farmers who did not receive technical assistance (OR .245, 95%CI: .203-.296), indicating farmers who did not receive technical assistance were less likely to have ever used agrochemical and to potentially experience the health problems stated in RQ1. The difference in the odds ratio for ever use of agrochemical between farmers who received technical support and the farmers who did not receive technical support was statistically significant ($p<.001$). We, therefore, reject the null hypothesis that there was no relationship between receipt of technical assistance and ever used agrochemical. Table 27 shows the variables in the equation for logistic regression analysis with receipt of technical assistance and frequency of use of agrochemical.

Table 27

Logistic Regression Analysis with Frequency of Use of Agrochemical and Receipt of Technical Assistance

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
No receipt of technical assistance	-1.406	.096	213.081	1	.000	.245	.203	.296
Constant	2.139	.036	3574.613	1	.000	8.494		

Access to credit. The logistic regression model was statistically significant, $\chi^2(1, N = 8858) = 63.80, p < .01$). The model explained 1.4% (Nagelkerke R^2) of the variance in frequency of use of agrochemical by receipt of credit. The model correctly classified 88.1% of cases. Access to credit was used as the reference category in the analysis to investigate the relationship between access to credit and frequency of use of agrochemical. Compared to farmers who had access to credit, the odds ratio for ever use of agrochemical was lower than 1 for farmers who did not have access to credit (OR .211, 95%CI: .149-.300). The results indicated farmers who did not have access to credit were less likely to have ever used agrochemical and potentially experience the health problems stated in RQ1. The difference in the odds ratio for ever use of agrochemical between farmers who access credit and farmers who did not access credit was statistically significant (p<.001). We, therefore, reject the null hypothesis that there was no relationship between access to credit and ever used agrochemical. Table 28 shows the variables in the equation for logistic regression analysis with receipt of credit and frequency of use of agrochemical.

Table 28

Logistic Regression Analysis with Frequency of Use of Agrochemical and Receipt of Credit

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	95% C.I. for EXP(B) Upper
No receipt of credit	-1.554	.178	76.371	1	.000	.211	.149	.300
Constant	2.038	.034	3693.247	1	.000	7.676		

Legal status of land ownership. The logistic regression model was statistically significant, $\chi^2(2, N = 8858) = 8.76$, $p < .01$). The model explained <1% (Nagelkerke R^2) of the variance in receipt of legal status of ownership of land and frequency of use of agrochemical. The model correctly classified 88.1% of cases. Individual ownership of land was used as the reference group in further examination of the effect of the categories of land ownership status and frequency of use of agrochemical. Compared to farmers who had individual ownership of land, the odds ratio for ever use of agrochemical was higher than 1 and statistically significant for farmers who had joint ownership with household (OR 1.617, 95%CI: 1.088 – 2.171, p = .015) and nonhousehold members (OR 1.637, 95%CI: 1.192-.2.194, p = .002). The results indicated farmers with individual ownership of land were less likely to have ever used agrochemical and experience the health problems stated in RQ1. The overall difference in the odds ratio for ever use of agrochemicals between farmers who individual ownership of land and farmers who had joint ownership was statistically significant (p = .008). We, therefore, reject the null hypothesis that there was no relationship between land ownership status and ever used agrochemical. Table 29 shows the variables in the equation for logistic regression analysis with legal status of land ownership and frequency of use of agrochemical.

Table 29

Logistic Regression Analysis with Frequency of Use of Agrochemical and Legal Status of Land Ownership

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Individual ownership			9.605	2	.008			
Joint ownership with household members	.481	.156	9.541	1	.002	1.617	1.192	2.194
Joint ownership with nonhousehold members	.430	.176	5.956	1	.015	1.537	1.088	2.171
Constant	1.543	.151	103.985	1	.000	4.679		

Keeping farm records. The logistic regression model was statistically significant, $\chi^2(1, N = 8858) = 133.93$, $p < .01$). The model explained <3% (Nagelkerke R^2) of the variance in keeping farm records and frequency of use of agrochemical. The model correctly classified 88.1% of cases. Keeping farm records was used as the reference group to investigate the effect of land keeping farm records on the frequency of use of agrochemical. Compared to farmers who kept farm records, the odds ratio for ever use of agrochemical was lower than 1 for farmers who did not maintain farm records (OR .322, 95%CI: .269 – .385) indicating farmers who did not maintain farm records were less likely to have ever used agrochemicals and potentially experience the health problems stated in RQ1. The overall difference in the odds ratio for ever use of agrochemical between farmers who maintained farm records and farmers who did not maintain records was statistically significant (p = .008). We, therefore, reject the null hypothesis that there was no relationship between maintaining farm records and ever used agrochemical. Table 30 shows the variables in the equation for logistic regression analysis with keeping farm records and frequency of use of agrochemical.

Table 30

Logistic Regression Analysis with Frequency of Use of Agrochemical and Keeping Farm Records

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Do not keep farm records	-1.133	.091	154.452	1	.000	.322	.269	.385
Constant	2.131	.036	3503.993	1	.000	8.425		

Farmers unpaid hours of work on farm. The logistic regression model was statistically significant, $\chi^2(1, N = 7293) = 66.177, p < .01$). The model explained about 2% (Nagelkerke R^2) of the variance in receipt of unpaid hours of work on the farm and frequency of use of agrochemical. The model correctly classified 87.0% of cases. Working ≤ than 35 hours (part time) on the farm was used as the reference group to investigate the effect of the categories of unpaid hours worked on the farm and the frequency of use of agrochemical. Compared to farmers who worked ≤ than 35 hours, the odds ratio for ever use of agrochemical was higher than 1 for farmers who worked ≥36 unpaid hours on the farm (OR .2.378, 95%CI: .269 – .385). The results indicated farmers who worked ≥36 unpaid hours on the farm were more than two times likely to have ever used agrochemical. The farmers who worked ≥35 unpaid hours were also more likely to experience the health problems stated in RQ1. The overall difference in the odds ratio for ever use of agrochemical between farmers who worked ≥35 unpaid hours and farmers who worked ≥36 unpaid hours on farms was statistically significant (p<.01). We, therefore, reject the null hypothesis that there was no relationship between number of unpaid hours of work on the farm and ever used agrochemical. Table 31 shows the variables in the equation for logistic regression analysis with farmers unpaid hours of work and frequency of use of agrochemicals.

Table 31

Logistic Regression Analysis with Frequency of Use of Agrochemical and Farmers Unpaid Hours of Work

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
≥36 unpaid hours	.866	.100	74.546	1	.000	2.378	1.954	2.895
Constant	1.133	.093	148.522	1	.000	3.105		

Size of household. The logistic regression model was not statistically significant, χ^2(2, N = 8858), 3.17, *p = .168*). The model explained about <.1% (Nagelkerke R^2) of the variance in size of household and frequency of use of agrochemical. The model correctly classified 88.1% of cases. The category with the smallest number of household members, 1-4, was used as the reference group to investigate the effect of household size on the frequency of use of agrochemical. Compared to farmers who had 1-4 members in the household, the odds ratio for ever use of agrochemical was lower than 1 for farmers who had 5 or more number of members in the household. The results indicated farmers with smaller households, with 1-4 members, were more likely to have ever used agrochemical and potentially experience the health outcomes stated in RQ 1. The overall difference in the odds ratio for ever use of agrochemical between farmers who had 1-4 members in the household and farmers who had 5 or more number of members in the household was not statistically significant (p = .153). We, therefore, fail to reject the null hypothesis that there was no relationship between size of household and ever used agrochemical. Table 32 shows the variables in the equation for logistic regression analysis with size of farmers' household and frequency of use of agrochemical.

Table 32

Logistic Regression Analysis with Frequency of Use of Agrochemical and Size of Farmers Household

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
0-4 household members			3.750	2	.153			
5-9 household members	-.095	.076	1.572	1	.210	.909	.783	1.055
≥10 household members	-.388	.247	2.462	1	.117	.678	.418	1.102
Constant	2.027	.038	2803.016	1	.000	7.592		

Number of unpaid nonhousehold members working on the farm in the last week - The logistic regression model was not statistically significant, $\chi^2(3, N = 8858)$ =

18.67, *p<.01*). The model explained <1% (Nagelkerke R^2) of the variance in the number of unpaid nonhousehold members working on the farm in the last week and frequency of use of agrochemicals. The model correctly classified 88.1% of cases. The category with the smallest number of unpaid nonhousehold members working on the farm, zero members, was used as the reference in investigating the relationship number of unpaid nonhousehold members working on the farm and the frequency of use of agrochemicals. Compared to farmers who did not have unpaid nonhousehold members working on the farm in the last week, the odds ratio for ever used agrochemical was higher than 1 and statistically significant for all other categories with at least 1 unpaid nonhousehold member working on the farm. Farmers who had 1-2 unpaid nonhousehold members working on the farm were at least 10 times (OR 10.165, 95%CI: 2.275 – 45.487, p<.01) more likely to have ever used agrochemical. Further, farmers who had 3-4 unpaid nonhousehold members (OR .6.930, 95%CI: .1.524 – 31.517, p = .012) and 5 and more workers (OR 6.545, 95%CI: 1.281 – 33.451, p = .024) were about 7 times more likely to have ever used agrochemical. This finding indicated that farmers who had at least one nonhousehold member working on the farm in the last week had a greater potentially to experience the health problems stated in RQ 1. The overall difference in the odds ratio for ever use of agrochemical between farmers who had 1-2 and 3 or more unpaid nonhousehold members working on the farm in the last week was not statistically significant (p<.01). We, therefore, reject the null hypothesis that there was no relationship between number of unpaid nonhousehold members and ever used agrochemical. Table 33 shows the variables in the equation for logistic regression analysis with number of unpaid nonhousehold members working on the farm in the last week and frequency of use of agrochemicals.

Table 33

Logistic Regression Analysis with Frequency of Use of Agrochemical and Number of Unpaid Nonhousehold Members Working on the Farm in the Last Week

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
None			20.207	3	.000			
1-2	2.319	.765	9.200	1	.002	10.165	2.272	45.487
3-4	1.936	.773	6.275	1	.012	6.930	1.524	31.517
≥5	1.879	.832	5.095	1	.024	6.545	1.281	33.451
Constant	-.288	.764	.142	1	.706	.750		

Number of parcels of land operated - The logistic regression model was not statistically significant, χ^2(1, N = 8858), 140.662, $p<.01$). The model explained 3.0% (Nagelkerke R^2) of the variance in ever use of agrochemical by parcels of land operated. The model correctly classified 88.1% of cases. The category with the smallest number of parcels of land operated, 1-2 parcels, was used as the reference group to investigate the effect of the categories of parcels of land operated on ever use of agrochemical. Compared to farmers who operated 1-2 parcels of land, the odds ratio for ever use of agrochemical was higher than 1 (OR 2.854, 95%CI: 2.424 – 3.359) for farmers who operated 3 or more parcels of land. The results indicated farmers who operated larger number of parcels of land were more likely to have ever used agrochemical and potentially experience the diseases stated in RQ1. The overall difference in the odds ratio for ever use of agrochemical between farmers who had 1-2 parcels of land operating and farmers who had 3 or more parcels of land operating was statistically significant (p<.01). We, therefore, reject the null hypothesis that there was no relationship between parcels of land operating and ever use of agrochemical. Table 34 shows the variables in the equation for logistic regression analysis with number of parcels of land operated and frequency of use of agrochemicals.

Table 34

Logistic Regression Analysis with Frequency of Use of Agrochemical and Number of Parcels of Land Operated

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
≥ 3 parcels of land operated	1.049	.083	159.305	1	.000	2.854	2.425	3.359
Constant	1.108	.074	221.628	1	.000	3.029		

Number of paid workers on the farm in the last week - The logistic regression model was not statistically significant, χ^2(4, N = 8858), 119.11, *p<.01*). The model explained <2.6% (Nagelkerke R^2) of the variance in the number of paid workers on the farm in the last week and frequency of use of agrochemical. The model correctly classified 88.1% of cases. The category with the smallest number of paid workers on the farm, zero workers, was used as the reference in investigating the relationship between number of paid workers on the farm in the last week and the frequency of use of agrochemical. Compared to farmers who did not have paid workers on the farm in the last week, the odds ratio for ever use of agrochemical was higher than 1 for all other categories with at least 1 paid worker on the farm. Farmers who had 1-3 paid workers were at least 7 times (OR 7.807, 95%CI: 2.822 – 21.584, p<.01) more likely to have ever used agrochemical. Further, farmers who had 4-6 paid workers were more than 7 times (OR .3.998, 95%CI: .1.437 – 11.121, p<.01) more likely to have ever used agrochemical. Farmers who had 7-10 (OR .2.656, 95%CI: .922 – 7.647, p = .070) and 11 or more (OR 2.087, 95%CI: CI: .626 -6.952, p = 231) paid workers and were also more than twice likely to ever used agrochemical. The findings indicated that farmers who had at least one paid worker on the farm in the last week before the interview were more likely to also experience the health problems stated in RQ 1. The overall difference in the odds ratio for ever use of agrochemical between farmers who did not have paid workers on the farm and farmers who had at least 1 paid worker on the farm in the last week was statistically significant (p<.01). We, therefore, reject the null hypothesis that there was no relationship between number of paid workers on the farm in the last week before the interview and ever used agrochemical. Table 35 shows the variables in the equation for logistic regression analysis with number of paid workers on the farm in the last week before the interview and frequency of use of agrochemical.

Table 35

Logistic Regression Analysis with Frequency of Use of Agrochemical and Number of Paid Workers on the Farm in the Last Week Before Interview

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
0 paid workers			130.257	4	.000			
1-2 paid workers	2.055	.519	15.669	1	.000	7.804	2.822	21.584
3-4 paid workers	1.386	.522	7.050	1	.008	3.998	1.437	11.121
5-6 paid workers	.977	.540	3.276	1	.070	2.656	.922	7.647
≥7 paid workers	.736	.614	1.435	1	.231	2.087	.626	6.952
Constant	.134	.518	.067	1	.796	1.143		

Additional Statistical Test Emerging from the Analysis of the Hypothesis for RQ1

The results of the logistic regression analyses for RQ1 show that there were statistically significant relationship between each independent variable, except for the size of the farmers' households, and the frequency of use of agrochemicals. Subsequently, a model was developed to investigate whether there was a better fit of the independent variables with the dependent variable and to predict which independent variables had an effect on the dependent variable when all other characteristics of the farmers in Grenada were held constant. Table 36 shows the best fit model with predictors of the outcome of the dependent variable.

The Omnibus Test of Model Coefficient shows the chi square results that indicated whether the model was a significant improvement in the fit of the independent variables with the dependent variables as compared to the null model shown in the Pearson correlation coefficient. The results of the test indicated that the model was statistically significant for predicting the relationships between the independent and dependent variable for RQ, 1 $\chi 2$ (10, N = 7230) = 557.308, $p < .01$). Table 36 shows the results of the Omnibus Tests of Model Coefficients for the model for RQ1.

Table 36

Omnibus Tests of Model Coefficients for the Model for RQ1

	Chi-square	df	Sig.
Step	557.308	10	.000
Block	557.308	10	.000
Model	557.308	10	.000

The Cox & Snell R Square and Nagelkerke R Square values indicate the proportion of the dependent variable explained by the effect of the independent variables or predictors. The Nagelkerke R^2 is a revision of the Cox & Snell R^2 and is suitable to report the proportion of the effect of the independent variables on the dependent variable (Laerd Statistics, 2018). The findings show that the model explained about 13.7% of the effect on the dependent variable by the independent variables for RQ 1.

The Hosmer and Lemeshow Test is a chi square test that indicates whether there is goodness of fit of the variables in the model. Goodness of fit indicates how well the observed outcomes match the expected outcomes (Frankfort-Nachmias & Leon-Guerrero, 2015). A significance level of $p>0.05$ indicated goodness of fit of the model to predict the outcome of the dependent variable (Frankfort-Nachmias & Leon-Guerrero, 2015). The Hosmer and Lemeshow Test result for RQ1, $\chi 2$ (8, N = 7230) = 11.955, $p = .153$, indicated that the goodness of fit condition was met for the model.

The classification table provided information on the sensitivity and specificity, percentage accuracy in classification (PAC), and the positive predictive and negative predictive value of the binomial regression analysis results (Laerd Statistics, 2018). Table 40 show the cut value is .500 which is the lower limit of probability for a case to be included in the “yes” category for actual classification in the “yes” category. The sensitivity of the model is the ability to correctly identify the “true positive” cases in the “yes” category (Laerd Statistics, 2018). The positive predictive value is the percentage of cases that were correctly predicted as having the characteristic of interest compared to the total number of cases that were predicted as having the characteristic (Laerd Statistics, 2018). Table 37 shows 50 cases were correctly categorized in the “yes” category and 897 cases were “false positives.” The positive predictive value of the model is shown as 5.3%.

The specificity of the model is the ability to correctly identify the “true negative” cases in the “no” category (Laerd Statistics, 2018). The negative predictive value is the percentage of cases that were correctly predicted as not having the characteristic compared to the total number of cases that were predicted in the category (Laerd Statistics, 2018). Table 37 shows 6237 cases were correctly categorized in the “no” category and 46 cases were “false positives.” The positive predictive value of the model is shown as 99.3%. The result indicated that the test is more adept to correctly identify the “true negative” cases. The percentage accuracy in classification (PAC) shows the overall percentage of cases that can be correctly classified as true negative when the independent variables are added in the model. Table 37 shows the percentage accuracy in classification (PAC) as 87.0%.

Table 37

Classification Table for RQ 1

Observed		Predicted: Frequency of use of agrochemical		
		Ever use agrochemical	Never used agrochemical	Percentage Correct
Frequency of use of agrochemical	Ever used agrochemical	50	897	5.3
	Never used agrochemical	46	6237	99.3
Overall Percentage				87.0

The cut value is .500

Table 38 shows the independent variables that had statistically significant relationship with the dependent variable and were predictors of the outcome of the dependent variable.

Table 38

Variables in the Equation in the Model

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	95% C.I. for EXP(B) Upper
Gender	.372	.095	15.451	1	.000	1.451	1.205	1.746
Farmers weekly unpaid hours of work on farm	-.330	.110	9.022	1	.003	.719	.580	.892
Level of education completed	-.088	.034	6.505	1	.011	.916	.856	.980
Market presence	-.559	.040	197.123	1	.000	.572	.529	.618
Income from agriculture	.108	.028	14.968	1	.000	1.114	1.055	1.176
Membership is a farm organization	.383	.078	23.822	1	.000	1.467	1.258	1.711
Receipt of technical assistance	.731	.115	40.601	1	.000	2.078	1.659	2.602
Receipt of credit	.416	.219	3.605	1	.058	1.516	.987	2.328
Number of paid workers on the farm in last week	-.312	.060	27.297	1	.000	.732	.651	.823
Number of parcels of land operated by farmer	-.437	.099	19.704	1	.000	.646	.532	.783
Constant	.380	.540	.497	1	.481	1.463		

Results for RQ 2

RQ2: What is the relationship between socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's disease?

Null Hypothesis: There was no relationship between the socioeconomic characteristics of farmers in the 2012 agricultural census in Grenada and cumulative risk exposure at levels that can potentially cause ESRD and Parkinson's disease.

Tables 39 and 40 show the calculation for cumulative intensity risk exposure score in the reporting period. The lapse period was also calculated to show the number of years of exposure that was likely to be associated with farmers experiencing ESRD and Parkinson's disease at the reported frequency of ≥12 times per year.

Table 39

Calculation of Average Work-Day Risk Exposure

Survey question	Task	Risk for Exposure Value	Exposure Situation
#07, #08	Mix	9	Assumption that farmers mixed agrochemical more than 50% of the time. A few farmers had paid workers.
#23	Apply	+ 8	Farmer most commonly used knapsack sprayers to apply agrochemicals in Grenada. This data were extracted from the dataset.
	Repair	+2	An assumption was made that the farmer generally repaired/loaded the knapsack sprayer in the field.
	PPE	X .80	Each of 5 PPE item contributed 20% reduction in exposure. Rubber boots were the main PPE used by farmers in Grenada. Therefore, the level of exposure is about 80%.
	Intensity risk score	15.2	

Table 40

Calculation of Cumulative Intensity-weighted risk exposure Risk Exposure Score

Survey question	Task	Risk for Exposure Value	Exposure Situation
	Average Work-day Exposure Risk Score	15.2	Based on calculations above.
#22	Frequency/days per year of use of pesticides	X 12	The highest frequency reported for use of herbicides is ≥12 days per year.
	Duration of years	X 1	One year was used in the calculation, given the recall period of 12 months in the census.
	Cumulative intensity weighted exposure risk score	182.4	

The cumulative intensity-weighted risk exposure-days score is calculated by: years of use × days per year × intensity level (Lebov et al., 2016). The cumulative intensity risk exposure score is equal to 182.4 in the period of one year. Therefore, at the reported frequency of use of herbicide ≥12 times per year, farmers were likely to have achieved the risk score of ≥ 2088 over 11 years. Additionally, at the reported frequency of use of herbicide ≥12 times per year, farmers were likely to have used herbicide 25 times over a period of two years.

Gender. The logistic regression model was not statistically significant, $\chi^2(1, N = 620) = .629, p = .428$). The model explained <1% (Nagelkerke R^2) of the variance in gender and the frequency of use of herbicide≥12 times per year. The model correctly classified

95.5% of cases. Male was used as the reference category. The odds of females' use of herbicide≥12 times per year was higher than 1 (OR 1.593, 95% CI: .471-5.382, *p*<.454). The results indicated that females were more likely to have used herbicide >12 times per year and achieve a score of ≥2088 which would have also increased the likelihood of females experiencing ESRD and Parkinson's disease over the respective lapse period compared to males. The overall difference in the odds of having used herbicide ≥12 time per year between males and females was not statistically significant. Therefore, we fail to reject the null hypothesis that there was no relationship between gender and use of herbicide ≥12 times per year. Table 41 shows the variables in the equation for logistic regression analysis with gender and use of herbicide≥12 times per year.

Table 41

Logistic Regression Analysis with Frequency of Use of Herbicide ≥12 Times Per Year and Gender

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Gender (F)	.466	.621	.562	1	.454	1.593	.471	5.382
Constant	-3.455	.586	34.720	1	.000	.032		

Age. The logistic regression model was not statistically significant, $\chi^2(6, N = 608) = 2.22$, $p < .898$). The model explained about 1.2% (Nagelkerke R^2) of the variance in age and use of herbicide ≥12 times per year. The model correctly classified 95.4% of cases. The youngest age category, 15-24 years, was used as the reference group to compare the relationship between age-groups and use of herbicide ≥12 times per year.

Compared to the youngest age group, the odds ratio for use of herbicide ≥12 times per year was higher than 1, but not statistically significant for farmers aged 25-34 years (OR 3.556, 95% CI: .202- 62.632, *p* = .386), 45-54 years (OR 1.455, 95% CI: .164- 112.904, p = .737), 55-64 years (OR 1.778, 95% CI: .222- 14.243, p = .888), 65-74 years (OR 1.684, 95% CI: .196- 14.502, p = .635), and above 75 years (OR 1.524, 95% CI: 1.52- 15.242, p = .720). The results indicated that, generally, older farmers were more likely to have used herbicide ≥12 times per year and potentially experience ESRD and Parkinson's disease over the respective lapse period. The overall difference in the odds of use of herbicide ≥12 times per year between farmers aged 15-24 years and older age groups was not statistically significant (*p>.05*). We, therefore, reject the null hypothesis that there was no relationship between age and ever use of agrochemicals. Table 42 shows the variables in the equation for logistic regression analysis with age and use of herbicide ≥12 times per year.

Table 42

Logistic Regression Analysis with Frequency of Use of Herbicide ≥12 Times Per Year *and Age*

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
15-24			1.937	6	.925			
25-34	1.269	1.464	.751	1	.386	3.556	.202	62.632
35 -44	-.523	1.432	.134	1	.715	.593	.036	9.804
45-54	.375	1.114	.113	1	.737	1.455	.164	12.904
55-64	.575	1.062	.294	1	.588	1.778	.222	14.243
65-75	.521	1.098	.225	1	.635	1.684	.196	14.502
≥75	.421	1.175	.129	1	.720	1.524	.152	15.242
Constant	-3.466	1.016	11.647	1	.001	.031		

Education. The logistic regression model was statistically significant, $\chi^2(1 = 620) = 2.141$, $p = .143$). The model explained about 1.00% (Nagelkerke R^2) of the variance in use of herbicide ≥12 times per year by education. The model correctly classified 95.5% of cases. The lowest level at which education was completed—secondary school and lower—was used as the reference group. Compared to the farmers who completed their education higher levels that primary and secondary, the odds of use of herbicide ≥12 times per year was higher than 1 (OR 1.827, 95 CI : .792 – 4.216, p = .157) for farmers who completed education at higher than secondary level. The results indicated that farmers who completed education at levels higher than secondary school were more likely to have used herbicide ≥12 times per year and potentially experience ESRD and Parkinson's disease. Overall, the differences in the odds of use of herbicide ≥12 times per year between farmers who completed education at the primary and secondary level and farmers who completed their education at a level higher than secondary school was not statistically significant ($p = .157$). We, therefore, fail to reject the null hypothesis that there was no relationship between education and use of herbicide ≥12 times per year. Table 43 shows the variables in the equation for logistic regression analysis with level of completion of education and use of herbicide ≥12 times per year.

Table 43

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Level of Completion of Education

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
Above primary and secondary school	.603	.427	1.998	1	.157	1.827	.792	4.216
Constant	-	.359	91.841	1	.000	.032		

Markets. The logistic regression model was not statistically significant, χ^2(1, N 620) = .047, p < .828). The model explained about <1.0% (Nagelkerke R^2) of the variance in market presence and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. No market presence was used as the reference group in further examination of the effect of market presence on use of herbicide ≥12 times per year. Compared to farmers who did not sell to market, the odds ratio was lower than 1 (OR .915, 95%CI: .406 – 2.058) for use of herbicide ≥12 times per year by farmers who sold to markets. The results indicated that farmers who sold produce to markets were less likely to have used herbicide at a level that can potentially cause farmers to experience ESRD and Parkinson's disease over the respective lapse period. The difference in the odds ratio for use of herbicide ≥12 times per year between farmers without market presence and farmers with market presence was not statistically significant (p<.829). We, therefore, reject the null hypothesis that there was no relationship between market presence and use of herbicide ≥12 times per year. Table 44 shows the variables in the equation for logistic regression analysis with market presence and use of herbicide ≥12 times per year.

Table 44

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Market Presence

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)

							Lower	Upper
Sell to markets	-.089	.414	.047	1	.829	.915	.406	2.058
Constant	-3.022	.235	165.424	1	.000	.049		

Income from agriculture production. The logistic regression model was statistically significant, $\chi^2(4, N = 640) = 9.490, p < .050$). The model explained about 4.9% (Nagelkerke R^2) of the variance in income from agriculture production and use of herbicide ≥12 times per year. The model correctly classified 95.5.0% of cases. The highest category of earning from agriculture, all income, was used as the reference group in the investigation of the relationship between income from agriculture production and use of herbicide ≥12 times per year. Compared to the farmers who earned all income from agriculture, the odds of use of herbicide ≥12 times per year was at least 4 times more likely for farmers who did not earn income from agriculture production (OR 11.200, 95 CI: 1.373 – 91.330, p = .024), half of their income (OR 4.148, 95CI: .478 – 36.027, p = .197), earned about ¼ of income (OR 7.049, 95 CI: .880 – 56.464, p = 066), and earned less than ¼ of income (OR 4.590, 95 CI: .528 – 39.894, p = .167).

The difference in odds ratio was statistically significant between farmers who earned all income from farming and farmers who did not earn income from farming (p = .024). Compared to the reference group, the odds of use of herbicide ≥12 times per year was higher than11 for farmers who did not earn income from farming, indicating that the latter group was more likely to use herbicide at a level that can potentially cause farmers to experience ESRD and Parkinson’s disease over the respective lapse periods. Further, the odds of using herbicide at a level that can potentially increase risk for ESRD and

Parkinson's disease was higher than 1 for farmers that earned less than all income from agriculture activities compared to farmers that earned all income from agriculture production. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who earned all income and farmers who earned a percentage of income of income from agriculture was not statistically significant (p = .126). We, therefore, fail to reject the null hypothesis that there was no relationship between income from agriculture and use of herbicide ≥12 times per year. Table 45 shows the variables in the equation for logistic regression analysis with income from agriculture production and use of herbicide ≥12 times per year.

Table 45

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Income from Agriculture Production

							95% C.I.for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
All income			7.194	4	.126			
No income	2.416	1.071	5.091	1	.024	11.200	1.373	91.330
Half of income	1.423	1.103	1.664	1	.197	4.148	.478	36.027
¼ of income	1.953	1.062	3.384	1	.066	7.049	.880	56.464
<1/4 of income	1.524	1.103	1.908	1	.167	4.590	.528	39.894
Constant	-4.718	1.004	22.067	1	.000	.009		

Membership in a farm organization. The logistic regression model was statistically significant, $\chi^2(1, N = 620) = 4.711, p = .30$). The model explained 2.5% (Nagelkerke R^2) of the variance in membership in a farm organization and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. Belonging to a farmers organization was used as the reference category to investigate the relationship between membership in a farm organization and use of herbicide ≥12 times per year. Compared to farmers who had membership in a farm organization, the odds ratio for use of herbicide ≥12 times per year was at least twice time higher for farmers who did not belong to a farm organization (OR 2.481, 95%CI: 1.039- 5.926). The results indicated farmers who did not belong to a farm organization were more likely to have used herbicide ≥12 times per year and experienced ESRD and Parkinson's disease over the respective lapse period. The difference in the odds ratio for use of herbicide ≥12 times per year between farmers who had and did not have membership in a farm organization was statistically significant ($p = .041$). We, therefore, reject the null hypothesis that there was no relationship between membership in a farm organization and use of herbicide ≥12 times per year. Table 46 shows the variables in the equation for logistic regression analysis with membership in farm organization and use of herbicide ≥12 times per year.

Table 46

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Membership in Farm Organization

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Does not belong to farm organization	.909	.444	4.187	1	.041	2.481	1.039	5.926
Constant	-3.645	.383	90.639	1	.000	.026		

Receipt of technical assistance. The logistic regression model was statistically significant, χ^2(1, N = 620) = 1.507, *p* = *.220*). The model was weak and explained <1.0% (Nagelkerke R^2) of the variance in receipt of technical assistance by farmers and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. Receiving technical assistance was used as the reference category in the analysis to investigate the relationship between farmers' receipt of technical assistance and use of herbicide ≥12 times per year. Compared to farmers who received technical assistance, the odds ratio of used herbicide ≥12 times per year was higher than 1 for farmers who did not receive technical assistance (OR 1.733, 95%CI: .744- 4.037), indicating farmers who did not receive technical assistance were more likely to have ever used herbicide ≥12 times per year and to potentially experience ESRD and Parkinson's disease over the respective lapse periods. The difference in the odds ratio for use of herbicide ≥12 times per year between farmers who received technical support and the farmers who did not receive technical support was not statistically significant (p = .202). We, therefore, fail to reject the null hypothesis that there was no relationship between receipt of technical assistance and use of herbicide ≥12 times per year. Table 47 shows the variables in the equation for logistic regression analysis with receipt of technical assistance and use of herbicide ≥12 times per year.

Table 47

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Receipt of Technical Assistance

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper

Did not receive technical assistance	.550	.431	1.626	1	.202	1.733	.744	4.037
Constant	-3.180	.228	194.191	1	.000	.042		

Access to credit. The logistic regression model was statistically significant, $\chi^2(1, N = 620) = 5.086$, $p = .024$). The model only explained 2.7% (Nagelkerke R^2) of the variance in access to credit and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. Having access to credit was used as the reference category in the analysis to investigate the relationship between access to credit and use of herbicide ≥12 times per year. Compared to farmers who had access to credit, the odds of use of herbicide ≥12 times was at least 3 times for farmers who did not have access to credit (OR 3.804, 95%CI: 1.357-.10.663), indicating farmers who did not have access to credit were more likely to have used herbicide ≥12 times per year and potentially experience Parkinson's disease and ESRD over the respective lapse period. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who access credit and farmers who did not access credit was statistically significant (p< = .011). We, therefore, reject the null hypothesis that there was no relationship between access to credit and use of herbicide ≥12 times per year. Table 48 shows the variables in the equation for logistic regression analysis with receipt of credit and herbicide ≥12 times per year.

Table 48

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Receipt of Credit

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Did not receive technical assistance	1.336	.526	6.456	1	.011	3.804	1.357	10.663
Constant	-3.192	.213	225.161	1	.000	.041		

Legal status of land ownership. The logistic regression model was statistically significant, $\chi^2(2, N = 620) = 6.098$, $p < .047$). The model explained 3.2% (Nagelkerke R^2) of the variance in receipt of legal status of ownership of land and use of herbicide ≥12 times per year. The model correctly classified 95.5.% of cases. Individual ownership of land was used as the reference group in further examination of the effect of the categories of land ownership status and use of herbicide ≥12 times per year. Compared to farmers who had individual ownership of land, the odds ratio for use of herbicide ≥12 times per year was lower than 1 for farmers who had joint ownership with household (OR .248, 95%CI: .087 – .704, p = .009) and nonhousehold members (OR .163, 95%CI: .030-.891, p = .03). The results indicated that farmers who had joint ownership of land were less likely to have used herbicide ≥12 times per year and potentially experienced Parkinson' disease and ESRD over the lapse period. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who individual ownership of land and farmers who had joint ownership was statistically significant (p = .022). We, therefore, reject the null hypothesis that there was no relationship between land ownership status and use of herbicide ≥12 times per year. Table 49 shows the variables in the equation for logistic regression analysis with legal status of land ownership and herbicide ≥12 times per year.

Table 49

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Legal Status of Land Ownership

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Individual ownership			7.643	2	.022			
Joint ownership with household members	-1.396	.533	6.860	1	.009	.248	.087	.704
Joint ownership with nonhousehold members	-1.812	.865	4.385	1	.036	.163	.030	.891
Constant	-1.758	.484	13.178	1	.000	.172		

Keeping farm records. The logistic regression model was statistically significant, χ^2(1 = N = 620) = 3.836, p = .050). The model explained <2.0% (Nagelkerke R^2) of the variance in keeping farm records and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. Keeping farm records was used as the reference group to investigate the effect of land keeping farm records on the use of herbicide ≥12 times per year. Compared to farmers who keep farm records, the odds ratio for use of herbicide ≥12 times per year was about two times for farmers who did not maintain farm records (OR 2.304, 95%CI: 1.036 – 5.125) indicating farmers who did not maintain farm records were more likely to have used herbicide ≥12 times per year and potentially experienced ESRD and Parkinson’s disease. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who maintained farm records and farmers who did not maintain records was statistically significant (p = .041). We, therefore, reject the null hypothesis that there was no relationship between maintaining farm records and use of herbicide ≥12 times per year. Table 50 shows the variables in the equation for logistic regression analysis with keeping farm records and use of herbicide ≥12 times per year.

Table 50

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Keeping Farm Records

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Does not keep farm records	.835	.408	4.189	1	.041	2.304	1.036	5.125
Constant	-3.277	.240	186.285	1	.000	.038		

Farmers unpaid hours of work on the farm in the last week - The logistic regression model was statistically significant, $\chi^2(1, N = 620) = 3.755$, $p = .053$). The model explained about 2.1% (Nagelkerke R^2) of the variance in receipt of unpaid hours of work on the farm in the last week and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. Working ≤ than 35 hours (indicating part time) on the farm was used as the reference group to investigate the effect of the categories of unpaid hours worked on the farm in the last week and use of herbicide ≥12 times per year. Compared to farmers who worked ≤ than 35 hours, the odds ratio for use of herbicide ≥12 times per year was lower than 1 for farmers who worked ≥35 unpaid hours on the farm (OR .419, 95%CI: .181 – .969), indicating farmers who worked ≥35 unpaid hours on the farm were also less likely to have experienced ESRD and Parkinson's disease over the respective lapse period. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who worked ≥35 unpaid hours and farmers who worked ≥35 unpaid hours on farms was statistically significant (p = .042). We, therefore, reject the null hypothesis that there was no relationship between number of unpaid hours of work on the farm and use of herbicide ≥12 times per year. Table 51 shows the variables in the equation for logistic regression analysis with farmers unpaid hours of work and use of herbicide ≥12 times per year.

Table 51

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Farmers Unpaid Hours of Work in the Last Week

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
≥36 unpaid hours	-.869	.428	4.134	1	.042	.419	.181	.969
Constant	-2.357	.349	45.659	1	.000	.095		

Size of farmer household - The logistic regression model was not statistically significant, χ^2(1, N = 620), 1.173, $p = .279$). The model was weak and explained <.1% (Nagelkerke R^2) of the variance in size of household and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. The category with the smallest number of household members, 0-4, was used as the reference group to investigate the effect of the categories of household size on the use of herbicide ≥12 times per year. Compared to farmers who had 1-4 members in the household, the odds ratio for use of herbicide ≥12 times per year was lower than 1 (OR .638, 95%CI: .288 – 1.413) for farmers who had 5 or more members in the household. The results indicated farmers with smaller households, 1-4 members, were more likely to have used herbicide ≥12 times per year and potentially experienced ESRD and Parkinson's disease. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who had 1-4 members in the household and farmers who had 5 or more members in the household was not statistically significant (p = .268). We, therefore, fail to reject the null hypothesis that there was no relationship between size of household and use of herbicide ≥12 times per year. Table 52 shows the variables in the equation for logistic regression analysis with size of farmers' household and frequency of use of herbicide ≥12 times per year.

Table 52

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Size of Household

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
≥5 household members	-.449	.405	1.226	1	.268	.638	.288	1.413
Constant	-2.741	.326	70.569	1	.000	.065		

Number of parcels of land operated - The logistic regression model was not statistically significant, χ^2(1, N = 620), 5.296, $p = .021$). The model explained 2.8% (Nagelkerke R^2) of the variance in herbicide ≥12 times per year by parcels of land operating. The model correctly classified 95.5% of cases. The category with the smallest number of parcels of land operated, 1-2, was used as the reference group to investigate the effect of the categories of parcels of land operating on the use of herbicide ≥12 times per year. Compared to farmers who operated 1-2 parcels of land, the odds ratio for use of herbicide ≥12 times per year was lower than 1 (OR .399, 95%CI: .185 – .857) for farmers who operated 3 or more parcels of land, indicating that farmers who operated smaller number of parcels of land operating were more likely to have used herbicide ≥12 times per year and potentially experience ESRD and Parkinson's disease. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who operated 1-2 parcels of land and farmers who operated 3 or more parcels of land was statistically significant (p = .018). We, therefore, reject the null hypothesis that there was no relationship between parcels of land operated and use of herbicide ≥12 times per year. Table 53 shows the variables in the equation for logistic regression analysis with number of parcels of land operated and frequency of use of herbicide ≥12 times per year.

Table 53

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Number of Parcels of Land Operated

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
≥ 3 parcels of land operated	-.920	.390	5.550	1	.018	.399	.185	.857
Constant	-2.459	.289	72.410	1	.000	.086		

Number of paid workers on the farm in the last week - The logistic regression model was not statistically significant, $\chi^2(1, N = 620)$, 4.424, *p<.01*). The model explained <2.5% (Nagelkerke R^2) of the variance in the number of paid workers on the farm in the last week and use of herbicide ≥12 times per year. The model correctly classified 95.5% of cases. The category with the smallest number of paid workers on the farm, zero workers, was used as the reference in investigating the relationship between number of paid workers on the farm and use of herbicide ≥12 times per year. Compared to farmers who did not have paid workers on the farm in the last week, the odds ratio for use of herbicide ≥12 times per year was lower than 1. The results indicated farmers with paid workers on the farm were less likely to have used herbicide ≥12 times per year and experience ESRD and Parkinson's disease over the respective lapse period. The overall difference in the odds ratio for use of herbicide ≥12 times per year between farmers who did not had paid workers on the farm and farmers who had at least 1 paid worker on the farm was statistically significant (p<.029). We, therefore, reject the null hypothesis that there was no relationship between number of paid workers on the farm in the last 2 weeks before the interview and use of herbicide ≥12 times per year. Table 54 shows the variables in the equation for logistic regression analysis with number of paid workers on the farm in the past week before the interview and frequency of use of herbicide ≥12 times per year included.

Table 54

Logistic Regression Analysis with Use of Herbicide ≥12 Times Per Year and Number of Paid Workers on the Farm 2 Weeks Before Interview

							95% C.I. for EXP(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
≥1 paid worker	-.879	.402	4.768	1	.029	.415	.189	.914
Constant	-2.246	.317	50.204	1	.000	.106		

Additional Statistical Test Emerging from the Analysis of the Hypothesis for RQ2

Binomial regression analysis was conducted with the inclusion of the independent variables that were found to have a statistically significant relationship with the dependent variable in RQ2 – membership in a farm organization, receipt of credit from an institution, land ownership status, keeping farm records, farmers unpaid weekly hours of work on the farm, number of parcels of land operated by the farmer, and number of paid workers on the farm in the last week before the interview. The model was statistically significant, χ^2(8, N = 464), 18.829, $p = .016$*)*. The model explained <11.3% (Nagelkerke R^2) of the variance in the use of herbicide ≥12 times per year by the independent variables. This result indicated that the model was weak in predicting the relationship between the group of independent variables and the dependent variable. Further, one independent variable, receipt of credit from a financial institution, was found to be statistically significant in the model. As such, the model was not suitable to predict the variance in the dependent variable by the group of independent variables.

Summary of Results for RQ 1

Logistic regression analyses were performed to ascertain the relationship between each independent variable and the dependent variable, frequency of use of agrochemical. The results of the analyses showed there were statistically significant relationships between 16 independent variables and the dependent variable. The independent variables that had statistically significant relationship with the dependent variable were age, gender, parish of location of the farm, highest level of education completed, market presence, income from agriculture production, experienced production issues, membership in farm organization, receipt of technical assistance, receipt of credit, land ownership status, maintaining farm records, number of paid workers, number of nonhousehold members working on the farm, number of parcels of land operated by the farmer, and number of unpaid hours of work on the farm. The size of the farmers' household was the only independent variable that was not found to have a statistically significant relationship with the frequency of use of agrochemicals.

The results also show that the odds ratio was >1 and statistically significant for ever use of agrochemicals by farmers who were aged 25-35 years compared to youth farmers, aged 15-24 years; owned farms located in Carriacou compared to farmers who owned farms located in St. George's; completed education at all levels above primary school compared to farmers who completed education at primary school; had market presence compared to farmers who did not have market presence; earned half of income from agriculture compared to farmers who earned all income from agriculture; had joint ownership of land compared to farmers who had individual ownership of land; worked full time unpaid hours on the farm compared to farmers who worked part time unpaid hours on the farm; had ≥1 unpaid nonhousehold members working on the farm in the week before the interview compared to farmers who did not have unpaid nonhousehold members working on the farm; operated ≥3 parcels of land compared to farmers who operated <3parcels of land; and had ≥1 paid workers on the farm in the last week before the interview compared to farmers who did not have paid workers on the farm in the last week. Consequently, there was a higher likelihood for the groups with higher odds ratio to experience allergic wheeze from exposure to carbaryl, both allergic and non-allergic wheeze from exposure to glyhosate, sleep apnea from exposure to carbaryl, rheumatoid arthritis from the use and exposure to carbaryl, and decreased DNA methylation from exposure to paraquat and carbaryl related to ever use of the agrochemicals.

A fit was found in a model of the independent variables to be statistically significant predictors of the outcome of the dependent variable. The model included gender, farmers unpaid weekly hours of work on the farm, highest level of completion of education, market presence, income from agriculture, membership in a farm organization, receipt of technical assistance, receipt of credit from a financial institution, and the number of paid workers on the farm in the week before the interview. These factors, therefore, indicated the group of independent variables that were significant in predicting the outcome of use of agrochemicals in Grenada.

Summary of Results for RQ 2

Logistic regression analyses were performed to ascertain the relationship between each independent variables and the dependent variable, frequency of use of herbicide ≥12 times per year. The results of the analyses showed there were statistically significant relationships between eight independent variables and the dependent variable. The independent variables that had statistically significant relationship with the dependent variable, use of herbicide ≥12 times per year, were: age, membership in farm organization, receipt of credit, land ownership status, maintaining farm records, farmers unpaid hours of work on the farm, parcels of land operated, and number of paid workers on the farm in the last week before the interview.

The results also show odds ratio was >1 but not statistically significant for use of herbicides ≥12 times per year by farmers who were females compared to males; 25-35 years and ≥45 years compared to youth farmers, aged 15-24 years; completed education above primary school compared to farmers who completed at primary school; earned no income or a part of income from agriculture compared to farmers who earned all income from agriculture; and compared to farmers who earned all income from agriculture. Further, the results show odds ratio was >1 and statistically significant for use of herbicides ≥12 times per year by farmers who had membership in a farm organization compared to farmers who did not have membership in a farm organization; did not received credit in the past 12months compared to farmers who received credit; and didold not maintain farm records compared to farmers who maintained farm records. Consequently, there was a higher likelihood for the groups with higher odds ratio to experience ESRD over an 11 year lapse period and Parkinson's disease over a three year lapse period from exposure to paraquat ≥12 times per year. A good fit was not found in a model of the independent variables to be significant predictors of the outcome of the dependent variable.

Sction 4 included a discussion on the application of this study to professional practice and implications for social change. The results of the descriptive and statistical analyses were interpreted and the signficance of the findings was discussed to explain the meaning of the findings within the context of the settings in Grenada. The discussion also included information on the difference in the study in Grenada and other studies published in the literature review. Lastly, recommendations were made for further research and to address gaps in public health and to bring about social change towards improving health outcomes in Grenada.

Section 4: Application to Professional Practice and Implications for Social Change

Introduction

The purpose of this quantitative cross-sectional study was to investigate the relationships between the social and economic characteristics of farmers who participated in the 2012 agricultural census in Grenada and the use of agrochemicals at levels that pose risks for specific health problems. Exposure to the chemicals have been found to be associated with Parkinson’s disease (Tanner et al., 2011), ESRD (Lebov et al., 2016), sleep apnea (Baumert et al., 2018), rheumatoid arthritis (Meyer et al., 2017), decrease in LINE-I DNA methylation (Alexander et al., 2017), and allergic and non-allergic wheezing (Hoppin et al., 2017). This research was an investigation of the potential of farmers in Grenada to experience these health problems based on the frequency of use of glyposate, paraquat, and carbaryl.

This study was an investigation of the relationships between (a) age, (b) gender, (c) highest level at which education was completed, (d) size of household, and (e) membership in a farm organization. The economic factors that were identified for inclusion in this study were: (f) parish of location of the farm, (g) markets, (h) receipt of credit, (i) number of paid workers, (j) status of land ownership, (k) maintenance of farm records, (l) number of nonhousehold members working on the farm, (m) number of parcels of land operated by the farmer, (n) daily number of hours farmer worked on the farm, (o) receipt of technical assistance, (p) production issues, and (q) income from agriculture production and (r) the frequency of use of agrochemicals (dependent variables).

Statistically significant relationships were found between 16 independent variables— age, gender, parish of location of the farm, highest level of education completed, market presence, income from agriculture production, experienced production issues, membership in farm organization, receipt of technical assistance, receipt of credit, land ownership status, maintaining farm records, number of paid workers, number of nonhousehold members working on the farm, number of parcels of land operated by the farmer, and number of unpaid hours of work on the farm—and the frequency of use of agrochemicals. Further, eight independent variables were found to be associated with the frequency of use of herbicide $\geq$ 12 times per year: namely, age, membership in farm organization, receipt of credit, land ownership status, maintaining farm records, farmers unpaid hours of work on the farm, parcels of land operated, and number of paid workers on the farm in the last week before the interview.

Interpretation of the Findings

Consistency of the Findings with the Literature

In this research in Grenada, about 12% of farmers reported that they used agrochemicals. This finding may be suggestive of a relatively small number of farmers using the chemicals. The proportion of farmers may be an underrepresentation of the population using agrochemicals, especially glyphosate, as the chemical is known to be very potent. Consequently, farmers may not have used the chemical in the recent period before the interview or during the census year, however, the famers would also have been considered as having ever used the agrochemical. As such, there may be underreporting in the 2012 agriculture census of the number of farmers in Grenada that ever used agrochemicals. The possibility of underreporting should be considered in comparing the prevalence of use of agrochemicals in Grenada and in other countries.

In the study in Grenada, a wider range of variables were included in the investigation of the relationship between socioeconomic characteristics and the frequency of use of agrochemicals. The publications of the findings in the AHS and other studies primarily included information on a few socioeconomic variables, namely age, gender, education level, and number of years in agriculture activities. A wider range of variables were included in the study in Grenada, thus contributing to the body of knowledge about other factors that have the potential to influence the use of agrochemicals at levels that may be hazardous for public health.

It was interesting to have found that females were more likely to use herbicides ≥12 times per year than men, although the difference in odds ratio was not statistically significant. Based on the findings in the study in Grenada, females who used paraquat with the highest reported frequency, that is use of the herbicide ≥12 times per year over 11 years, were at highest risk for experiencing low (insufficient) DNA methylation. Alexander et al. (2017) reported significant negative inverse relationship was found between use of carbaryl and paraquat and lower Line 1 DNA methylation among pesticide applicators in the AHS. Without specifying the number of days, Alexander et al. (2017) also noted that farmers with the highest lifetime days of exposure to agrochemicals in the AHS experienced the strongest negative association with DNA methylation.

van der Plaat et al. (2018), however, reported that low level of exposure to agrochemicals influenced DNA changes at two sites in the same direction as for high exposure in women and that methylation of the NKAIN3 gene was significantly higher in women compared to men. Based on the findings reported by van der Plaat et al. (2018) and Alexander et al. (2017), there may be an indication that females were more likely to experience some DNA effects from exposure to agrochemicals than males. Albeit, different to the findings by Alexander et al. (2017), the findings in the study published by van der Plaat et al. (2018) were indicative that women in Grenada who used paraquat for ≥12 times per year, over 11 years, were more likely to experience hypermethylation. Tanner (2011) also reported the odds of experiencing Parkinson's disease was 2.5 times higher among male applicators that used paraquat for >25 days as compared to applicators who did not use the herbicide and that the results did not, generally, differ for males and females. The results reported by Tanner (2011) may have also highlighted a risk for women in Grenada to experience health problems associated with the use of paraquat >25 days over a lapse period of about two years.

Meyer et al. (2017) found rheumatoid arthritis was associated with odds ratio higher than 1 for male applicators in the AHS who ever used carbaryl. In the study in Grenada, males were more likely to have ever used agrochemicals, including carbaryl and may, therefore, also be at higher risk for experiencing rheumatoid arthritis from exposure to carbaryl. Baumert et al. (2018) also found male applicators in the AHS was 1.11 times more likely to experience sleep apnea as a result of ever use of carbaryl as compared to two other carbamates, although the difference in the outcome between the group which used and did not used carbaryl was not statistically significant. The findings of the studies by Meyer et al. (2017) and Baumert et al. (2018) may indicate the possibility of higher incidences of sleep apnea and rheumatoid arthritis among male farmers in Grenada who ever used carbaryl.

In the study in Grenada, odds ratio lower than 1 was found for ever use of agrochemicals and use of herbicide ≥ 12 times per year by older farmers in Grenada as compared to younger farmers in the youth age group (15-24). Koureas et al. (2017) reported age was a strong interfering variable influencing the relationship between exposure to agrochemicals, including paraquat, and health problems. Hoppin et al. (2017) found an association between ever use of glyphosate in the AHS and allergic and non-allergic wheeze and between ever use of carbaryl and allergic wheeze with younger farmers, under 50 years, more likely to wheeze. Goldman et al., (2012) also reported that, although the difference between the groups was not significant, males who were exposed to paraquat were diagnosed with Parkinson’s disease at average younger age, 58.7 years, compared to men who were not exposed to the chemical (62.2 years). Furlong et al. (2015) also reported that the use of paraquat by male applicators, 40-60 years, and low use of protective equipment was associated with higher odds of Parkinson’s disease compared to male applicators who never used the chemicals. The findings in the study in Grenada were, therefore, generally consistent with the trends in the literature indicating that younger farmers were more likely to be exposed to agrochemicals and were also more likley to experience sleep apnea, Parkinson’s disease, and allergic and non-allergic wheezing compared to younger farmers aged 15-34 years. None of the studies reported on the likelihood of the health outcomes in youth versus adult farmers.

One study was found in the literature on an investigation of education and the use of agrochemicals and health outcomes. O'Donnell et al. (2011) reported on cases of low glomerular filtration rate (eGFR) <60 mL/min/1.73 m2, an indicator of renal problems, were less likely to have attended school (76% vs. 88%; P ¼ 0.009), and were also less literate than controls (73% vs. 90%; $p < 0.001$) in the study in Nicaragua. Pesticide exposure was positively associated with being a case of low glomerular filtration rate (eGFR) <60 mL/min/1.73 m2 (OR 1.85, 95% CI ¼ 0.84–4.07). Although O'Donnell et al. (2011) did not indicate the specific chemical to which the participants were exposed, the results provided useful insights into a potential factor – education—that may predispose farmers to renal disease as a consequence of exposure to agrochemicals. The findings in the research in Grenada, however, were contradictory to the findings by O'Donnell et al. (2011). In the study in Grenada, the odds of using agrochemicals and, therefore, potential for health problems realted to the use of agrochemicals was higher among farmers who completed education above primary school level, including at university level. Additionally, a higher odds ratio was found for use of herbicide ≥12 times per year for farmers who completed education above primary and secondary school. Further studies may be necessary to identify other factors that may also interact with education and influence the frequency of use of agrochemicals in different settings.

Ganpat et al. (2014) assessed compliance with good agriculture practices (GAP), including use of agrochemicals, by farmers in Trinidad and Tobago, the republic state which is located immediately south of Grenada. The type of agrochemicals used in the country was not specified. Ganpat et al. (2014), however, reported males were more likely to be compliant with GAP than females. This finding in the study in Grenada may reflect a contrary pattern to practices in Trinidad. In the study in Grenada, it was found that males were, generally, more likely to have used agrochemicals. The use of agrochemicals may be more prevalent in situations where GAP is least practiced. As such, the results in Grenada may be indicative of females being more compliant with GAP than males. With regard to education and use of agrochemicals, the findings in the study in Grenada were not consistent with findings by Ganpat et al. (2014) that show farmers with primary, secondary, and tertiary education were more likely to be consistent with GAP. In the study in Grenada, farmers who completed education at institutions higher than primary school were more likely to use agrochemicals which may be an indication of inconsistency with GAP. Ganpat et al. (2014) also found that farmers who were visited by extension officers 1-4 times per month practiced GAP more consistently than farmers who were visited by officers 5 or more times per month. This is an interesting finding as it is expected that farmers who received more technical support would also be more inclined or knowledgeable about GAP and use less agrochemicals. Similarly, the results from the study in Grenada show that farmers who received less technical support also had a lower tendency to have ever used agrochemical. The findings in Grenada and Trinidad may indicate that receipt of technical support is in direct correlation with production issues, possibly as a result of inconsistency with GAP, hence the higher odds of having ever used agrochemicals. From another perspective, glyphosate and paraquat may be used to control weeds on larger farms (rather than use of manual labor). The size of the farm, level of production, and type of crop may also indicate the demand for technical support. Further studies can be conducted to understand how these variables may impact the use of agrochemicals.

Ganpat et al. (2014) also found that farmers in Trinidad and Tobago who exported produce were more likely to practice GAP and possibly used less agrochemicals. The results from the study in Grenada show that presence in markets was associated with higher odds of using agrochemicals which may indicate less consistency with GAP. On the other hand, farmers who had access to markets were also less likely to use herbicide $\geq$ 12 times per year. Several factors may account for the difference including type of market and market quality standards. These factors should be investigated in future studies.

The results show farmers who had joint ownership with members in the same household were more likely to ever use agrochemicals indicating higher risk for experiencing health problems in RQ1 than farmers who had individual ownership status. This result is important as it shows family members may be exposed to hazardous chemicals, apart from the farmer. Further research is needed to understand risk from agricultural practice for household and community members in Grenada. Studies conducted in other countries show household members were at risk for health problems from assisting on farms and poor hygienic practices by farmers (Alavanja, Ross, & Bonner, 2013; Henry & Feola, 2013; Issa, Sham'a, Nijem, Bjertness, & Kristensen, 2010).

The literature review did not include information on the influence of membership in an organization, size of household, keeping farm records, location of farms, income from agriculture, receipt of credit, land ownership status, keeping farm records, size of household, number of parcels of land, and workers on farmers, respectively, and frequency of use of agrochemicals. As such, including those factors in this study and indicating their significance in the use of agrochemicals and health outcomes was informative and provided information for consideration to improve risk assessment studies.

Interpretation of the Findings in the Context of the Theoretical Framework

Within the context of the SCT, five constructs—knowledge, outcome expectations, observational learning, social support, and reinforcement and punishment – were most commonly used to explain the differences in the frequency of use of agrochemicals by farmers with individual socioeconomic characteristics. While contemporary norms, knowledge of technologies, and outcome expectation from knowledge of technologies may have been strong influences in younger farmers' decisions to use agrochemicals, older farmers may have favored traditional practices, favoring organic foods and reducing the use of chemicals to protect the health of consumers. In the settings of low-income countries, lower level of knowledge about new and emerging technologies including, agrochemicals, many also limit older farmers' use of agrochemicals.

Observational learning may be the key construct that could be referenced to explain higher odds of males ever using agrochemicals compared to females.

Traditionally, agriculture was the mainstay in Grenada and several other Caribbean countries (World Bank, International Center for Tropical Agriculture & Tropical Agricultural Research and Higher Education Center, 2014). Although there was a shift to tourism in several islands, agriculture was promoted as a livelihood for young people and regional governments have invested resources to attract residents to return to or remain in employment in the sector. The sector was male-dominated and this pattern of gender divide continued into contemporary times. The tradition was also reflected in the results of this study with 71.5% male participants. Paraquat and other agrochemicals were commonly used in the agriculture sector for over a decade; however, the use of PPE was not used regularly. As such, observational learning was a plausible explanation for the higher odds of men ever using agrochemicals. Further, observational learning, may also explain why males may be less likely to use PPE and potentially experience health problems, such as sleep apnea, rheumatoid arthritis, and allergic and non- allergic wheezing.

Protection of agriculture investments by the use of agrochemicals may have been a reinforcement resulting in the higher odds of farmers with market presence having ever used agro-chemicals. Controlled markets generally require produce that are safe for consumers and may discourage the frequent use of agrochemicals. However, agrochemicals use is increasing to protect agriculture investment (Lewis et al., 2016). As such, the construct of expected outcome was plausible to explain why farmers with market presence may have used agrochemicals more frequently than farmers without market presence. Further, the harsh, dry conditions in Carriacou may have also contributed t encourage farmers to use agrochemicals to increase production and protect crops, especially for markets.

The proximity of the farm/farmers' residence to agrochemical suppliers may have also played a role in influencing farmers to use agrochemicals. In Grenada, the two major agriculture shops were located in St. George's (town) and, therefore, there may be more ready access to agrochemicals by farmers who resided or worked in the urban parish. The odds of having ever used agrochemicals was >1 for farmers with farms located in the rural parishes (except Carriacou) compared to farmers with farms located in St. George (urban parish). Consequently, there may also be a higher risk of experiencing health problems by farmers who reside and own farms in the St. George. Over the years, the pattern of use of agrochemicals in the urban area may have also been transferred through social learning and support from older farmers in the area. While farmers who resided and worked in the urban parish may have had ready access to the chemicals, information about the risk from use of the products may not have been readily disseminated to the farmers.

The findings show that presence of a production issue was significantly associated with the use of agrochemicals in generals as well as the use of herbicide ≥12 times per year. An interesting difference, however, was noted in the direction of the relationship. Farmers who had production issue were also less likely to use agro chemicals. The expected outcome of use of the chemicals and observational learning may explain the findings. As such, the results may indicate that agrochemical use was not primarily to address the production problems identified in this study.

Social learning may be the most relevant tenet of the SCT theory to explain the findings related to belonging to an organization and using agrochemicals. Association in farm organizations may have been a key channel through which information was disseminated and through which farmers learned and were influenced to use agrochemicals. Application of the tenets of the HBM may have helped to provide a better understanding about intuition versus mental processing as influence on the use of agrochemicals.

Farmers who worked ≥35 hours per week on the farm may be considered as fulltime workers with lower odds of having ever used agrochemicals. The longer hours of work may have enabled farmers to provide better care for crops and reduce the demand for agrochemicals. At the same time, compared to the results of number of parcels of land operated by farmers, those who operated larger number of farms may not have dedicated as much time to each parcel of land and as such, may tend to use agrochemicals to increase and maintain productivity. The drive to increase or maintain production, despite shorter work hours and tending to a larger number of farms may have influenced the use of agrochemicals by the farmers. Large scale farmers, may work shorter hours in each plot but be more reliant on the use of agrochemicals in production.

The HBM was a commonly used theoretical framework for research on the subject and different tenets of the model have been referenced to develop research instruments and explain research findings. For example, Khan, Husnain, Mahmood, and Akram (2013) argued that perceived benefits and perceived barriers were the most critical factors that defined perception of risk and have influence on behavior change. And Jin, Wang, He, and Gong (2016) examined how the level of knowledge by farmers in China influenced pesticide safety decisions in agricultural practice. Bay and Heshmati (2016) also assessed the level of influence on pesticide safety behavior by factors that were aligned with each tenet of the HBM.

In future research, tenets of the HBM may be very useful for a comprehensive assessment of risk for health problems from use of and exposure to agrochemicals among agriculture workers and other stakeholders. In the absence of information about perception, the SCT was the more suitable model to explain the behaviors of farmers in this initial study in Grenada. Albeit, a further understanding of perception of susceptibility is fundamental knowledge but can also contextualize and explain findings of baseline studies to provide deeper insights about the relationship between agrochemical use and potential health outcomes. Several programs have been developed and implemented to address farmers' perception of susceptibility as the first level of intervention towards changing behaviors which may be instructive to address health and safety challenges in the agriculture sector.

Limitations of the Study

Given that secondary data were used in the analyses in this study, there were several limitations to the study in Grenada. First, a limitation of this study was the lack of data on the specific agrochemicals used by farmers in the country. As such, an assumption was made that farmers used at least one of the most commonly used agrochemicals in the country at the time of the study. This limitation may negatively affect the effectiveness of efforts to address public health challenges related to the use of specific agrochemicals. The findings of this research provided an initial indication of the potential public health problems that may exist or arise as a consequence of exposure to agrochemicals and may be used as baseline to inform further studies to provide more data that are specific for answering the research questions.

Another limitation of the study was gaps in the collection of data on the use of PPE. This data were essential for calculating the cumulative intensity risk exposure score. In the literature, there was indication of sparse use of PPE in Grenada, except for rubber boots (Semple, 2005). There was no mention of the use of chemical resistant gloves, respirators, overalls, and other PPE for protection against exposure to agrochemicals.

This study was conducted to determine which socioeconomic characteristic may be associated with the use of agrochemicals at levels that pose risk for health. The study drew on the findings of the AHS. In most of the publications, the number of social and economic factors that were investigated was limited to one or two factors. This also limited comparison of the findings in the study in Grenada with the AHS and other studies in the literature review.

Most of the AHS studies were conducted with White male applicators while the census in Grenada was conducted with Black male and female farmers. The differences in how agrochemicals may affect racial and gender groups were not considered in this study. This study did not focus on the pathways for the development or transmission of the health problems. The study was limited to investigating the association between the health problem and socioeconomic factors. An assumption was made that men and women were affected in similar ways from exposure to a specific agrochemical. Other studies, however, may provide critical information to enhance understanding about the adverse outcome pathways for the diseases.

Recommendations for Future Research

This research was the first to be conducted in Grenada to investigate the relationship between individual characteristics of farmers and the frequency of use of agrochemicals at levels that may pose risk for health. In this research, secondary data were used from the 2012 agriculture census. In conducting the census, a limited amount of information was collected on the use of agrochemicals and factors that may affect the use of the chemicals. As such, in conducting assessments to determine what health risk may exists for farmers related to the use of agrochemicals, a more comprehensive survey is required. This study may be used as a baseline to compare the results of future studies. However, given the public health significance of the issue in this study, future agriculture censuses should include questions on a wider set of factors for comprehensive and in depth assessment of the potential health risk for farmers in Grenada. While censuses capture information from a larger population, other studies may be conducted with selected groups of farmers to collect in-depth information which may also service to inform the scope of larger studies.

Future studies may also target a broader cross-section of the public, in particular, members of farmers' households and farm workers, to determine the level of exposure of the groups and factors that influence exposure to agrochemicals. Such inclusive studies may be used to provide a more comprehensive understanding about the interplay between the factors at each level in the ecology and to inform the most critical cross cutting strategies to address identified public health challenges.

There may be some ambiguity with regard to the farm location as the unit of analysis. The parish of residence of the farmer may be more critical to assess social and economic characteristics of farmers. In small island settings, such as in Grenada, farmers can readily operate farms in other parishes in which the social and economic conditions are not synonymous to the parish in which the farmer reside. At the same time, the location of the farm is less likely to be impacted by everyday social and economic conditions in the parish. As such, further studies in Grenada and in other countries should also deliberately investigate differences in the frequency of use of agrochemical based on farmers place or parish of residence.

Although farmers reported on the highest level of completion of education in the 2012 agriculture census, there were gaps in the data, limiting the assessment of knowledge and consistency with good agricultural practices, agriculture hygiene, chemicals use in production, stewardship in use, application, handling, and disposal of chemicals, and use of PPE. These are critical information to facilitate comprehensive public health risk assessment which is also necessary to inform policy development to protect public health. Importantly, risk assessment underscores an evidenced-based approach in the targeting and delivery of public health interventions. A recommendation is for the modification of the census data collection instrument to optimize the opportunity to collect the broadest range of information that can contribute to significantly improving the risk assessment mechanisms, surveillance, and the information machinery for evidence-based decision making.

Presence of agriculture issue and the relationship with use of agrochemicals was not investigated in the AHS. However, this research in Grenada shows that there is a potential for presence of agriculture issue to be associated with frequency of use of agrochemical and, potentially, cause health problems. This factor should, therefore, be considered for investigation in future studies relating to socioeconomic characteristics and the use of agrochemicals. Pest and disease should have been an important determinant of the outcome in Grenada, however, the results indicated the contrary. It can be considered that use of agrochemicals may not necessarily be on the basis of production issues, but the chemicals may be used arbitrarily. At the same time, the list of issues that farmers were required to choose from may not have included the major factors that influenced the use of the chemicals. As such, further research is needed, possibly using a focus group design to collect information on a wider range of factors that may inference the outcome.

In Jamaica, it was found that having attended training in the past 5 years was associated with the use of PPE by farmers in coffee production (Henry & Feola, 2013) however, in another study, only 25% of 359 farmers reported receiving training (Ncube, Fogo, Bessler, Jolly, & Jolly, 2011). Glyphosate, paraquat, and carbamate were found to be among the most commonly used agro-chemicals in the Dominican Republic (Hutter et al., 2018). The Dominican Republic is located in the northern part of the Caribbean. Between 4-5% of farmers reported use of PPE during application of agro-chemicals.

Further, the results of the study also show odds ratio higher than 1 (OR 3.1, 95% confidence interval: 1.3 – 7.4) for frequency of presence of all biomarkers of toxic oral or respiratory exposures among exposed farmers. Agricultural practice were not investigated in the agriculture census, however, the findings from the study in Trinidad, Jamaica and the Dominican Republic highlights the usefulness of collecting and analyzing information on consistency with GAP and use of PPE in occupational risk assessment. Detailed risk assessment studies provide the overall benefit of guiding decision makers in streamlining interventions and policies to improve effectiveness.

Implications for Professional Practice and Social Change

The study produced results about the relationship between social-economic characteristics of farmers in Grenada and the frequency of use of agro-chemicals at levels that can potentially cause farmers to experience sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze, ESRD, and Parkinson’s disease. The results show social-economic characteristics have different influence on the farmers’ use of agro-chemicals in general and the frequency of use of herbicides specifically. Identification of these characteristics of farmers can provide a basis for monitoring the use of the chemicals among specific sub-population groups. The information that is provided about the factors that may influence the use of agro-chemicals and the possible health outcomes can serve to direct strategies by the Ministry of Health and the Ministry of Agriculture to address gaps in knowledge, practice, and systems to improve and maintain the health and well-being of citizens in Grenada.

This study was the first to provide specific information on the relationship between the use of agrochemicals and health in the agriculture sector. Consequently, there is an opportunity for the Ministry of Health, Ministry of Agriculture and other stakeholders to collaborate to address apparent gaps in knowledge and practice that increase health risk. More importantly, the results from this study can be used to improve targeting and the effectiveness of interventions. The farmers that were identified to be at higher risk based on previous higher use of the chemicals should be given priority in interventions to eliminate, minimize and control the onset of health problems. Furthermore, the institutions may refer to the finding of this study to determine whether there is a need to address the type of agrochemicals that are used in Grenada, whether there is a need to address agricultural practices related to personal protection, and whether there is a need to modify the surveillance system to monitor occupational-related diseases. Further research is, however, needed to provide more in-depth knowledge about the frequency of use of the specific agrochemicals. This study was premised on the general frequency of use observed in sale of the product at agricultural stores.

The results showed farmers who had joint ownership with members in the same household were more likely to ever use agrochemicals indicating higher risk for experiencing health problems in RQ1 than farmers who has individual ownership status. Further research is needed to understand the scope of the risk from agricultural practice regarding use of chemicals. Meanwhile this result indicated the need for intervention to extend to the family and not be restricted to monitoring and addressing farmers.

The results indicated that market presence was associated with higher use of herbicides but not other agrochemicals. Generally, high agrochemical use is regarded as a risk for both farmers and consumers and many markets tend to monitor and discourage high level of use of agrochemicals. Markets can be encouraged to incorporate monitoring systems for vendors. Inadvertently the risk for farmers can also be reduced they are also likely not to invest in PPE. The Ministry of Agriculture, may therefore need to develop a comprehensive program to also promote safe use among all residents who may produce crops for use but not necessarily sell to markets through which monitoring and information may be provided.

Membership in a farm organization may be an important factor associated with the frequency of use of agrochemicals. Farmers in an association were more likely to use agrochemical in general and herbicide overall with odds above 1. The indication of the importance of this channel was useful to help in targeting interventions to increase risk communication and to receive feedback on behaviors among farmers. Targeting farmers at the individual level can be challenging and may frustrate the efforts of authorities and threaten sustainability. Farm organizations can be equipped as vehicles for change. A specific program should be developed for broad based stakeholder collaboration to address the public health challenges rather than individual effort of the MOH.

Monitoring of agrochemicals use in Carriacou is also recommended given that the results show there was a higher odds of farmers on the island using agrochemicals. Extension programs should be developed to engage farmers in education programs and monitoring the frequency of use of agrochemicals in field practice. The extension officers in the Ministry of agriculture should Provision of technical support to adopt good agricultural practices, including alternative and safer technologies should also be highly underscored in the agriculture sector in Grenada.

Although this information may be considered as baseline, while systems are being developed to address health risk, the MOH can reference the findings of this study to conduct retrospective studies on patterns of the diseases. A retrospective health study may be necessary to assess the prevalence of symptoms of the diseases specified in this study among the farming population, following which systems can be established for both active and passive monitoring of symptoms among farmers. Collection and use of data on occupational health and practices is also a prudent action to enhance monitoring and implementation of preventive measures in clinical practice. The current health system does not require doctors to document occupational history and make linkages to clinical issues. New policies should be developed to address this gap. Proper medical care and screening can be extremely useful in preventive care. Additionally the Pesticides and Toxic Chemical Control Bill, which is currently under review in Grenada, should be modified to influence stricter control of procurement, use, and monitoring of agrochemicals in all sectors.

Conclusion

This study was the first of its kind in Grenada to provide information on the relationships that existed between the socioeconomic characteristics of farmers in Grenada and the frequency of use of agro chemicals at levels that were hazardous to human health. In this study, it was found that there was statistically significant relationships between age, gender, parish of location of the farm, highest level of education completed, market presence, income from agriculture production, experienced production issues, membership in farm organization, receipt of technical assistance, receipt of credit, land ownership status, maintaining farm records, number of paid workers, number of nonhousehold members working on the farm, number of parcels of land operated by the farmer, and number of unpaid hours of work on the farm, respectively and the frequency of use of agrochemicals. The results of the analyses also showed there were statistically significant relationships between age, membership in farm organization, receipt of credit, land ownership status, maintaining farm records, farmers unpaid hours of work on the farm, parcels of land operated, and number of paid workers on the farm in the last week before the interview, respectively and the use of herbicides ≥12 times per year. These significant relationships were also indicative of a greater likelihood for the farmers to experience health problems that were found in the AHS to be associated with the use of and exposure to agrochemicals.

The conduct of this study may be an advantage for public health in Grenada. The results of this study may be used as a reference to make projections about health problems that may arise in the local farming community. As such, health planners, policy makers, community members, and other stakeholder can take a proactive approach to address the aspect of use of agrochemical to reduce the risk for diseases in the farming population. The health status of farmers has implications for production, food security, and nutrition in Grenada. Despite an aging farming population, the proposal of the WHO is pivotal for sustainability of the local agriculture sector. The WHO urged public health practitioners and health care authorities to identify and address upstream determinants of health as one of three critical steps to achieve equity in health and to improve the social conditions. As such, based on the results in this study, the following should be considered by public health practitioners:

1. Whether there is a need to address the type of agrochemicals that are used in Grenada;
2. Whether there is a need to address agricultural practices related to personal protection;
3. Whether there is a need to modify the surveillance system to monitor occupational-related diseases.

An affirmative approach is needed to address the higher odds of experiencing health problems by farmers in Grenada. The outcome of the Dewayne Johnson case in California in August 2018 is a sterling example of the health consequences that workers may face stemming either from a lack of information or failing to act on information to protect public health. An increase in the incidence of the diseases identified in this study can be treacherous for the framers household as well as the local health care system that is typical of low income and developing countries.

Two measures may be most critical to respond to the findings in this study. First, the underpinning principle of public health practice, prevention, should be adopted. Prevention of health problems should be the main aim of any policy or intervention related to the use of agrochemicals in Grenada. Second, the precautionary principle should be promoted in the immediate period to create awareness of the issue and to encourage farmers to be cautions and take responsibility for their health. Personal responsibility for prevention can be an effective strategy to reduce exposures to harmful agrochemicals in the short term while other long term interventions are developed.

Highlighting the characteristics of farmers that predispose the population to environmental and occupational health risk is a benefit to inform effective targeting and delivery of programs to reduce public health problems. An additional benefit of this study is the wider range of variables investigated to substantiate evidence of the problem in Grenada. Research is costly and few population based studies were conducted in Grenada to assess population risk. This study, therefore, may be regarded as valuable to inform local and regional strategies to improve public health. The findings of this study may be extrapolated to generate similar knowledge in other countries in the Caribbean region to address the current gap in knowledge about the use of agrochemicals and the potential health risks.

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Appendix A: Grenada 2012 Agriculture Census Farm Questionnaire

MINISTRY OF AGRICULTURE CENTRAL STATISTICAL OFFICE

CONFIDENTIAL

FARM QUESTIONNAIRE

GRENADA AGRICULTURAL CENSUS (GAC)

I RESPONSIBILITIES GAC-02

Enumerator's Name	Date	Supervisor's Name	Date	District Co-ordinator's Name	Date
Quality Controller's Name	Date	Coder's Name	Date	Entry Operator's Name	Date

II QUESTIONNAIRE IDENTIFICATION

0 1	....				
Register	Questionnaire No.	Parish	WS	ED	Farm No.

III FARM AND FARMER'S TODAY

01 Parish	Village	Location	Name of The Farm

Farmer's Name				Farmer's Address
First Name	Middle Name	Last Name	Alias	Village/Location/Street & No.

Contact Information *(Phone)*			
Home Number	Work Number	Cell Number	Cell Number

Informant's Name, if Not the Farmer		Household Head Name, If Not the Farmer	
First Name	Last Name	First Name	Last Name

Remarks ____________________________________

____

____

Official Use Only
DATA ENTRY

1

0 2	....
Register	Questionnaire No.

IV FARMER AND HOUSEHOLD POPULATION INFORMATION

02 What Is The **Legal Status** Of the Farm?

Individual	1
2 Or More Of Same Household	2
Joint Farmer (**2 Or More Members Of Different Households**)	3

Company	4
Cooperative	5
Government	6
Other	7
No Answer	9

Go to **08**

03 What is the total number of persons living in this household? (***see question 6 on Short Form***) [ ]

04 Who Were The **Persons** 15 years and over Living In This Household During The ***Last Week*** (Sunday Through Saturday) and the **average unpaid hours worked per week** on the farm?

Number	First Name & Last Name	Sex		Age	Average No. of unpaid Hours worked Per Week on the Farm
		Male	**Female**		
01	Farmer	1	2		
02		1	2		
03		1	2		
04		1	2		
05		1	2		
06		1	2		
07		1	2		
08		1	2		
09		1	2		
10		1	2		
11		1	2		
12		1	2		
00	**TOTAL**				

05 Number of persons in the household **under 15** years by sex.

Male			
Female			
TOTAL			

06 What is the highest Level of **Formal Education** attained by the Farmer?

None	1		Primary	2		Secondary	3
Vocational	4		Tertiary	5			

07 What Was The **Main Occupation** Of The Farmer During The ***Last Twelve Months?*** ______________________ Code [ ]

Remarks ____

____

0	3	…………………….
Register		Questionnaire No.

V FARM LABOUR INFORMATION

08 a **Last Week**, Were There Any **Unpaid Non-Household Members** On The Farm? Yes 1 No 2

Unpaid Non-Household Members	Total	Males	Females

08 b **Last Week**, Were There Any **Paid Workers** On The Farm? Yes 1 No 2

Paid Workers			**Cash Or Cash/Kind**			**Only Kind**		
Total	Males	Females	Total	Males	Females	Total	Males	Females

Remarks ____

____

____

0	4	…………………….
Register		Questionnaire No.

VI TOTAL LAND & LAND TENURE FOR THE FARM BY PARCEL

09	How Many **Parcels** of Land does The Farmer Operate on This Farm ***Today***?

10	What Is The **Total Land** Of This Farm ***Today*** Parcel by Parcel?

NO	NAME OF THE PARCEL	LOCATION OF THE PARCEL BY PARISH		AREA (ACRES)	TENURE CODE	SLOPE OF LAND		
			Code			Flat	Rolling	Steep
01				.		1	2	3
02				.		1	2	3
03				.		1	2	3
04				.		1	2	3
05				.		1	2	3
06				.		1	2	3
07				.		1	2	3
08				.		1	2	3
09				.		1	2	3
10				.		1	2	3
00		TOTAL FARM AREA		.				

Land Tenure Codes: Owned – 1; Family Land – 2; Government Rented – 3; Private Rented – 4; Free use – 5 ; Squatted – 6; Other – 9;

0	5a	....			.
Register		Questionnaire No.	Parcel No.		Parcel Area (From Question 10)

VII ACTUAL LAND USE OF THIS PARCEL TODAY

11 What is the **Actual Land Use** Of This Parcel ***Today*** Plot By Plot?

PLOT #	Crops & Other Land Use Of This Parcel Today	Code			Type of Planting (use codes)	Area Planted (Acres)	Number Of Plants or Trees (For Scattered Crops or when Area is Unknown or very small)		Age of Trees (Years)
							# of Plants or Trees	Spacing (Feet x Feet)	
						.			
						.			
						.			
						.			
						.			
						.			
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						.			
						.			
	Non Agricultural Land	0	0	5		.			
	TOTAL AREA					.			

Planting Codes: Pure Stand or Mono Crop – 1; Interplanted – 2; Mixed Crop – 3; Scattered Crop – 4;
Land Use Codes - Livestock – 006; Temporary – 007

5

0	5b	…………………			.
Register		**Questionnaire No.**	**Parcel No.**		**Parcel Area (From Question 10)**

12 What Are The **Temporary Crops Planted and Harvested** On this Parcel During The **Last 12 Months?**

PLOT	Temporary Crops Planted and Harvested On this Parcel during the **Last 12 Months**	Code			Area Planted (Acres)	Number Of Plants	Planted	Disposal % *(Row must add up to 100)*			
						Planted	Spacing (Feet x Feet)	For Sale %	Home Use %	Waste Spoilt %	Stolen %
					•						
					•						
					•						
					•						
					•						
					•						
					•						
					•						
					•						
					•						
					•						
					•						
					•						
	TOTAL				•						

Remarks ____

____

0	6

Register .... **Questionnaire No.** | | | **Parcel No.**

VIII IRRIGATION

13 During the **last twelve months** did you **use irrigation** on this Parcel? Yes 1 No 2

Type of System	Used		Area (Acres) of land irrigated	Crop Irrigated			Main Water Source *(one only)*			
	YES	NO		Veg.	Root	Fruit	River	NAWASA	Wells	Other
Drip	1	2	•	1	2	3	1	2	3	4
Micro sprinklers	1	2	•	1	2	3	1	2	3	4
Overhead	1	2	•	1	2	3	1	2	3	4
Other	1	2	•	1	2	3	1	2	3	4

0	7

Register .... **Questionnaire No.**

IX LIVESTOCK TODAY

14 Does This Farm Have Any **Cattle** ***Today***? Yes 1 No 2

If **Yes:** How Many Cattle Does This Farm Have?

Male Calves	Female Calves	Steers	Heifers	Bulls	Cows	Total Cattle

15 Does This Farm Have Any **Sheep** ***Today***? Yes 1 No 2

If **Yes:** How Many Sheep Does This Farm Have?

Male Lambs	Female Lambs	Rams	Ewes	Total Sheep

16 Does This Farm Have Any **Goats** ***Today***? Yes 1 No 2

If **Yes:** How Many Goats Does This Farm Have?

Male Kids	Female Kids	Bucks	Does	Total Goats

17 Does This Farm Have Any **Pigs** ***Today***? Yes 1 No 2

If **Yes:** How Many Pigs Does This Farm Have?

Piglets	Gilts	Fatteners	Boars	Sows	Total Pigs

18 Does This Farm Have Any **Other Livestock** or **Bee Hives**? Yes 1 No 2

If **Yes:** How Many Livestock Does This Farm Have?

Horses	Donkeys	Rabbits	Bee Hives	

19 Does This Farm Have Any **Poultry** ***Today***? | Yes | 1 | | No | 2 |

If **Yes:** How Many Poultry Does This Farm Have?

Layers	Broilers	Yard Fowls	Total Chickens	Turkeys	Ducks	Pigeons

20 **In The Census Year**, Did this farm dispose of any animals? | Yes | 1 | | No | 2 |

If Yes, How Many Animals Have Been Sold Alive, Slaughtered, Lost or Otherwise Disposed?

Type Of Livestock	Sold Alive	Slaughtered	Lost/Other Disposals
Cattle			
Goats			
Sheep			
Pigs			
Chickens			

Remarks ____

____

____

0	8	....

Register **Questionnaire No.**

X. FERTILIZERS AND AGRO-CHEMICALS

21 Did the Farm use any Chemical Fertilizer, Organic Manure or Agro-Chemicals, **during the last 12 months**? | Yes | 1 | | No | 2 |

22 If yes, what was the level of use?

Item	**Used**		**Light use**	**Medium use**	**Heavy Use**
	YES	NO			
Chemical Fertilizer	1	2	1	2	3
Organic Manure	1	2	1	2	3
Fungicide	1	2	1	2	3
Herbicide	1	2	1	2	3
Insecticide	1	2	1	2	3
Other Pesticide	1	2	1	2	3
	1	2	1	2	3

0	9

....

Register Questionnaire No.

XI FARM MACHINERY/EQUIPMENT

23 Does This Farm Own, Rent or use the Services of Any **Farm Machinery &/ Equipment, during the last 12 months**?

Yes	1	No	2

Equipment and Machinery	**Used**		**Number**				**Number of Days used per year**
	YES	**NO**	**Owned**	**Rented**	**Borrowed (no charge)**	**Government Hire**	
Motor vehicles (Land rovers, pickups, Jeep, etc.)	1	2					
Tractors	1	2					
Rotovators & Ploughs	1	2					
Knapsack sprayers	1	2					
Mist Blowers	1	2					
Seed planters	1	2					
Brush /Line cutters	1	2					
Chain saws	1	2					
Plucking machine	1	2					
Other -	1	2					
Other -	1	2					
Other -	1	2					

Remarks ____

____-____

____

0	10

....

Register Questionnaire No.

XII OTHER MISCELLANEOUS INFORMATION

24 Where Does the Farmer **Sell** The Products? ***(Circle all that apply)***

Do Not Sell	1	On The Farm	5	Association	9
Hotel/Restaurant	2	Supermarkets	6	Marketing Board	10
Municipal Market	3	Traffickers/Exporters	7	Farmer's Market	11
Road side vending	4	Agro-processors	8	Schools	12
				Other	15

25 Does the Farmer Belong To Any Of These **Farm Organisations?** Yes 1 No 2

Organisation	Yes
Fair Trade	1
GCA	1
GCNA	1
Poultry Association	1
Farm Watch	1

Organisation	Yes
Livestock Associations	1
Carriacou Farmers Association	1
Other -	1
Other -	1
Other -	1

26 Did The Farmer Receive Any **Technical Assistance/Information** From These Institutions During the last 12 months? Yes 1 No 2

Institution	Yes
MOA/DOA	1
Farm Organisation	1
Media	1

Institution	Yes
NGO	1
Chinese Mission	1
CARDI	1

Institutions	Yes
IICA	1
Other -	1
Other -	1

27 Did The Farm Receive Any **Credit** From Any Of These Institutions During the last 12 months? Yes 1 No 2

Institution	**Yes**
Development Bank	1
Commercial Bank	1
Farm Organisation	1

Institution	**Yes**
MOA	1
NGO	1
Credit Union	1

Institution	**Yes**
MNIB	1
Other	1
Other	1

28

All income	1	About a Quarter	4
About Three quarters	2	Less than a Quarter	5
About Half	3	No Answer	9

29 Are You Keeping Any **Farm Records**? Yes 1 No 2

0	11

Register .... **Questionnaire No.**

30 **XIII PRODUCTION ISSUES**

ISSUES	**An Issue**		**Minor Issue**	**Major Issue**
Access Roads	1	2	1	2
Praedial Larceny	1	2	1	2
Pest	1	2	1	2
Disease	1	2	1	2
Technical Support	1	2	1	2
Access to Credit	1	2	1	2
Access to Land	1	2	1	2
Dog Predation	1	2	1	2
Storage	1	2	1	2
Availability of inputs	1	2	1	2
Marketing	1	2	1	2

End of Interview

Appendix B: Grenada 2012 Agriculture Census Explanatory Notes

Grenada – Grenada Agricultural Census 2012 - Explanatory Notes

Historical outline

Previous agricultural censuses were conducted in 1961, 1975, 1981, and 1995.

Legal basis and organization

The Statistics Act of December 1960 established that there should be a Statistical office and prescribes its duties, the first one is "to take any census". In Section 4 establishes that the Statistical Officer may delegate in writing his powers and functions under the Act. For the Grenada Agricultural Census 2012, such delegation was done by the Grenada Cabinet of Ministers that approved and gave authority to conduct the census to the Planning Unit of the Ministry of Agriculture. It was founded by the European Unions and the National budget and received the FAO technical assistance by means of two Technical Cooperation Projects. The field work for the 2012 Agricultural Census, involved 287 enumerators and 65 field supervisors.

Enumeration period

The census of agriculture was enumerated during the period October-November 2012.

Reference period/date

The census reference year was the 12 months prior to the visit of the enumerator.

Day of visit for: holding identification and location, identification and legal status of holder, holding area, number of parcels, land tenure, land use, livestock,

The reference period for labour force was the week before the enumeration day.

Definition of the statistical unit:

The agricultural census enumeration unit was defined as an "economic unit" of agricultural production under single management comprising all livestock kept and all land used, wholly or partly, for agricultural production purposes, without regard to title, legal form, or size. Single management may be exercised by an individual or household, jointly by two or more individual or households, by a clan, village, or by a juridical person such as a company, co-operative or government agency. The farm land may consist of one or more parcels located in one or more watersheds (WSs), providing the parcels share the same "production means" utilized by the farm, such as labour, farm buildings, machinery or draught animals.

There are two types of agricultural holdings: 1) holdings in the household sector: those operated by household members (individual or household, joint individuals from different households); 2) holdings in the non-household sector: those operated by cooperatives, corporations, government institutions, church institutions and other non-household enterprise.

Geographical coverage

The census covered the whole country.

Statistical coverage

The holdings with activity over at least one of the following cut-off limits were enumerated by means of a long questionnaire. The rest of holdings (those below all the cut-off limits) were enumerated using a short questionnaire (short listing form)

- 0.25 acre of garden crops; or
- 1 head of cattle; or
- 5 sheep plus goats plus pigs; or
- 25 poultry; or
- 25 Nutmeg + cocoa + banana mats + fruit trees + nut + spice trees.

Data items coverage

Two questionnaires were used: a "short listing form" and a "long farm questionnaire".

Items of the short listing form comprised: livestock (including poultry), some permanent and semi-permanent crops, garden temporary crops, engagement in fishing activities and other non-agricultural activities in the household. The short listing form acted also a screening form to identify households operating agricultural holdings above any of the cut-off limits.

The information collected through the long farm questionnaire (GAC02), applied to holdings above the threshold, covered: General information, identification and legal status and main activity of holding, demographics characteristic of households, employment, land use, land tenure, area or number of plants for permanent crops, area and end use of temporary crops, irrigation, livestock, machinery and equipment, selected practices and facilities, production issues.

Frame

A list of large farms or "non-household" farms was prepared prior to the census taking. The rest of units were identified through the short questionnaire applied for screening all households in the country.

Methodology

The country was divided in Enumeration Districts (ED) (287 including 19 in the islands of Carricou and Petit Martinique). Enumerators had to canvass the assigned ED identifying all households in it and applying the short questionnaire (GAC01) in order to identify those holdings above the threshold and also to collect information in small holdings below it. The second questionnaire (GAC02) was applied to all holdings above the threshold.

The information was collected by means of personal interviews with manual filling of paper questionnaires.

Strong field supervision was applied to ensure quality during the field operations.

Data were manually edited, coded and keypunched.

Post census techniques to check census quality

No post enumeration survey (PES) was applied. Checking against external data was prformed to assess the accuracy of the data.

Data Dissemination and Use

The final results of the 2012 Census of Agriculture will be delivered through a final printed report, CD Roms and the official website.

Special features

No community survey was taken. Fishing activities of households were reported in the short listing form.

Data source

Questionnaires; Field Team Manuals; Website: http://www.gov.gd/ministries/agriculture.html

Mailing address / Census contact points

Daniel Lewis. Email: dannypoo2009@hotmail.com

Appendix C: Grenada 2012 Agriculture Census Field Manual

GRENADA MINISTRY OF AGRICULTURE

AGRICULTURE CENSUS

FIELD TEAM MANUAL

St. George's, Grenada, September, 2012

TABLE OF CONTENTS

ACRONYMS

ACF	Agricultural Census Frame
AD	Agricultural District
CSO	Central Statistics Office
ED	Enumeration District
FAO	Food and Agricultural Organization
GAC	Grenada Agricultural Census
GRN	Grenada
MOA	Ministry of Agriculture
WS	Water Shed

1. INTRODUCTION

The first Agricultural Census of Grenada was conducted in 1961, the second in 1975 the third in 1981 and the last one in 1995. You are participating in the fifth Agricultural Census which is the 2012 Grenada Agricultural Census (2012 GAC).

This ENUMERATORS MANUAL is designed to be used by the census field team to answer the questions that may come up while they are collecting the data from the field. It explains all phases of the data collection from the beginning to the end. When the field staff face a problem, an answer can be found in this manual. For this reason it is very important to read this **MANUAL** very carefully and to be familiar with it.

The Census and Statistics Act of Grenada provides for the total CONFIDENTIALITY of the information collected in the census. The information can only be used for the purpose of compiling statistics and no individual information can be disclosed to anyone outside the census organization.

2. OBJECTIVES AND ORGANISATION OF THE 2012 GAC

2.1 OBJECTIVES

- To measure the actual structure of the agricultural sector by collecting information on those variables that do not change rapidly from year to year.
- To provide an adequate frame for the establishment of an On-going Agricultural Information System of Grenada to monitor and evaluate the changes occurring in this sector on a regular and continuing basis.
- To strengthen the capabilities of the Planning Unit in the Ministry of Agriculture (MOA), and other related institutions, to plan, design, collect, process, analyse and disseminate information for the agricultural sector.

2.2 THE 2012 GAC ORGANISATION

The 2012 GAC has a hierarchical organisation for successful execution. The Grenada Cabinet of Ministers has approved and given authority to conduct the 2012 GAC. According to this authority the Planning Unit of MOA is in charge of conducting or given the responsibility to conduct the 2012 GAC, with the co-operation of the Central Statistics Office of the Ministry of Finance.

For the purposes of the GAC, the country is divided first into Parishes and then into ENUMERATION DISTRICTS (EDs), There are 287 such EDs in Grenada including 19 on Carriacou and Petite Martinique. Each ED is allocated to an enumerator who is responsible for visiting ALL households in that ED and recording the relevant information. Each enumerator has a supervisor who will check the work and resolve any issues. Typically each supervisor will be responsible for 4 or 5 enumerators. The success of the census depends entirely on the work in the field. EVERY EFFORT must be made to include all households and to record accurate information. Where necessary, repeat the visits to the households which will be required to collect the data. This is part of the work of the enumerator. When all members of a household are absent at the time of the visit, or the key informant (farmer) is not at home, arrangements must be made for a return visit. This is very important.

3. BASIC TERMS AND DEFINITIONS

3.1 AGRICULTURAL CENSUS

It is the complete enumeration of all farming households and farm enterprises existing in Grenada on the census day without omission or duplication.

3.2 REPORTING UNIT

The **"HOUSEHOLD"** is the initial entry point for the Agricultural Census. This is the same unit as used in the Population and Housing Census. Through the Household we identify all the Farms above our cut-off limits. The "**FARM**" is the reporting unit for the 2012 GAC. In addition your supervisor will have a list of large farms or non-household farms that will not be picked up by visiting households. Your supervisor MUST ensure all these Non-household Farms are also enumerated. One Farm Questionnaire (GAC-02) MUST be filled out for EACH farm.

3.3 UNIVERSE OR POPULATION OF 2012 GAC

It is composed of all households and farms (reporting units) existing in Grenada on the census day.

3.4 ENUMERATION DISTRICT (ED)

It is an area containing approximately 100 households with clear, stable, physical boundaries marked on a map.

3.5 AGRICULTURAL CENSUS FRAME (ACF)

It is the complete list of all EDs prepared in Grenada for the 2012 GAC.

3.6 TOPOGRAPHIC MAP

It is a reduced (for example 100 times) and simplified representation of the "NATURAL AND ARTIFICIAL FEATURES" of the terrain such as hills, rivers, creeks, forests, swamps, etc. and towns, villages, roads, path roads, bridges, canals, power lines, etc. Each topographic map has a "LEGEND" of symbols representing these features of the terrain. One important symbol is called the" CONTOUR LINES" representing the elevations or inequalities (relief) of the land surface.

3.7 SKETCH

It is the representation, without regarding the scale, of the main natural and artificial features, themes or subjects.

3.8 SCALE

It is the ratio of a distance on a map to its corresponding distance on the ground. Scale may be expressed as a ratio (1:25,000), a representative fraction (1/20,000), or an equivalence (1 cm on the map = 250 meters on the ground).

3.9 FARM

It is an **"ECONOMIC UNIT"** of agricultural production under single management comprising all livestock kept and all land used, wholly or partly, for agricultural production purposes, without regard to title, legal form, or size. Single management may be exercised by an individual or household, jointly by two or more individual or households, by a clan, village, or by a juridical person such as a company, co-operative or government agency. The farm land may consist of one or more parcels located in one or more **WATERSHEDS (WSs),** providing the parcels share the same "**PRODUCTION MEANS**" utilized by the farm, such as labour, farm buildings, machinery or draught animals.

3.10 PARCEL

A farm parcel is any piece of land under a single form of tenure, entirely surrounded by other land, water, road, forest, etc. not forming part of this farm. A parcel may consist of one or more plots adjacent to each other.

3.11 PLOT

A plot is a continuous piece of land inside a PARCEL devoted to a crop in pure or mixed stand or any other land use. A parcel may consist of one or more plots adjacent to each other. If a parcel has several crops (or mixed crops), the area -of each crop is a plot. If a crop has been planted on different dates then each of these plantings is a plot.

3.12 FARMER

S/He is a person or juridical institution who exercises management control over the agricultural farm operations and takes major decisions regarding resource use. The farmer has technical and economic responsibility for the farm and may undertake all responsibilities directly, or delegate responsibilities related to-day-to-day work management to a hired manager.

The work of a farmer can be material, when he conducts directly by himself the physical agricultural activities of the farm or only intellectual, like in the case of that farmer who lives in the city, and travels periodically to the farm, or not, but takes the major decision on the farm operation.

It is important to take into account the following considerations in the determination of a farmer:

There MUST always be a one-to-one correspondence between a farmer and a farm.

In rural areas, a one-to-one correspondence between a farm (farmer) and a household is quite common. Thus households serve to identify farms.

In most of the cases the farmer is a single person. But in some households, both husband and wife may share the decision making and thus the management of the farm. As only ONE farmer can be identified in Section III of the Farm Questionnaire, the respondent will have to decide whose name should be recorded here. HOWEVER, section IV (04) can be used to record situations where more than one person is involved in the management of the farm. To do this enter 'FARMER' after the name of each person who operates in this decision making capacity on the farm.

In other situations, a household may have more than one farmer, when each person operates different piece(s) of land. Then, each piece of land becomes a farm and a separate GAC-02 must be completed for each farm. . However, if the agricultural operation and the production obtained in all those pieces of land is **COMMUNAL** for all members of the household, there will be only one farmer and only one farm to answer questions (farmer's name & address), 3, 4, 5 & 6 of Long Farm Questionnaire GAC-02. In this case, the farmer will be the household member, who spends more time in the farm (for example, in some cases the wife may spend more time); and, if more than one person spends equal time, the farmer will be chosen according to these priorities: father, mother, eldest son and so forth. The other household members participating in the work of the farm will be regarded as members of the labour force of the farm.

When two or more persons belonging to different households operate the same farm, each one will be considered as **JOINT FARMER.** However, the enumerator **MUST** decide with the informant who is going to be the farmer to answer questions 1, 2, 3, 4, 5, 6 & 7 of the Long Farm Questionnaire GAC-02. The member of the household who spends more time in the farm will be considered the farmer. If more than one member of the **JOINT** households spend equal time, the eldest will be the farmer.

A farmer can operate land that is owned and/or leased and/or under any other form of land tenure.

A farmer can operate land without any rights to agricultural use of the land.

A hired manager or administrator will not be considered as the farmer of the farm he is managing. However, if he has livestock and poultry in the land of the farm, which he operates then he will be considered as a farmer of a farm without land.

When a manager, administrator or any worker of the farm, has received land for his own use, then he will be considered a farmer.

When a person, who has two or more households, is operating land for agricultural purposes in the different households with the same **"PRODUCTION MEANS"** in different WS, he will be considered as one farmer and one farm.

3.13 WATERSHED (WS)
A physical area (basin) or structure down which water flows through a system of streams, creeks, ravines, etc. draining the excess water into a main river going to the sea. The boundaries of the WSs are usually the hill or mountain ridges. An ED may be divided into different pieces by the WS boundaries.

3.14 BUILDING
It is a physical structure which is separate and independent of any other structure. It MUST be covered by a roof and enclosed within external walls. A building may be a factory, shop, detached dwelling, apartment building, warehouse, repair shop, poultry pen, etc. NOTE that detached rooms relating to main buildings are treated as part of the main buildings, for example detached kitchens, toilets, servants quarters, garages, etc.

3.15 DWELLING UNIT
It is any building or separate and independent part of building in which a person or a group of persons is living at the time of the census enumeration. It MUST have direct access from the street or road or common landing, staircase, passage or gallery where occupants can enter or leave without passing through anybody else's living quarters.

3.16 PRIVATE DWELLING
It is a dwelling in which a private household resides. This may be a single house, flat, apartment, out room, part of a commercial building, or a boarding house catering for less than six persons.

3.17 CLOSED DWELLING UNIT
It is a dwelling unit which is occupied, but during the enumeration period, the occupants are temporarily away, that is away for less than six (6) months.

3.18 VACANT DWELLING UNIT
If a dwelling unit is habitable but no one is living there at the time of your enumeration, you **MUST** also do at least one call back so that you can interview anyone who may have moved in since your previous visit.

3.19 PRIVATE HOUSEHOLD
It consists of one or more persons living together; i.e. sleeping most nights of a week with the household, and sharing at least one daily meal. In general, therefore, a household will comprise a father, mother and children living together. It is important to note, however, a member of the household is not necessarily a relative of the main family. For example, a boarder or a domestic servant, who sleeps in most nights of the week and shares at least one daily meal is also included as a member of the household. It is possible for a household to consist of just one person, or of more than one family; as long as they share living arrangements. A group of unrelated persons living together can also comprise a household.

3.20 CENSUS YEAR
It is the calendar year from 1 January 2012 to 31 December 2012. (In practice the 'last 12 months' is used as the reference period for many questions).

3.21 CENSUS DAY (Day of Visit)
It is the day the agricultural census enumerator conducts the interview with the farmer.

3.22 RESPONDENT
The respondent is the person from whom the data is collected about the household/farm. Normally it is the farmer. But sometimes, it could be a qualified person who knows very well the information being collected, such as the manager, the administrator, competent worker or an old farmer's relative.

3.23 ACRE
It is the unit used in measuring land area in Grenada. One acre is equal to around 70 by 69 yards or around 43,500 square feet.

3.24 GEOGRAPHICAL LOCATION
You will be required to enter information on **'location'** for the household, the farm and each separate parcel of land.

For the Household Questionnaire (GAC-01B) you should enter the location of the HOUSEHOLD.

In Section II of the Farm Questionnaire you should enter the location of the Household as recorded on GAC-01B.

In Section III of the farm Questionnaire you should enter the Parish, Village and Location of the FARM. This may be the same as for the household but it may be different. A unique reference point, called "HEADQUARTERS", is defined and located for each farm. A farm then belongs to the ED in which its headquarters is located. In most cases the headquarters is defined through the farmer's household. But, when there is not a household in the farm, then the location of the headquarters is made through any building existing in the farm in the following order: occupied dwelling *(s)* by other persons, who are not the farmer (relatives and/or workers), unoccupied dwellings, other constructions, such as: warehouses or livestock stables. If there is not any construction, the farm has to be located in the ED where the parcel is; when there is more than one parcel, the farm has to be located in the ED that has the largest parcel.

In Section VI, Q10, of the Farm Questionnaire you should enter the **VILLAGE** or **COMMUNITY**, and **PARISH** where **EACH PARCEL** is located.

4. FIELD ENUMERATION PROCEDURES

4.1 THE SUPERVISOR

After- receiving all materials and supplies, each supervisor is responsible for:

4.1.1 Making sure everything that is needed is in the enumerator's hands before leaving for the field. For each ED assigned make sure you have the map showing the assigned ED; also ensure that your **Enumeration Kit** contain the following: Field Team Manual, Household Questionnaire Booklet(s) GAC-01, Farm Questionnaires GAC-02, the List of Important and Specialized Farms GAC-04, census bag, copybook, copybook, clipboard, pencils with eraser, sharpener and identification card.

4.1.2 Making sure adequate extra supplies are secured.

4.1.3 In a team meeting, allocate the EDs to the enumerators. In most cases only one enumerator will work in an ED. Some enumerators will be required to cover more than one ED. In exceptional cases (very large EDs or EDs where work has been delayed or done badly) more than one enumerator may work in an ED. However, great care must be taken to clearly define the segments of the ED that each enumerator will work in.

4.1.4 Once the allocation of EDs has been completed, and agreed, the boundaries of each ED must be determined. In some cases, these boundaries are straightforward, following roads or other easily identified landmarks (rivers, etc.). If the boundaries are straightforward, and the enumerator comes from the area, it may be sufficient to go through the boundaries on the map to make sure the enumerator is clear where the boundaries are. Where a boundary is a road, care must be taken to only visit households on the side of the road included in the ED and not to cross the road. Where boundaries are less clear or the enumerator is from outside the area or the enumerator is not sure where the boundaries are, THE SUPERVISOR MUST GO WITH THE ENUMERATOR AND WALK RIGHT AROUND THE BOUNDARY. If the boundary coincides with another ED under the same supervisor, both enumerators should walk around with the supervisor. **ACCURATE IDENTIFICATION OF ED BOUNDARIES IS ESSENTIAL FOR A GOOD CENSUS COVERAGE.**

4.1.5 The supervisor is responsible for the quality and coverage of the work in his/her area. The quality of forms MUST be checked for each enumerator early on in the enumeration (first few days) as this is the time to correct any miss-understandings or errors in enumeration. Ensuring good work from day one will result in good quality.

4.1.6 After the enumeration has been completed in an ED, check the coverage, comparing the total number of households visited with the 2011 Population Census results. If there is a difference of more than 10% (plus or minus) then you need to do a check in the field by yourself. If there is not a satisfactory explanation for the difference, send the enumerator to enumerate the complete ED again.

4.1.7 Check data quality systematically, 1/20 (5%) of **"HOUSEHOLD QUESTIONNAIRES GAC-01"** in each ED selected per coverage checking. Check especially carefully for the classification of households as Non-Farm; Under the cut-off and Farm. If there are many inconsistencies, send the enumerator to re-interview the complete ED.

4.1.8 Check data quality systematically, 1/20 (5%) of **"FARM QUESTIONNAIRES GAC-02"** in each ED selected per coverage checking. If there are many inconsistencies, send the enumerator to re-interview the whole ED.

4.1.9 The final check should include checking that every household identified as having a farm should also have a GAC-02 form. Check that every parcel identified in Section VI of GAC-02 has a parcel form. After the material (questionnaires and cartography) has been checked and accepted, transfer the enumerator to the next ED. Complete the summary sheet summarising the number of GAC-01B forms completed and GAC-02 forms completed and put all forms in the ED envelope.

4.1.10 Send as soon as possible the completed ED material to the Agricultural Census Office, in order that the **QUALITY CONTROL TEAM** may be able to start their own check. Remember that the Agricultural Census Office will authorize the final payments for the field staff only after the material has been accepted by, the **QUALITY CONTROL TEAM**.

4.2 THE ENUMERATOR

4.2.1 Go to the ED, as identified on the map provided, and familiarize yourself with the boundaries with the help of the supervisor, when needed.

4.2.2 Most of the time the enumerator is able to start immediately, the census data collection, without driving-walking around the entire ED. Observe what is inside: land use, cultivated crops, geographic features, dwellings and other buildings. This will be helpful in talking with farmers about the agricultural activities of the land they operate.

4.2.3 If necessary, find a well-informed person (a knowledgeable person of the village, for example), who can help to identify boundaries and the farmers existing inside the ED. The first household found may provide valuable information to identify the neighbouring households and farms.

4.2.4 Identify an easy **STARTING POINT** on the map and start the enumeration procedures to find the first dwelling. Organise your route through the ED so ALL dwellings are visited.

4.2.5 Fill the Listing Form GAC-O1 for each household in the assigned ED. If a dwelling is empty at the time of your visit, check with neighbours if it is VACANT or the household is temporarily absent (at work, visiting relatives or friends, on holiday, etc.). If temporarily absent, arrange to call back using the call back form. Complete Section I of a GAC-01B to remind yourself to call-back.

4.2.6 When an ED has been divided in different pieces by the WSs boundaries, collect the information, For each WS separately to facilitate your work and ensure you record the right WS number on each form.

4.2.7 Conduct the interview using the Farm Questionnaire GAC-02 for all the farms with 1/4 acre or more of TEMPORARY CROPS Or 25 PER (MANENT PLANTS & OR TREES Or 1 cattle head, Or total of 5 livestock (sheep, Or goats, Or pigs), Or BREEDING (Sheep, Or goats Or pigs) Or 25 poultry (chickens) of any type. For the remaining farms, fill the Listing Form GAC-O1.

4.2.8 The information on areas of Long Farm Questionnaire GAC-02 **MUST** be filled parcel by parcel.

4.2.9 Before starting the interview, qualify the **INFORMANT**. Normally it is the farmer. But in some cases it could be a person who knows very well, the information being collected, like the manager or the administrator, a competent worker, the farmer's wife, or an old farmer's relative.

4.2.10 Thank the informant for the interview. Inquire about other farmers, in the **ED** and where they can be contacted for an interview. Ask also for dwellings and households that are not on sight. Continue identifying dwellings and households until all existing farms inside the **ED** are accounted for.

4.2.11 When you are identifying the farms in the **ED,** check for the farms registered on the **"LIST OF THE IMPORTANT AND SPECIALIZED FARMS GAC-04"**. The main objective of this list is to assure that the farms having 25 acres or more of total land or farms having less acreage that specialize in particular items (mangos for exportation, for example) are included in the 2012 GAC.

4.2.12 Complete the enumeration of the **ED**. Make sure all questions on all questionnaires are answered before leaving the ED. Remember that it will not be easy to go back to the ED for incomplete questionnaires or inconsistent information.

4.3 TIPS ON INTERVIEWING

4.3.1 At the onset make clear what is your mission, the confidentiality of the information, and the use of the information.

4.3.2 Use a friendly, sincere attitude and establish a relationship of confidence.

4.3.3 Make questions sound interesting to the informant (but do not change the questions).

4.3.4 Get the respondent to talk freely and informatively.

4.3.5 Verify everything you feel doubtful about.

4.3.6 Be prepared to meet all sorts of respondents: those who will talk at length, those who hardly want to talk, and those in between.

4.3.7 Set up call-backs by phone or calling personally. Remember the out-of-the-way details that a personal interview will bring cannot be obtained by a phone call .

4.3.8 Make sure to record the responses during the interview.

4.3.9 Make the interview alive.

4.3.10 Look presentable: clean, neat, and business-like.

4.3.11 Listen attentively to avoid asking questions over and do everything possible to obtain all the information in the first visit. Since some villages and/or farms are in hard to reach areas, return for successive interviews will be more difficult.

4.3.12 If possible find out beforehand about your respondent.

4.3.13 Keep to your appointments: date, time, venue.

4.3.14 Remember that it is always better to conduct the interview with the respondent only, since the presence of another person(s) might influence his/her answers. '

4.3.15 In the case of a cultural group, institution or organization first seek the permission of the head before carrying out interviews with the members.

5. HOUSEHOLD QUESTIONNAIRE – GAC-01B

5.1.1 The purpose of the Household Questionnaire GAC-01B is to collect a minimum set of information from **ALL HOUSEHOLDS** in the Country. This information will be used to identify households with an agricultural holding (farm), as defined in the 2012 Census. Such households will then complete the Farm Questionnaire (GAC-02). For Non-farm households and households that have some small agricultural activities but do not qualify as operating an agricultural holding, additional information on livestock kept, and crops grown, will also be collected before the interview is terminated.

5.1.2 The Household Questionnaire consists of a single piece of paper with 4 Sections on the front and back of the form. ALL Households will complete Sections I, II and IV. Households that are classified as Non-agricultural as well as those that do not meet the minimum size limits, as identified in Section II, will also complete Section III.

5.1.3 It is your job to visit **every household** in your ED(s) and complete one Household Questionnaire for each household. Your supervisor knows how many households to expect in each ED based on the results of the Population and Housing Census, May 2011 and will use this to check the coverage in your area.

Complete the identification information in Section I.

ALL YES/NO ANSWERS SHOULD BE COMPLETED BY CIRCLING THE APPROPRIATE BOX.

5.1.4 Section II is designed to identify households with an agricultural holding. To do this we need to evaluate each of the cut-off limits to decide whether or not the household meets them.

5.1.5 **Cut-off Limits are:**

1 or more cattle
5 or more sheep, goats and pigs (combined)
Breeding sheep, goats or pigs
25 or more poultry
25 or more fruit, nut or spice trees (combined)
¼ acre (10,000 sq.ft) of land used for garden crops (temporary vegetables, root crops, herbs, melons, pineapples, flowers, etc.)
Annual sales of agricultural produce of EC$2,500 or more.

5.1.6 For each livestock type, ask whether the household keeps this type of livestock. If 'NO' circle the box with code '2' and continue to the next line. If a household keeps a particular livestock type, circle YES (the box with code '1') and record the number kept. Then you need to identify if the household meets the cut-off limit for this type of livestock. If One or more cattle, circle '1' the YES box. For Sheep, Goats and Pigs, the cut-off is based on there being 5 or more such animals across all three species. Add the number of Sheep, Goats and Pigs together and enter this total in the box provided in Q5. If 5 or more, circle the '1' in the YES box, if less than 5 in total, circle '2' in the NO box.

5.1.7 As well as the number of animals kept, we also need to consider whether or not the household is breeding livestock. ALL HOUSEHOLDS breeding livestock will be considered to have an agricultural holding. Ask if the household is keeping any of their Sheep, Goats or Pigs for breeding. If YES, circle the '1' in the Yes box. If NO, circle '2' in the NO box.

5.1.8 Ask whether the household keeps poultry, including backyard poultry. If YES, circle '1' and enter the number kept and indicate whether or not this meets the cut-off limit of 25 or more poultry. If the precise number is not known ask the respondent to make an estimate. If NO, circle '2'.

5.1.9 Ask whether the household has any Fruit, Nut or Spice trees. If YES, ask specifically about Nutmeg trees, Cocoa trees and Banana species (all types of bananas and plantains) and complete the lines accordingly. If YES, circle '1' and record the number of trees. If NO, circle '2'. Lastly, ask whether the household has any other fruit, nut or spice trees and if YES, circle '1' and record the total number of these other trees. If NO, circle '2'. As with livestock, the total number of nutmeg, cocoa, banana and other tree crops combined is the criteria for an agricultural holding. Add together the number of Nutmeg trees, Cocoa trees, Banana and Other Fruit, Nut and Spice trees and complete with this total. Indicate whether this total meets the cut-off criteria of 25 or more trees by circling '1' for YES and '2' for NO.

5.1.10 As well as cut-off limits associated with Livestock and Fruit, Nut and Spice trees, we are also interested in the area of garden crops (vegetables, root crops, herbs, melons, passion fruit, pineapples, flowers, etc.). Ask the household whether or not they have grown any garden crops **in the last 12 months** and circle the box accordingly (YES or NO.) If YES, enter the area of land used for growing garden crops either in acres (3 decimal places) or Square Feet. Check if the area is greater than the cut-off (1/4 of an acre (0.25) or 10,000 Square Feet) and circle the box accordingly (YES or NO).

5.1.11 We also need to know about the **value of** sales of all agricultural and livestock products, by the household, **in the last 12 months.** The main purpose of this question is to see if the sales exceed the cut-off limit of EC$2,500. **You do not need to know the exact amount.** First ask if the household sold any such produce in the last 12 months (NO/YES). If No circle the 'No Sales' box Code 1. If YES, ask whether it was more or less than EC$2,500 and circle the appropriate box (code 2 or 3).

5.1.12 On the basis of the information collected in Section II, you must now classify each household as Non-farm (code 1), a household under the cut-off limits (code 2) or a household for which you will complete the Farm Questionnaire GAC-02 (code 3). To do this you must evaluate whether they have any livestock or crop activities. If they have answered 'NO" to each question then this is a Non-farm Household (no livestock or poultry, no tree crops, no land under garden crops and no income from agriculture). If they have answered YES to one or more of the questions but have **not met any of the cut-off limits** then this is a household 'under the cut-off limits'(the answers relating to the cut-off limits in the last 2 columns should all be code '2' NO. If they have met one or more of the cut-off limits then this is a household that will complete a Farm Questionnaire GAC-02.

5.1.13 If the Household is classified as Non-farm or under the cut-off limits, ask what is the household's main employment or source of income. This could be an occupation or could be remittances, pension, income from investments or other sources of income.

You have now completed Section II of the Household Questionnaire.

5.1.14 If the household meets any of the cut-off limits, it will complete GAC-02. SKIP Section III and complete Section IV before administering the Farm Questionnaire (GAC-02). For all other households: non-farm and under the cut-off limits, complete Sections III and IV and **DO NOT** complete a Long Questionnaire for these households.

5.1.15 Section III is designed to collect additional information on livestock, tree crops, vegetable crops and root crops for non-farm households and households identified as being below the cut-off limits.

PART A - Ask if the household keeps any horses, rabbits, donkeys/mules or bee hives. Circle the code for YES or NO for each type. If YES, enter the number of livestock or bee hives.

PART B

- FOR NON-FARM HOUSEHOLDS, SKIP TO SECTION IV.
- FOR HOUSEHOLDS UNDER THE CUT-OFF LIMITS BUT ANSWERING 'NO' TO Q11 SECTION II (OTHER FRUIT, NUT OR SPICE TREES), SKIP TO PART C
- FOR HOUSEHOLDS UNDER THE CUT-OFF LIMITS THAT RECORDED 'OTHER' FRUIT, NUT OR SPICE TREES IN Q11 OF SECTION II, CONTINUE.

5.1.16 Start by reminding the household of the information provided in Section II on these crops. (Number of Nutmeg trees, Cocoa Trees, Bananas/Plantains and Other Fruit, Nut or Spice Trees). In this part of Section III, you are only interested in the trees classified in Section II as 'Other Fruit, Nut and Spice Trees' (Q11). Remind the household of how many of these 'other' trees you recorded. Then ask them what variety these trees are and how many of each variety. Enter this information for the Fruit, Nut and Spice Tree varieties on the form and put any other trees in the box marked 'Other'.

REMEMBER the sum of all these trees entered in section IIIB should be equal to the number recorded as 'other tree crops' in Section II Q11.

PART C

- FOR HOUSEHOLDS UNDER THE CUT-OFF LIMITS BUT ANSWERING 'NO' TO Q13 SECTION II (GROW GARDEN CROPS), SKIP TO SECTION IV
- FOR HOUSEHOLDS UNDER THE CUT-OFF LIMITS THAT RECORDED 'YES' TO GROW GARDEN CROPS IN Q13 OF SECTION II, CONTINUE.

5.1.17 Enter the number of plants of each temporary crop grown in the last 12 months. For multiple plantings of short-term crops, add together all the plantings in the last 12 months. If the crop is not listed put it in other vegetable crops.

5.1.18 Enter the number of plants of each type of root crop grown in the last 12 months. For multiple plantings, add together all the plantings in the 12 months. If the crop is not listed put it in other root crops.

5.1.19 Enter the age and sex of the household member **mainly responsible** for the agricultural activities of the household.

Section IV: TO BE COMPLETED BY ALL HOUSEHOLDS

5.1.20 Ask if the Household produces CHARCOAL FOR SALE and circle the appropriate code (YES/NO)

5.1.21 Ask if the household produces MANURE FOR SALE and circle the appropriate code (YES/NO)

5.1.22 Ask if the Household practices any AGRO-FORESTRY and circle the appropriate code (YES/NO). If YES, enter the number of trees owned by the household of the FOUR types listed.

5.1.23 Ask if any members of the household engaged in any fishing activity in the LAST YEAR. If **NO**,CIRCLE '2' (the 'NO' box) for **each type** of fishing listed as well as the question on selling fish. Enter '0' for average number of fishing trips per month.. If **YES**, ask which type of fishing the household members engage in and circle the code for YES/No for each type as appropriate. Ask whether the household sold any fish or aquatic products (circle the code for YES/NO as appropriate) and **enter the average number of fishing trips per month.**

5.1.24 Ask if the household is engaged in GROWING FLOWERS OR POT PLANTS for sale and circle the appropriate code (YES/NO)

5.1.25 Ask if the Household is engaged in any AGRO-PROCESSING ACTIVITIES and circle the appropriate code (YES/NO)

5.1.26 Ask if the Household has a NURSERY raising plants/seedlings for sale, and circle the appropriate code (YES/NO)

The Household Questionnaire is now complete. Thank the household for their time and for providing the information and continue to the next household.

6. FARM QUESTIONNAIRE GAC-02 INSTRUCTIONS

6.1 GENERAL

Every farm, with at least 1/4 acre of garden crops Or 25 or more Permanent Fruit, Nut or Spice Trees Or 1 or more Cattle Or 5or more Sheep, Goats or Pigs Or 25 or more Poultry Or Annual Sales of agricultural produce of EC$2,500 or more has to be interviewed with the LONG FARM QUESTIONNAIRE GAC-02. It is the enumerator's responsibility to account for each questionnaire and interview all farmers who have met the conditions to be interviewed with the Farm Questionnaire GAC-02.

Ensure that you are completely familiar with the Farm Questionnaire GAC-02 and that you fully understand these instructions before you start the census work.

Remember the links between the Household Questionnaire and the Farm Questionnaire related to livestock and poultry numbers, numbers of tree crops and area of land under temporary crops. As you come to these sections in GAC-02, remind the household of their previous answers and ensure the 2 questionnaires remain consistent.

If you make a mistake, rub it out neatly with a rubber and enter the correct answer.

Write carefully, neatly and legibly. Make sure numbers and decimals are clearly written. Complete all the questions you are required to complete.

Make all entries clear and easy to read. Use "Black" lead pencil; however, a Number 2 pencil is recommended with rubber attached. **DO NOT USE INK.**

Each answer **MUST** be written within the box or space provided. Where codes are given for YES/NO questions, CIRCLE the appropriate code.

Enter a dash (-) if the question is "NOT APPLICABLE" and a "0" if the answer is none. Never leave an answer cell blank. If an entire question or page or register is "NOT APPLICABLE", do not write dashes (-) in each cell; cross two lines through the entire question, page or register.

After completing the Farm Questionnaire GAC-02, look through each section of the questionnaire, page by page, to see that all the information is complete. YOU WILL NOT BE PAID FOR INCOMPLETE QUESTIONNAIRES.

6.2 SPECIFIC INSTRUCTIONS TO FILL THE LONG FARM QUESTIONNAIRE GAC-02

SECTION I. RESPONSIBILITIES

Complete that part of Section I with your name and date, relevant to your position in the census organization.

SECTION II. QUESTIONNAIRE IDENTIFICATION

⇒ Leave blank the cells corresponding to QUESTIONNAIRE No.

⇒ **Copy the CODES of Parish, Watershed (WS) and ED from the Household Questionnaire GAC-01B**

⇨ **Copy the household number from the GAC-01B and use it as the Farm Number and record it in the first section or first three boxes of the Farm No. If a household operates one farm, enter the number 1 in the last box or second section of the Farm No. If a household operates more than one farm, then the other related Farm Questionnaires will have the same household number recorded in the first section of the Farm No. but in the second or last section you will record the corresponding number 2, 3 or 4 to indicate that it is the second, third or fourth farm operated by this household.**

SECTION III. FARM AND FARMER'S IDENTIFICATION TODAY

⇨

QUESTION | 01 | **FARM &FARMER'S ADDRESS**

Period of Reference: Day of visit.

Phone numbers are important for follow-up and to answer any queries. Please ensure at least one phone number for each household is recorded.

SECTION IV. FARMER AND HOUSEHOLD POPULATION INFORMATION

QUESTION | 02 | **LEGAL STATUS OF THE FARMER**

a. Definitions: Two types of legal status of farmer are first differentiated: private and government; then a further disaggregation is defined:

b. Period of Reference: Day of visit.

c.. Specific Instructions: Draw a circle around only one code. **DO NOT USE CODE 9 (office use only)**

PRIVATE FARMER WITH THE FOLLOWING CATEGORIES:

⇨ **Individual** where the farm is operated by one person.

⇨ **Household** where two or more members of the **same** household (for example husband & wife, father & son, etc.) jointly operate the same farm. It is possible that a household member who jointly operates such a farm may also be the farmer of another farm operated by him/herself alone. In this case there are 2 farms associated with this household.

⇨ **Joint Farmer** when two or more individuals of **different** households jointly operate a farm.

⇨ **Company** when the farm is operated by juridical persons. Joint stock companies, constitute typical examples of this category.

⇨ **Co-operatives** include several kinds of organizations in which the principles of individual, joint ownership, or leasehold, are combined to various degrees.

⇨ **Government** – farms operated for a central or local government directly or through a special body

⇨ **Other**: They are private farmers not specified in any classes mentioned above. Examples are clans, private schools and religious institutions.

QUESTION | 03 | **TOTAL NUMBER OF HOUSEHOLD MEMBERS**

⇨ This information was collected on the Household Questionnaire so refer to the number given.

QUESTION **04** **HOUSEHOLD MEMBERS AGED 15 YEARS AND OVER**

⇒ Ask for the names of all adults aged 15 years and over, living in the household during the **Last Week**, starting with the farmer, by sex circle code), age and average numbers of hours worked on the farm per week during the last 12 months. **If the farm is operated as a 'Household' enter the word 'FARMER' after the name of each person operating this farm.** Enter the total number of adults listed, at the bottom of this table in the box provided.

QUESTION **05** **HOUSEHOLD MEMBERS UNDER 15**

⇒ Ask for the number of household members aged under 15 years, by sex.

CHECK THE SUM OF HOUSEHOLD MEMBERS UNDER 15 PLUS THOSE 15 YEARS AND OVER IS EQUAL TO THE TOTAL IN Q3 AND THE SAME AS ON THE HOUSEHOLD QUESTIONNAIRE GAC-01B. RECONCILE THE DATA AS REQUIRED.

QUESTION **06** **LEVEL OF EDUCATION OF THE FARMER**

⇒ Circle the code for the highest level of education achieved by the Farmer.

1. None
2. Primary
3. Secondary
4. Vocational
5. Tertiary

QUESTION **07** **MAIN OCCUPATION OF FARMER DURING LAST TWEVE MONTHS**

Enter the Main Occupation of the Farmer during the last 12 months.

a. Definition of Occupation: It is the kind of work done during the reference period by the person employed (or the kind of work done previously, if unemployed), irrespective of the industry or employment status. For persons reporting more than one occupation. **MAIN OCCUPATION** is determined as the occupation which was most remunerative during the period.

Write a **COMPLETE** description of the **MAIN OCCUPATION** (examples: farmer on own account; a construction worker at Coyaba hotel; an extension officer at the MOA; a manager at Legendary Tourism Agency; fishing for a living; etc.). LEAVE CODE BLANK.

SECTION V. FARM LABOUR INFORMATION

QUESTION [8a] UNPAID NON-HOUSEHOLD MEMBERS

a. *Period of Reference: The last week*

Information on unpaid work on the farm by household members was recorded in Q04. Now you need to record details of all UNPAID NON-HOUSEHOLD MEMBERS WORKING ON THE FARM IN THE LAST WEEK. Enter the number of males and females working in this capacity, irrespective of how many hours they worked. Calculate the total.

QUESTION [8b] PAID WORKERS

a *Period of Reference: The last week*

This section is designed to record the number of PAID WORKERS on the farm in the last week broken down by sex and whether they are paid cash or cash/kind, or only in kind.

⇒ **PAYMENT IN CASH**
It refers to the payment in cash ONLY for labour performed.

⇒ **PAYMENT IN KIND**
It refers to any form of payment for labour performed which does not involve payment in cash (free food, free board, share of production, etc.).

⇒ **PAYMENT IN CASH AND KIND**
It refers to the mixed form of payment in cash and kind for labour performed.

When there is no information in this question 8, cross a horizontal line along the entire question and state the reason in remarks.

SECTION VI. TOTAL LAND & LAND TENURE FOR THE FARM BY PARCEL

QUESTION [09] NUMBER OF PARCELS

a. Definition: See definition of parcel in Chapter 3

b. Period of Reference: Day of Visit.

Record the TOTAL number of separate parcels operated by the farm located both inside and outside the ED.

QUESTION **10** TOTAL LAND OF THE FARM

IMPORTANT INSTRUCTION
REMEMBER THAT ALL THE INFORMATION ON FARM AREA COLLECTED IN THIS SECTION VI AND NEXT SECTION VII MUST BE IN ACRES.

a. Definition: Total land of the farm is the combined area of all the parcels operated by the farmer.

b. Period of Reference: Day of visit

c. Specific Instructions:

⇒ For each parcel, record the name (if there is one), the location (Parish) the land in acres, the land tenure (see codes) and circle the code that best describes the slope of the land.

⇒ Sum the land areas of each parcel to get the total land farm area.

⇒ Do not include the land owned by the farmer, but rented to others (rented out). But include the land rented or operated (squatting, for example) from others (rented in). **BE CAREFUL WITH DECMAL PLACES.**

⇒ Include the area of the farmer's house and the land occupied by farm buildings and other installations.

⇒ Do not include the share of the communal land, if the farm livestock is grazing on it.

Land tenure refers to arrangements or rights under which the farmer holds or uses the farm land. A farm may be operated under one or more tenure forms (see codes at bottom of the page). A parcel can only have one land tenure code. If a piece of land has more than one tenure arrangement it should be split into multiple parcels depending on these land tenure arrangements.

a. Definitions:

⇒ **AREA OWNED (FREEHOLD)**

It is the farm area for which the holder possesses title of ownership and has the right to determine the nature and extent of its use. It does not include the area owned but rented to others.

⇒ **AREA OPERATED UNDER "FAMILY LAND" BASIS**

Land in this category is held when the land is inherited by family members, but it has not been assigned to any individual of the family legally.

⇒ **GOVERNMENT RENTED**

All land rented or leased from Government

⇒ AREA RENTED FROM OTHERS

This includes total area of all farm parcels rented by the farmer from other private persons or private or public institutions, usually for a limited time period. Rental arrangements may take different forms:

• Land rented for an agreed amount of money and/or produce with land administration, management and operation generally being the farmer's responsibility, namely the lessee.

• Land rented for a produce share or "crop sharing" (in exceptional cases the equivalent of money). The share amount varies according the local conditions and type of agriculture involved (crops, livestock and livestock products, poultry, etc.). Technical responsibility for farm management may be exclusively the farmer's or shared to a limited degree; with the landlord if the latter contributes tools, fertilizers, or other aids. Economic risks of operation to income are shared by farmer and landlord.

• Land rented in exchange of services: the use is granted to farmer instead of wages. Two examples are: 1) Agricultural labourer operates a piece of land received from the landlord, in return for which he must work, unpaid, for a certain number of days. 2) Farmer is granted land use in partial payment for services to government, religious organization or other.

⇒ FREE USE

This includes all land used by the farmer without any form of payment to the owner.

⇒ AREA OPERATED ON A SQUATTER BASIS

It is total land operated by farmer without ownership title, without the owner's consent and without paying rent while retaining total control over the land's use. Land occupied by squatters may be private or public property occupied.

⇒ AREA OPERATED UNDER OTHER FORMS OF TENURE

AREA OPERATED UNDER TRIBAL OR TRADITIONAL TENURE FORMS

Land in this category is held, often without careful planning, with joint or communal use because of traditional or tribal conditions. Land is held on tribal, village or family basis with certain individual rights held by virtue of membership in the social unit. Land title, often vested in the tribal chief, is communal in character, but not absolute.

AREA HELD IN OWNER-LIKE POSSESSION (CROWN LEASE)

It comprises the land area held under conditions which enable it to be operated as if owned by the farmer without possessing an ownership title. It does not include area held in owner-like possession but rented to others or occupied and used by others. Some common types of owner-like possession include:

• Land operated under perpetual and under long-term lease or hereditary tenure, usually ranging from 30-99 years, with a nominal rent.

• Land operated peacefully and without interruption for a time period, such as 30 years, by the farmer without ownership title or long-term lease or payment of rent.

• The system under which a rent-free plot or tribal "communal" land is received and retained as long as it is kept under cultivation by recipient's personal labour and that of household, but which cannot be sold or mortgaged.

Other forms of tenure include land operated under forms other than those described above. Examples are: land operated under transitory forms, such as trusteeship (operated by trustee); land received by members of a collective farm for individual use; or land under inheritance proceedings.

b. Period of Reference: Day of visit..
c. Specific Instruction: Enter the tenure code.

QUESTION | 10 | **SLOPE OF LAND**

a. Definition: It is the inclination of the land.
b. Period of Reference: Day of visit.
c. Specific Instruction: Circle the code that most accurately reflects the slope of the parcel.

SECTION VII. ACTUAL LAND USE OF THIS PARCEL TODAY

QUESTION | 11 | **ACTUAL LAND USE PARCEL BY PARCEL**

REMEMEBER THE HOUSEHOLD HAS ALREADY GIVEN YOU INFORMATION ON NUMBERS OF TREE CROPS AND AREA OF LAND UNDER TEMPORARY CROPS ON THE HOUSEHOLD FORM (GAC-01), REFER TO THIS WHEN COMPLETING THIS SECTION. IF NECESSARY, RECONCILE THE DATA ON THE TWO FORMS.

a. Period of Reference: It is today

- ⇒ **ALL PARCELS LISTED IN Q10 SHOULD HAVE AN ASSOCIATED PARCEL FORM INCLUDING FALLOW PARCELS AND PARCELS UNDER PASTURE, FOREST/BUSH AND NON-AGRICULTURAL LAND. SCATTERED PLANTS ON THESE PARCELS SHOULD ALWAYS BE RECORDED. USE SUPPLEMENTARY SHEETS AS REQUIRED.**
- ⇒ WORK PLOT BY PLOT. DRAW A LINE UNDER EACH PLOT. NUMBER PLOTS SEQUENTIALLY.
- ⇒ REMEMBER TO LIST ALL FALLOW PLOTS, PASTURE PLOTS AND FOREST/BUSH PLOTS AND ANY SCATTERED CROPS ASSOCIATED WITH THEM.
- ⇒ LIST ALL CROPS GROWING IN EACH PLOT, INCLUDING SCATTERED CROPS.
- ⇒ ENTER THE CODE FOR THE TYPE OF PLANTING.
- ⇒ ENTER AREA PLANTED IN ACRES. WHERE AREA IS UNKNOWN OR VERY SMALL (LESS THAN 0.1 ACRE), OR THE CROP IS GROWN AS A SCATTERED CROP, ENTER THE NUMBER OF PLANTS OR TREES AND THE SPACING IN FEET.
- ⇒ FOR TREE CROPS ONLY, ENTER THE AVERAGE AGE OF THE TREES

Definitions:

⇒ **TEMPORARY CROPS AND FORAGES**

These include all land in the open air used for crops with an under-one-year growing cycle, which must be newly sown or planted for further production after harvest. Crops remaining in the plot more than one year should also be considered temporary crops if harvesting destroys the plant (for example cassava). Crops grown in rotation and destroyed when the land is ploughed should be considered as temporary crops. The forages are considered temporary crops when the plant is destroyed after harvest.

⇒ **PERMANENT CROPS**

These include land cultivated with long-term crops which do not have to be replanted for several years after each harvest (sugar cane, coconut, cocoa, citrus, etc.)

Be very careful to include in this category the permanent crops 'ASSOCIATED" with temporary crops (for example coconuts inter-planted with cocoa and associated with cassava, and yams); sugar cane associated with beans. Also include coconuts mixed with pastures for grazing purposes.

⇒ **PURE STAND**

This is a single crop cultivated alone in a plot. A pure stand crop may be either temporary or permanent and may have scattered crops associated with it.

⇒ **MIXED CROPS**

Mixed crops are two or more different crops grown simultaneously in the same plot. The number, kind and proportions of crops in the mixture will generally vary according to prevailing practices or other factors, such as meteorological conditions. Mixed crops differ from inter-planted crops in that they do not follow a pattern. Scattered crops may be associated with a mixed crop plot.

⇒ **INTERPLANTED CROPS**

Inter-planted crops are crops planted between rows of another crop (examples: beans between corn rows; cocoa between rows of coconuts). Inter-planted crops may be temporal or permanent crops.

Yields of some mixed and inter-planted crops may be as large as when grown alone, and even when favourable interactions, in the case of special mixtures, may result in increased yields. Scattered crops may be associated with inter-planted plots.

⇒ **SCATTERED CROPS**

Scattered crops are usually grown in small numbers in an 'ad hoc' fashion within a plot of any type. A plot may contain just scattered crops in which case it should be recorded as 'planting type' fallow, pasture, forest/bush plot and the scattered plants/trees listed under this plot.. This will provide the area of the plot.

⇒ **FALLOW ONE YEAR AND LESS**

It is the land lying fallow where a crop was harvested during last season (from January, 2012 to census day), that has been prepared or being prepared (ploughed for example), which will be put under crops soon afterwards.

It could be another land use, like pastures or bush, under that land prepared or being prepared, to be put under crops during next season.

⇒ **FALLOW MORE THAN ONE YEAR AND UPTO THREE YEARS**

This is a land at prolonged rest from more than one year to three years before recultivation.

Land remaining fallow for more than three years may acquire characteristics requiring it to be reclassified, such as "PASTURES" (if used for grazing) or "FOREST/BUSH" (if overgrown with trees that could be used for timber, firewood, etc.), or "NON-AGRICULTURAL LAND" (if it becomes wasteland).

⇒ **PASTURES (CULTIVATED AND NOT)**

These include land used permanently (for one year or more) to grow herbaceous forage crops, through cultivation or naturally for mowing or grazing (wild prairie or grazing land). Permanent pastures on which trees and shrubs are grown should be recorded under this heading only if the growing of forage crops is the most important use of that area.

Do not include temporary forages if harvesting destroys the plant; include them under temporary crops.

⇒ **NATURAL AND PLANTED FOREST AND BUSH**

This includes natural or planted woodlots or timber tracts, constituting part of the farm which have or will have value as wood, timber, other forest products or for protection. Row, belts, and small clumps of natural trees, bamboo and other woody natural vegetation should be included in natural forest. Natural woodland or natural forest used only for recreation purposes should be excluded and reported under the farm "NON-AGRICULTURAL LAND". Bush land and land fallow for more than 3 years should be entered here.

⇒ **NON-AGRICULTURAL LAND**

This includes all other land of the farm, not elsewhere specified, whether or not potentially productive. It covers two land classes:

• Unused and undeveloped land potentially productive for agriculture or forestry, but not yet developed.

• Land in the farm not elsewhere specified.

⇒ **Unused and undeveloped potentially productive land**

This includes uncultivated land, comprising part of the farm but not included under the preceding headings, producing some kind of utilizable vegetable product, such as reeds or rushes for matting and bedding for livestock, wild berries, plants and fruits (bread trees), or land that could be brought into crop production with little more effort in addition to that required in common cultivation practices.

⇒ **Land in the Farm not elsewhere specified**

This includes land occupied by buildings, parks and ornamental gardens, roads or lakes, irrigation canals, open spaces needed for storing equipment and products, wasteland, land under water, mangroves, dasheen may grow) and any other land not reported under previous classes.

QUESTION | 12 | **TEMPORARY CROPS ALREADY HARVESTED**

a. Definitions:

⇒ **SUCCESSIVE CROPS**

The same short-term or temporary crops, may be grown and harvested "SUCCESSIVELY" on the same land, several times during the period of reference (12 months). The plot, or part of it, may be left fallow during one or more cropping seasons, or sown or planted and harvested during each crop season, in the same period of reference.

In order to capture the annual production of temporary crops we need to record crop plantings that have taken place in the census year but already been harvested and are not in the ground at the time of the visit. Each separate planting of a crop that has taken place during the census year, where the crop has already been harvested.

should be reported each time the area was sown or planted during 2012 (census year). Thus, if two different crops are grown successively on the same plot, the plot area will appear twice occupying two lines in question 12, or sometimes more if the farmer is having more than two crop seasons in the same period of reference. Similar area counting also occurs if the same crop is grown successively during the period of reference. Short-term crops such as lettuce will often feature in this section.

Successive harvests from the same standing crops should not be confused with successive cropping. Area for the farmer should be reported once, unless the same crop is sown or planted and harvested more than once during 2012 (census year). This is the case of dasheen, yams and tannias where two harvests are obtained before replanting again the same or other crop. Also sweet peppers, tomatoes, cucumbers, beans and other similar crops may have more than one harvest without replanting.

b. Period of Reference: It is 2012 (the census year).

c. Specific Instructions:

⇒ Register the information on the temporary crops already harvested in 2012 following the same general instruction given above in question 11.

⇒ Use different lines for successive crops in **"PURE & MIXED AND INTERPLANTED STANDS"**. Treat them like different plots, since' they were planted or sown and harvested several times although in the same physical area. Always remember to ask about successive crops since the tendency of enumerator and farmer is to get and give information on actual season, forgetting about crops planted and harvested in last season (s) during 2012 (the census year). .

⇒ As a special case, Register only once the planted, and harvested areas of dasheen, yams and tannias (include also sweet peppers, tomatoes, cucumbers, beans and other similar crops) in **"PURE &MIXED AND INTERPLANTED STANDS"** when there are two harvests in the census year (January/2012 - December/2012) with-out, replanting (explain this situation in remarks). Otherwise, consider these crops as normal successive crops.

SECTION VIII. IRRIGATION

QUESTION 13

Indicate whether or not irrigation has been used on the Farm in the Census year (2012) by circling the code (YES/NO)

If YES, indicate for each type of irrigation listed, whether or not used and if used, the area in acres of the land irrigated with this type, the type of crop, or crops, that were irrigated and the main water source. (Circle codes)

SECTION IX. LIVESTOCK TODAY

QUESTIONS [14] THROUGH [20]

REMEMBER THE HOUSEHOLD HAS ALREADY GIVEN YOU TOTAL LIVESTOCK AND POULTRY NUMBERS ON THE SHORT FORM. REFER TO THIS INFORMATION WHEN ASKING THESE MORE DETAILED QUESTIONS. IF NECESSARY, RECONCILE THE DATA ON THE TWO FORMS.

a. Definitions:

⇒ **LIVESTOCK**

Livestock refers to all animals kept or reared in captivity on the farm, for agricultural purposes.

⇒ **LIVESTOCK POPULATION**

The livestock population refers to numbers of animals present on the farm today, regardless of ownership. Livestock population includes livestock temporarily absent or in transit on enumeration day.

⇒ **CATTLE (SPECIES: BOVINE)**

- COWS: female bovine which has at least one calf in her life time
- CALVES: offspring of a cow, from birth until one year old
- STEERS: castrated male bovine, usually used for meat
- HEIFERS: young female bovine of one year, until her first calf is weaned
- BULLS: uncastrated male bovine, used for service

⇒ **SHEEP (SPECIES: OVINE)**

- LAMBS: male or female ovine, from birth to weaning
- RAMS: uncastrated male ovine, used for service
- EWES: mature female ovine

⇒ **GOATS (SPECIES: CAPRINE)**

- KIDS: young goat of either sex not exceeding one year
- BUCKS: uncastrated male caprine, used for service
- DOES: mature female goat

⇒ **PIGS (SPECIES: PORCINE)**

- PIGLETS: young pig from birth to weaning (between 6-8 weeks after birth)
- FATTENERS: castrated male pig (from birth to 7 months), usually used for meat
- BOARS: uncastrated male pig, used for service
- SOWS: female pig after birth of first litter
- GILTS: female pig up to her first litter is weaned.

b. Period of Reference:Day of visit.

c. Specific Instructions:

⇒ Remember that livestock data refers to the **"TOTAL FARM"** inside and outside the selected ED.

⇒ Check that each total of livestock **MUST BE EQUAL** to the sum of the parts.

⇒ Sometimes it is possible that the informant does not know the livestock classification by sex. In this case, register the total and explain the reasons in remarks.

QUESTION 20 LIVESTOCK DISPOSALS

⇒ Ask about Livestock and Poultry sold alive, slaughtered or otherwise lost or disposed of during the Census Year (2012). For each type of livestock, record the numbers sold alive, slaughtered and lost or otherwise disposed of.

SECTION X. USE OF FERTILIZERS &AGRO-CHEMICALS

Q21. Circle the code (YES/NO) to indicate if the household used any fertilizers, organic manure or agro-chemicals during the last 12 months. If NO, go to Section XI.

Q22. If YES, for each type of fertilizer and agro-chemicals listed, indicate if used (YES/NO) and if YES, the extent of use (light use, moderate use, heavy use). The extent of use is determined by the number of crops fertilized or treated with agro-chemicals and the frequency of application. It is a subjective indicator provided by the farmer.
Circle ONE use code ONLY.

⇒ **CHEMICAL FERTILIZERS**

Also known as inorganic fertilizers, these are classed into three main types: **STRAIGHT FERTILIZERS** (nitrogenous, phosphatic, potassic); **MIXED FERTILIZERS** (mixture of two or more STRAIGHTS); **COMPOUNDS** containing two or more of the STRAIGHTS that are manufactured by a chemical reaction.

⇒ **ORGANIC MANURE**

Are the fertilizers produced from plant and animal by-products. The term organic fertilizers include: **FARMYARD MANURE, ABATTOIR RESIDUES, COMPOST** (plant remains), **GREEN MANURE** and **SEAWEED.**

⇒ **AGRO-CHEMICALS**

Refers to chemicals used in farming. These include PESTICIDES (control of pests); HERBICIDES (weed killers), INSECTICIDES (insect killers), FUNGICIDES (controlling fungus), HORMONES (fruit initiating), etc.

LIGHT USE
Chemicals or fertilizers are used once or 1 to 5 times for the year

MEDIUM USE
Chemicals or fertilizers are used once or 6 to 11 times for the year

HEAVY USE
Chemicals or fertilizers are used 12 or more times for the year
b. Period of Reference: It is 2012 (census year).

SECTION XI. FARM MACHINERY AND EQUIPMENT

QUESTION | 23 | **MACHINERY & EQUIPMENT**

a. Definition:

⇒ **GENERAL DEFINITION**

This item identifies machinery and equipment used by the farm, wholly or partly for agricultural production. All machinery and equipment used exclusively for non-agricultural purposes during 2012 (the census year) are excluded.

Only machinery and equipment in working order should be reported, including those under repair, or awaiting repair, for less than one month.

It refers to all machinery and equipment for which the farmer owns that is possesses title of ownership and has the right to determine the nature and extent of its use, primarily for agricultural work on his farm. The machinery and equipment may be owned solely by farmer or owned jointly by the farmer and others. For machinery and equipment owned or part-owned, enter the number of units owned or part-owned.

Circle the code (YES/NO) to indicate if the household owned, rented or used any farm machinery and equipment during the last 12 months. If NO, go to Section XII.

If YES, **for each type of machinery of equipment**, indicate if it is USED (YES/NO). If YES, indicate the **number of units owned** and /or whether or not this types of equipment has been Rented, Borrowed or Hired from Government in the Census Year (2012) (Circle 1 or 2 for YES/NO). Lastly, indicate the number of days in the year when the equipment was used, irrespective of the duration of the use. If not known precisely, enter an estimate.

b. Period of Reference: For ownership it is today. For renting, borrowing and government hire it is the census year.

SECTION XII. OTHER MISCELLANEOUS INFORMATION

QUESTIONS | 24 | **THROUGH** | 29 |

For each question in Section XII, circle the appropriate answer(s). If the answer is NO to the first question, skip to the next section.

⇒ **SALE OF AGRICULTURAL PRODUCTS**

Circle the code(s) that best describe where the farmer sells his produce.

⇒ **FARM ORGANIZATION**

Refers to institutions which assist farmers in. producing or disposing of agricultural products.

⇒ **TECHNICAL ASSISTANCE**

It is the knowledge and skills on agricultural practices applied by the farmers to improve the farm production and its disposal given by the agricultural technicians.

⇒ **CREDIT**

It is the money given to the farmers by the financial institutions to enhance their agricultural production and disposal.

h. Period of Reference: It is 2012 (census year).
c. Specific Instruction: Draw circles around one or more codes of each question.

QUESTION 28 FARMER'S INCOME

a. Definition:

⇒ **INCOME**

It is the payment in cash and/or kind, received by the farmer, for performing any work inside the farm and/or outside the farm. The income from the farm comes from the sale of its produce, renting machinery, etc.

b. Period of Reference: It is 2012 (census year).
c. Specific Instructions:

⇒ Draw a circle only around one code of this question.

⇒ There **MUST** be an answer to this question.

QUESTION 29 FARM RECORDS

a. Definition: They are physical means (copybook, record-keeping book, computer, etc.) where the farmer registers the results of the different activities performed on the farm, such as buying seeds, fertilizers, machinery & equipment, paying the labour, selling the produce.

b. Period of Reference: It is 2012 (census year).
c. Specific Instructions:

⇒ Draw a circle around the code 1 or 2.

SECTION XIII. PRODUCTION ISSUES

Q30. This section is designed to give the farmer the opportunity to tell you, the enumerator, about production issues s/he is currently facing. For each issue listed, indicate by circling the relevant code (YES/NO) whether or not the farmer is facing this issue and if YES, whether s/he considers it a minor or major issue (circle one code). If the farmer has other issues s/he is concerned about, list them on the form with the extent of the issue.

CHECK THE FORM CAREFULLY TO MAKE SURE ALL ANSWERS HAVE BEEN ENTERED CORRECTLY AND LEGIBLY. THANK THE FARMER FOR HIS/HER TIME AND MOVE TO THE NEXT HOUSEHOLD.

7. SPECIAL ENUMERATION SITUATIONS

7.1 NO QUALIFIED RESPONDENT AVAILABLE

If a qualified respondent (farmer, manger or administrator, competent worker, old farmer's relative) is not available, the enumerator MUST get some information on when the respondent will be back and/or where to find him/her. Then the enumerator will prepare a schedule for new visits, if s/he is still working in the ED.

The priority for the enumerator is to work as efficiently as possible and to complete an ED in the schedule time. Within this constraint, if the qualified respondent would be available the next day because s/he is visiting a nearby village and is expected back, the enumerator should return the next day for an interview if the team will still be working in the area.

If all the other work has been completed by the team in the area and only one or two farms are in need of completion, the priority is to contact some other informed source (a neighbour, for example) for an interview and only as a last resort to record information as much as possible on the questionnaire by direct observation. In any case a Household Questionnaire GAC-01 has to be started with a clear indication in Section 1 on the information sources. Many questions could remain without answers. Inform your supervisor about this particular household.

7.2 CROP LAND NOT PLANTED TODAY (FALLOW FOR LESS THAN ONE YEAR)

Ask about the crops harvested from January, 2012 to today. Many enumerators tend to forget to ask these questions.

7.3 IMPORTANCE OF HARVESTING DATES FOR TEMPORARY. CROPS

These dates are crucial, to help the enumerator to collect the complete information of temporary crops harvested from January, 2012 to today, especially in areas with successive crops. For example, if the enumerator finds one acre of beans planted in August, 2012, to be harvested in November, 2012, he/she **MUST** collect information about the crops which were harvested from January, 2012 to July, 2012. Enumerators have a tendency to forget about the previous harvest.

7.4 COMPLETELY ENUMERATE THE ASSIGNED ED

THE ENUMERATOR MUST COLLECT THE INFORMATION FROM ALL THE PIECES FORMED BY THE WS BOUNDARIES WITHIN AN ASSIGNED ED. If the ED contains too many small farmers that will take too much time to conduct all the interviews, inform your supervisor. The supervisor will report to the census office in St. George's.

Appendix D: Letter of Approval from Ministry of Agriculture, Grenada

Ref. No. ....
In replying the above Number and date of this letter should be quoted.

MINISTRY OF AGRICULTURE
AND LANDS
MINISTERIAL COMPLEX
BOTANICAL GARDENS
ST. GEORGE'S
GRENADA, W.I.

June 4, 2018

Mrs. Lindonne Glassgow
Tempe
ST. GEORGE

Dear Mrs. Glasgow,

With regard to your request, dated October 22, 2017, for the use of the dataset from the 2012 Agriculture Census in Grenada, please be informed that I have approved the request to grant you access to the dataset for use in pursuit of your Doctor of Public Health degree at Walden University.

Further, you may also access the relevant documentations, including the Agriculture Census Manual, related to the agriculture census, which are published online or available at the Ministry.

As part of the conditions for accessing and using the dataset, please note the following:

1. The dataset should be used only for the purpose of your studies at Walden University.
2. Should you intend to use the dataset for any other purpose, you should seek approval from the Ministry.
3. The dataset, in part or whole, should not be distributed or shared with other parties.

The Ministry extends best wishes to you in your studies. We also look forward to you sharing the results of the study with the Ministry as this is an important study that can contribute to improving the policies that protect the health of farmers in Grenada.

For any additional information, please contact Ms. Lavern Mapp at lamapp2011@gmail.com or at telephone # 440-3083/2708

Sincerely,

....

PERMANENT SECRETARY

Phone: (473) 440-2708/3386/3078 Email: agriculture@gov.gd. Fax: (473) 440-4191