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Agriculture in the Urbanizing Chesapeake Bay Watershed: Views on Water Quality, Agricultural-Related Conflicts, And the Adoption of Nutrient Management Plans

Edem Avemegah
Utah State University

AGRICULTURE IN THE URBANIZING CHESAPEAKE BAY WATERSHED: VIEWS ON WATER QUALITY, AGRICULTURAL-RELATED CONFLICTS, AND THE ADOPTION OF NUTRIENT MANAGEMENT PLANS

by

Edem Avemegah

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Approved:

Jessica Ulrich-Schad, Ph.D. Committee Chair	Courtney Flint, Ph.D. Committee Member
Sarah Church, Ph.D. Committee Member	Jennifer Givens, Ph.D. Committee Member
Mehmet Soyer, Ph.D. Committee Member	D. Richard Cutler, Ph.D. Vice Provost of Graduate Studies

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ABSTRACT

Agriculture in the Urbanizing Chesapeake Bay Watershed: Views on Water Quality, Agriculture-related Conflict, and the Adoption of Nutrient Management Plans

by

Edem Avemegah, Doctor of Philosophy

Utah State University, 2024

Major Professor: Jessica Ulrich-Schad, Ph.D.
Department: Sociology & Anthropology

Agriculture remains a significant land use activity within the Chesapeake Bay Watershed (CBW), crucial to the regional economy and food production. However, agriculture within the region faces various challenges, ranging from the loss of farmland to sprawling suburban development and nutrient pollution of different water bodies due to fertilizer runoff from farm fields. The future of agriculture in CBW is still being determined due to the potential loss of farmlands, and regulations will likely be tightened. This dissertation examines agriculture in the urbanizing CBW by investigating views on water quality, agriculture-related conflict, and farmers' adoption of nutrient management plans (NMPs). The following questions were asked: What is the level of concern among non-agricultural and agricultural residents about water quality issues in local streams and the CBW, and to whom do the two groups attribute water quality problems? What are nonfarming residents' and farmers' levels of support for various interventions outlined in previous research on water quality issues in local streams and the CBW? What is the level of concern of nonfarming residents and farmers about their proximity to one another in the CBW? Have these concerns led to conflict between farmers and nonfarming residents in CBW, including potential solutions? How do the theories of planned behavior and diffusion of innovations attributes help to understand farmers' future intention to use a nutrient management plan? These research questions are of utmost significance, and three studies were conducted that answered them, providing valuable insights.

The first study used data from two separate surveys: one from non-agricultural residents and the other from agricultural residents in the southern part of the CBW (Maryland, Virginia, and Delaware) to quantitatively explore the residents' perceptions of water quality issues, causes, and interventions in the CBW. Results show farmers were less likely to see water quality as poor than nonfarming residents. To address both urban lawn and farm nutrient runoff, utility and tax credits were highly supported by both residents and least supportive of laws and litigation that would require a behavior change. The second study also utilizes the data from the two surveys and key informant interviews conducted in Howard County, Maryland, to examine urban-agricultural tension in the CBW. Findings indicate that farmers were more concerned about legal actions against them, while nonfarming residents were more concerned about exposure to chemicals/pesticides. Findings also show that addressing the concerns requires different strategies focused on education, communication, community engagement, and policy development. The third paper explores the social-psychological reasons regarding farmers' adoption of NMPs to test a proposed framework that integrates the theory of planned behavior (TPB) and diffusion of innovation attributes (DOI). Findings show that relative advantage and compatibility were positively associated with attitudes toward NMPs, while complexity was negatively associated with attitude. There was also a positive relationship between compatibility, perceived behavioral control, observability, and subjective norms related to NMPs.

(169 pages)

PUBLIC ABSTRACT

Agriculture in the Urbanizing Chesapeake Bay Watershed: Views on Water Quality, Agriculture-related Conflict, and the Adoption of Nutrient Management Plans

Edem Avemegah

This dissertation analyzes Chesapeake Bay Watershed (CBW) agriculture by exploring residents' views on water quality issues, agriculture-related conflict, and farmers' adoption of nutrient management plans. The following questions were asked: What is the level of concern among non-agricultural and agricultural residents about water quality issues in local streams and waterways and the CBW, and to whom do the two groups attribute water quality problems? What are nonfarming residents' and farmers' levels of support for various interventions outlined in previous research on water quality issues in local streams and waterways and the CBW? What is the level of nonfarming residents' and farmers' concerns about their proximity to one another due to nuisance generated by farming activities and complaints by nonfarming residents in CBW? Have these concerns led to conflict between farmers and nonfarming residents in CBW, including potential solutions? How do the theories of planned behavior (TPB) and diffusion of innovations attributes (DOI) help to understand farmers' future intention to use NMPs?

The first study used survey data from non-agricultural and agricultural residents in the southern part of the CBW (Maryland, Virginia, and Delaware) to quantitatively explore the residents' perceptions of water quality issues, causes, and interventions in the southern part of the CBW. Results show farmers were less likely to see water quality as poor than nonfarming residents. To address both urban lawn and farm nutrient runoff, utility and tax credits were highly

supported by both residents and least supportive of laws and litigation requiring a behavior change.

The second study also utilizes data from the two surveys (non-agricultural and agricultural residents survey) and key informant interviews conducted in Howard County, Maryland, to examine urban-agricultural tension in the CBW. Findings indicate that farmers were more concerned about legal actions against them, while nonfarming residents were more concerned about exposure to chemicals/pesticides. Findings also show that addressing the concerns requires multifaceted strategies focused on education, communication, community engagement, and policy development. The third paper explores the social-psychological reasons regarding farmers' adoption of NMPs to test a proposed framework that integrates the TPB and DOI attributes. Findings indicate that relative advantage and compatibility were positively associated with attitudes toward NMPs, while complexity was negatively associated with attitude. There was also a positive relationship between compatibility and perceived behavioral control and observability and subjective norms related to NMPs.

DEDICATION

This dissertation is in honor of my father, Mr. Raphael Tsey Avemegah. Your love for education and encouraging me to pursue advanced studies in the United States of America have been a blessing to me. Thank you for your unconditional love, motivation, and encouragement throughout my academic journey. This degree attests that all your sacrifices have not been in vain, and this award, in a sense, is also yours.

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CHAPTER 1

INTRODUCTION

The Chesapeake Bay Watershed (CBW)[1] covers more than 64,000 square miles and has more than 150 rivers and streams aligning with six states (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and the District of Columbia (Sims and Coale 2002; Savage and Ribaudo 2013; Morgan and Owens 2001). The various rivers within the CBW support activities such as recreation, tourism, and providing seafood, generating revenue for the states that align with it (Kleinman et al. 2019; Sims and Coale 2002; Morgan and Owens 2 001; Arnold et al. 2021). Water quality has been an issue and has deteriorated since the 1970s, primarily due to concentrated agriculture causing nutrient runoff from farm fields into various water bodies. Population growth leading to urbanization and the development of impervious surfaces such as roads, parking lots, and buildings also exacerbate runoff into various water bodies, reducing water quality (Savage and Ribaudo, 2013; Ator et al., 2020). The decline in water quality and nutrient concentration negatively impacting aquatic and marine life made Chesapeake Bay the first estuary to be targeted for protection and restoration by the U.S. Environmental Protection Agency (EPA) in 1975 as directed by the U.S. Congress (Sims and Coale 2002; Savage and Ribaudo 2013).

In 1982, the EPA conducted a study to identify the causes of declining water quality in the Bay and found three primary factors contributing to the decline: sediment, nitrogen, and phosphorus (Perkinson 1994; Sims and Coale 2002). These findings suggested that agriculture production significantly contributed to the decline of water quality in various rivers and the

[1] The Chesapeake Bay is the 200-mile estuary along the East Coast and CBW refers to the entire land area that drains into the Chesapeake Bay and its tributaries hence they are not used interchangeably.

Chesapeake Bay in general (Sims and Coale 2002). Specifically, the EPA found that nutrient runoff from farm fields through erosion contributed to the pollution of the Chesapeake Bay (Sims and Coale 2002). Research has also found that agriculture is not the only contributor to the decline in water quality of various water bodies in the watershed and Chesapeake Bay (Perkinson 1994). Population growth and urban development in the region have led to the development of impervious or impenetrable surfaces that increase urban runoff, also contributing to the degraded water quality in the region (Perkinson 1994). Addressing the pollution of the Chesapeake Bay has been a crucial concern and focus of efforts for various stakeholders, including government and non-governmental organizations, environmental organizations, farmers and nonfarming residents, and community leaders within the CBW.

Due to the significant economic, environmental, and social implications of the Chesapeake Bay health, it is essential to address water quality issues in the region (Phillips and McGee 2016). As the largest estuary in North America and the U.S., the Chesapeake Bay provides a natural environment for numerous plant and aquatic life and supports a diverse ecosystem (Kleinman et al. 2019; Phillips and McGee 2016). Residents within the region benefit from the Bay by engaging in numerous activities, such as commercial and recreational fisheries and tourism, and poor water quality can limit these activities (Phillips and McGee 2016; Savage and Ribaudo 2013). Poor water quality will, therefore, lead to the distraction of the natural environment by harming aquatic life and disrupting the ecosystem; hence, improvement in water quality is critical for the economic prospects and the general well-being of residents of the region (Savage and Ribaudo 2013; Hager et al. 2014; Morgan and Owens 2001).

Along with local efforts, several state and regional actions have been implemented to enhance water quality in the CBW. For example, the EPA initiated the Chesapeake Bay Total

Maximum Daily Load (TMDL), a pollution reduction strategy to help improve the water quality and restore the health of the Chesapeake Bay. The TMDL set a limit concerning the amount of sediments, nitrogen, and phosphorus that can be present in the Chesapeake Bay to attain improved water quality and restore the Bay (Kleinman et al. 2019; Moore et al. 2018; Savage and Ribaudo 2013). Another action is the promotion of various Best Management Practices (BMPs) for agricultural operations, such as nutrient management plans (NMPs), conservation tillage, cover crops, forest buffers, and streamside fencing due to their ability to reduce nutrient runoff from farm fields (Savage and Ribaudo 2013; Chesapeake Bay Program 2024). Decades of management efforts have resulted in a moderate reduction of nutrient loads from the watershed, yet significant improvements in water quality remain a challenge (Murphy et al. 2022). An estimate from the U.S. Geological Survey suggests that fulfilling the nutrient reduction targets for the Bay may require removing around 44% of the region's approximately 8.2 million acres of farmland from production, which would inevitably impact farm income and the region's economy (Clune and Capel 2021).

It is evident that many actors, including farmers and nonfarming residents, contribute to water quality problems in different ways, yet attempting to address the causes and perceived equitable solutions to water quality issues can result in conflict due to blame-shifting, particularly between agricultural and non-agricultural residents (Armstrong et al. 2022; Armstrong and Tucker 2019; Church et al. 2021; Gasteyer 2008; Hu and Morton 2011). Blame shifting refers to the circumstances where farmers and nonfarming residents try to shift the responsibility for causing water quality problems away from themselves and onto others (Church et al. 2021). Conflict can also arise due to farmers' increasing proximity to nonfarming residents in previously more agricultural or rural areas. Increased urbanization presents new challenges to farmers and nonfarming residents. Farmlands are converted to residential development, bringing farmers close to nonfarming residents and changing the environmental landscape in the CBW. Nonfarming residents sometimes complain about nuisance generated by farming activities, and farmers may also complain about lawsuits against them by residents (Brandes et al. 2018; Vaserstain and Kelsey 2000; Sullivan et al. 2004). Due to the changing environmental landscape in the CBW, it is essential to delve into the disputed root causes and potential solutions for water quality problems, understand what motivates farmers to adopt BMPs such as NMPs, and address tensions or conflicts among residents in the CBW.

Environmental knowledge and causes of environmental problems are often contested in the contemporary U.S. because of various factors, including differing perspectives, economic interests, political ideologies, and the complex nature of environmental problems (Druckman et al. 2013; Brown 2023; Daniel 2019). In addition, establishing the causes of environmental problems, such as water quality issues, can be challenging because many factors are responsible for poor water quality, and many are not easily seen (Armstrong et al. 2022). For example, tracing nutrient runoff from a specific farm field is challenging due to its nonpoint nature. Addressing the water quality problems and tensions between farmers and nonfarming residents in the CBW is vital for maintaining the region's environmental and public health, economic prosperity, and regulatory compliance.

This dissertation provides evidence-based approaches to understanding and resolving water quality problems and promoting environmentally sustainable and economically viable agriculture in the CBW with three independent empirical studies. The first paper assesses the degree to which there is an alignment between agricultural and non-agricultural residents' concerns and perceptions about water quality issues and their support for various interventions to deal with them. The second paper addresses urban agricultural tensions in CBW by assessing their perspectives on concerns and pathways to reduce conflict or tension. The third paper examines farmers' intention to voluntarily adopt NMPs in the next five years by examining a proposed conceptual framework that integrates the theory of planned behavior (TPB) and the diffusion of innovation attributes (DOI). Papers one uses quantitative data from non-agricultural and agricultural residents' surveys conducted in the southern part of the CBW (Maryland, Virginia, and Delaware) in 2021 and 2022, respectively. Paper two used mixed methods where concerns about the proximity of farming to residential areas were assessed and how certain socio-economic and demographic variables are related to those concerns. Nine key informant interviews were also conducted in Howard County, Maryland, to understand better the tensions between farmers and nonfarming residents and various pathways residents themselves see as strategies to reduce conflicts. Paper three uses quantitative data from the agricultural survey. In this introductory chapter, I review relevant literature and briefly overview this dissertation's three papers.

Literature Review

Nutrient pollution by point and non-point sources contributes to water quality problems in the CBW that must be addressed for improved water quality and a healthy ecosystem (Morgan and Owens 2001). Point sources of pollution can be easily identified or traced to their origin (Loague and Corwin 2006). Examples include sewage treatment and industrial discharge. Non-point sources, on the other hand, refer to dispersed or scattered sources of pollution that are difficult to identify or trace to a specific origin or location (Loague and Corwin 2006). Common examples include agricultural and stormwater runoff f. To improve the water quality of deteriorating rivers within the CBW, it is necessary to mitigate both point and non-point-source pollution across the watershed (Moore et al. 2018). Non-point source pollution is usually controlled by encouraging farmers and nonfarming residents to adopt Best Management Practices (BMPs) to reduce nutrient runoff (Bockstael et al. 1989). Point sources, conversely, are controlled by ensuring facilities such as sewage treatment plants and industries obtain permits before they release or discharge any waste.

The causes and solutions to water quality problems often create tensions between urban residents and agriculture producers, with both groups sometimes blaming each other for water quality problems (Gasteyer 2008; Hu and Morton 2011; Church et al. 2021). Establishing the causes of environmental problems, such as water quality issues, can be challenging because many factors are responsible for poor water quality, and many are not easily seen. Farmers and nonfarmers have different views and attitudes about water quality issues (Busse et al. 2015; Berenguer et al. 2005). Farmers often recognize water quality problems but may disagree that they are responsible for those problems (Busse et al. 2015; Pease and Bosch 1994). Findings suggest that farmers in Maryland and Virginia recognized and were concerned about the water quality problems but disagreed that the issues originated from their farms or local area (Lichtenberg and Lessley 1992; Pease and Bosch 1994; Paolisso and Maloney 2000).

Some studies have also shown that nonfarming residents believe farmers are primarily responsible for poor water quality (Busse et al. 2015; Berenguer et al. 2005). Nonfarming residents viewed farmers as the primary culprit during the Pfiesteria (toxic algal bloom) incident in Maryland in 1997 (Paolisso and Maloney 2000). Farmers were also not seen as a group that would voluntarily participate in efforts to reduce nitrogen and phosphorus runoff (Paolisso and Maloney 2000). However, farmers regard big businesses and industries as the primary cause of poor water quality problems. They believe big businesses are motivated economically to pollute the environment because it is more profitable to illegally dispose of industrial waste materials and pay a fine if found guilty rather than dispose of them properly (Paolisso and Maloney, 2000). Unlike corporations, farmers are confident in their ability to self-regulate their activities, considering themselves driven by the necessary motivation (Perez 2015; Paolisso and Maloney 2000).

Farmers tend to believe they are good stewards of the land and the environment and, hence, would not do anything detrimental that could hurt their neighbors (Paolisso and Maloney, 2000). In addition, farmers think they are wrongly judged for polluting the environment (Perez 2015; Paolisso and Maloney 2000). Schall et al. (2018) argue that farmers claim to be good stewards of the land but ignore the evidence that suggests that their practices hurt the environment. Suppose farmers have no awareness or belief of water quality problems from their farms and practices. In that case, educational efforts and voluntary programs will likely be unsuccessful in promoting widespread changes in farming practices (Pease and Bosch 1994). For farmers to accept and be willing to adopt any BMPs meant to reduce the negative impact of their activities on the environment, they must first believe the problem exists (Ribaudo and Horan (1999). BMPs are usually recommended by various stakeholders within the agriculture sector to reduce farming's negative impact. Still, adoption is often low and varies by practice (Carlisle 2016), and findings have been inconsistent regarding the factors that motivate farmers to adopt them (Prokopy et al. 2019). This variation could be due to comparing different conservation practices in various contexts using different measurements (Avemegah et al. 2024; Bennett et al. 2023).

Savage and Ribaudo (2013) believe that voluntary approaches to reducing water pollution from farmers have not been successful. However, they believe that voluntary programs can succeed if farmers consider societal demand for water quality when making production decisions. They recommend that farmers adopt water-quality BMPs early, as it can protect them from future regulations, which can be burdensome. Centner (2002) also suggested that agricultural producers can protect themselves from conflict related to environmental problems if they adopt BMPs. Understanding the perceptions of farmers and nonfarming residents is essential for achieving sustainable agriculture, resolving disputes, developing effective policies, and engaging communities. Church et al. (2021) proposed that policy tools that help build relationships can better help resolve conflicts than legal options.

In the U.S., farmers are encouraged to engage in various BMPs that are environmentally sustainable due to the negative impact of conventional farming practices. Conventional farming practices, such as intensive tillage, heavy irrigation systems, and the use of synthetic chemical fertilizer, nutrients, pesticides, and genetically modified seeds, are believed to have high production efficiency (Beus and Dunlap 1990; Weisberger et al. 2021; Gao and Arbuckle 2021). However, the conventional farming system creates many environmental problems, including some due to over-reliance on synthetic fertilizers. The government also heavily subsidizes these unsustainable practices. Nutrient loss from agricultural production is a global problem due to its negative impact on reducing water quality and marine life (Schwab, Wilson, and Kalcic 2021). Nutrient loss from agricultural production through erosion is the primary cause of algal blooms leading to hypoxia (dead zone) in the Chesapeake Bay, contributing to the loss of aquatic life and reducing water quality (Armstrong et al. 2022; Olguı´n, Sa´nchez, and Mercado 2004; Beegle 2013; Schwab et al. 2021). Excess agricultural nutrients also limit the ability of lakes and rivers to supply clean drinking water, recreation, and livelihoods (Robertson and Vitousek 2009; Armstrong et al. 2022).

Effective nutrient management is, therefore, necessary to ensure that excess nutrients do not end up in various water bodies. The main goal of nutrient management is to ensure that the nutrient supply meets plants' needs and that there are no excess nutrients on the farmlands that end up in various water bodies due to soil erosion. The 4Rs of nutrient management refer to applying nutrients at the right rate, at the right time, at the right place, and with the right source. They are also promoted to reduce the risk of nutrient pollution in water bodies, improve nutrient use efficiency, and minimize the environmental impact of agricultural practices. Nutrient management also helps maximize the economic benefits of nutrients (Beegle, Carton, and Bailey 2000).

Nutrient management practices are encouraged to reduce agricultural nutrient loss and its negative environmental impacts (Schwab, Wilson, and Kalcic 2021). Gao and Arbuckle (2021) believe that without proper management, additional nitrogen to the soil beyond what the crop demands will not be used; hence, excess nutrients remain in the soil, which could then run off into the water. Beegle et al. (2000) contend that nutrient management is an accepted strategy internationally to address farm nonpoint source or field nutrient loss. There are nutrient balance differences between farms; hence, nutrient management strategies will not be the same for all farms (Beegle et al. 2000). Farms can be classified into nutrient deficit, nutrient balanced, and nutrient surplus, which can help to select appropriate nutrient management options (Beegle et al. 2000). It is, therefore, important that farmers work with local experts and conduct soil tests to identify nutrient needs on their farms to ensure an appropriate Nutrient Management Plans (NMPs) is drafted that is environmentally sustainable and economically viable.

Farmers are sometimes skeptical about nutrient management practices because of the uncertainties regarding how they might affect crop yield (Gao and Arbuckle 2021). Their decisions to adopt nutrient management practices can be economic, social, or moral. Society demands that farmers be accountable for their impact on the environment. The government can also regulate their management practices by asking farmers to submit NMPs, as is the case in Maryland, Delaware, and Virginia (Perez 2025; Beegle et al. 2000). However, some farmers do not like the idea of regulation or mandatory adoption of NMPs because they feel regulation limits their roles as stewards of the land (USDA NRCS 2003). NMPs document all crops' nutrient needs, soil test results, and all nutrients (including manure) applied to the fields**.** Adopting NMPs by agricultural producers can have economic and environmental benefits.

Understanding the factors influencing farmers' adoption decisions is necessary to draft educational programs that can help reduce agriculture non-point pollution and improve water quality (Liu et al. 2018). When it comes to understanding agricultural innovations and their adoption, Everett Rogers has played an essential role by formulating a theory, diffusion of innovation (DOI), that includes constructs that measure the personal characteristics of farmers, attributes of the innovation, and the timing of their adoption or non-adoption of a particular innovation (Rogers 1962; 1983; Rogers and Shoemaker 1971; Rogers 2003). The Theory of Planned Behavior (TPB) has also been used extensively to understand farmers' intentions and behavior regarding adopting sustainable agriculture practices. Currently, the TPB is the most widely used social psychological framework to study farmers' decisions regarding adopting conservation practices (Delaroche 2020; Prokopy et al. 2019). Both the theory of DOI and TPB provide a holistic view of the adoption process. DOI focuses on innovation attributes and how they spread, while the TPB delves into individual cognitive processes and behavioral intention. Understanding and combining both theories will address the complexities of adoption by considering the innovation’s attributes and farmers’ attitudes, social influence, and perceived control over the future intention to use NMPs in the CBW.

Disagreement about water quality issues (sources of pollution and solutions to address water quality problems) is one cause of conflict between farmers and nonfarming residents. Parts of the U.S. are experiencing changes in land use due to metropolitan expansion, leading to the direct conversion of farmland for housing, commercial development, and transportation, bringing nonfarming residents closer to farms. This development is expected to increase in the CBW as the population demand for housing rises. Currently, the population in the CBW is 18.5 million, and it is likely to grow to nearly 20 million by 2030 (Chesapeake Bay Program 2023). The future projection of population increase suggests that more people will live in the CBW, which will likely lead to more farms closer to increasing numbers of nonfarming residents in the CBW. The rural-urban fringe and suburbanization of traditional agricultural areas have brought farmers closer to nonfarming residents, sometimes leading to tensions or conflict between farmers and their new neighbors (Vaserstain and Kelsy 2000; Sullivan et al. 2004).

Expanding urban areas where farmland is consumed by nonfarming development has resulted in conflicts in many ways. Conflict sometimes arises due to competition for resources, as there can be a difference in the purpose and value of farmland between urban dwellers and farmers (Handel 1998). Urban dwellers might regard farmland as a land bank where city officials can always encroach when the demand for housing increases (Handel 1998). Conflicts can also arise due to nuisance generated by farming activities from the residents' perspectives, and complaints made against farmers by residents irritate farmers as they do not understand why their neighbors complain (Janni 2020; Kolbe 2013). The movement of people into rural areas often leads to circumstances where new residents may persuade the local authorities to impose restrictions on farming activities such as pesticide use, spraying of pesticides and herbicides, movement of machinery, or spreading of manure, which can reduce efficiency and increase farmers' cost of production (Lockeretz 1989).

Lopez et al. (1988) also found that the causes of conflict between farmers and neighbors involve trespassing and vandalism by residents on farmers' property. Other prominent sources of conflict are nuisance issues, livestock, limitation ordinances, and other municipal ordinances (Lopez 1988). From the farmers' perspective, they do not like the intrusion of urban residents, leading to the demand for special management practices that can increase their cost and labor and reduce productivity (Handel 1998). Many farmers aim to minimize their operational costs and increase their profits. Hence, instances where complaints by residents make them spend more will frustrate them (Handel 1998).

While farmers may face various complaints and sometimes legal action from residents due to the pollution and other environmental problems generated by farming activities, some state governments have put laws in place to protect the interests of farmers. One example of such laws initiated by the government is the right-to-farm laws. These laws seek to supersede the common law of nuisance and promote agricultural land use (Lopez et al. 1988). Such laws protect farmers based on the idea that if farming activities constitute a nuisance, it is only because there has been a land-use change that brings other residents who are not farmers or know nothing about farming close to farmers (Vasertein and Kelsey 2000). Therefore, neighbors are responsible for any nuisance on their property. Urbanization significantly affects agriculture in terms of land regulatory effects, which hurts agriculture. Still, the right-to-farm laws can help remedy some of the adverse effects (Lopez et al. 1988). For interdependent communities to thrive, farmers and their nonfarming neighbors must agree on some mechanism for addressing common environmental and other issues that impact their livelihood, the natural environment, and wellbeing in general.

Research Overview

The dissertation consists of three empirical studies, which are separate but related and contribute to the literature regarding the environmental sustainability and economic viability of agriculture in an urbanized landscape like the CBW. The three papers aim to understand agriculture in the urbanizing CBW by examining views on water quality, agricultural-related conflict, and farmers' adoption of NMPs. This dissertation answers the following research questions with three empirical studies:

1. What is the level of concern among non-agricultural and agricultural residents about water quality issues in local streams and waterways and the CBW? To whom do the two groups attribute water quality problems? What are residents' and farmers' levels of support for various interventions outlined in previous research on water quality issues in local streams and waterways and the CBW?
2. What is the level of nonfarming residents' and farmers' concerns about their proximity to one another due to nuisance generated by farming activities and complaints by nonfarming residents in CBW? Have these concerns led to conflict between farmers and nonfarming residents in CBW, including potential solutions?
3. How do the theories of planned behavior and diffusion of innovations attributes help to understand farmers' future intention to use nutrient management plans?

The first paper (chapter 2) is a quantitative analysis that assesses the degree to which there is alignment between non-agricultural and agricultural residents' concerns and perceptions about water quality issues and their support of various interventions to deal with them. The second paper (chapter 3) used a mixed-method approach; thus, both quantitative surveys and qualitative interviews were used to understand urban-agricultural tension in the CBW by exploring the concerns farmers and nonfarming residents have due to their increasing interaction at the rural-urban interface. This paper also provides an overview of some pathways that residents themselves think can help address these concerns and mitigate the tensions. The third paper (chapter 4) used a quantitative approach to examine a proposed conceptual model that integrates the theory of planned behavior (TPB) and diffusion of innovation (DOI) attributes to understand farmers' future intention to adopt NMPs voluntarily. Overall, paper one provides insights into where there is convergence and disagreement on water quality issues, causes, and interventions that can help stakeholders understand the broader landscape of perceptions, which can inform policy initiatives to mitigate nutrient pollution from diverse sources in the CBW. Paper two provides insights into the concerns of farmers and nonfarming residents, which can lead to conflict because of their interaction, and offers various pathways to address those concerns and mitigate the conflict. Paper 3 provides insight into how social psychological frameworks can help understand farmers' decisions to adopt NMPs, an important mechanism for addressing water pollution in the CBW.

Overview of Chapter 2

Chapter 2 is titled "Agricultural and Non-Agricultural Residents' Perceptions of Water Quality Issues, Causes, and Interventions in the Chesapeake Bay Watershed." This paper examines agricultural and non-agricultural residents' perceptions of water quality issues, causes, and interventions in the CBW. Two survey datasets were analyzed, one with non-agricultural residents and the other with agricultural residents in the southern part of the CBW (Maryland, Virginia, and Delaware). In my analysis, farmers expressed significantly more concern about poor water quality in local streams and the CBW than nonfarming residents. However, farmers were less likely to see the water quality as poor than nonfarming residents at their local streams and the Chesapeake Bay. To address both urban lawn and farm nutrient runoff, utility and tax credits were highly supported by both farmers and nonfarming residents, while both groups were least supportive of laws and litigation that would require behavior change. Findings also indicated that education, age, income, gender, and the level of urban and suburban development where respondents reside are related to residents' support of utility and tax credits. This paper fills in a gap in the literature regarding up-to-date knowledge of how nonfarming residents and farmers acknowledge their contribution and role in addressing water quality problems in their local streams and waterways and the CBW and their support for various interventions to address poor water quality problems suggested in past studies (Church et al. 2021). The target journal for this paper is the *Journal of Environmental Management*, which publishes research on managing environmental systems and improving environmental quality.

Overview of Chapter 3

Chapter 3 is titled "Addressing Urban-Agricultural Tensions in the Chesapeake Bay Watershed: Perspectives on Concerns and Remedies." This paper used a mixed method to understand urban-agricultural tensions in the CBW by examining the concerns and remedies to reduce tensions between farmers and nonfarming residents at the rural-urban interface. The paper explores whether these concerns have led to conflict between farmers and nonfarming residents in the CBW and includes some potential approaches to help alleviate conflict. I used data from an online panel of 955 non-agricultural residents and a probability sample mail/online survey of 365 agricultural residents across the southern part of the CBW (Maryland, Virginia, and Delaware) in 2021 and 2022, respectively. I also conducted nine key informant interviews in

Howard County, Maryland, to help understand tensions at the rural-urban interface better. Results indicate that CBW nonfarming residents were primarily concerned about exposure to chemicals/pesticides. At the same time, farmers were more concerned about residents' legal actions against them due to the nuisance generated by their activities. The findings indicate that addressing the concerns requires multifaceted strategies focused on education, communication, community engagement and policy development. This paper provides current knowledge about the tensions or conflicts that exist or could arise between farmers and nonfarming residents due to their increasingly close contact and various pathways to address the tension or conflict. The target journal for this paper is *Agriculture and Human Values*, which publishes research about the values that shape and the structures that underlie current and alternative visions of food and agricultural systems.

Overview of Chapter 4

Chapter 4 is titled “Understanding Farmers' Intentions to Voluntarily Adopt Nutrient Management Plans in the Chesapeake Bay Watershed, United States.” The third paper examines the usefulness of the TPB and DOI attributes in understanding farmers' intentions to adopt NMPs in the CBW voluntarily. Understanding farmers' intention to use NMPs from a social-psychological perspective is essential to drafting educational programs and policies to help reduce the negative environmental impacts of nutrient loss from farmlands. While acknowledging other contributors to water quality problems in the CBW, this paper focuses on agricultural producers because of the larger scale of impacts, potential nutrient runoff, and economic effects of agricultural practices, making them a significant contributor to nutrient runoff and water pollution in the region. I used an online/mail survey from a probability sample of 365 agricultural producers in the southern part of the CBW (Maryland, Virginia, and

Delaware) where NMPs are mandatory to test a proposed conceptual model that integrates the TPB and DOI attributes to understand farmers intention to adopt NMPs. I found that relative advantage and compatibility were positively associated with attitudes toward NMPs, while complexity was negatively associated with attitude. There was also a positive relationship between compatibility and perceived behavioral control and observability, and subjective norms related to NMPs. The target journal for this paper is the *Journal of Environmental Psychology*, which publishes research on the psychological and behavioral aspects of people and nature.

Conclusion

In this dissertation's three papers, I provide knowledge regarding some pathways to ensure agriculture is environmentally sustainable, ways to address water quality problems that span multiple jurisdictions, and user interests, like the CBW, ways to address the concerns of farmers and nonfarming residents at the rural-urban interface due to their increasing interaction, and social psychological motivations regarding farmer decision to adopt of NMPs in the future. Findings from this dissertation can inform policy aimed at addressing nutrient pollution from various sources in the CBW and ensuring that agriculture is environmentally sustainable and economically viable within the region.

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CHAPTER 2

AGRICULTURAL AND NON-AGRICULTURAL RESIDENTS' PERCEPTION OF WATER QUALITY ISSUES, CAUSES, AND INTERVENTION IN THE CHESAPEAKE BAY WATER

Abstract

Nutrient pollution by point and nonpoint sources has led to water quality problems in the Chesapeake Bay Watershed (CBW) that must be addressed for a healthy ecosystem. This study assesses the degree to which there is alignment between non-agricultural and agricultural residents' concerns and perceptions about water quality issues and their support of various interventions to deal with them. Data were drawn from an online panel of 955 nonfarming residents and a mail/online survey of 365 agricultural producers across the southern part of the CBW (Maryland, Delaware, and Virginia) in 2021 and 2022, respectively. Farmers expressed a significantly higher concern about poor water quality in local streams and the CBW than nonfarming residents. However, farmers were less likely to see the water as poor quality than nonfarming residents at both scales. To address both urban lawn and farm nutrient runoff, utility and tax credits were highly supported by both farmers and nonfarming residents, while both groups were least supportive of laws and litigation that would require behavior change. A binary logistic regression also indicated that education, age, income, gender, and the level of urban and suburban development where respondents reside are related to residents' support of utility and tax credits. This study provides insights into where there is convergence and disagreement on water quality issues, causes, and interventions that can help stakeholders understand the broader landscape of perceptions, which can inform policy initiatives to mitigate nutrient pollution from diverse sources in the CBW.

Introduction

Nutrient pollution from both point and nonpoint sources is the primary cause of water quality problems in the Chesapeake Bay Watershed (CBW). The CBW covers more than 64,000 square miles and includes more than 150 rivers and streams that align with six states (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and the District of Columbia (Sims and Coale 2002; Savage and Ribaudo 2013; Morgan and Owens 2001). The Chesapeake Bay is North America's largest, most fruitful estuary and is well-studied because it provides seafood, recreation, and tourism that generate revenue for the CBW states (Kleinman et al. 2019; Sims and Coale 2002; Morgan and Owens 2001; Arnold et al. 2021). Water quality has been on the decline in the CBW since the 1970s because of concentrated agriculture leading to nutrient runoff from farm fields and population growth leading to urbanization and impervious surfaces such as roads, parking lots, and buildings that increase runoff (Savage and Ribaudo 2013; Ator et al. 2020). Due to environmental concerns, including water quality, loss of submerged aquatic vegetation, and overfishing, the Chesapeake Bay became the first estuary targeted for protection and restoration by the United States (U.S.) Environmental Protection Agency (EPA) in 1975 as a directive from the U.S. Congress (Sims and Coale 2002; Savage and Ribaudo 2013).

In 1982, the EPA conducted a study to identify the causes of declining water quality in the Bay and found three primary factors contributing to the water quality decline: sediment, nitrogen, and phosphorus (Perkinson 1994; Sims and Coale 2002). These findings suggested that agriculture production significantly pollutes the Chesapeake Bay (Sims and Coale 2002). Specifically, the EPA found that nutrient runoff from farm fields through erosion contributed to the pollution of the Chesapeake Bay (Sims and Coale 2002). Agriculture is not the only contributor to the pollution of the Chesapeake Bay; population growth and urban development in the region has led to the development of impervious surfaces that increase urban runoff and contribute to the degraded water quality of the Bay (Perkinson 1994). Addressing the pollution of the Chesapeake Bay has been a significant concern and focus of efforts for various stakeholders, including government and non-governmental organizations, environmental organizations, farmers and nonfarming residents, and community leaders within the CBW.

Addressing water quality issues in the CBW is paramount due to the significant environmental, economic, and social implications of the Bay's health (Phillips and McGee 2016). As the largest estuary in the U.S., the Chesapeake Bay provides a vital habitat for numerous plant and animal species (Kleinman et al. 2019). The Chesapeake Bay also supports a diverse ecosystem and sustains commercial and recreational fisheries, tourism, and other industries (Phillips and McGee 2016). Poor water quality can degrade habitats, harm species, and disrupt the balance of the ecosystem (Savage and Ribaudo 2013). Improvement in water quality is therefore crucial for the region because it can increase and improve recreational activities, keep commercial fisheries viable, and protect human health, which are vital for the economic prospects and the general well-being of residents of the region (Hager et al. 2014; Morgan and Owens 2001).

Along with local efforts, several state and regional actions have been implemented to enhance water quality in the CBW. For example, the EPA initiated the Chesapeake Bay Total Maximum Daily Load (TMDL), a pollution reduction strategy to help restore the health of the Chesapeake Bay. The TMDL set a limit regarding the amount of sediments, nitrogen, and phosphorus that can be present in the Chesapeake Bay to attain improved water quality and restore the Bay (Kleinman et al. 2019; Moore et al. 2018; Savage and Ribaudo 2013). Another action is the promotion of various Best Management Practices (BMPs) for agricultural operations, such as nutrient management plans (NMPs), conservation tillage, cover crops, forest buffers, and streamside fencing due to their ability to reduce nutrient runoff from farm fields (Savage and Ribaudo 2013; Chesapeake Bay Program 2024). Decades of management efforts have resulted in a moderate reduction of nutrient loads from the watershed, yet significant improvements in water quality remain a challenge (Murphy et al. 2022). An estimate from the U.S. Geological Survey suggests that fulfilling the nutrient reduction targets for the Bay may require removing around 44% of the region's approximately 8.2 million acres of farmland from production, which would inevitably impact farm income and the region's economy (Clune and Capel 2021).

It is evident that many actors, including farmers and nonfarming residents, contribute to nutrient pollution of rivers and streams in different ways, yet attempting to address the causes and perceived equitable solutions to water quality issues can result in conflict due to blame-shifting, particularly between agricultural and non-agricultural residents (Armstrong et al. 2022; Armstrong and Tucker 2019; Church et al. 2021; Gasteyer 2008; Hu and Morton 2011). Blame shifting here refers to the circumstances where farmers and nonfarming residents try to change the responsibility for causing water quality issues or problems away from themselves and onto others (Church et al. 2021). Due to the changing environmental landscape in the CBW, it is essential to delve into the disputed root causes of water quality problems. Environmental knowledge and causes of environmental issues are often contested in the contemporary U.S. because of various factors, including differing perspectives, economic interests, political ideologies, and the complex nature of environmental problems (Druckman et al. 2013; Brown 2023; Daniel 2019). In addition, establishing the causes of environmental problems, such as poor water quality issues, can be challenging because many factors are responsible for poor water quality, and many are not easily seen (Armstrong et al. 2022).

This study assesses non-agricultural and agricultural residents' concerns regarding water quality issues, who they attribute water quality problems to, and their support for various interventions outlined in previous research on water quality policy tools (see Church et al. 2021). While past studies have outlined ways that addressing water quality issues can impact urban-agricultural relationships (Yoder, Church, and Wagner 2024; Church et al. 2021; Gastever 2008; Hu and Morton 2011), this study provides insights into where there is convergence and disagreement on water quality issues, causes, and interventions that can help stakeholders understand the broader landscape of perceptions which can help at addressing nutrient pollution from various sources in the CBW.

Agricultural and Non-Agricultural Residents Perceptions of Water Quality Issues and Interventions

Agriculture remains a significant land use activity within the CBW, playing a crucial role in the regional economy and food production. More than 83,000 farms in the CBW, including crop production, livestock, poultry, and dairy farms, contribute over $10 billion in agricultural production each year (USDA NRCS 2013). While agriculture is economically important in the region, the activities of farmers have resulted in nutrient pollution in various rivers and water bodies (Beegle 2013; Hamilton et al. 1993). Agriculture, notably non-point source pollution from nutrient and sediment runoff, is considered one of the significant contributors to water quality issues (Savage and Ribaudo 2013). Nutrient loss from agricultural production is also the primary cause of hypoxia (dead zone) in the Chesapeake Bay, contributing to the loss of aquatic life and reducing water quality (Olguı´n, Sa´nchez, and Mercado 2004; Beegle 2013; Schwab et al. 2021).

The population increase in the CBW has also put more stress on the Chesapeake Bay and other rivers within the CBW due to increased construction activities, as suburban sprawl is ranked as one of the top threats to the Bay's recovery (Morgan and Owens 2001). Development activities leading to constructing impenetrable surfaces, such as roadways and parking lots, can increase runoff into local watersheds (Poor, Pessangno, and Paul 2007). For example, land development (urban/suburban sprawl) and a high precipitation rate contributed to excess phosphorus being discharged into the Chesapeake Bay (Ryberg et al. 2018). The current population in the CBW is 18.5 million and is expected to grow by 3.5 million between 2025 and 2055 (Bhatt et al. 2023). The future projection of population increase suggests that the problem of poor water quality in the region will increase. This is because more forest land will likely be converted into housing, thereby reducing the ability of the forests to filter nutrients before reaching any river or lake within the CBW. Forest land has the potential to improve water quality in the region. For example, Delia et al. (2021) found improved water quality in the James River Watershed in Virginia, where forest land areas are preserved throughout the watershed.

While agriculture has often been the primary focus of water quality interventions, it is evident that non-agricultural residents also play a crucial role in influencing water quality (Chesapeake Bay Foundation 2024). Thus, understanding the attitudes and beliefs of both agricultural and non-agricultural residents towards water quality is critical in designing successful interventions and programs to help improve water quality. Some research has shown that farmers and non-farmers have different views and attitudes about water quality issues (Busse et al. 2015; Berenguer et al. 2005). It is evident that farmers often recognize water quality problems but may not feel that they are responsible for those problems (Busse et al. 2015; Pease and Bosch 1994). For example, Lichtenberg and Lessley (1992) found that even though farmers in Maryland recognized the existence of water quality problems, they disagreed or believed that the problems originated from their farm or local area. Most farmers in Virginia also expressed concerns about water quality issues. Still, they disagreed about the seriousness of the problem and maintained that water quality problems were not serious on their farms (Pease and Bosch 1994). Maryland, lower Eastern Shore farmers were also skeptical about the link between nutrient runoff from their farms and poor water quality (Paolisso and Maloney 2000). These findings suggest that farmers are sometimes reluctant to link their on-farm activities to broader water quality issues, which can affect policy and intervention programs designed to improve water quality at a watershed or regional level.

Some studies have also shown that non-agricultural residents believe farmers are primarily responsible for poor water quality, and urban residents support water quality protection more than farmers (Busse et al. 2015; Berenguer et al. 2005). For example, during the Pfiesteria (toxic algal bloom) case that occurred in Maryland in 1997, farmers were viewed as the primary source of nutrient pollution by non-farming residents through semi-formal and formal ethnographic interviews (Paolisso and Maloney 2000), which aligned with findings about the primary contributors. They were also not seen as a group that would voluntarily participate in efforts to reduce nitrogen and phosphorus runoff. This same research found that farmers often had a different perception of industry and business operations and their care for the environment. For example, farmers believed that big businesses and industries are motivated economically to pollute the environment as it is more profitable for them to illegally dispose of industrial waste materials and pay a fine if found guilty than dispose of them properly. Unlike corporations, farmers were confident in their ability to self-regulate their activities, considering themselves driven by the necessary motivation (ibid).

Some research has also indicated that farmers believe they are good stewards of the land and do their best to care for the environment; they would not do anything detrimental and could hurt their neighbors (Paolisso and Maloney, 2000). Farmers also tend to think they are wrongly judged for polluting the environment, which goes against their view as good stewards of the land and the environment (Perez 2015; Paolisso and Maloney 2000). Schall et al. (2018) argue that farmers claim to be good stewards of the land but ignore evidence that suggests that their practices hurt the environment. Suppose farmers have no awareness or belief in water quality problems from their farms and practices. In that case, educational efforts and voluntary programs will likely be unsuccessful in promoting widespread changes in farming practices (Pease and Bosch 1994). BMPs are usually recommended by various stakeholders within the agriculture sector to reduce the negative impact of farming. Still, adoption is often low and varies by practice (Carlisle 2016), and findings have been inconsistent regarding the factors that motivate farmers to adopt them (Prokopy et al. 2019). This variation could be due to comparing different conservation practices in various contexts using different measurements (Bennett et al. 2023; Avemegah et al. 2024).

Savage and Ribaudo (2013) believe that voluntary approaches to reducing water pollution for farmers have not been successful. They argue that voluntary programs can succeed if farmers consider societal demand for water quality when making production decisions and if conservation practices increase net returns. They suggested that if farmers adopt water-quality BMPs early, it can protect them from future regulations, which can be burdensome since they prefer to avoid being regulated. Centner (2002) also suggested that adopting BMPs can be a way for agricultural producers to protect themselves from conflict when it comes to issues related to environmental problems. Understanding the perceptions of both agricultural and non-agricultural residents is essential for achieving sustainable agriculture, resolving disputes, developing effective policies, and engaging communities. In their study on how water quality improvement efforts influence urban-agriculture relationships, Church et al. (2021) proposed that policy tools that help build relationships and engage with people's emotions and identities can potentially shape people’s ability to change and adapt compared to litigation.

Blame-shifting and resulting inaction toward addressing water quality clearly exists. However, what it looks like currently in the CBW is still being determined. Residents' perceptions regarding water quality issues are an essential area of research as it is necessary for effective policy and program implementation (Armstrong et al. 2019). Church et al. (2021) also believe that concentrating on urban–agricultural relationships is an essential area of research because there continue to be divides or conflicts that obstruct any meaningful intervention. Flint et al. (2017) believe that research focusing on natural resources issues in distinct locations while also considering the social complexity within the population enhances the relevance of research for management and policy decisions. Therefore, it is crucial to understand diverse residents’ views on strategies to improve water quality issues in the CBW, which can be one of the steps to formulating policies and interventions to address the water quality issues and the possible tensions between agricultural and non-agricultural residents. A collaborative watershed governance approach (CWGA) can be a strategy to address water quality problems at the watershed level. The CWGA provides a framework where different stakeholders, such as farmers, nonfarmers, planners, and policymakers, work together to resolve an environmental problem at the watershed level (Benson et al. 2013).

This research seeks to assess the perceptions of agricultural and non-agricultural residents about water quality issues, how much various activities contribute to water quality issues, and multiple strategies or policy tools to control urban lawn and farm runoff in the CBW. Based on the goals of this study, the following research questions were developed:

1. How does the concern between agricultural and non-agricultural residents about water quality issues in local streams and the CBW vary?
2. Is there an alignment or difference between agricultural and non-agricultural residents on perceptions of water quality locally and in the CBW?
3. Is there an alignment or difference between agricultural and non-agricultural residents' support for various interventions outlined in previous research on water quality policy tools?
    a. What factors support interventions?

Methods

Data for this study is from two surveys of residents, one agricultural and the other non-agricultural, in the Southern part of the CBW (Maryland, Delaware, and Virginia). Both surveys asked about residents' awareness, concern, and views on water quality issues in local streams and waterways and the CBW in general. Questions also investigated residents' perceptions of the causes of water quality issues, how to address water quality issues and the future of agriculture in the region.

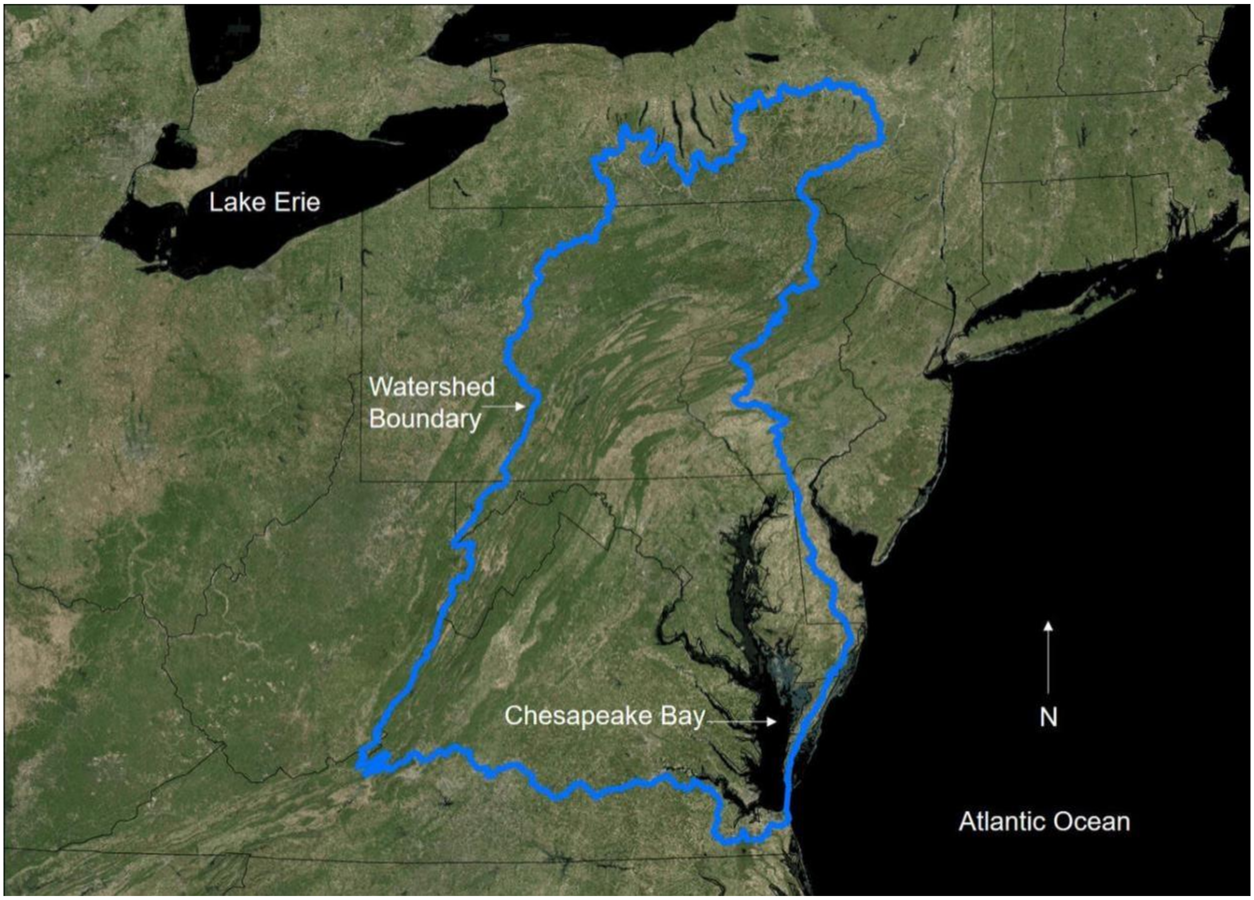

Figure 1. Map of the Chesapeake Bay and the state in the CBW Source P. Haggerty, USGS

CBW Resident Survey

From May to July 2021, a survey of residents of the CBW was conducted by Qualtrics through an online panel. Qualtrics provided a small amount of compensation for participants. The CBW intersects with six states: New York, Pennsylvania, Delaware, Virginia, West Virginia, and the District of Columbia. Respondents were selected from counties in each state that overlap with the CBW. However, this study is focused on responses from the southern part of the CBW (Maryland, Delaware, and Virginia) given where most of the agricultural sample resides. Overall, 79.93%, 14.78%, and 5.38% of responses were from Maryland, Delaware, and Virginia, respectively. Because the survey used non-probability sampling methods, we created rake weights[2] using age, gender, level of education, and race estimates from the American Community Survey (2015-2019) at the county level to generate more representative estimates.

CBW Farmer Survey

From March to June 2022, an online and mail survey of agricultural producers was conducted in the CBW, primarily in the Southern half (Maryland, Delaware, and Virginia). The survey targeted crop producers (corn and soybeans), livestock producers (beef and dairy), and farmers who produce crops and livestock, but not hobby farmers or those with livestock only. The sample included information on 2403 producers (name, address, planted acres, gross financial income, and crops and/or animals produced). It was purchased from DTN, a company that provides contact information for agricultural producers in the United States (U.S.). A recent publication assessing the quality of sample sources for survey research with agricultural producers in the U.S. suggests that private vendors are useful sampling sources because of their ability to provide generalizable samples and the option to conduct non-response bias tests with the background data provided (Ulrich-Schad et al. 2022). Producers with 50+ acres of operated land within the CBW were selected using simple random sampling. 50+ acres of acres were selected due to the insights they can provide into practices and trends that drive economic growth. To get an accurate sampling frame of agricultural producers within the CBW, DTN was provided with a list of counties and zip codes overlapping with the CBW. The completed sample included 1326 (55.18%) producers from Maryland, 393 (16.35%) from Delaware, 663 (27.59%) from Virginia, 14 (0.58%) from Pennsylvania, 3 (0.12%) from West Virginia, 3 (0.12%) from District of Columbia and 1 (0.04%) from New York. According to DTN, due to the parameters

[2] Rake weights were applied in this case because it helps the sample distribution to align with the population on the specified variables (Omisakin 2023; Mercer 2018).

that was required by location and size of farm (50+ acres) for the sample, there were fewer producers in general from the states of New York, Pennsylvania, and West Virginia, and the District of Colombia in their database accounting for the low sample size in these four states. Given DTN's limitation in the sample they could provide, the analysis is focused on the three states clustered in the south of the watershed and with the most responses (Maryland, Delaware, and Virginia).

Producers were contacted up to four times using a modified tailored design approach (Dillman et al. 2014). The advance letter contained information and an explanation of the purpose of the overarching research project. It was also mentioned that their thoughts or insights about water quality issues and how they managed their farmlands will help the research team plan for a thriving future of agriculture in the CBW, ensuring that producers remain in business. The advance letter also contained a link to an online survey so that producers who wanted to take the survey immediately online could do so.

The second contact was a mail survey with a stamped return envelope for those who have yet to respond to the first wave. The third wave was a postcard reminder for producers who had not yet responded to both the first and the second waves. The last contact was another mail survey with a stamped return envelope to farmers who did not respond to previous waves. The process of multiple contacts and incentives has proven to increase the response rate in survey research, specifically among agricultural producers (Avemegah et al. 2021). We asked producers to indicate their farming status (e.g., renting out the land or no longer farming) and whether they live in the CBW via mail and online surveys. Producers not currently farming or retired were asked to stop the study and indicate so for our records. Overall, the process of multiple contacts achieved a response rate of 16.2% after 371 questionnaires were completed and returned (online

= 145 and mail = 226) and after wrong mailing addresses and those not currently farming were removed (N = 118).

Measures

Dependent Variable

The dependent variable for the multivariate analysis was residents' support for policy tools to control urban and farm runoff (utility and tax credits). I focused on these interventions because they were the most supported. Respondents who indicated support for the policy tool were coded as 1, and those in opposition were coded as 0.

Independent Variables

The independent variables included in the multivariate models are shown in Table 1. In the farmers' model, they include their level of understanding regarding population growth in the CBW, age, level of education, farm size, number of years being a decision maker regarding their farming operation, whether they own livestock, whether they earn income off the farm, and whether any family member owns or operate the farm before they did. In the resident model, the independent variables included their level of understanding regarding population growth in the CBW, level of education, gender, household income, and age.

We also measured concerns and perceptions regarding water quality in local streams and the CBW. Concerns were measured using a scale ranging from 5= extremely concerned to 1= not at all concerned. The perception of water quality was also measured with a scale ranging from 4 = excellent to 1 = poor. The support for various policy tools to reduce farm and urban lawn runoff was also measured with a scale ranging from 5 = strongly support to 1 = strongly oppose. To measure critical contributors to water quality issues, respondents were asked how much they think various sources (e.g., industrial pollution and agricultural activities) contribute to water quality issues in their local streams and waterways and the CBW. Responses were measured using a scale ranging from 4 = very much to 1 = not at all.

Data Analysis

The statistical software Stata version 16 (Stata Corp LLC, College Station, Texas) was employed to analyze the data. Basic descriptive statistics on variables of interest were run to show the percentages, mean, and standard deviation for agricultural and non-agricultural residents. We also employed a t-test to understand whether the perceptions and concerns regarding current water quality and support for various policies varied between the two groups. The perception, concern, and support for different policy tools were treated as continuous variables in the t-test analyses. I also employed Pearson's chi-square test to determine if there were significant differences between agricultural and non-agricultural residents on crucial contributors to water quality issues in their local streams and waterways and the CBW in general.

A logistic regression model was also run on farmers' and non-farming residents' data separately to understand how various socio-demographic and economic variables are related to support for policy tools to control farm and urban lawn runoff. The logistic regression model predicts the logit of the dependent variable (support for utility and tax credit) from the independent variables (socio-demographic and economic variables). The likelihood of a farmer or non-farming resident being in support of utility or tax credit policy is predicted by odds (Y=1), which is the ratio of the probability that Y=1 and the probability that Y≠1:

$$\text{The Odds of } Y = \frac{P(Y=1)}{(1-P(Y=1))} \tag{1}$$

The logit (Y) is given by the natural log of Odds;

$$ln\left(\frac{P(Yi=1)}{(1-P(Yi=1))}\right) = \text{log odds} = \text{Logit (Y)} \tag{2}$$

It can also be expanded as:

$$\text{Logit}(Y) = \alpha + \sum\beta_1 X_1 + \sum\beta_2 X_2 + \ldots + \sum\beta_n X_n + \varepsilon_i \quad (3)$$

where P is the probability of supporting utility or tax credit, (1-P) is the probability that a farmer or a non-farming resident does not support utility or tax credit, ln is the natural log, α is Intercept, β_1, β_2, etc., are the coefficient of the respective independent variable, and ε_i is the error term (Avemegah et al. 2024). However, the non-agricultural resident survey data was a nonprobability sample; hence, the binary logistic regression was weighted. Therefore, the results should be interpreted with caution.

Results

Table 1 shows demographic and respondent location characteristics from each survey. The highest percentage of farmers (33.93%) indicated that less than high school was their highest level of education. In comparison, the highest rate of residents (30.47%) indicated their highest level of education as high school. Most farmer respondents were male (89.05%), which is common in surveys targeting operations and the person in them who makes most decisions, while most resident respondents were female (64.26%). Most responses from farmers (60.55%) and residents (79.93%) were from Maryland. The average age of farmers and general residents in the southern part of the CBW was 69.37 and 47.65 years, respectively.

Table 1. Summary and descriptive statistics of the study independent variables.

Variable Measure	**Descriptive Statistics**			
	Farmers		**Residents**	
	N	**Percentage**	**N**	**Percentage**
Level of education	**336**		**955**	
Less than high	114	33.93	215	22.51
High school diploma/GED	94	27.98	291	30.47

4-year college degree	79		23.51		275		28.80	
Advanced degree (Masters, PhD, professional degrees, etc.)	49		14.58		174		18.22	
Gender	**338**				**944**			
Male	301		89.05		336		35.59	
Female	37		10.95		608		64.41	
State	**365**				**955**			
Maryland	221		60.55		756		79.93	
Delaware	47		12.88		140		14.78	
Virginia	97		26.58		51		5.38	
Level of urban and suburban development	**356**				**955**			
Too fast	305		85.67		517		54.14	
Too slow	4		1.12		130		13.61	
About right	47		13.20		308		32.25	
Farm size	**365**							
Small (1-499 acres)	100		27.40					
Large (500-999 acres)	64		17.53					
Very large farm (1,000+ acres)	200		55.07					
Own livestock	**336**							
Yes	157		46.73					
No	179		53.27					
Off-farm income	**334**							
Yes	110		32.93					
No	224		67.07					
Did any family member own the farm before you	**335**							
Yes	231		68.96					
No	104		31.04					
Household income					**904**			
Less than $25,000					158		17.48	
$25,000 - $49,999					208		23.01	
$50,000 - $74,999					153		16.92	
$75,000 - $99,999					138		15.27	
$100,000 - $149,999					151		16.70	
$150,000 - $199,999					72		7.96	
$200,000 and above					24		2.65	
	Range	**N**	**Mean**	**SD**	**Range**	**N**	**Mean**	**SD**
Age	25 – 94	284	69.37	11.96	18 - 88	965	47.65	18.26
Number of years being a decision-maker	1 – 85	319	34.41	16.04				

Table 2 shows the mean difference between non-agricultural and agricultural residents' views on current water quality and their concern about the current water quality in their local streams and the CBW. I found that agricultural residents recorded a higher mean score regarding perceptions of current water quality than nonagricultural residents in their local streams and the CBW. I also found that farmers were more concerned about water quality issues in local streams and the CBW than non-agricultural residents. The difference in response regarding concerns about water quality issues in local streams was not statistically significant but was in the CBW.

Table 2. Residents' perceptions and concerns about water quality in local streams and CBW.

	Nonagricultural residents	**Agricultural residents**	**Significance**
Current water quality in local streams and waterways	2.39	3.03	***
Current water quality in the CBW	2.37	2.57	***
Concern about current water quality in local streams	3.41	3.48	NS
Concern about current water quality in the CBW	3.46	3.64	*

Note: Water quality was measured on a scale of 1 poor—4 excellent. Concern about water quality was measured at a scale of 1 not at all concerned—5 extremely concerned.

* = $p<0.05$, ** = $p<0.01$ and *** = $p<0.001$. NS: not significant

Figure 2 shows the results of what activities agricultural and non-agricultural residents perceive to contribute to water quality problems in their local streams and waterways. Findings suggest that non-agricultural residents perceive industrial pollution (44.77%) and urban/suburban stormwater runoff (44.77%) as the two most significant contributors to water quality problems in their local streams and waterways. Agricultural residents, on the other hand, perceive urban/suburban stormwater runoff (53.62%) and sewage treatment (53.31%) as the two major contributors to water quality problems in their local streams and waterways. However, farmers saw agricultural activities as contributing less to water quality issues in their local streams and waterways than non-farmers.

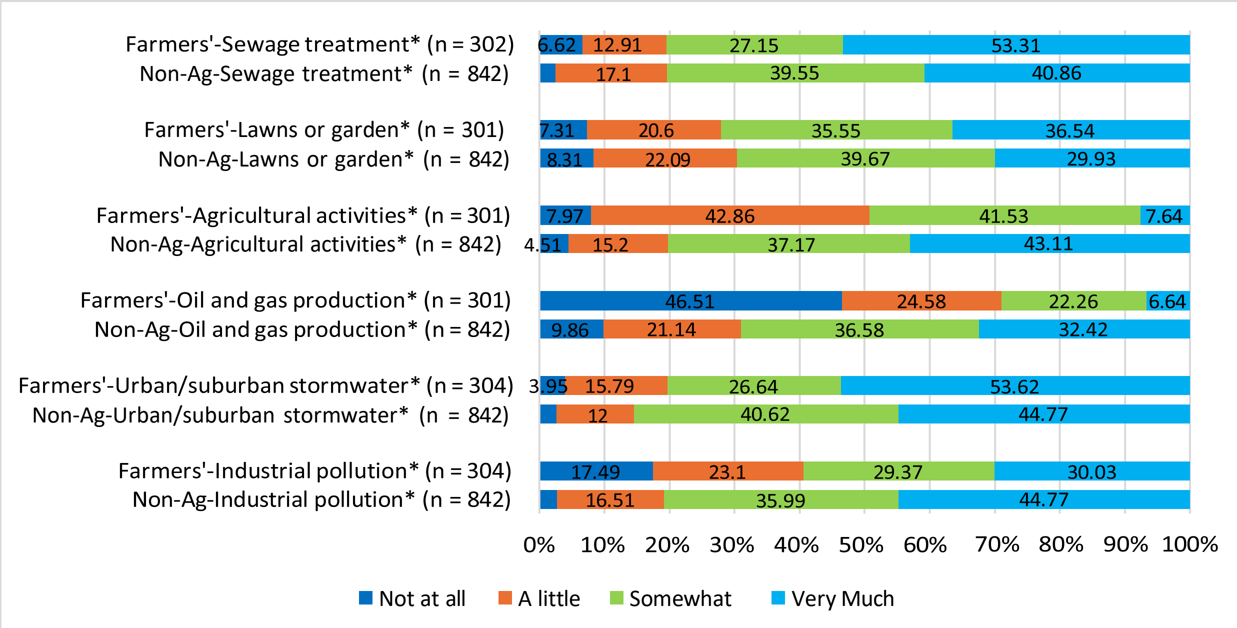

Figure 2. Residents' and farmers' perceptions of how much various activities contribute to water quality issues in local streams and waterways.

Note: *indicates statistically significant difference (p, 0.05) between groups

Figure 3 shows what activities non-agricultural and agricultural residents perceive to contribute to water quality problems in the CBW. The results indicate that farmers view urban and suburban stormwater runoff (65.98%) and sewage treatment (64.83%) as the major contributors to water quality issues in the CBW while seeing their contribution as relatively minor. Regarding agricultural activities, only 11.34% of agricultural residents indicated water quality problems came from farming, compared to 44.98% of non-agricultural residents. On the other hand, non-agricultural residents view industrial pollution (62.92%) and agricultural activities (44.98%) as the two primary sources of water quality issues in the CBW, respectively.

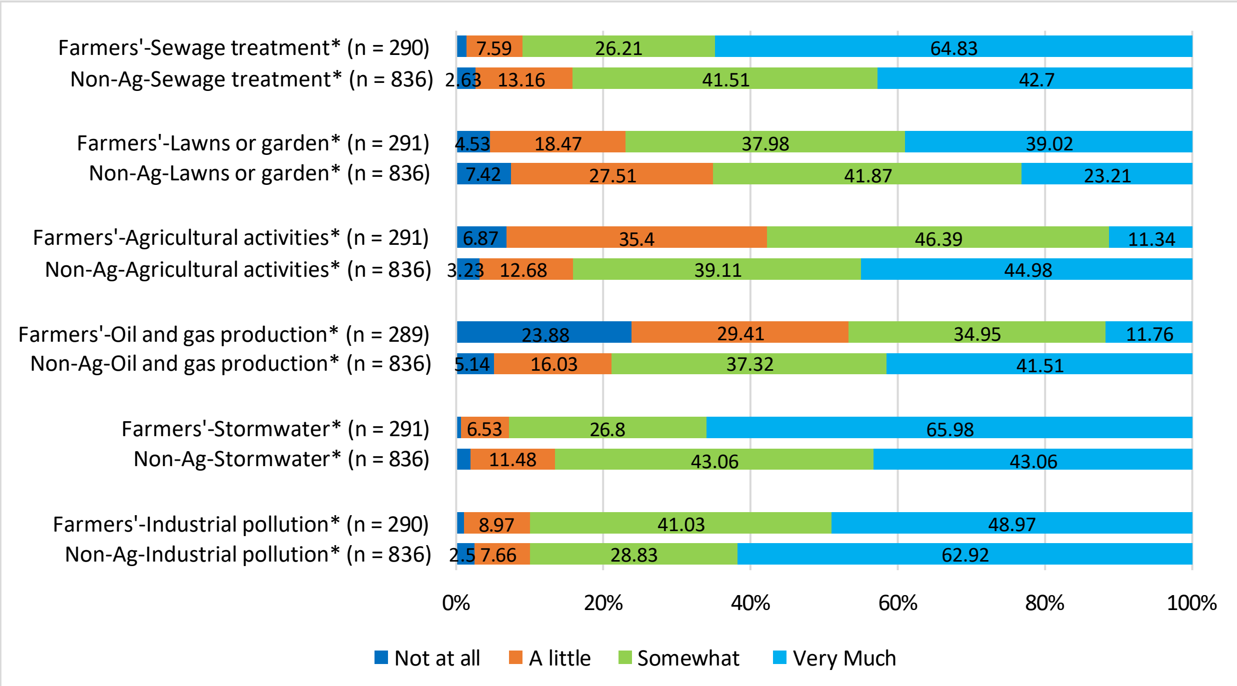

Figure 3. Residents' and farmers' perceptions of how much various activities contribute to water quality issues in the CBW.

Note: *indicates statistically significant difference (p, 0.05) between groups

Table 3 shows the difference in average scores between residents' support for strategies to control urban lawn runoff. Non-agricultural residents recorded a significantly higher mean score for all strategies than agricultural residents. However, both most supported utility credits as the best strategy to control urban lawn runoff where they live. Non-agricultural residents recorded an average score of 3.98, while agricultural residents recorded an average of 3.43.

Table 3. Agricultural and non-agricultural residents' level of support or opposition to the following strategies to control urban lawn runoff where they live.

	Nonagricultural residents	**Agricultural residents**	**Significance**
Require urban residents to adopt practices to reduce polluted runoff with a law	3.70	3.51	***
Encourage residents to adopt practices to reduce polluted runoff with credits that lower water utility bills	3.98	3.43	***
Rely on urban residents to voluntarily reduce runoff without government involvement	3.43	2.99	***
Adopt programs where cities/towns pay farmers to adopt practices that reduce polluted runoff to meet overall water quality goals	3.73	3.14	***

Note: These policy tools were measured with a 5-point Likert scale (1 strongly oppose – 5 strongly support)

* = $p<0.05$, ** = $p<0.01$ and *** = $p<0.001$.

Table 4 shows residents' perceptions of policy tools to control farm runoff. There was a statistically significant difference between agricultural and non-agricultural residents on all the policy tools for controlling farm runoff except for relying on farmers to reduce runoff without government involvement voluntarily. Non-agricultural residents recorded a higher average score on all strategies than agricultural residents, except for relying on farmers to voluntarily reduce runoff without government involvement. However, both supported encouraging farmers to adopt practices to reduce polluted runoff with credits from public funds.

Table 4. Agricultural and non-agricultural residents' level of support or opposition to the following strategies to control farm runoff where they live.

	Nonagricultural residents	**Agricultural residents**	**Significance**
Require farmers to adopt practices to reduce polluted runoff with a tax on farmers who produce the most runoff	3.65	2.01	***
Encourage farmers to adopt practices to reduce polluted runoff with tax credits from public funds	3.90	3.51	***
Encourage a certification program so farmers who adopt practices to reduce polluted runoff can market their products as "CBW Friendly."	3.97	3.12	***
Install off-farm technologies to reduce the impact of polluted runoff using public funds	3.76	3.19	***
Rely on farmers to voluntarily reduce runoff without government involvement	3.31	3.41	NS
A special sales tax on fertilizer (for both agricultural and household uses)	3.38	1.55	***
Use lawsuits to get farmers to reduce runoff	2.97	1.38	***
Use water resource planning processes that include many stakeholder groups (e.g., farmers, non-farmers, planners, policymakers)	3.72	2.96	***

Note: These policy tools were measured with a 5-point Likert scale (1 strongly oppose – 5 strongly support)

* = p<0.05, ** = p<0.01 and *** = p<0.001. NS: not significant.

Table 5 provides a binary logistic regression result showing the relationship between socio-demographic and economic variables and farmers' support for tax and utility credits to control farm and urban runoff, respectively. Farmers' level of education was found to statistically and significantly influence their level of support to encourage them to adopt practices to reduce polluted runoff with credits that lower water and utility bills. The results suggest that farmers with 4-year college and advanced degrees are 2.52 and 3.66 times more likely to support utility credits as a strategy or policy tool to control urban lawn runoff compared to those with less than a high school level of education, respectively.

Table 5. Binary logistic regression models showing the relationship of agricultural residents' support for tax credits for farmers to reduce farm runoff and utility credits for residents to reduce urban lawn runoff.

Variable	**Variable Categories**	**Tax credit odds ratio (SE)**	**Utility credit odds ratio (SE)**
Level of urban and suburban development	Too fast	(ref)	(ref)
	Too slow	0.89 (1.08)	1.08 (1.13)
	About right	0.91 (0.41)	0.72 (0.28)
Farm size	Small (1-499 acres)	(ref)	(ref)
	Large (500-999 acres)	1.04 (0.45)	0.89 (0.33)
	Very large farm (1,000+ acres)	1.72 (0.62)	1.09 (0.33)
Level of education	Less than high school	(ref)	(ref)
	High school diploma/GED	2.16 (0.90)	1.57 (0.52)
	4-year college degree	2.03 (0.88)	**2.52 (0.90) ***
	Advanced degree (Masters, PhD, professional degrees, etc.)	1.14 (0.55)	**3.66 (1.67) ***
Number of years being a decision-maker	N/A	1.01 (0.01)	1.02 (0.01)
Age	N/A	1.02 (0.01)	0 .97 (0.01)
Own a livestock	Yes	(ref)	(ref)
	No	0.62 (0.20)	0.78 (0.20)
Off-farm income	Yes	(ref)	(ref)
	No	0.95 (0.32)	0.90 (0 .26)
Did any family member own a land before you	Ye	(ref)	(ref)
	No	0.56 (0.20)	0.58 (0.18)
Number of years of farming in the current location	N/A	0.97(0.01)	0.99 (0 .01)
Model statistics			
Observations (n)		261	259
Hosmer-Lemeshow chi2		11.99	13.87
Hosmer-Lemeshow p-value		0.15	0.08

Notes: N/A = not applicable, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Table 6 also provides results from a binary logistic regression showing the relationship between socio-demographic and economic variables and non-agricultural residents' support for tax and utility credits to control farm and urban runoff, respectively. The results suggest that non-agricultural residents who indicated that the level of urban and suburban development was too slow were 0.49 and 0.43 times less likely to support tax and utility credits than those who pointed out that it was too fast. Respondents were asked to describe whether they think the CBW's urban and suburban population growth level was too fast, too slow, and about right. Residents with advanced degrees were 1.91 and 2.39 times more likely to support tax and utility credits than residents with less than high school. For an additional year increase in age, non-agricultural residents were 1.01 and 1.02 times more likely to support tax and utility credits, respectively. The result also indicates that for a unit increase in income, non-agricultural residents are 0.87 times less likely to support utility credit. Females were also 0.66 times less likely to support tax credits than males.

Table 6. Binary logistic regression models showing the relationship of non-agricultural residents' support for tax credits for farmers to reduce farm runoff and utility credits for residents to minimize urban lawn runoff.

Variable	**Variable Categories**	**Tax credit odds ratio (SE)**	**Utility credit odds ratio (SE)**
Level of urban and suburban development	Too fast	(ref)	(ref)
	Too slow	**0.49 (0.13) ***	**0.43 (0.12) ****
	About right	0.71 (0.150)	0.92 (0.21)
Level of education	Less than high school		(ref)
	High school diploma/GED	0.90 (0.21)	1.26 (0.32)
	4-year college degree	1.54 (0.40)	1.39 (0.37)
	Advanced degree (Masters, PhD, professional degrees, etc.)	**1.91 (0.57) ***	**2.39 (0.73) ****
Gender	Male	(ref)	(ref)
	Female	**0.66 (0.13) ***	0.98 (0.20)
Household income	N/A	0.98 (0.04)	**0.87 (0.04) ****
Age	N/A	**1.01 (0.01) ****	**1.02 (0.01) ****
Model statistics			
Observations (n)		920	920
Hosmer-Lemeshow chi2		10.20	15.69
Hosmer-Lemeshow p-value		0.25	0.04

Notes: N/A = not applicable, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Discussion

This study explored both agricultural and non-agricultural residents' concerns about water quality issues, their perception of water quality issues, who they think is responsible for water quality issues, and their support for various policy tools to reduce urban lawn and farm runoff in their local streams and the CBW in general. Findings suggest farmers are less likely to recognize poor water quality in their local streams and the CBW than non-farming residents. Farmers are mostly blamed for poor water quality by non-farming residents (Busse et al. 2015; Berenguer et al. 2005; Paolisso and Maloney 2000; Perez 2015). Poor water quality could also trigger the government and policymakers to impose more regulations on farming activities. Therefore, to maintain a positive image of their activities, they might not want to acknowledge poor water quality because poor quality might result in more government regulation of farmers' activities. It is also evident that farmers prefer to avoid being regulated as they often consider themselves good stewards of the environment (Perez 2015; Paolisso and Maloney 2000). In contrast, because non-agricultural residents directly rely on local water sources for their daily house use, such as drinking and cooking and sometimes recreational activities, and how that can affect their health and wellbeing, they might be more likely to report or acknowledge poor water quality compared to agricultural residents.

The results also suggest that agricultural residents were more concerned about water quality than non-agricultural residents. This result was surprising because farmers were less likely to perceive poor water quality in their local streams and the CBW than non-agricultural residents. Yet, they were more concerned about water quality than their non-agricultural counterparts. Even though research has shown that farmers are less likely to admit that their activities cause water quality problems (Busse et al. 2015; Pease and Bosch 1994; Lichtenberg and Lessley 1992), their level of concern about water quality is promising regarding the reception of policy or intervention strategies to improve water quality. Church and Prokopy (2017) found that farmers do not want to be regulated; thus, to demonstrate they are doing the right thing, they sometimes voluntarily engage in conservation programs that improve water quality. Farmers are also concerned about the public perception of their activities; hence, acknowledging concern about water quality issues can be a proactive way to show their commitment to being stewards of the environment and improving their reputation within the community (Paolisso and Maloney 2000).

Findings also indicate that farmers perceive urban and suburban stormwater runoff and sewage treatment as significant sources of water quality problems in their local streams and the CBW while seeing themselves as lesser contributors. This result is also unsurprising, considering past studies have found that farmers are less likely to admit that water quality issues originate from their farm fields or local areas. (Busse et al. 2015; Pease and Bosch 1994; Lichtenberg and Lessley 1992). Farmers engage in farming to sustain their livelihood; hence, admitting their practices negatively harm the environment could be seen as a threat to their economic stability. Farmers are also concerned about the increased regulatory scrutiny (Beegle 2013), which can be one of the reasons why they are more likely to shift water quality problems to other sources than themselves. Farmers are also concerned about the public perceptions and stigma associated with their practices (Paolisso and Maloney 2000); therefore, admitting or acknowledging their negative impact can lead to condemnation from the public and environmental organizations.

On the other hand, non-agricultural residents view industrial pollution and agricultural activities as the primary contributors to water quality problems in their local streams and the CBW. One of the reasons why non-agricultural residents may see farmers contributing more to water quality problems can be due to where they receive information about water quality issues

(Paolisso and Maloney 2000). For example, suppose non-agricultural residents receive news about water quality issues that emphasize the negative impact of agricultural practices on water quality. In that case, it can result in the idea that farmers are the primary culprits (Perez 2015). For example, non-agricultural residents saw farmers as primarily responsible for the Pfiesteria incident in Maryland in 1997 (Paolisso and Maloney 2000). Non-agricultural residents' assumptions were correct because scientific studies suggested that nutrient pollution leading to the Pfiesteria case mainly originated from farm fields (Perez 2015). These results point to avenues for water quality improvement intervention where government, nongovernmental organizations, environmental organizations, and academic and research institutions can educate farmers and nonfarming residents about the accurate sources of water quality problems. Both residents' understanding of where water quality problems originate from can help design intervention programs that will be receptive by both residents. If farmers are concerned about poor water quality but do not think it is their fault, they will be less likely to support any meaningful intervention that targets them.

The results in Table 3 also show that non-agricultural residents exhibit a consistently higher level of support for all proposed strategies to control urban lawn runoff than agricultural residents. This difference is evident from regulations to voluntary initiatives and demonstrates the divide in perspective between farmers and nonfarming residents. These distinctions suggest that non-agricultural residents may perceive regulatory approaches and financial incentives as effective for controlling urban lawn runoff. The statistically significant difference observed indicates the importance of considering agricultural and non-agricultural residents' distinct preferences and priorities in formulating runoff control policies. Both farming and nonfarming residents were in agreement with support for utility credit policy tools or strategies to control urban lawn runoff in their respective areas. The consensus on utility credits as a preferred strategy highlights an opportunity for policymakers to leverage a common ground approach in addressing urban lawn runoff concerns.

The results in Table 4 also shed light on the divergent perceptions of policy tools to control farm runoff, which show significant variation observed between agricultural and non-agricultural residents. One outstanding result was the considerable support from agricultural and non-agricultural residents for encouraging farmers to adopt practices through credits from public funds. This finding points to a shared recognition of a potential water quality improvement intervention of financial incentives in promoting environmentally friendly practices but with more significant support from non-agricultural residents. Studies have also shown that financial incentives can motivate agricultural producers to engage in BMPs (Ranjan et al. 2019). Conversely, the policy requiring farmers to adopt practices with a tax on those producing the most runoff received significantly disparate support as non-agricultural residents overwhelmingly supported this approach compared to agricultural residents. The significant difference highlights a potential disconnect in how farmers and non-farming residents perceive the role of taxation as a regulatory tool in addressing farm runoff. Understanding the reasons behind this gap in support through qualitative research could provide valuable insights for policymakers.

Interestingly, when relying on farmers to reduce runoff without government involvement voluntarily, agricultural residents expressed more support than non-agricultural residents. The result could mean that nonfarming residents think farmers should do the right thing, and the government will not have to spend taxpayer dollars doing that. Farmers, on the other hand, may feel that they can self-regulate. However, the result highlights a potential area of common ground where both groups see voluntary efforts by farmers as a viable strategy, indicating an opportunity for collaborative initiatives without direct government intervention. This result also supports past studies that suggest that farmers see themselves as good stewards of the land and the environment in general and, hence, can self-regulate themselves (Church and Prokopy 2017; Paolisso and Maloney 2000; Beegle 2013). The survey question that asked about the possible implementation of a certification program allowing farmers to market their products as "CBW Friendly" also revealed a noticeable difference in support, with greater support from (3.97) nonagricultural residents compared to (3.12) of agricultural residents. This suggests that non-agricultural residents value market-driven approaches that link environmental responsibility to product branding. The lower support of certification programs from farmers could mean that farmers don't want to deal with certification, considering past studies have found that the process of certification (initial cost of certification, the cost of inspection, and the paperwork) discourages them (Veldstraa, Alexandra, and Marshall 2014). The least favored strategy by farmers and non-farming residents was using lawsuits to compel farmers to reduce runoff, which received minimal support overall.

Tables 5 and 6 also demonstrate how various socio-demographic and economic variables relate to agricultural and non-agricultural residents' support for utility and tax credits to control urban and farm runoff. Findings suggest that a higher level of education among agricultural producers is related to their support for utility credits to control urban lawn runoff. Education has always played a significant role in farmers' decision-making, especially in adopting BMPs meant to reduce farm runoff (Prokopy et al. 2019; Prokopy et al. 2008; Lambert et al. 2007). Farmers with higher education often have a better understanding of environmental issues, including the negative impact of agriculture practices on water quality. They may also be aware of the potential adverse effect of urban lawn runoff on local streams and the ecosystem, hence their support for the policy tool to reduce urban lawn runoff.

A higher level of education was also related to non-agricultural residents' support for the policy tool to reduce both farm and urban lawn runoff. As indicated earlier, higher education can lead to knowledge and awareness about the negative impact of runoff. Also, as age increases, non-agricultural residents tend to support utility and tax credit policy tools for reducing both farm and urban lawn runoff, which can also be explained by the fact that age comes with experience and knowledge. Hence, as people age, they tend to lean towards actions meant to improve the environment. As income increases, non-agricultural residents are less likely to support utility credits to control urban lawn runoff. Residents with higher incomes may be more concerned about the economic impact on their finances through tax increases. Residents who think urban and suburban development is slow might assume a lower risk of runoff problems. An assumption that slow growth can give a false idea can influence residents' support for tax and utility credits as a policy to reduce farm and urban lawn runoff. Findings also suggested that females were less likely to support tax credits than males. Still, it is essential to approach the discussion regarding gender differences in policy preference cautiously because individual perspectives are diverse and multifaceted.

The findings from the socio-demographic and economic variables and their association with the support for utility and tax credits can help tailor messaging and intervention programs to farmers and nonfarming residents in the CBW. Educational campaigns can be implemented through local schools, community colleges, universities, and public information sessions that emphasize the negative impacts of runoffs and the benefits of policy tools to mitigate them. Since both residents' support utility and tax credit policies to reduce urban lawn and farm runoff, these messages should be tailored to older demographics through community groups, senior centers, and local media channels. Residents' financial concerns can also be addressed by emphasizing the long-term economic benefits of improved water quality and environmental health. Gender differences should also be approached sensitively by acknowledging the diversity of perspectives in each gender and ensuring inclusivity in policy discussions.

Conclusion

Although past studies have outlined ways that addressing water quality issues can impact urban-agricultural relationships, this study provides insight into where there is convergence and disagreement on water quality issues and interventions. Some blame-shifting occurred between non-agricultural and agricultural residents, including perceptions of pollution sources and water quality perceptions between local water and the larger CBW. While these differences could signal different values and may point to impending disagreements toward water protection, focusing on concurrent values and perceptions could be a starting point for water quality improvement. For example, both residents were in high agreement to support utility and tax credits as a policy tool to reduce urban lawn and farm runoff. There were also some variations between farmers and nonfarming residents regarding strategies to control urban lawns and farm runoff, primary contributors to water quality issues, concerns, and perceptions regarding water quality in local streams and the CBW. The high agreement on utility and tax exhibited by both residents creates an opportunity for collaborative governance in addressing water quality concerns because it’s rooted in finding common ground for a problem.

Addressing water quality problems that span multiple jurisdictions and user interests, like the CBW, can utilize the collaborative watershed governance approach (CWGA). The CWGA convenes a multi-actor group that works together to resolve environmental problems at the watershed level. It has been promoted as a medium to address complex water management problems worldwide (Benson et al. 2013; Ansell and Gash 2007). Generally, collaborative efforts are preferable to command-and-control strategies for solving complex environmental issues with different stakeholder interests (Schlager and Blomquist 2008; Yoder 2020). The traditional top-down approach to implementing policies poses diverse challenges because of the high cost and politicization of regulation (Ansell and Gash 2007; Daniel 2019). However, problem-solving methods and approaches centered on collaboration and coordination are more adequate for understanding and addressing complex problems (Daniel 2019). The CWGA takes various forms but generally incorporates multiple stakeholders, including government agencies, local communities, non-governmental organizations, businesses, and other interested parties. Governance is not one person deciding but a group of individuals making decisions, usually involving communication and influence between agencies and stakeholders (Ansell and Gash 2007).

Surprisingly, farmers were least supportive of using a water resource planning process that includes many stakeholder groups, such as farmers, non-farmers, planners, and policymakers. However, broadening the participation of agricultural producers in collaborative management is vital in transforming policies and encouraging residents to engage in practices that reduce environmental pollution (Jackson-Smith et al. 2018; Armitage 2008). Eaton et al. (2022) believe that recognizing the contextual factors that encourage or hinder farmers' participation in collaborative environmental management in agricultural settings can help improve collaborative processes that address environmental problems. One of the reasons why farmers may be disinterested in collaborating with other stakeholders may be the fear of losing control over their farming practices. For example, Eaton et al. (2022) found that farmers in

Mifflin County, Pennsylvania, expressed having little influence on decision-making about water and agriculture issues, including regulatory processes. Farmers were also concerned that participating in conservation programs or university-sponsored research could bring new challenges and regulatory requirements. They also expressed how non-farmers usually did not understand farming and were concerned about interacting with nonfarming stakeholders as they believe non-farmers do not also have their interests at heart (Eaton et al. 2022). For example, farmers in Pennsylvania, Nebraska, and Arizona felt the public and public agencies misunderstood them as legitimate users of water resources, leading to their mistrust in collaborating with other stakeholders.

Even though this idea was ranked low among agricultural residents on strategies to reduce farm runoff, encouraging a sense of community, enhancing awareness, building trust, and demonstrating the tangible benefits of collaboration can help farmers to be receptive to this approach. The health of the watershed is a collaborative community effort, where actions taken by individuals and organizations with diverse land use priorities collectively impact the well-being of the entire system (Elzufon 2015). Therefore, exploring these stakeholders' perspectives can help craft targeted educational campaigns to improve the water quality and ecosystem services within the CBW. Eaton et al. (2022) suggested that stakeholders aiming to gather new collaboration efforts involving agricultural producers to address a problem should begin by investigating farmers' perceptions about collaboration with other stakeholders rather than assuming they are open to collaboration. Getting farmers on the same page with different stakeholders at the initial stage will be a step toward a successful collaboration.

The common ground regarding policies in this study signifies a potential area for collaborative policy development. At the same time, the divergences highlight the importance of considering local contexts and engaging stakeholders in formulating effective runoff control measures. One of the challenges of the CWGA is the absence of interdependent consequences. For example, upstream water users might not experience the negative effects of their actions that downstream users experience. This makes parties reluctant to collaborate to address the problem since they don't perceive any advantage (Yoder 2020). By embracing collaborative governance, agricultural and non-agricultural residents and organizations can work together to find sustainable and equitable solutions to water quality issues, balancing the needs of agriculture with those of the broader communities.

Certain demographic variables such as education, age, urban and suburban development level, income, and gender were found to shape residents' perspectives and support for runoff policy tools. Understanding these socio-demographic variables is vital for tailoring outreach and engagement strategies. Future research should focus on understanding the underlying reasons for the variations regarding water quality perceptions, concerns, critical contributors to water quality problems, and support or opposition to policy tools to control runoff. An understanding of the variation can be accomplished through a qualitative study, where researchers can conduct in-depth interviews and focus group discussions with different stakeholders within the CBW, which can inform the development of more effective and inclusive policies.

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CHAPTER 3

ADDRESSING URBAN-AGRICULTURAL TENSION IN THE CHESAPEAKE BAY WATERSHED: PERSPECTIVES ON CONCERNS AND REMEDIES

Abstract

Parts of the United States (U.S.) are experiencing changes in land use due to metropolitan expansion, leading to the conversion of farmland to housing, commercial development, and transportation. This phenomenon has increased interactions between farming and nonfarming residents, sometimes leading to tensions over nuisance and resident complaints. To understand the implications of this trend, I draw upon data collected from an online panel of 955 nonagricultural residents and a probability sample mail/online survey of 365 agricultural residents across the southern part of the Chesapeake Bay Watershed (CBW; Maryland, Virginia, and Delaware) in 2021 and 2022, respectively. Interviews were also conducted in Howard County, Maryland, in 2024, where key informants helped to understand tensions at the rural-urban interface better. Results indicate that CBW nonfarming residents were primarily concerned about exposure to chemicals/pesticides. At the same time, farmers were worried about new residents' legal actions against them due to the nuisance generated by their activities. The findings indicate that addressing the concerns requires multifaceted strategies focused on education, communication, and policy development. Efforts to integrate agricultural education into school curricula, organize farm tours and farmers' markets, and foster better relationships between farmers, nonfarming residents, and elected officials can help reduce tensions or conflict at the rural-urban interface and promote more sustainable and resilient communities in CBW.

Introduction

Parts of the United States (U.S.) are experiencing changes in land use due to metropolitan expansion, leading to the conversion of farmland to housing, commercial development, and transportation infrastructure (Bradshaw and Muller 1998; Lockeret 1989; Sleeter et al. 2013; Xie et al. 2023). The American Farmland Trust found that approximately four million acres of farmlands were transformed into highly developed urban land use between 2001 and 2016 (Xie et al. 2023). Xie et al. (2023) also suggest that if urban development continues at the current rate, 18 million acres of agricultural land will be lost by 2040, with the highest along the East Coast. Jantz, Goetz, and Jantz (2005) also found that there was a 61% increase in developed land in the Chesapeake Bay Watershed (CBW) from 1990 to 2000, and most of this new development, 64%, occurred on agricultural and grassland. Alig, Kline, and Lichtenstein (2004) argued that increased population density and growing personal income are some drivers of farmland being converted to urban development. The rising development (i.e., residential housing, commercial and industrial projects, transportation infrastructure, etc.) in the CBW is a significant cause of agricultural land being converted into developed land use due to the pressure and high demand for residential development (Claggett et al.2023; Claggett et al. 2004). One of the reasons why developers target farmlands is because of good characteristics, such as flat land, that are very attractive for residential development.

The development of farmland into housing, commercial development, and transportation infrastructure is expected to increase as the population in the U.S. and the CBW keeps growing. By 2050, the U.S. population will likely rise to 403 million, exacerbating the loss of farmland. Currently, the population in the CBW is 18.5 million, and it is expected to grow by 3.5 million between 2025 and 2055 (Bhatt et al. 2023). The projection of population increase suggests that unless the density of development patterns shifts, interactions between farmers and nonfarming residents in previously rural or agricultural areas will continue to increase. Population growth and demand for housing are presenting new challenges - nuisance complaints by nonfarming residents and trespassing complaints by farmers at the rural-urban interface in the U.S., which sometimes lead to conflicts or tensions (Vaserstein and Kelsey 2000; Sullivan et al. 2004).

For agriculture to thrive in an increasingly urbanizing landscape like the CBW, some of these problems must be addressed, including considering the concerns of farmers and nonfarming residents. Some recent studies have examined the conflict or tension between farmers and nonfarming residents. However, they focus on disagreements regarding water quality issues and how policy choice concerning water quality issues impacts urban-agricultural relationships (Armstrong 2019; Armstrong 2022; Church et al. 2020; Yoder, Church, and Wagner 2024). However, there has not been recent research on the broader concerns and conflict between farmers and nonfarming residents due to their increasing proximity leading to problems such as odor, chemical use, theft, vandalism of property, trespassing, etc., in the CBW region. In addition, most of the research was conducted nearly two decades ago (Vaserstein and Kelsey 2000). Therefore, there is the need for current research in the region regarding the problems associated with farmers being closer to nonfarming residents.

To address this gap in research, this study assesses the concerns of farmers and nonfarming residents with their increasing proximity to each other to understand what shared values exist at the rural-urban interface. This study uses data from 2021 and 2022 surveys of nonfarming residents and farmers from the southern part of the CBW (Maryland, Virginia, and Delaware), respectively. Data from key informant interviews conducted in 2024 in Howard County, Maryland, is also used to supplement the survey data to provide a more nuanced and comprehensive understanding of tensions that can arise and how best to address them. Based on the goals and objectives of this study, the following research questions were developed.

1. What are the primary concerns of farmers and nonfarming residents in the CBW associated with the growing proximity of farming to residential or urban areas?
2. What are the primary sources of tension between farmers and nonfarming residents in the CBW?
3. What do residents see as potential solutions to the tensions, and how can they be implemented?

Tensions Between Farmers and Nonfarming Residents

The rural-urban fringe and suburbanization of traditional agricultural areas have brought farmers into closer proximity with nonfarming residents, sometimes leading to a source of tension or conflict between farmers and their new neighbors (Vaserstain and Kelsy 2000; Sullivan et al. 2004; Lopez et al. 1988). When farmlands are sold for development projects, tensions can arise when new residents experience nuisance and other environmental problems associated with agricultural production. New neighbors sometimes do not understand why farmers engage in certain practices, and farmers also do not understand why their neighbors complain about their farming activities, which they see as normal activities when it comes to farming (Vaserstain and Kelsy 2000).

Expanding urban areas where farmland is consumed by nonfarming development, bringing farmers close to residents who do not farm, has resulted in conflicts or tensions in various documented ways from both farmer and nonfarmer perspectives. Lopez et al. (1988) conducted a study in New Jersey and found that farmers were concerned about four main kinds of local-level land-use conflicts: nuisance issues, municipal ordinances, trespassing, and vandalism. Nuisance issues include noise, odor, and dust, while municipal issues involve roadside marketing, livestock, and other zoning ordinances. Vandalism and trespassing are due to simple theft and damage to agricultural machinery (Lopez et al. 1988). Kelsey et al. (2000) conducted a study to understand neighbors' perceptions regarding animal agriculture in five rural townships in Lancaster County in Pennsylvania. They found that 57% of neighbors were concerned about odor-related problems. Vaserstein and Kelsey (2000) also conducted a study in Chester County, Pennsylvania, finding that one of the reasons for conflict between farmers and their nonfarming residents was cultural differences between farmers and laborers who are usually from Mexico (Vaserstein and Kelsey 2000). Other causes of conflicts were complaints about allergies from dust and odor from compost. The size of a farm also plays a role in the level of complaints of residents. For example, Kelsey and Singletary (1996) found that larger farms were more likely to receive complaints about compost.

Conflict also can arise from competition for resources, as there can be differences in the purpose and value of farmland between urban dwellers and farmers (Handel 1998). Urban dwellers might regard farmland as a land bank where city officials can encroach when the demand for housing increases (Handel 1998). However, farmlands are perceived because they are also preserved for open space and the aesthetic views they provide residents (Brinkley 2012; Sullivan et al. 2004). For example, residents in Lancaster County, Pennsylvania, perceived livestock farms as necessary because they ensure the community's economic wellbeing (Kelsey et al. 2000). They also saw livestock farms as adding aesthetic and amenity values to their community. Conflicts can also arise due to nuisance generated by farming activities from the residents' perspectives, and complaints made against farmers by residents irritate farmers as they do not understand why their neighbors complain (Janni 2020; Kolbe 2013). The movement of people into rural and semi-rural areas often leads to circumstances where new residents may persuade local authorities to impose restrictions on farming activities such as limiting pesticide use, spraying of pesticides and herbicides, movement of machinery, or spreading of manure, which can reduce efficiency and increase farmers' cost of production (Lockeretz 1989). Residents demand restrictions sometimes due to the medical problems they experience from farming activities. For example, Hoppin et al. (2017) found that residents' exposure to pesticides led to various allergic reactions that had a negative impact on their health. From the farmers' perspective, they didn’t like the intrusion of urban residents, which led to the demand for unique management practices that increased their costs and labor and reduced productivity (Handel 1998). The goal of many farmers is to minimize their operational costs and increase their profit; hence, instances where complaints made by residents make them spend more usually frustrate them.

Handel (1998) believes firm boundaries should be established by planting buffers to separate urban and agricultural land uses to reduce conflicts between farmers and urban residents. Also, urban dwellers should be educated to increase their knowledge regarding why farmers engage in certain farm management practices (Handel 1998). When residents know they are moving closer to a farm and know what farming entails and some of the problems associated with living close to a farm, they will be less concerned about nuisances from farming activities. For example, residents who were aware of the mushroom farms before moving to Chester County, Pennsylvania, had significantly lower concerns about the farming activities in the area than those who were unaware of the mushroom farms (Vaserstein and Kelsey 2000). Many factors lead to people wanting to relocate and live in rural and semi-rural areas, including lower population in the destination place, lower prices of land, lower property taxes, and the beauty of the natural environment associated with rural areas (Sullivan et al. 2004). Others also prefer to live in rural areas because of the peaceful nature of rural life, but their dream of having a peaceful life does not always materialize.

While farmers may face various complaints and sometimes legal action from residents due to the pollution and other environmental problems generated by farming activities, some state governments have put laws in place to protect the interests of farmers. One example of such laws initiated by the government is right-to-farm laws to protect farmers from nuisance lawsuits and mitigate the conflict between farmers and nonfarming residents (Kelsey and Singletary 1996; Lopez et al. 1988). Right-to-farm laws seek to supersede the common nuisance law and promote and protect agricultural land use (Lopez et al. 1988). Such laws protect farmers based on the idea that if farming activities constitute a nuisance, it is only because there has been a land-use change that brings other residents who are not farmers or know nothing about farming close to farmers (Vasertein and Kelsey 2000). Therefore, neighbors are responsible for any nuisance on their property. Right-to-farm laws can also create the impression that the government supports farmers to the detriment of nonfarming residents when complaints are made, sometimes exacerbating the tension. For example, most Chester County, Pennsylvania residents believed the local government supported farmers (Vaserstein and Kelsey, 2000). However, even though right-to-farm laws generally protect farmers from complaints, it does not protect farmers from the stress and legal expenses they go through (Vasertein and Kelsey 2000; Kelsey and Singletary 1996). Urbanization significantly affects agriculture regarding land regulatory effects, which hurts agriculture, but the right-to-farm laws can help remedy some of the adverse effects (Ashwood et al. 2023; Lopez et al. 1988).

This study builds on existing literature concerning the tensions or conflict between farmers and nonfarming residents at the rural-urban interface by assessing what shared concerns exist and how those concerns can lead to disputes in the CBW. This research uses a mixed-method approach, where a quantitative analysis was conducted first to provide a broader picture of the problems from farming and nonfarming resident perspectives. Key informant interviews were also conducted to understand better the tensions or conflicts and the different pathways to address the issue so farmers and nonfarming residents can live harmoniously.

Materials and Methods

Data for this study is from two surveys of residents, one agricultural and the other nonagricultural, in the southern part of the CBW (Maryland, Delaware, and Virginia). Key informant interviews were also conducted in Howard County, Maryland, to get a deeper understanding, insights, and experience of farmers and nonfarming residents regarding their concerns and problems likely to occur with their proximity to one another and how best to address both residents' concerns. The survey asked both residents their level of concern regarding some of the problems associated with the proximity of farming operations to residential or urban areas. Both surveys also asked about residents' levels of awareness concerning the loss of agricultural land in the CBW to development (for example, residential housing, commercial businesses), their perception of the level of urban and suburban population growth in the CBW, how they feel about farmland being converted to developed land, and their concern about the loss of farmland in the CBW.

CBW Resident Survey

From May to July 2021, an online survey of residents of the CBW was conducted. Qualtrics recruited respondents through an online panel and were modestly compensated for their participation by Qualtrics. The CBW intersects with six states: New York, Pennsylvania, Delaware, Virginia, West Virginia, and the District of Columbia. Respondents were selected from counties in each state that overlap with the CBW. However, this study focuses on responses from the southern part of the CBW (Maryland, Delaware, and Virginia), given where most of the agricultural sample resides. Overall, 766 (80.21%), 134 (14.03%), and 55 (5.76%) of responses were from Maryland, Delaware, and Virginia, respectively. Because the survey used non-probability sampling methods, we created rake weights using age, gender, level of education, and race estimates from the American Community Survey (2015-2019) at the county level to generate more representative estimates. Rake weights were applied in this case because they helped the sample distribution to align with the population on the specified variables (Omisakin et al. 2023; Mercer 2018).

CBW Farmer Survey

From March to June 2022, an online and mail survey of agricultural producers was conducted in the CBW, primarily in the southern half (Maryland, Delaware, and Virginia). The survey targeted crop producers (corn and soybeans), livestock producers (beef and dairy), and farmers who produce crops and livestock, but not hobby farmers or those with livestock only. The sample included information on 2,403 producers (name, address, planted acres, gross financial income, and crops and/or animals produced). It was purchased from DTN, a company that provides contact information for agricultural producers in the U.S. A recent publication assessing the quality of sample sources for survey research with agricultural producers in the U.S. suggests that private vendors are useful sampling sources because of their ability to provide generalizable samples and the option to conduct non-response bias tests with the background data provided (Ulrich-Schad et al. 2022). Producers with 50+ acres of operated land within the

CBW were selected using simple random sampling. To get an accurate sampling frame of agricultural producers within the CBW, DTN was provided with a list of counties and zip codes overlapping with the CBW. The completed sample included 1,326 (55.18%) producers from Maryland, 393 (16.35%) from Delaware, 663 (27.59%) from Virginia, 14 (0.58%) from Pennsylvania, 3 (0.12%) from West Virginia, 3 (0.12%) from District of Columbia and 1 (0.04%) from New York. According to DTN, due to the parameters I required by location and size of farm (50+ acres) for the sample, there were fewer producers in general from the states of New York, Pennsylvania, and West Virginia, and the District of Colombia accounting for the low sample size in these four states. Given DTN's limitation in the sample they could provide, the analysis is focused on the three states clustered in the south of the watershed and with the most responses (Maryland, Delaware, and Virginia).

Producers were contacted up to four times using a modified tailored design approach (Dillman et al. 2014). The advance letter contained information and an explanation of the purpose of the overarching research project. It was also mentioned that their thoughts or insights about water quality issues and how they managed their farmlands will help the research team plan for a thriving future of agriculture in the CBW, ensuring that producers remain in business. The advance letter also contained a link to an online survey so that producers who wanted to take the survey immediately online could do so. The second contact was a mail survey with a stamped return envelope for those who did not respond to the first wave. The third wave was a postcard reminder for producers who did not respond to both the first and the second wave. The last contact was another mail survey with a stamped return envelope to farmers who did not respond to previous waves. The process of multiple contacts and incentives has proven to increase the response rate in survey research, specifically among agricultural producers (Avemegah et al.

2021). Producers were asked to indicate their farming status (e.g., rent out the land or no longer farming) and whether they live in the CBW in the mail and online surveys. Producers not currently farming or retired were asked to stop the survey and indicate so for our records. Overall, the multiple contact process achieved a response rate of 16.2% after 371 questionnaires were completed and returned (online = 145 and mail = 226) and after bad mailing addresses and those not currently farming were removed (N = 118).

Key Informant Interviews

Nine key informant interviews were also conducted in Howard County, Maryland, to supplement the survey data. Key informants include farmers and residents with formal or informal leadership roles in Howard County. Howard County was chosen for the interviews because there have been reports on official government pages, such as the University of Maryland, about challenges and tensions at the urban-ag interface in the area. Moreover, a key informant in the area from the Thriving Agriculture in Urbanized Landscapes project stakeholder advisory board (https://thrivingag.org/) served as a connection to the area. The county is also known for its agricultural industry and has a significant farming community comprised of crops and livestock. The county also offers a mix of urban and rural areas with diverse populations beyond farming, making it a convenient and suitable location for conducting interviews.

Some key informants were identified by their past or current role in Howard County, who were believed to have some insights and knowledge about relationships between farmers and nonfarming residents. Of the nine key informants, three were nonfarming residents who worked with the government in Howard County, and six were farmers who had previously held agricultural-related positions and were currently residing in Howard County at the time of the interview. An email was sent to each potential interviewee describing the goal and purpose of the study and how their experiences and thoughts on land use change, agriculture, and the conflict among residents would help ensure that agriculture is environmentally sustainable and economically viable in an increasingly urbanized region like the CBW. Respondents were given a chance to write back, indicating whether they were interested in participating in the study so that an interview could be scheduled. Respondents were also assured that all identifying information would be kept confidential in publications or presentations. The email also indicated that the interview would take approximately 45 minutes, and respondents were allowed to choose an in-person interview or Zoom. All nine respondents agreed to be interviewed on Zoom, which was recorded and transcribed for thematic coding and analysis. Six key informants were given a $50 Amazon gift card each as a token of appreciation for their time and insights, while the remaining three declined the gift card because they could not receive them as government workers.

Measures

Survey measures

Residents' level of concern about the problems associated with the proximity of farming operations to residential or urban areas was measured using a four-point Likert scale (1 = Not at all concerned, 2= Somewhat concerned, 3 = Concerned, and 4 = Very concerned). A literature review was conducted to understand the various problems farmers and nonfarming residents are likely concerned about with their increasing proximity. The concerns examined in the farmers' survey included litter by residents, trespassing (e.g., pets entering the field), restrictions regarding farming activities, loss of rural life, legal action by new residents, vandalism of property by new residents, and theft. Concerns examined from the nonfarming residents' survey included water pollution, odor or smells of livestock, nutrient run-off from applying fertilizers to fields, exposures to chemicals or pesticides, allergies, noise from machines, the slow movement of farm equipment on the road blocking traffic, and dust generated from mowing and harvesting. Both residents' level of awareness about the loss of agricultural land in the CBW to development, their perception of urban and suburban population growth, how they feel about farmlands being converted to developed land, and their concern about the loss of farmlands in the CBW were also measured. The level of awareness about the loss of agricultural land was also measured using a 4-point Likert scale.

Interview measures

A semi-structured interview guide was used with key informants in Howard County. Questions were written to understand how respondents think residents of Howard County view farming, what they believe is the relationship between nonfarming residents and agricultural residents or agriculture, how they have seen farming change over the last 10 years, how they feel about the growing population, and whether they have noticed if there has been a loss of farmland and their thoughts about the changes. Interview questions also asked whether the changes in population or land use have led to any sources of tension or conflict, whether there have been any successful approaches to mitigating the conflict, what role they think the local government, community organizations, farmers, or individual residents can play in addressing the conflict, and what they believe is the best path forward to address conflict and promote sustainable agriculture and community development in Howard County and the CBW as a whole.

Data Analysis

The statistical software Stata version 16 (Stata Corp LLC, College Station, Texas) was employed to analyze the survey data. Basic descriptive statistics on variables of interest were run to show the percentages, mean, and standard deviation for agricultural and nonagricultural residents. A chi-square test was also employed to understand the relationship between various socioeconomic and demographic variables and the top concerns of residents and nonfarming residents indicated (i.e., legal action by new residents from the farmers' survey and exposure to chemicals and pesticides from the residents' survey). Key informant interviews were transcribed and analyzed using Atlas.ti, a software used for analyzing qualitative data. Interviews were coded (thematic coding) by the researcher, and major themes were identified that helped understand the tensions or conflict in Howard County and answer the research questions.

Results

Table 1 below shows demographics, respondent location characteristics, and their perceptions of land use change within the CBW from each survey. The highest percentage of farmers (33.93%) indicated that less than high school is their highest level of education. In comparison, the highest rate of nonfarming residents (30.47%) indicated that their highest level of education is high school. Most farmer respondents were male (89.05%), which is common in surveys targeting operations and the person in them who makes most decisions, while most resident respondents were female (64.26%). Most responses from farmers (60.55%) and residents (79.93%) were from Maryland. The average age of farmers and general residents in the southern part of the CBW was 69.37 and 47.65 years, respectively.

Regarding residents' views of urban and suburban development levels in the CBW, most farmers indicated the level of development was too fast (85.67%), compared to 54.14% of nonfarming residents. Most farmers were also aware of the loss of agricultural land (73.54%) compared to 23.98% of nonfarming residents. Concerning their awareness of the loss of agricultural land in the CBW, 12.25% of nonfarming residents indicated they weren’t aware of this phenomenon compared to 2.5% of farmers. Regarding concern about the loss of farmland, 77.99% of farmers indicated they were extremely and very concerned about the loss of farmland, while 54.66% of nonfarming residents indicated so. Most farmers (91.90%) and nonfarming residents (72.46%) also indicated they feel strongly that there is too much or probably too much farmland being converted to developed land.

Table 1. Summary and descriptive statistics of demographic variables of agricultural and nonagricultural survey respondents

Variable Measure	Descriptive Statistics			
	Farmers		Residents	
	N	Percentage	N	Percentage
Level of education	336		955	
Less than high school	114	33.93	215	22.51
High school diploma/GED	94	27.98	291	30.47
4-year college degree	79	23.51	275	28.80
Advanced degree (Masters, PhD, professional degrees, etc.)	49	14.58	174	18.22
Gender	338		944	
Male	301	89.05	336	35.59
Female	37	10.95	608	64.41
State	365		955	
Maryland	221	60.55	756	79.93
Delaware	47	12.88	140	14.78
Virginia	97	26.58	51	5.38
Level of urban and suburban development	356		955	
Too fast	305	85.67	517	54.14
Too slow	4	1.12	130	13.61
About right	47	13.20	308	32.25
Level of awareness about the loss of agricultural land	359		955	
Not at all aware	6	1.67	172	18.01
Somewhat aware	80	22.28	437	45.76
Very aware	264	73.54	229	23.98
I don’t know	9	2.51	117	12.25
Concerned with the loss of farmland in the CBW	359		955	
Not at all concerned	12	3.34	46	4.82
Somewhat concerned	67	18.66	387	40.52
Very concerned	164	45.68	325	34.03
Extremely concerned	116	32.31	197	20.63

Feelings about farmland being converted to developed land	358						955	
I feel strongly that there is too much farmland is being converted into developed land	240		67.04		357		37.38	
I feel that there is probably too much farmland being converted to developed land	89		24.86		335		35.08	
I feel that there is the right amount of farmland being converted to developed land	20		5.59		95		9.95	
I feel that there is probably too little farmland being converted to developed land	1		0.28		43		4.50	
I feel strongly that there is too little farmland being converted to developed land	3		0.84		22		2.30	
I don't know	5		1.40		103		10.79	
	Range	N	Mean	SD	Range	N	Mean	SD
Age	25 – 94	284	69.37	11.96	18 - 88	955	47.65	18.26

Figure 1 shows farmers' concerns with their proximity to nonfarming residents. The bars of the figure are arranged to indicate at the top what farmers are concerned about most and the least at the bottom. Most farmers were concerned about legal action by residents, as 86.40% of farmers indicated they were concerned and extremely concerned about that problem. The second most concerning issue farmers indicated was restrictions they sometimes experience regarding their farming activities living close to nonfarming residents, of which 85.95% of farmers indicated they were concerned and extremely concerned. The loss of rural life was the third issue of greatest concern, followed by thefts, vandalism of properties, and litter by new residents. Trespassing, for example, pets entering the farm field, concerned farmers the least.

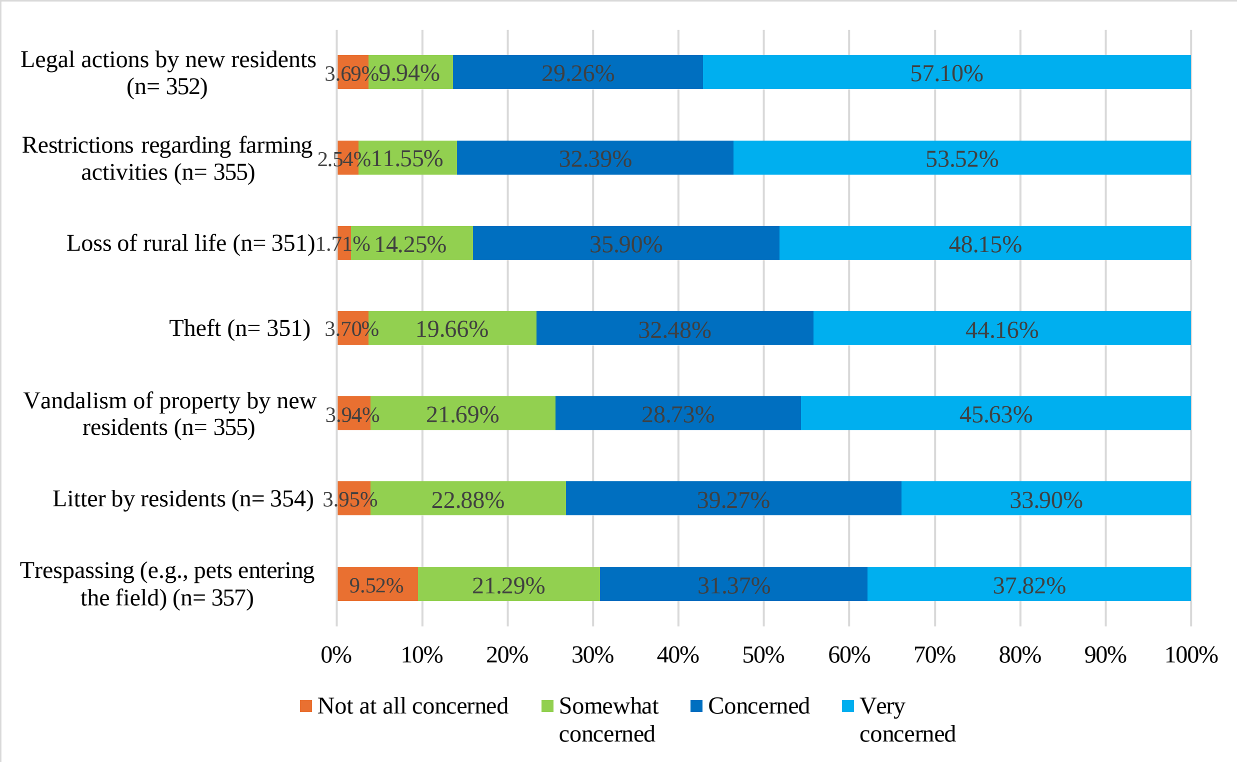

Figure 1. Farmers' level of concern about problems associated with living close to nonfarming residents.

Figure 2 below shows concerns that nonfarming residents expressed about their proximity to farmers. Residents indicated that they were primarily concerned about exposure to chemicals, as 80.63% indicated they were very concerned and concerned about exposure to chemicals. Water pollution (74.66%) was the second most concerning problem, followed by nutrient runoff from farm fields (74.55%). Other concerns nonfarming residents indicated were allergies, odor/smells of livestock, dust from mowing and harvesting, and slow movement of farm equipment.

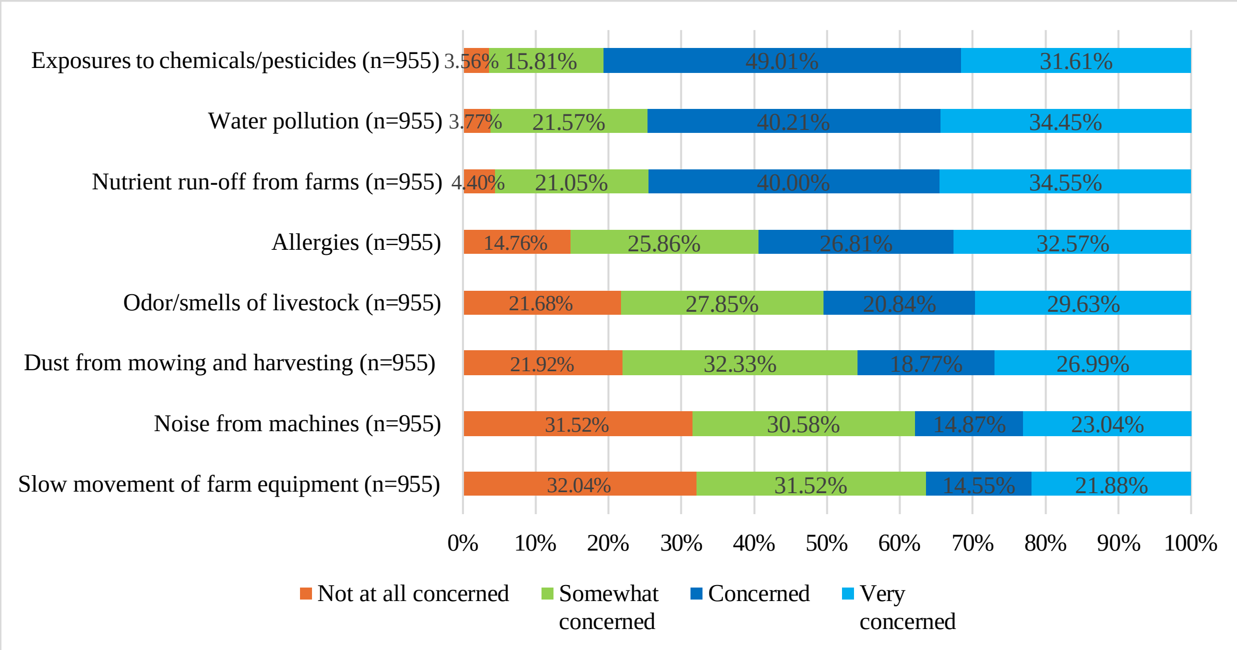

Figure 2. Residents' level of concern about problems associated with living close to a farm.

Table 2 shows the chi-square test results of nonfarming residents' level of education, political ideology, and gender and how they are associated with residents' concerns regarding exposure to chemicals and pesticides with being close to farming. The results indicate that nonfarming residents with higher levels of education, thus those with four years of college or an advanced degree, are significantly more likely to be concerned (concerned and very concerned) about exposure to chemicals than those who indicated to have some college or technical school level of education and high school or less. Nonfarming residents who also indicated liberal as their political ideology were significantly more likely to be concerned about exposure to chemicals compared to those who showed themselves to be conservative and those who didn’t lean to either side. The results also suggest that females were significantly more likely to be concerned about exposure to chemicals or pesticides than males with their proximity to a farm.

Table 2. Relationship between exposure to chemicals and pesticides concerns among nonfarming residents and socio-demographic variables

	Not at all concerned	Somewhat concerned	Concerned	Very concerned	Total	X^2 value	P-value
Level of education							
High school or less	6.05	20.93	43.72	29.30	100.00	18.72	0.028
Some college/technical school (n = 955)	3.09	16.84	51.55	28.52	100.00		
4- year college degree	3.27	10.91	52.00	33.82	100.00		
Advanced degree	1.72	15.52	46.55	36.21	100.00		
Political Ideology (n = 887)							
Liberal	1.34	12.57	53.74	32.35	100.00	19.19	0.004
Conservative	6.14	18.77	43.34	31.74	100.00		
Don't lean to either side	3.18	15.00	50.91	30.91	100.00		
Gender (n = 944)							
Male	3.27	16.96	41.96	37.80	100	11.53	0.009
Female	3.78	15.46	52.47	28.29	100		

Table 3 displays chi-square test results of agricultural residents' level of education, whether they own livestock, and whether row crops, small grains, hay and forage, livestock and no one source makes up more than 50% of their farm income in 2021 and how they are associated with farmers' level of concern regarding legal action against them by nonfarming residents. The results indicate that farmers with high school or less and those who indicated to have some college or technical school were significantly more likely to be concerned (concerned and very concerned) about legal action compared to those who indicated having a 4-year college or advanced degree. Farmers who indicated they owned livestock were significantly less likely to be concerned about legal action than those who stated no livestock. Farmers who also indicated to have grown row crops as other sources of income were more likely to be concerned about legal action against them by nonfarming residents compared to those who indicated to have cultivated small grains, hay and forage, livestock, and have more than one source of income.

Table 3. Relationship between legal action concerns among farmers and socio-demographic variables.

	Not at all concerned	Somewhat concerned	Concerned	Very concerned	Total	X^2 value	P-value
Level of education (n = 329)							
High school or less	0.91	6.36	33.64	59.09	100.00		
Some college/technical school	2.15	7.53	23.66	66.67	100.00	24.89	0.003
4- year college degree	2.56	11.54	35.90	50.00	100.00		
Advanced degree	12.24	16.33	26.53	44.90	100.00		
Own a livestock (n = 328)							
Yes	2.56	16.03	25.00	56.41	100.00	15.19	0.002
No	3.45	4.02	35.06	57.47	100.00		
Other sources of farm income (n = 321)							
Row crops	1.70	5.11	30.11	63.07	100.00		
Small grains	11.54	11.54	23.08	53.85	100.00		
Hay and forage	6.25	6.25	50.00	37.50	100.00	26.16	0.010
Livestock	3.23	20.97	25.81	50.00	100.00		
No one source	2.33	13.95	27.91	55.81	100.00		

Howard County, Maryland: A deeper dive into tensions between farmers and nonfarming residents in an urbanizing area

Howard County is in Maryland, between Washington, D.C., and Baltimore, experiencing rapid suburban growth. One of the interviewees stated, "*It's a place that everybody knew everybody back in the day, and now, with the influx of development, it's like you hardly know anybody anymore*." From a geographical standpoint, Howard County is split into the western and the eastern sides. According to one of the key informants interviewed, the county's western side is more rural, and you would probably never realize that you're in a metropolitan area if you lived in the west. The bulk of farming is in the west, and most agricultural lands are also preserved in the west, but it is increasingly becoming a home for housing development. For example, one key informant said, "*There probably will not be nearly as much farmland out in the western part of the county as there currently is*." The eastern part of Howard County is more urban and has extensive housing and minimal agriculture activities. To most interviewees, Howard County is generally more urban than rural due to rapid growth caused by population increases and the demand for housing, especially in the eastern and some places in the western part of the county.

Regarding how farming has changed in Howard County over the last ten years, most key informants interviewed indicated the significant problems are the population growth and the number of housing developments in the County. The loss of agricultural land to development was one of the major themes of the interviews. Some of the key informants interviewed indicated that because Howard County is close to significant urban areas such as Washington D.C. and Baltimore, a lot of urban sprawls are happening, leading to large parcels of farmland being sold off for housing development; for example, an interviewee said, "*They quit growing crops and put houses on them. I always say developing a home was more profitable than growing a crop."* The economics of agriculture is one of the driving forces behind many people's disinterest in farming as a full-time occupation because it is difficult to make money from agriculture, which discourages many people from engaging in it, especially the younger population. For example, someone said, "*The economics of farming are so challenging, so whether the kids love to farm or not, if they can't make money doing it, they will find it difficult to live.*" Other interviewees also indicated that they've heard people selling their property to developers, creating the impression that farming in this context is challenging. According to some of the key informants, farming alone has never been profitable unless you add value or find additional sources of income to help pay the bills. According to most key informants interviewed, the changes in population growth, the loss of farmland, and the demand for housing in Howard County have led to tension or conflict among farmers and their nonfarming neighbors. For example, someone said, "*Our first conflict with neighbors came when the first housing development was built adjacent to our farm.*

The neighbors were concerned about chemical use, large equipment, and the associated noise and dust."

Views on farming in Howard County

Regarding how key informants think people in Howard County view farming or agriculture in general, the central theme was that most people are removed from farming and lack an understanding of what it entails. Some key informants indicated this was particularly the case for residents of the eastern part of the county. However, the residents in the West tend to have more understanding of what farming involves. Some of the interviewees indicated that farming was highly respected in the past. However, the general population of Howard County does not think about how their food is produced, where it comes from, or how important it is for them to survive. For example, one key informant said, "*Most of our neighbors are not familiar with or have a proper understanding of where their food comes from or how it's produced."* Key informants indicated that most people generally have no idea about what farming entails, and they like the idea of farming but don't want to be close to it. For example, one of the interviewees said, *"I think they are clueless." "I think, in general, people are probably for farming as long as it's not near them. Yeah, they love farming, but they just don't want it closer to them." "They say they don't want the noise. They don't like the smell. They don't like traffic. But all those things go hand in hand with farming*." The major themes from the interviews point to how people have negative views about conventional farming systems, which are associated with intensive use of chemicals, big machines and cars blocking traffic, odor or the smell from manure or compost, and noise from machines. Some of the farmers interviewed believed that not everyone has a wrong perception of farming. For example, one key informant said, "*In the east, most people are pro-farming because they don't live with or close to it.*" Therefore, so long as people do not live close to farming and experience some of the nuisance generated by farming, they are okay with it.

The relationship between farmers and their nonfarming neighbors can be contentious because of the perception of farming and some of the nuisance generated by agriculture. Most interviewees indicated that the relationship between farmers and nonfarming residents in Howard County is hostile. For example, a farmer said, "*I don't think we have a great relationship with our neighbors, which is sad and disappointing. We've tried to do some things on our property that the neighbors have objected to, and it's created strife between the two and a kind of conflict between us because they, again, don't understand*." Nonfarming residents who live near a farm may have valid concerns about certain practices, such as exposure to chemicals. For example, statements like "*they're trying to kill us with those chemicals.*" Studies have shown that exposure to chemicals can lead to people developing allergies and cancer (Hoppin et al. 2017; Pathak et al. 2022). Some of these valid or unknown concerns, and others can trigger complaints against farmers. For example, a farmer was reported for cutting down trees on his property, which was appropriate and legal. "*My neighbor reported me for cutting down all these trees. And when the forestry guy came out, I told him, and he's like, yeah, you're right. Cut them, burn them up in your fireplace, and get rid of them. But I still got reported. My neighbors reported me to the Department of Forestry every six months because I had cut down those trees. What they'll do is call and report you. So, they'll call the police and say, like, cows, sheep, horses, they like to lay down sometimes. And if they lay down in the pasture, and they're taking a nap, to someone who's inexperienced or isn't paying attention, they'll drive by, call the police, and say they've seen a dead cow in the field.*"

Farmers are also not happy with how residents' trespass on their property. They view it as an invasion of privacy. According to one of the key informants, residents sometimes walk, jog, and walk their dogs on farmer's property. Sometimes, residents argue that the land is an open space preserved with the county's money; hence, they feel entitled to it. However, to the farmers, this is their private property and should be respected, and residents should not regard it as a park because they own the land and pay mortgage and taxes on it. For example, a farmer indicated drones had been flown around his property and to him, thus an invasion of privacy.

Pathways to ease tensions between farmers and nonfarming residents

Key informants were also asked what approaches might help mitigate the tensions between farmers and their nonfarming neighbors. Several suggestions were made, including farmers developing good relationships with elected officials and people in power and organizing farm tours for the communities so people know what goes into farming. Some of the farmers interviewed indicated they need a strong voice at the county and state levels to support farmers. They believed that if those who made the laws understood what farming entails and supported them, they could keep making favorable laws and policies to help keep farmers in business. Education was also one of the major themes of the interviews. Most farmers believe fewer complaints will occur once the public understands certain practices, such as the smell from the spread of manure, and that it is a limited-time event. For example, a farmer said. "*The short answer and the simple answer is education. And I think, and maybe it's outreach and education. I think the more that we talk to people and show them what we're doing, how we're doing it, why we're doing it, the more, and on the one hand, I feel we shouldn't always have to defend ourselves.*" Others also believe that development in the west, where most farmers reside, should be reduced, which the county's planning and zoning department has advocated for.

Most farmers interviewed indicated that the public is usually misinformed about agricultural activities. Because most nonfarming residents perceive farming negatively and have hostile relationships with farmers, some farmers may feel reluctant to educate them about what they do. For example, a farmer said, "*I would welcome inviting neighbors to our farm if they could have a positive viewpoint. But I feel like some of our experiences with neighbors have been so negative that I don't want that interaction. It is sad because I want to promote and educate people about agriculture and farming, how food is produced, and where it comes from."* Even when farmers organize farm tours to educate the public, there are instances where people will sign up for a farm tour not to learn but to look for evidence against the farmer. Some farmers indicated that they let people sign up to have the list ahead of time and probably know who is coming and whether they are there to learn or look for evidence that they are doing something illegal. A farmer also indicated that people yelled at him during several events when he attempted to educate the public about agriculture. For example, "*A lady came over to me and started yelling at me about how the farmers were spraying these chemicals right next to the elementary school, and it was going to kill all the kids*."

Most of the key informants interviewed believed that fostering understanding through communication and education would be a good strategy for getting on the same page with their neighbors. They emphasized that tension or conflict will be lessened if they can discuss each other's concerns. However, some farmers indicated they've not had good communication or interaction with their neighbors, making it difficult for them to educate their neighbors on what they do. Some farmers indicated they sometimes make the first move to create a good relationship with their neighbors, but that hasn't always been fruitful. For example, someone said, "*We've tried to do as much as you could make friends, right, like, or at least come to an* *understanding and communicate with each other. And some of that got met with opposition.*" Another farmer said, "*We just tried not to engage with that neighbor. They don't want to engage with us. We don't want to inflame any of those issues again. So, we're just trying to do as little as possible to deal with them.*" From the interviews, it is evident that the problems between farmers and their nonfarming neighbors are dynamic. There is no one solution to the problems, and there are also different issues in different contexts. However, some steps can be taken by various stakeholders – including farmers, nonfarming residents, government and nongovernmental agencies, and policymakers - to reduce the tensions.

The role in easing tensions and promoting sustainable agriculture and community development

Most interviewees indicated that in the past, agriculture was more widespread in the county, people interacted more with farmers, and there was no need to include information about it in the school system. Currently, most people are removed from agriculture, hence the need to include it in elementary, middle, and high school curricula so the younger generation understands how their food is produced and where it comes from. For example, one nonfarming resident stated, "*So if we're ever going to resolve these conflicts, education is critical; let's try to get some social media that talk about farms and all the benefits they bring to the community. I think we must integrate it into our educational system. People need to understand agriculture at a global level better, but certainly, and maybe more importantly, at a local level*." Some respondents also indicated that elected officials need to be educated to understand the farming community, their challenges, and opportunities, considering that most do not have a farming background. There were also suggestions that there is a need to put more of a spotlight on agriculture, for example, through regular events such as farmers' markets and the promotion of the purchase of local foods. Through that, the rest of the people who do not farm or have no idea about agriculture can interact more with farmers and learn about farming and how food is produced.

Discussion

This study investigates the concerns of farmers and nonfarming residents that can lead to conflict and provides some pathways that residents themselves see as viable to address them. Farmers and nonfarming residents indicated that the urban and suburban development level was too fast and demonstrated a high level of awareness about the loss of agricultural land. However, farmers were more concerned and aware of these issues than nonfarming residents. Farmers' greater awareness and concern could stem from the fact that most of the time, when there is urban and suburban development, there is often an encroachment on agricultural land, reducing the amount of available land for farming (Xie et al. 2023; Claggett et al. 2023; Claggett et al. 2004). This directly affects the livelihood of farmers who depend on the land for survival; hence, farmers likely notice these changes more quickly than those not involved in agriculture. Again, because farming communities usually have strong community ties (Park and Deller 2021), the influx of new neighbors due to rapid urbanization can disrupt these communities, leading to the loss of community and identity (Potts 2022). For example, one of the respondents interviewed said Howard County used to be where they knew each other, but the influx of development made it difficult for them to know one another. Farmers also tend to be more concerned about the loss of agricultural land because, most times, it results in housing development that brings them close to nonfarming residents who are unaccustomed to farming which has been shown to lead to tension or conflict (Vaserstain and Kelsy 2000; Sullivan et al. 2004; Lopez et al. 1988). Farmers' proximity to nonfarming residents could also be because they are more likely to be near the changes.

Findings also suggest that farmers were concerned about legal actions against them by residents. New residents are often not accustomed to farming operation's sight, sound, smells, and noise from machinery and use of fertilizers and pesticides and sometimes file nuisance complaints against farmers (Vaserstain and Kelsy 2000; Kelsey et al. 2000; Sullivan et al. 2004; Lopez et al. 1988). There are different farming systems, and the conventional agricultural system is often characterized by intensive tillage, the use of heavy farm equipment, heavy use of synthetic fertilizers, pesticides, and herbicides (Knowler and Bradshaw 2007; Beus and Dunlap 1990; Weisberger et al. 2021). This farming system is becoming unpopular because of its negative environmental impact, which includes soil erosion leading to the runoff of nutrients from farm fields to various local and regional water bodies. Best Management Practices (BMPs) such as conventional tillage, planting of cover crops, and nutrient management plans are widely adopted in the CBW (Sekellick et al. 2019). However, large farming operations still engage in conventional farming practices despite their negative environmental impact, and most residents are concerned about their activities. Despite the right-to-farm laws protecting farmers from nuisance complaints, which benefits all types of farmers, including large farming corporations, the stress and legal fees can be frustrating. The right-to-farm laws can also frustrate nonfarming residents as the law seems to support farmers over any nuisance complaint, sometimes making residents feel the government is not concerned about their complaints. What farmers must do is demonstrate how the practices they engage in consider soil and water conservation and the environment in general. They can achieve that by engaging in various environmentally sustainable and economically viable best management practices (BMPs).

It is also not surprising that nonfarming residents were very concerned about exposure to chemicals or pesticides, as there have been instances where people have complained about various allergic reactions from exposure to chemicals (Hoppin et al. 2017). Most people have negative perceptions and experiences with exposure to chemicals and how they can negatively affect their health (Hoppin et al. 2017). The results from the interviews also show how people were very concerned about being exposed to chemicals, with statements like "*they are trying to kill us with these chemicals*." Farmers interviewed suggested that to resolve some of these concerns from their neighbors, they've tried not to apply manure or fertilizer and chemicals or pesticides during the weekend or public holidays when there are usually many people at home. Others also indicated they've tried to reduce the number of pesticides by engaging more in organic farming. Some farmers also indicated that they must wake up early to transport their heavy farm equipment to avoid blocking traffic on the road.

Findings also suggest a relationship between farmers' concern about legal action by residents and their level of education, whether they own livestock or have other income sources. The results indicate that farmers with lower levels of education were more concerned about legal action than those with higher levels of education. This may be because farmers with lower education levels might have less understanding of their legal rights, such as the right-to-farm laws, and hence may feel more vulnerable to legal challenges. Farmers' lack of knowledge about various legal rights they have to farm can exacerbate the anxiety regarding potential lawsuits and their implications. On the other hand, when they are more educated, they are more likely to know some basic legal principles relevant to farming, such as the right-to-farm laws, land use laws, and various environmental regulations. Farmers' awareness about their legal right to farm can also be achieved through programming and education that helps them to understand their rights.

Farmers who indicated they do not have livestock tended to be more concerned about legal action than those with livestock. The possible reason is that crop farmers might be more exposed to different legal risks and regulations, which can lead to more significant concern about potential legal actions than livestock farmers. Even though both crop and livestock farming create environmental problems and are at risk of legal actions by residents, crop farming has substantial environmental impacts, such as soil erosion, pesticides, chemical runoff, and water use, which are often more visible and directly connected to legal land and water use disputes (Yoder et al. 2021). Therefore, crop farmers are more likely to be affected by neighboring property disputes related to pesticides and chemical exposure, water pollution, and land use changes. Farmers who indicated row crops make up more than 50% of their income were also more likely to be concerned about legal action than those with hay and forage, livestock, and no one source of income. Intensive agricultural practices such as row crop farming often use a lot of fertilizers, pesticides, and herbicides, which has a negative environmental impact. Fertilizers and chemical runoff from farm fields contribute to poor water quality, sometimes resulting in tension or conflict and sometimes legal disputes among residents due to blame-shifting. These could be some of the reasons why farmers who engage in row crop farming might be more concerned about legal actions.

Findings also indicated a relationship between nonfarming residents' concerns about exposure to chemicals and pesticides and their level of education, political ideology, and gender. The result suggests that nonfarming residents with a four-year college degree and advanced degree were more likely to be concerned about exposure to chemicals and pesticides than those with high school or some college or technical school. With a higher level of education, people tend to understand environmental issues, which include the potential risk of exposure to chemicals and pesticides (Jaoul-Grammare and Stenger 2022; Pathak et al. 2022). The results also indicate that nonfarming residents who identified their political ideology as liberal were more concerned about exposure to chemicals and pesticides than conservatives. The different perspectives shown in the result between liberals and conservatives can be explained based on the different values, beliefs, and priorities. McCright and Dunlap (2010) found that people who identified as liberals were more concerned about protecting the environment than conservatives. People with liberals ideologies also generally support government regulation that protects public health and the environment (McCright and Dunlap 2010); hence, they mostly favor stricter controls on the use of chemicals and pesticides. However, people with conservative ideologies often favor deregulation and limit government involvement while prioritizing economic and business interests. These differences in perspectives and priorities explain why liberals might be more concerned about exposure to chemicals than conservatives. The findings also suggest that females were more worried about the exposure to chemicals and pesticides than males. Research indicates that women generally perceive health risks, including those from environmental pollutants, more than men (Xiao and McCright 2015; Carlton and Jacobson 2013).

The key informant interviews conducted in Howard County also demonstrated how transitioning from a predominantly rural to a rapidly growing suburban region has brought agriculture closer to nonfarming residents, resulting in various challenges. The finding indicates that the western part of Howard County is more rural and has a lot of farming activities, which is undergoing pressure from residential development, resulting in the loss of farmland. Based on the interview, suburbanization has resulted in tension between farmers and nonfarming residents. Some of the conflicts were driven by a lack of knowledge regarding farming practices and some of the nuisance associated with farming. The economic difficulties of agriculture and the demand for profitable agricultural land for housing discourage many, especially the younger generation, from engaging in agriculture as a career. Even though the government has been trying to support farmers, the sustainability of farming in Howard County and the CBW is threatened by urban sprawl and a general lack of public understanding about agriculture.

Stakeholders, including government, community organizations, farmers, or individual residents, must focus on education and communication to address the tensions and conflict between farmers and their nonfarming residents. Farmers should also engage in environmentally friendly practices that produce less nuisance. Integrating agricultural education into school curricula, organizing farm tours, organizing farmers' markets, and promoting better relationships between farmers and elected officials can help bridge the gap between the farming community and the public (Stewart 2021; Warsaw 2021; O'Hara and Coleman 2017). Illuminating or throwing more light on the significance of agriculture through events like farmers' markets and promoting the purchase of local foods can enhance community support for farming (O'Hara and Coleman 2017). Addressing the tensions and complex relationships between farmers and their nonfarming neighbors requires a multifaceted approach. The diversity of farms and the context of development also make it difficult.

While there is no single solution to the problem, increasing awareness, fostering mutual respect, and creating policies that balance development and agricultural sustainability are vital to ensure thriving agriculture and community development in the CBW. The government, specifically the zoning and land use planning departments within the CBW region, must establish buffer zones between farming and residential areas to reduce the tension or conflict related to the nuisance (noise, odors, and pesticide drift) generated by agriculture. There should be designated areas for agricultural use, and they should be protected from encroachment by developers. Organizing community meetings that create an avenue where farmers and nonfarming residents can express their concerns and collaborate on solutions can be another strategy to reduce the tension at the rural-urban interface. The government should also develop clear regulations that address nuisance issues such as noise, odor, and pesticide, balancing the needs of both agricultural and non-agricultural residents. Through collaborative efforts, it is possible to maintain and enhance agricultural sustainability, accommodating people's growth and development needs.

Conclusion

This study investigates the complex dynamics and relationship between farmers and non-farming residents in the CBW, emphasizing the tensions and conflict that can arise from rapid urban and suburban development, increasing the close interaction between farmers and their non-farming neighbors. The conversion of farmlands to housing and residential development threatens agricultural sustainability and disrupts the strong community ties vital to rural life. Farmers express a higher level of concern about growth and the loss of farmland than nonfarming residents, which can be attributed to how this phenomenon directly affects their livelihoods and community identity. Urban sprawl introduces new challenges, such as losing farmland to residential development and bringing farmers closer to neighbors who are unaccustomed to farming practices. Legal action was the topmost concern of farmers indicated by their proximity to nonfarming residents unaccustomed to agricultural operations, further deteriorating the relationship between both parties. Nonfarming residents were also found to be more worried about exposure to chemicals or pesticides, which was also related or associated with educational attainment, political ideology, and gender. Addressing the conflicts between farmers and their nonfarming residents requires multiple strategies. Educational initiatives integrating agriculture knowledge into the school curricula can help bridge the understanding gap between farmers and their nonfarming residents. Farmers believe that once people learn about agriculture from an early age, they will be more likely to understand some of the practices they engage in. Some of the key informants interviewed also indicated that once the kids learn about agriculture from school, they will be better positioned to educate their parents about certain farming practices.

One limitation of this study is that most of the key informants interviewed, even those who were not farmers, demonstrated support for agricultural producers and their activities. However, it is essential to understand that the concerns of nonfarming residents cannot be overlooked or disregarded. Being worried about exposure to chemicals is a valid concern, as studies indicate it can lead to the development of allergies and cancer (Hoppin et al. 2017; Pathak et al. 2022). To reduce the tension at the rural-urban interface, farmers must also consider nonfarming residents' complaints and engage in more sustainable agricultural practices that are less harmful to the environment and residents' health. Some indicated they tried not to spray chemicals during public holidays or weekends when many people are at home, which is the right step toward easing the tension between these two demographics. Others also revealed that since they do not want to cause traffic, they transport their heavy equipment early in the morning or late at night when the road is less busy. Future research should focus on what nonfarming residents who live close to farms think should be the right pathways to live harmoniously with farmers. Farming is crucial for the survival of people. Therefore, some residents would not want to be seen or heard criticizing farmers because they might view it as not socially desirable. Hence, having access to that population and their insights and perspectives can significantly contribute to knowledge that can help stakeholders craft appropriate policies and educational programs that can help ease the tension or conflict between farmers and nonfarming residents.

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CHAPTER 4

UNDERSTANDING FARMERS' INTENTIONS TO VOLUNTARILY ADOPT NUTRIENT MANAGEMENT PLANS IN THE CHESAPEAKE BAY WATERSHED, UNITED STATE

Abstract

Nutrient management plans (NMPs) can benefit farmers and the environment by improving farm productivity and water quality in the Chesapeake Bay Watershed (CBW), United States. Even though NMPs are mandatory in some states in the CBW, it is essential to understand the social-psychological reasons behind farmers' intentions to adopt NMPs voluntarily. Farmers do not like being regulated as they consider themselves land stewards. Therefore, understanding how attitudes, beliefs, and social norms play a role in their intentions can help design education and outreach programs that promote a positive reception of these plans. I examined farmers' future intention to adopt NMPs in the CBW in the next five years using Structural Equation Modeling (SEM) that test a conceptual framework integrating the theory of planned behavior (TPB) and diffusion of innovation attributes (DOI). I collected data using an online/mail survey from a probability sample of 365 agricultural producers in the southern part of the CBW (Maryland, Virginia, and Delaware), where NMPs are mandatory. I found that relative advantage and compatibility positively influence attitudes toward NMPs, while complexity negatively influences them. There was also a positive relationship between compatibility and perceived behavioral control and observability, and subjective norms related to NMPs. The results can help plan education and outreach programs that help farmers comply willingly in the region.

Introduction

Conventional farming practices such as intensive tillage, heavy irrigation systems, and the use of synthetic chemical fertilizers, nutrients, pesticides, and genetically modified seeds are prevalent in the United States (U.S.) and are believed to generate high production efficiency (Beus & Dunlap, 1990; Weisberger et al., 2021; Gao & Arbuckle, 2021). Farmers have relied on nutrients such as nitrogen, phosphorus, potassium, and other micronutrients to improve yield, which has resulted in a pronounced increase in their ability to grow more food (Schwab et al., 2021; Green et al., 2005; Davidson et al., 2015). However, the conventional farming system creates many environmental problems due to over-reliance on synthetic fertilizers and intensive tillage that increases nutrient runoff from farm fields (Girip et al., 2020; Beus & Dunlap, 1990; Knowler & Bradshaw, 2007). The U.S. government also heavily subsidizes these unsustainable, nutrient-dependent agricultural practices (Weber, Key, & Donoghue, 2015; Jackson-Smith, Ulrich-Schad, & Grimm, 2013). For example, government policies such as the federal crop insurance programs promote farming practices such as monoculture or simplified crop rotation, which relies heavily on fertilizers and pesticides (Jackson-Smith et al., 2013).

These nutrients are essential for plant growth, but they also have the potential to create various environmental problems (Schwab et al., 2021). For example, nutrient loss from agricultural lands through erosion is a global problem due to its negative impact on reducing water quality and marine life (Schwab et al., 2021). In the U.S., nutrient loss from agricultural production is the primary cause of hypoxia (dead zone) in the Chesapeake Bay and the Gulf of Mexico, leading to the loss of aquatic life and the cause of algal blooms in various lakes and rivers (Olguı´n et al., 2004; Beegle, 2013; Schwab et al., 2021; Goolsby et al., 1999). Excess agricultural nutrients also limit the ability of lakes and rivers to supply clean drinking water, recreation, and livelihoods (Robertson & Vitousek, 2009). Effective nutrient management is, therefore, necessary to ensure that excess nutrients do not end up in the environment where they can impact air and water quality. David et al. (2014) found that fertilizer timing reduces nitrate loss from farm fields into various water bodies and rivers.

This study focuses on understanding the factors influencing farmers' intention to use nutrient management plans (NMPs) in the next five years in the southern part of the Chesapeake Bay Watershed (CBW) (Maryland, Virginia, and Delaware). Nutrient management practices can range from farmers conducting a soil test to know nutrient concentration in the soil before applying fertilizer, use of fertilizer application timing, use of rate application technology, and use of NMPs (Ulrich-Schad et al., 2017). Nutrient management is an accepted strategy internationally to address farm nonpoint source or field nutrient loss (Daxini et al., 2018; Beegle et al., 2000). The NMPs document all crops' nutrient needs, soil test results, and all nutrients (including manure) applied to the field**s**. NMPs aim to optimize yield while limiting the amount of nutrients lost to the environment. When farmers effectively and efficiently use the nutrient resources, it reduces wastage and saves farmers money.

The CBW covers over 64,000 square miles in six states (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and the District of Columbia (Sims & Coale, 2002; Savage & Ribaudo, 2013). Agricultural activities remain a major contributor to nutrient pollution of various rivers and water bodies within the watershed (Chesapeake Bay Program, 2024; Malone et al., 1993). More than 83,000 farms in the CBW contribute over $10 billion in agricultural production each year (McNabb & Swenson, 2023). Despite the economic contribution of agriculture in the region, it is evident that farming activities contribute negatively to the environment (Chesapeake Bay Program, 2024). Agriculture has often been the primary focus of water quality interventions due to the nonpoint source nature of farm runoff. It is difficult to trace the source of pollution from farm runoff to a specific origin or location. The agricultural sector also has the greatest opportunity to reduce nutrient pollution in Chesapeake Bay (Chesapeake Bay Foundation, 2024). Some drastic measures, such as removing about 44% (approximately 8.2 million acres) of farmland from production in the CBW, have been proposed to limit the amount of nutrients entering various water bodies within the watershed (Clune & Capel 2021). However, such a measure will affect farm income and the region's economic prospects. Therefore, it is crucial to manage agricultural activities effectively to be economically viable and environmentally sustainable in the CBW.

To reduce the negative environmental impact of agricultural activities and to ensure that agriculture is environmentally sustainable and economically viable, BMPs have been encouraged to help reduce nutrient runoff from farmlands (Schwab et al., 2021; Gao & Arbuckle 2021). BMPs include continuous no-till, cover crops, buffers along streams or field edges to filter nutrients and sediment runoff, and NMPs. In the CBW, BMPs such as conventional tillage, planting of cover crops, and NMPs are widely adopted (Sekellick et al., 2019). Even though BMPs are widely adopted in the CBW, some farmers still engage in conventional farming practices despite their negative environmental impact (Chesapeake Bay Foundation, 2024). Studies also suggest that adopting these practices at the farm level is still a challenge (Prokopy et al., 2019; Carlisle, 2016). Climate change leading to extreme weather events such as intensive rainfall also exacerbates the rate of nutrient runoff.

The government has made some of these practices, such as NMPs, mandatory in states like Maryland, Delaware, and Virginia. The law in Maryland requires all farming operations with a yearly gross income of at least $2500 or 8000 pounds of live animal weight to adhere to NMP when applying fertilizer to crops and managing animal manure or waste (Hall & Essman 2019). Due to the complexity of these plans, all three states ensure they are prepared by a certified professional or a trained farmer (Perez, 2015). Delaware requires all animal feeding operations (AFO) with more than eight animal units and any who owns or leases more than 10 acres of land where nutrients are applied to have an NMP (Hall & Essman 2019). In Virginia, the Department of Environmental Quality regulates the discharge of animal waste to surface water, and it applies to all AFOs that fall beneath the state's National Pollutant Discharge Elimination Systems (Hall & Essman 2019). Maryland and Delaware agricultural operators must file NMPs and yearly reports of NMP implementation with the state.

However, farmers often consider themselves good stewards of the land and the environment and do not like being regulated (Perez, 2015). NMPs can either be mandatory or voluntary. Voluntary adoptions are successful through education, technical assistance, and financial assistance (Beegle et al., 2000). Mandatory adoption, on the other hand, is successful when collaborative (when farmers work together with expertise in preparing the NMPs) (Perez, 2015). Government mandates are contentious among agricultural producers, and many farmers do not comply with regulations. For example, the Maryland Department of Agriculture conducted an on-farm audit and found that 59% of the operations complied with their NMPs (Hall & Essman, 2019). This result indicates that 41% of farmers do not comply with or follow their NMPs. Even though it is mandatory - past studies in the area have shown low compliance (Perez, 2015; Hall & Essman, 2019). Additionally, regulations meant to reduce the negative impact of agriculture on the environment are challenging to implement and enforce, and they are rarely monitored for environmental outcomes (Perez, 2015). Social psychological variables have been found to influence conservation decisions (Avemegah et al., 2024; Florees et al., 2017). Perez (2015) believes that even though NMPs are required, several aspects of implementation and enforcement indicate that plan compliance was largely voluntary. Therefore, it is important to understand the social-psychological reasons for farmers' adoption decisions. This can help design education and outreach programs that promote a positive reception and farmers' voluntary compliance.

I, therefore, use data from the 2022 survey of agricultural producers from the southern part of the CBW (Maryland, Virginia, and Delaware) to understand CBW farmers' future intention to use NMPs in the next five years. By integrating the theory of planned behavior (TPB) and diffusion of innovation attributes (DOI), I propose a conceptual framework that helps us to understand the social psychological reason for farmers' perceptions and future intention to use NMPs. The TPB and DOI frameworks have been used extensively and demonstrated to have significant predictive power in understanding and explaining behavior, including farmers' decisions concerning the adoption of various BMPs (Avemegah et al., 2024; Delaroche, 2020; Dentzman & Wardropper, 2021). Both theories provide a holistic understanding of farmers' behavior and hence were appropriate for this study (Wauters et al., 2010; Delaroche, 2020; Prokopy et al., 2019; Ansari & Tabassum, 2018; Lavoie et al., 2021). Integrating the TPB and DOI attributes can provide a comprehensive and nuanced understanding of farmers' decisions regarding their future intention to adopt NMPs. Understanding the psychological and social reasons for farmers' adoption decisions can help policymakers and conservation practitioners within the region design targeted and effective interventions and regulation compliance regarding NMPs in the CBW.

Nutrient Management in the United States

An enormous amount of nitrogen fertilizer has been applied to agricultural lands in the U.S. since the 1850s to promote crop production (Cao et al., 2018). The U.S. is the world's largest producer of corn; farmers rely on nitrogen, phosphorus, and other nutrients for their production (Heinemann et al., 2014; Liebam et al., 2008). The amount of nitrogen fertilizer applied to farms in the U.S. has increased (50-fold) between 1929 and 1990 (Nelson, 1990). About 35% of cropland planted in 2006 in the U.S. that received nitrogen fertilizers met the three nutrient best management practices (rate, timing, and method), suggesting that 65% do not use nitrogen fertilizer efficiently (Ribaudo et al., 2011). Ribaudo et al. (2011) indicated that the remaining cropland needs improvement in management to increase nitrogen use efficiency. Therefore, proper management of nutrients is crucial because adding nutrients to the soil beyond what crops demand will not be used, eventually runoff from the farm through erosion (Gao & Arbuckle, 2021).

Recognizing the adverse effects of nutrient loss, several U.S. states have developed recommendations for directly applying phosphorus and nitrogen onto agricultural land (Sharpley et al., 2003). NMPs are a strategic approach that ensures the efficient use of nutrients and reduces the risk associated with nutrient transfer from agricultural land without negatively affecting farm-level profitability (McCormack et al., 2021). The primary goal of NMPs is to align the nutrient supply with plants' needs, thereby eliminating excess nutrients on the farmlands. NMPs contribute to environmental sustainability and offer significant economic benefits by reducing input costs (Beegle et al., 2000; Daxini et al., 2018). The U.S. government and stakeholders within the agricultural sector are actively advocating for the adoption of NMPs to ensure efficient nutrient use (Kaplan et al., 2004). Shepard (2005) found that farmers with NMPs applied lower rates of total nitrogen, phosphorus, and potassium compared to farmers without NMPs, highlighting the potential of NMPs to optimize nutrient use on the farm. Despite the clear environmental and economic advantages of NMP, its adoption is not yet a priority for many farmers (Ehmke, 2014; Osmond et al., 2015). Research has shown that farmers who develop an NMP do not necessarily follow the plan (Osmond et al., 2015).

Drafting NMPs is costly in terms of money and time, and farmers are sometimes skeptical about adopting them because they see them as unnecessary and doubt their economic and environmental impacts (USDA NRCS, 2013). Osmond et al. (2015) argue that little advancement in adoption will be made without proper communication with farmers and significant investment that rewards farmers for taking what they see as a risk regarding adopting NMPS. For example, recommendations can be made to reduce fertilizer application rates after conducting soil tests, which farmers may see as a risk. Excessive fertilizer use is often considered a risk mitigation strategy to secure high yields and maintain economic stability (Stuart et al., 2014). Trust is paramount for farmers to adopt NMPs. They must trust the organization or institution's recommendation (Osmond et al., 2015). Osmond et al. (2015) found that farmers in three watersheds in North Carolina (Neuse, Tar-Pamlico, and Jordan Lake) did not entirely apply NMPs because they did not trust the advice coming from the university. They, however, use recommendations made by fertilizer dealers (Osmond et al., 2015).

Fertilizer dealers and independent consultants have also been found to recommend an increase in fertilizer rates rather than extension agents to farmers in Maryland who made NMPs (Lawley et al., 2009). This highlights the need for open and transparent communication, fostering trust and understanding between all parties involved in developing NMPs. Beegle et al. (2000)

believe that when farmers work with their normal advisors, whether public agencies (cooperative extension) or private agricultural dealers or consultants, to develop NMPs, they will be more likely to be adopted and implemented. Farmers rely on various sources of information when planning to prepare and adopt NMPs (Houser et al., 2019). Ulrich-Schad et al. (2017) found that farmers who seek information in workshops (including demonstration sites or meetings) significantly influence their adoption of NMPs.

Stakeholders' involvement is, therefore, vital to increasing farmers' adoption of NMPs. Farmers' adoption of NMPs is essential, and all stakeholders within the agriculture sector need to work with farmers to ensure positive reception and compliance. Beegle et al. (2000) believe that successful implementation of NMPs starts with engaging a wide range of stakeholders because they are critical in developing obtainable objectives for farmers. Society demands that farmers be accountable for their environmental impact (Perez, 2015). While efforts are being made to ensure efficient use of nutrients, some government policies also encourage farmers to rely on nutrients to increase crop yield (Weber et al., 2015). For example, crop insurance policy in the U.S. compels farmers to move towards specialized farming systems associated with high nutrient use. Similarly, Jackson-Smith et al. (2013) found that farm risk management, insurance, and disaster programs tend to encourage behaviors like monoculture, which are usually heavily dependent on fertilizers and have a detrimental environmental effect.

Nutrient Management in the Chesapeake Bay Watershed

During the 1980s, states inside the Chesapeake Bay Watershed created agricultural BMPs cost-share projects and nutrient management programs to reduce the adverse consequences of farming in the watershed. Nutrient management in the Chesapeake Bay started in Pennsylvania in 1985 and 1989 in Maryland and Virginia after the EPA found that nutrient runoff from farm fields was a major cause of pollution of the Bay. The Chesapeake Bay Commission concluded that voluntary agricultural assistance programs would not be enough to restore the Bay (Chesapeake Bay Commission, 1985). This resulted in some of the states within the CBW making NMPs mandatorily. In 1997, the *Pfiesteria event* (fish killed in the Chesapeake Bay because of nutrient pollution) led the Maryland lawmaking body to enact the Water Quality Impact Assessment (WQIA), which requires farmers to have nitrogen and phosphorus-based NMPs and to decrease the phosphorus in manure (Perez, 2015). Delaware passed the 1999 Nutrient Management Law, and Virginia passed the 1999 Poultry Waste Law (Perez, 2015). The three states adopted these regulations that require farmers to follow state-certified NMPs that would increase yield and reduce nutrient pollution from agricultural nonpoint sources (Perez, 2015).

NMP has benefited the Chesapeake Bay by reducing the amount of nitrogen and phosphorus entering the Bay. Savage and Ribaudo (2013) believe that the voluntary approach to farmers' adoption of BMPs to meet water quality goals is insufficient, but not all farmers favor government regulation. Perez (2015) found that farmers viewed regulation as unjust, hurtful, and senseless, creating a lot of anger within the farming community when the *Pfiesteria* event occurred. Farmers were also unhappy with how the media linked *Pfiesteria* and nutrient pollution to farming and poultry production (Perez, 2015). Some indicated they felt they were treated like criminals and had to fight for their livelihood as no one was ready to hear them (Perez, 2015). Perez's (2015) findings also suggest that the policy-making process in Maryland was contentious, leading to poor administrative compliance. However, that was not the case in Delaware at the initial stage, as there was good compliance because the process was more collaborative. Overall, Perez’s (2015) findings indicated that the adoption of NMPs was poor (60% or less within all three states) even though it was mandatory. This creates the impression that regulation is insufficient to influence farmers' decision to adopt NMPs in the CBW.

Studies have also shown that farmers who were mandated to adopt soil testing do not rigidly follow the recommendations when making nutrient management decisions (Daxini et al., 2018; Buckley et al., 2015). Daxani et al. (2019) also believe that whether the mandatory requirement of developing NMPs is an effective tool for encouraging such plans remains inconclusive. Perez (2015) believes monitoring the use of NMPs is difficult and not easy to regulate. Some studies also show that agricultural regulations aimed at improving water quality often have a limited impact on the number of farmers they affect and the extent of behavioral change they require (Perez et al., 2007). Perez (2015), in their study regulating farmer nutrient management in Maryland, Virginia, and Delaware, concluded that plan-based agricultural regulations are, in reality, voluntary.

Therefore, one optimal strategy to get farmers to adopt NMPs willingly and comply is to promote a positive attitude and perception of NMPs among the farming community. To achieve that, it is necessary to consider a social theory, or theories, that help explain farmers' decisions to engage in pro-environmental behavior. Neglecting the impact or influence of psychological factors on behavior can lead to an incomplete understanding of farmers' intentions regarding adopting specific BMPs (Avemegah et al., 2024; Borges et al., 2014; Zeweld et al., 2017). The Theory of Planned Behavior (Ajzen, 1991) and Diffusion of Innovations attributes (Rogers, 2003) can help explain some psychological and social factors related to farmers' intention to use NMPs in the CBW.

The Theory of Planned Behavior (TPB) and Diffusion of Innovations (DOI)

The TPB is a social psychological theory designed by Icek Ajzen (1991) to understand and predict a specific behavior. According to the theory, human behavior originates from the intention to engage in a behavior determined by three independent psychological constructs (Ajzen, 1991). These psychological constructs are attitude, subjective norms, and perceived behavioral control, which lead to a positive or negative behavioral intention. Attitude measures how people feel about a particular behavior, constituting two dimensions: behavioral beliefs and evaluation of the potential outcome of performing the behavior in question (Ajzen, 1991; Wauters et al., 2010; Avemegah et al. 2024). Behavioral beliefs are the individual idea or perception that engaging in a particular behavior will lead to a certain outcome. On the other hand, outcome evaluation has to do with the benefits related to behavioral outcomes (Ajzen, 1991). It is centered on how the person engaged in the behavior assesses the expected outcome of the behavior (Avemegah, 2020; Avemegah et al., 2024).

Subjective norms are the social pressure people feel or experience from others to engage in a particular behavior (Ajzen, 1991). It focuses on individual social networks, friends, colleagues, group beliefs, and people they look up to. Subjective norms comprise two components or elements: normative beliefs and motivation to comply. Normative beliefs are the beliefs about how people who are important to them think they should engage in the behavior or not. It also indicates the probability that an important reference group (people an individual looks up to for advice or influence) would approve or disapprove of a behavior (Ajzen, 1991). When a reference group approves of a behavior, people are more likely to engage in the behavior. Motivation to comply is the evaluation of how important it is to have others who are important to approve of the behavior (Ajzen, 1991). Both normative beliefs and motivation to comply must be observed to lead to a positive subjective norm. The third component of TPB, perceived behavioral control, refers to the degree to which a person believes they can control any given behavior. It explains how easy or difficult it is to display a specific behavior. Two components explain the perceived behavioral control constructs: control beliefs and control frequency. Control beliefs are the perception of control someone has in performing a specific behavior. Control frequency is the degree of ease or difficulty in carrying out that behavior. According to the theory, the more favorable these three constructs are, the more likely the behavior intention leading to the actual performance or engagement in the behavior (Ajzen, 1991; Wauters et al., 2010; Avemegah et al., 2024).

The TPB framework has been tested and shown to explain farmers' adoption decisions regarding various agricultural BMPs, including nutrient management practices (Avemegah et al., 2024; Delaroche, 2020; Doran et al., 2020; Wauters et al., 2010; Daxini et al., 2018; Daxini et al., 2019; Lalani et al., 2016). Daxini et al. (2018) found that subjective norms and perceived behavioral control were positively related to farmers' intention to apply fertilizer based on soil tests. Daxini et al. (2019) also found that the three constructs of the TPB were positively associated with farmers' intention to adopt NMP. However, their findings indicate that perceived behavioral control was the most important determinant of farmers' intention to follow NMPs. Doran et al. (2020) also found that perceived behavioral control had the largest size and strongest significance on farmers' intention to adopt nutrient best management practices (nutrient input reduction practices, cropping practices, and nutrient capture practices).

The diffusion of innovations theory, which Everett M. Rogers developed, explains how new ideas spread through a specific population or a social system (Rogers, 2003). According to Rogers, adoption does not occur simultaneously in a social system, but it is a process whereby some people are more likely to adopt the innovation than others (Rogers, 2003). Rogers established four components in the diffusion of innovations: the innovation attributes, communicated channels, time, and social system. The innovation attributes describe the features or elements of the innovation that demonstrate the probability of its adoption. Communication channels are how information or a message is disseminated or transferred to prospective adopters. On the other hand, time affects the innovation process in several ways, as groups of people are considered early adopters, early majority, late majority, and laggards (Rogers, 2003). Rogers (2003) explains the social system as “a set of interrelated units engaged in joint problem solving to accomplish a common goal” (p. 23). Hence, a social system is the individuals and groups through which an innovation is communicated and adopted.

The innovation attribute argues that five factors influence the adoption rate of an innovation. They include a relative advantage, which describes the degree to which an innovation is regarded as better than a previous idea (Rogers, 2003; Looney et al., 2022). Compatibility, the second factor, describes how consistent the new idea is with the potential adopter's values, experience, and needs. Complexity explains how easy or difficult innovation is to understand (Rogers, 2003). When the innovation or the new idea is easy to understand, people are more likely to accept it and vice versa. Trialability is the extent to which the innovation or the new idea can be tested or experimented with before a commitment to adoption (Rogers, 2003). When the innovation can easily be tested, the rate of adoption or acceptance increases. Finally, observability is the extent to which the benefit of innovation can be seen by others and provide tangible, visible results (Rogers, 2003).

The DOI theory has been used to understand farmers' decisions to adopt various BMPs. The rate of adoption and acceptance of an innovation is directly related or associated with that specific innovation's relative advantage, compatibility, trialability, and observability. However, it is inversely proportional to its complexity (Atwell et al., 2009). Atwell et al. (2009) found that farmers' willingness to adopt conservation practices is strongly influenced by how compatible the practices are with the farmer's current farming system (Atwell et al., 2009). A practice incompatible with the current farming system can hinder farmers' adoption decisions (Looney et al., 2022). Pannell et al. (2006) also emphasize that innovations are more likely to be adopted when they have a high relative advantage and are readily triable. When an innovation shows tangible and visible results, people are likelier to adopt it because of their collective social proof of benefits.

The TPB and DOI attributes demonstrate a comprehensive framework that helps us understand the adoption process better. While the DOI attributes focus on understanding how farmers perceive the characteristics of NMPs, the TPB focuses on the individual cognitive processes of adoption, providing a holistic framework to understand farmers' behavior regarding NMPs. Integrating these theories will address the complexities of adoption by considering the innovation’s attributes and farmers’ attitudes, social influence, and perceived control over the future intention to use NMPs in the CBW. This study is unique as no current research incorporates the TPB and DOI attributes to understand farmers' perceptions and intentions to use NMPs.

Research Questions and Hypotheses

The primary objective of this study is to test a proposed conceptual framework that integrates the TPB constructs and DOI attributes. The aim is to understand farmers' intention to adopt NMPs in the next five years. NMPs are mandatory in the study region, but farmers' compliance and adherence to the NMPs is still a challenge; it is crucial to understand the social-psychological reasons and farmers' perceived characteristics of NMP and how that influences their future intention to use it. This study seeks to determine the accuracy of the statements developed to measure the three constructs of the TPB and the five constructs of DOI. It also examines the relationship between the constructs of the TPB and DOI attributes and farmers' intention to use NMPs in the next five years. The DOI indicates that potential adopters of an innovation form their attitudes based on their perceptions of the five attributes of the innovation. The TPB also suggests that attitude, subjective norms, and perceived behavioral control influence people's intentions. In this study, I hypothesize that attitude can be predicted from Roger’s five innovation attributes. The five attributes of DOI are generally positively associated with adoption except for complexity, which is negatively associated with adoption (Zolait et al., 2008). Therefore, the following hypotheses were developed. Figure 1 displays the path diagram of the hypothesized relationship.

H1: Attitude toward NMP is positively related to future intention to use NMP.

H2: Subjective norm is positively related to future intention to use NMP.

H3: Perceived behavioral control positively relates to future intention to use BMP.

H4: Relative advantage is positively related to attitude toward NMP.

H5: Compatibility is positively related to attitude toward NMP.

H6: Complexity is negatively related to attitude toward NMP.

H7: Observability is positively related to attitude toward NMP.

H8: Trialability is positively related to attitude toward NMP.

H9: Compatibility is positively related to perceived behavioral control.

H10: Observability is positively related to subjective norms.

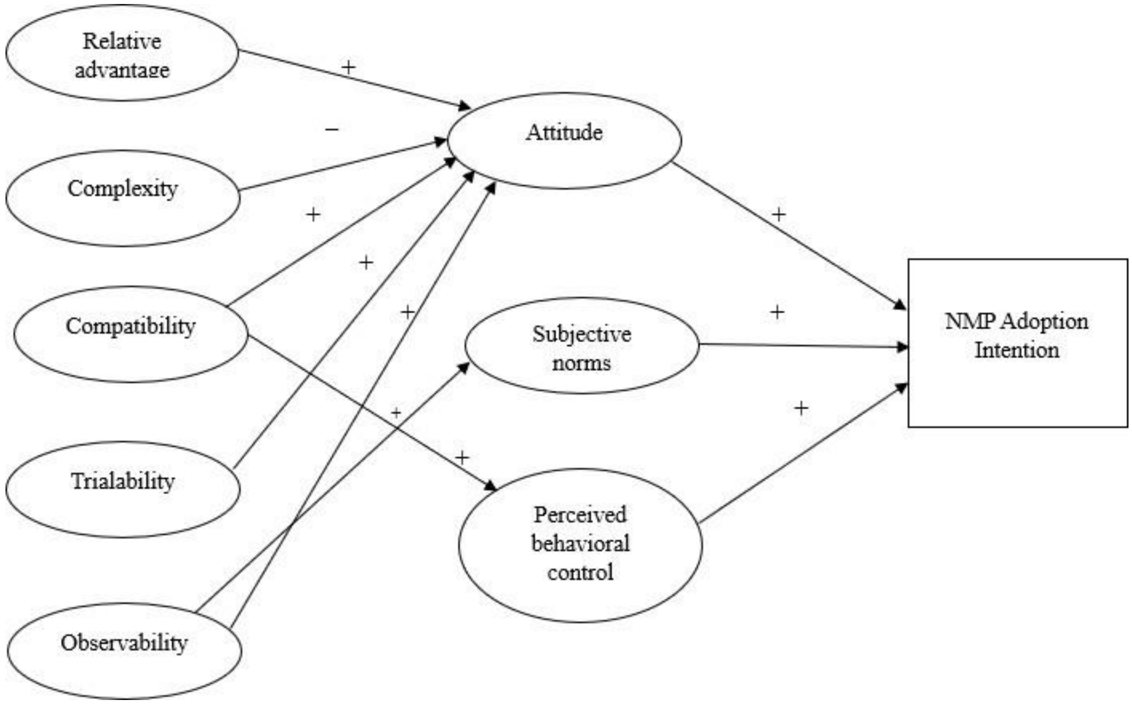

Figure 1. Conceptual Framework of Behavioral Intention Determinants

Materials and Methods

Data Collection

From March to June 2022, an online and mail survey of agricultural producers was conducted in the CBW, primarily in the Southern half (Maryland, Delaware, and Virginia). The survey asked about respondents' awareness of and views on water quality issues in local streams and waterways and the CBW in general. Questions also investigated agricultural producers' perceptions of causes of water quality issues, how to address water quality issues, and the future of agriculture in urbanized areas (including their knowledge and intention to continue using various Best Management Practices (BMPs), their views and perceptions of NMPs and views on how agriculture can be sustainable in an urbanized landscape like the CBW. The survey targeted crop producers (corn and soybeans), livestock producers (beef and dairy), and farmers who produce crops and livestock, but not hobby farmers or those with livestock only. Hobby farmers were excluded due to their low level of economic and environmental impact. The sample included 2403 producers' information (name, address, planted acres, gross financial income, and crops and animals produced). It was purchased from DTN (previously Farm Market ID, or FMID), a company that provides contact information for agricultural producers in the U.S. A recent publication assessing the quality of sample sources for survey research with agricultural producers in the U.S. suggests that private vendors are among the most accurate and helpful sampling sources because of their ability to provide generalizable samples and the option to conduct non-response bias tests with the background data provided (Ulrich-Schad et al., 2022). Producers with 50+ acres of operated land within the CBW were selected using simple random sampling. To get an accurate sampling frame of agricultural producers within the CBW, we provided a list of counties and zip codes overlapping with the CBW to DTN. The completed sample included 1326 (55.18%) producers from Maryland, 393 (16.35%) from Delaware, 663 (27.59%) from Virginia, 14 (0.58%) from Pennsylvania, 3 (0.12%) from West Virginia, 3 (0.12%) from District of Columbia and 1 (0.04%) from New York. According to DTN, due to the parameters, we required by location and size of farm (50+ acres) for the sample, there were fewer producers in general from the states of New York, Pennsylvania, and West Virginia, and the District of Colombia accounting for the low sample size in these four states. Given these limitations, the analysis is focused on the three states clustered in the south of the watershed and with the most responses (Maryland, Delaware, and Virginia).

Producers were contacted up to four times using a modified tailored design approach (Dillman et al., 2014). The advance letter also contained a link to an online survey so that producers who wanted to take the survey immediately online could do so. The second contact was a mail survey with a stamped return envelope for those who did not respond to the first wave. The third wave was a postcard reminder for producers who did not respond to both the first and the second wave. The last contact was another mail survey with a stamped return envelope to farmers who did not respond to previous waves. The process of multiple contacts and incentives has proven to increase the response rate in survey research, specifically among agricultural producers (Dillman et al., 2014; Avemegah et al., 2021). We asked producers to indicate their farming status (e.g., rent out the land or no longer farming) and whether they live in the CBW via mail and online surveys. Producers not currently farming or retired were asked to stop the survey and indicate so for our records. Overall, the process of multiple contacts achieved a response rate of 16.2% after 371 questionnaires were completed and returned (online = 145 and mail = 226) and after wrong mailing addresses and those not currently farming were removed (N = 118).

Measures

Farmers' future intention to use NMPs in the next five years is a dichotomous variable where 1 represents the intention to use NMPs in the next five years, and 0 represents the intention not to use NMPs in the next five years (see Table 1). The TPB and DOI attributes were measured with statements that capture farmers' attitudes, subjective norms, perceived behavioral control, relative advantage, compatibility, complexity, trialability, and observability. A literature review was conducted to understand how other researchers measure the TPB and DOI attribute constructs to ensure that the instrument measures the latent constructs. Three statements were used to measure each of the constructs of the TPB and DOI attributes, specifically in relation to

NMPs. Responses to statements measuring the construct of TPB and DOI were captured using five-point Likert scales (see Table 2).

Data Analysis

The statistical R package with the Lavaan function was employed to analyze the data for this study (Rosseel, 2012; R Core Team, 2021). A confirmatory factor analysis (CFA) was conducted where the factor variance was fixed to 1 to understand how each statement measured the construct of the TPB and DOI attributes loaded onto the latent construct. Fixing the factor variance to 1 helped answer the research question of whether the statements designed to measure each construct measure the latent variable of interest. The chi-square test, comparative fit index (CFI), Tucker-Lewis's index (TLI), mean square error of approximation (RMSEA), and sörbom's root means square residual (SRMR) values were used to determine the model fit of the data. The cutoff point or an acceptable value for model fit indicators is CFI > 0.95, TLI > 0.95, SRMR <= 0.08, and RMSEA < 0.05, and the p-value for the chi-square should be > 0.05 (Bentler & Bonnet, 1980; Browne & Cudeck, 1993; Bentler, 1990; Steiger & Lind, 1980; Hu & Bentler, 1999). A structural regression was also estimated to understand and test the proposed model. In a structural regression analysis, the measurement model, covariance between the latent constructs, and the regression were estimated. All three TPB constructs, and the five DOI attributes were assessed based on conceptual frameworks and hypotheses formulated. A likelihood ratio test was also conducted using the chi-square difference test to understand whether the full or reduced model better fits the data or whether fitting an additional parameter within the model is worthwhile. This was done by estimating the full model and subsequent models where each latent construct was constrained to 0.

Results

Sample Characteristics

The characteristics of the sample are documented in Table 1. Most of the farmers were male (89.12%), with an average age of 69.37. The age of farmers in the sample data is higher than the average age of 58.5 in Virginia and 57 in Maryland and Delaware, respectively (USDA 2017). Most farmers in the sample had high school or less (34.02%) as their highest level of education, while the least had advanced degrees (Masters, PhD, Professional degrees, etc.) (14.50%). The average years farmers have been the primary decision-makers for their operation and farming in the current location were 34.63 and 40.75 years, respectively. This indicates that most farmers have been farming in their current location for quite some time and continue to make decisions regarding the farming operation. The average farm size of the sample data was 1094.53 acres, which is higher than average farm sizes in Maryland (161 acres), Virginia (184 acres), and Delaware (230 acres) (USDA 2017). The vast difference between the average farm size of the sample data and the study regions was due to parameters I required by location and farm size (thus 50+ acres) from DTN. Most respondents came from Maryland (60.55%). Most farmers also indicated they do not earn income off the farm (67.26%) and do not own livestock (52.96%).

Table 1. NMP Intentions and Respondent Characteristics

Variable and Measure	**Descriptive Statistics**		
DEPENDENT VARIABLE	**N**	**Percent**	
Future intention to adopt NMP	**288**		
(1) Intend to use in the next 5 years	266	92.36	
(0) Do not intend to use in the next 5 years	22	7.64	
RESPONDENT CHARACTERISTICS	**N**	**Percent**	
Gender	**340**		
(1) Male (2) Female	303 37	89.12 10.88	
Educational level	**338**		
(1) Less than high school or less	115	34.02	
(2) Some college/technical school	94	27.81	
(3) 4-year college	80	23.67	
(4) Advance degree (Masters, PhD, Professional degrees, etc.)	49	14.50	
Off-farm income	**336**		
(1) Yes	110	32.74	
(2) No	226	67.26	
Owning of livestock	**338**		
(1) Yes	159	47.04	
(2) No	179	52.96	
Geographical location	**365**		
(1) Maryland	221	60.55	
(2) Virginia	47	12.88	
(3) Delaware	97	26.58	
	N	**Mean**	**SD**
Age (Range = 25 - 94)	284	69.37	11.96
Farm size (Total acres) (Range = 14 – 13221)	238	1094.53	1646.39
Years of primary farm decision maker (Range = 1 – 85)	323	34.63	16.17
Years of farming in the current location (Range = 3 – 98)	328	40.75	15.99

Table 2 displays the percentages, average values, standard deviation, and Cronbach's alpha values of the constructs of the TPB and DOI attributes. Attitude and compatibility about NMPs recorded the highest average values, thus 3.86 and 3.88, respectively. The Cronbach's alpha values for the construct of the TPB and DOI attributes were all above 0.70. However, Cronbach's alpha for perceived behavioral control recorded 0.39, suggesting a lower internal consistency. Statement two, "Whether I engage in a nutrient management plan or not is entirely up to me," was removed, and the alpha value increased to 0.80. Cronbach's alpha value above 0.70 is usually recommended for social science research (Nunnally, 1978); hence, all the latent constructs had good reliability, suggesting good internal consistency and reliability regarding the items measuring the constructs. The average score of each construct was also above 3.0, indicating a relatively high score for the constructs.

Table 2 also shows the factor loading of all the TPB and DOI attribute constructs from a confirmatory factor analysis model where the factor variance is fixed to 1. Factor loadings of 0.50 and above are good when the factor variance is fixed to 1. Most factor loadings exceeded the recommended threshold (Hair et al., 2017). There were, however, a few items that need to be reconsidered considering their factor score. The second statement measuring perceived behavioral control recorded a negative factor loading and hence was not included in the measurement model in the structural regression analysis. The result from all the model fit indicators met the cutoff point; thus, CFI > 0.95, TLI > 0.95, SRMR <= 0.08, and RMSEA < 0.05, and the p-value for the chi-square should be > 0.05, suggesting the data fit the model well.

Table 2. Theory of Planned Behavior and Diffusion of Innovation Constructs

Items	**n**	**SD**	**D**	**N**	**A**	**SA**	***m***	***AM***	***SD***	**Factor Score**
Attitude (α = 0.93)								**3.86**		
(1) Nutrient management plans have a positive impact on water quality	349	2.87	3.44	17.77	55.59	20.34	3.87		0.87	0.83
(2) Nutrient management plans protect natural resources for future generations	349	2.87	5.17	20.40	52.01	19.54	3.80		0.90	0.82
(3) Using nutrient management plans is a good idea	349	1.72	4.58	16.63	54.15	22.92	3.91		0.85	0.73
Subjective norms (α = 0.84)								**3.45**		
(1) Most people who are important to me would think I should use a nutrient management plan to improve the environment	344	2.33	6.98	34.88	43.90	11.92	3.56		0.87	0.80

(2) The people who influence my decisions would think that I should use a nutrient management plan	341	2.35	7.33	34.90	43.40	12.02	3.55		0.88	0.82
(3) Seeing other farmers successfully using nutrient management plans is important in my decision to use them	344	4.36	14.24	39.83	34.01	7.56	3.26		0.94	0.55
Perceived behavioral control (α = 0.80)								**<u>3.77</u>**		
(1) I am very confident that I can use a nutrient management plan successfully because I have the knowledge	345	1.16	4.35	16.81	52.75	24.93	3.95		0.83	0.79
(2) Whether I engage in a nutrient management plan or not is entirely up to me	346	15.90	16.18	15.32	36.99	15.61	3.20		1.32	-0.08
(3) I have the skills I need to be able to successfully use a nutrient management plan on my farm	345	0.58	2.03	10.72	54.49	32.17	4.15		0.73	0.52
Relative advantage (α = 0.78)	344	1.74	4.07	15.41	50.87	27.91	3.99	**<u>3.77</u>**	0.86	
(1) using a nutrient management plan helps to protect the environment										0.33
(2) Using a nutrient management plan improves soil health	347	1.73	5.19	21.61	46.40	25.07	3.87		0.90	0.81
(3) Using a nutrient management plan is more cost-effective than conventional farming management	345	2.32	11.59	40.87	30.14	15.07	3.44		0.96	0.73
Complexity (α = 0.84)								**<u>3.59</u>**		
(1) Nutrient management plans are easy to use	345	2.90	19.71	29.86	37.39	10.14	3.22		0.99	0.75
(2) It is easy to become skillful at using a nutrient management plan	345	1.16	11.30	35.65	39.42	12.46	3.50		0.89	0.89
(3) I have access to the necessary technical assistance to use a nutrient management plan.	344	1.16	4.65	15.41	55.52	23.26	3.95		0.82	0.45
Compatibility (α = 0.89)								**<u>3.88</u>**		
(1) A nutrient management plan is compatible with the land I operate	344	0.58	5.23	19.77	54.07	20.35	3.88		0.80	0.69
(2) A nutrient management plan fits into my current management system	344	0	5.81	19.77	52.91	21.51	3.90		0.79	0.77
(3) Nutrient management plans are compatible with my current farming equipment	344	0.58	5.23	21.22	52.33	20.64	3.87		0.81	0.69
Trialability (α = 0.94)								**<u>3.45</u>**		

(1) I want to be able to use a nutrient management plan on a trial basis before fully implementing	334	4.49	9.28	47.01	20.96	18.26	3.39		1.03	0.97
(2) I want to be able to use nutrient management on a trial basis long enough to see what it can do	336	4.46	8.63	46.13	22.02	18.75	3.41		1.03	0.99
(3) A demonstration of the effectiveness of nutrient management plans on an operation is important in my decision to adopt one	336	3.87	6.25	40.77	30.65	18.45	3.44		0.98	0.79
Observability (α = 0.95)								**3.30**		
(1) I will use a nutrient management plan when I see many farmers using one	335	6.57	15.82	48.66	12.24	16.72	3.16		1.08	1.13
(2) I will use a nutrient management plan after other farmers have had successful experience using them	333	6.91	13.81	46.25	17.72	15.32	3.20		1.07	0.93
(3) Farmers I have observed using nutrient management plans had positive experiences.	340	3.24	7.65	40.00	32.35	16.76	3.51		0.96	0.35

*Answer choices: SD = strongly disagree, D = disagree, N = neither agree nor disagree, A = agree, SA = strongly agree e***Answer choices: *m* = mean, *AM* = Average mean, *SD* = standard deviation

Table 3 shows the results of the significance of the path coefficients in the structural regression model. Regarding the five characteristics of NMPs, relative advantage and compatibility were positively and significantly related to attitudes toward NMPs. On the other hand, complexity had a negative significant relationship with attitude towards NMPs. Trialability and observability, however, had a negative non-significant relationship with attitude towards NMPs. Therefore, hypotheses 1, 2, 3, 9, and 10 are accepted, while hypotheses 4, 5, 6, 7, and 8 are rejected. The results also show a positive insignificant relationship between the three constructs of the TPB and the intention to use NMPs in the next five years. There was also a positive significant relationship between compatibility and perceived behavioral control and observability and subjective norms. Model comparison was also conducted using a likelihood ratio test approach where the full model was compared to various reduced models where one of the constructs was constrained to 0. The chi-square test difference suggests that the full model better fits the data than the reduced model. Therefore, estimating an additional parameter in the model gives us a substantial improvement in the model fit. Therefore, I conclude that it is worthwhile to estimate the additional parameter; hence, the full model was a better fit than the reduced model.

Table 3. Significance testing results of path coefficients

Hypothesis	**Path coefficients**	**p-value**	**Significance**
Relative advantage → Attitude	0.773	0.000	***
Complexity → Attitude	-0.415	0.041	**
Compatibility → Attitude	0.303	0.037	**
Trialability → Attitude	-0.007	0.953	**NS**
Observability → Attitude	-0.022	0.865	**NS**
Attitude → Intention	0.006	0.840	**NS**
Subjective norms → Intention	0.013	0.608	**NS**
Perceived behavioral control → Intention	0.002	0.881	**NS**
Compatibility → Perceived behavioral control	0.512	0.000	***
Observability → Subjective norms	0.236	0.000	***

* = p<0.05, ** = p<0.01 and *** = p<0.001. NS: not significant.

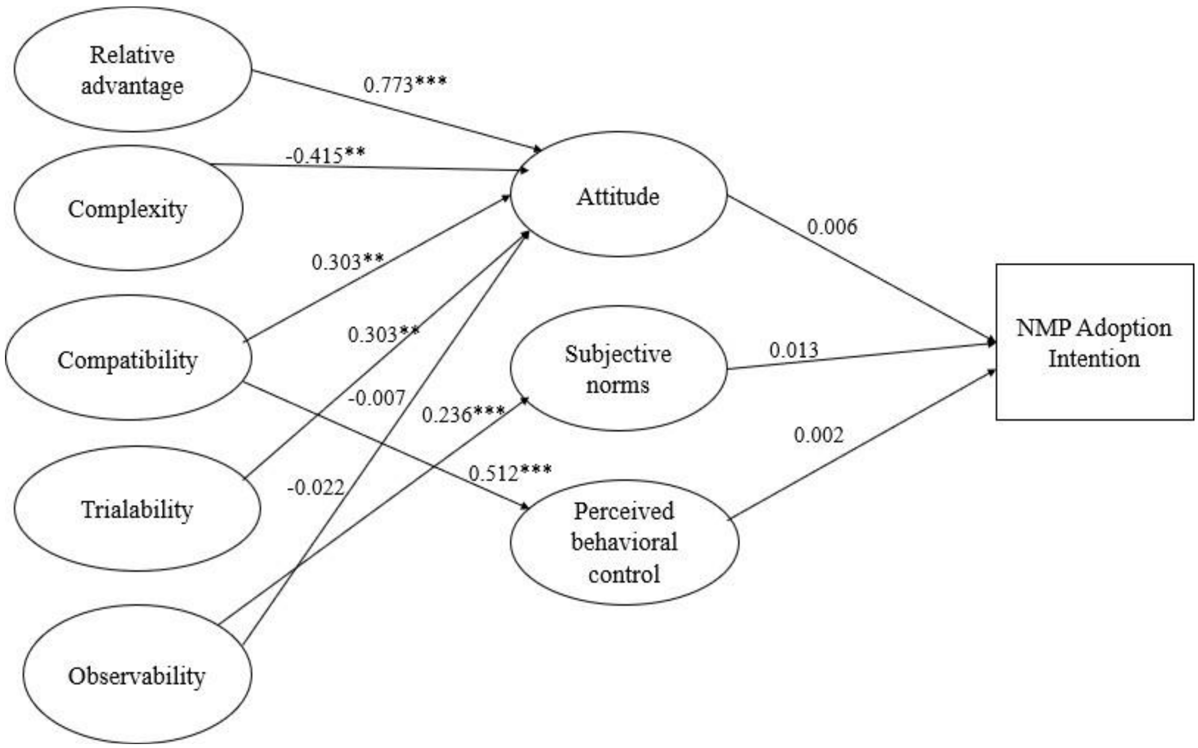

Figure 2. Path coefficients and their significance level

Discussion

This research examines how farmers’ perceptions of NMP characteristics in the southern part of the CBW (Maryland, Virginia, and Delaware) affect their attitudes toward NMPs and intentions to use NMPs. A conceptual framework integrating the TPB (Ajzen, 1991) and DOI attributes (Rogers, 2003) was developed to explain how the five DOI attributes are related to farmers' attitudes regarding NMPs, how perceived behavioral control is related to complexity, how observability is related to subjective norms and how the three constructs of the TPB are also associated with farmers' future intention to use NMPs in the next five years. This study provides insight into the social and psychological reasons for farmers' decisions regarding NMPs, which can help foster regulatory compliance and adherence among farmers within the CBW. Relative advantage and compatibility positively and significantly influence attitudes toward NMP, while complexity was significantly and negatively associated with attitudes. There was also a positive relationship between compatibility and perceived behavioral control and observability and subjective norms. The three constructs of the TPB, however, had a positive effect on intention, but they were not statistically significant.

The positive significant relationship between relative advantage and attitude towards NMPs implies that farmers perceive NMPs as advantageous compared to the conventional approach of managing nutrients (for example, traditional knowledge and visual observation). Farmers will support and participate in initiatives they perceive as advantageous and beneficial. This perception could be based on factors such as the cost-effectiveness of adopting NMPs and the environmental benefits associated with using NMPs compared to the conventional approach of applying and managing nutrients. Some benefits include improved soil health, cost-effectiveness, and the protection of the environment in general. Perez's (2015) study indicated that some farmers interviewed in Maryland, Virginia, and Delaware mentioned that they make more money following NMPs because it saves them from buying more Nitrogen and Potassium. Farmers also indicated that NMPs help them to conduct periodic soil tests. Hence, farmers who perceive NMPs as having a more significant relative advantage also have more favorable attitudes.

Therefore, perceived benefits translate into positive attitudes, which can be critical for successful implementation and compliance among farmers in the CBW. A positive attitude among farmers regarding NMPs indicates that they will be more likely to comply and adhere to NMPs. One factor that limits farmers' compliance with NMPs is a lack of trust in the organization preparing the NMPs, as well as the fear of how it might affect their yield. Therefore, collaborating with farmers to prepare the NMPs with the experts they trust can help increase compliance and adherence to NMPs in the CBW, considering studies have shown low compliance. However, when farmers perceive NMPs as unfavorable, they will resist, not comply, and not adhere to the plan when it is developed. For example, negative attitudes, such as farmers having the idea that they will go out of business if they follow NMPs due to the fear of potential yield loss, were some of the reasons for farmers not complying with the plan (Perez, 2015). When farmers believe that NMPs offer significant benefits over conventional practices of applying and managing nutrients, they are more willing to embrace them by adhering to the plans. By highlighting the advantages of NMPs and working with farmers' trusted experts in the preparation of NMPs, stakeholders can effectively promote acceptance and regulatory compliance among regional farmers. Farmers trust and comply with NMPs prepared by fertilizer dealers and crop consultants rather than NMPs prepared by university extension agents (Osmond et al., 2015). One of the reasons is that crop consultants and fertilizer dealers are more likely to recommend an increase in fertilizer use than extension agents (Lawley et al., 2009). Therefore, it is important for a public-private partnership agreement between government agencies and private companies to help farmers develop NMPs that will be collaborative and more likely to be adopted.

There was also a significant positive relationship between compatibility and attitude towards NMP. Compatibility suggests that NMPs align well with existing practices, technology, and farmers' current farming system. The alignment of NMPs with the current farming system limits the perceived difficulty and the effort needed to integrate NMPs into the farming system, resulting in more favorable attitudes among the farming population within the southern part of the CBW. Compatibility and attitude also recorded the highest average score with a mean value of 3.88 and 3.86, suggesting that farmers have a highly positive attitude and combability about NMPs. A positive relationship between compatibility and attitudes toward NMPs suggests easy integration and support among farmers, ultimately enhancing the NMP's effectiveness. Stakeholders working with farmers one-on-one to ensure they follow their NMP is crucial for easy integration of the NMP into the farming system (Perez, 2015). The positive relationship between compatibility and attitudes can also be explained by the fact that NMPs have been around for a long time, and the study region requires that farmers have NMPs (Perez, 2015). Therefore, farmers have changed their farming system and management to suit NMP adoption.

Findings also suggest a negative significant relationship between complexity and attitude, which indicates that when farmers perceive NMPs as complex or difficult to understand, it can lead to a negative attitude. Research shows that drafting NMPs is costly in terms of money and time, and some farmers may view it as irrelevant (USDA NRCS, 2013). This can result in frustration, confusion, and resistance among farmers, who may find it hard to understand the complexity of the NMPs. When farmers think NMPs are complex, it can pose a significant barrier to their adoption and implementation. Farmers may feel overwhelmed by the perceived technical requirements and data demands, resulting in a reluctance to engage in NMPs. The negative significant relationship between complexity and attitude indicates the importance of simplifying the NMPs and providing adequate technical support for farmers. Beegle et al. (2000) believe that farmers' voluntary adoption of NMPs is successful through education, technical and financial assistance. The compliance assistance approach, which focuses on informal and educational efforts by working with farmers, has been recommended compared to formal enforcement procedures (Perez, 2015). Therefore, providing accessible resources to improve the understanding and usability of NMPs can help farmers to accept and comply willingly.

There was also a significant positive relationship between compatibility and perceived behavioral control regarding NMPs. The positive relationship implies that farmers have the skills, knowledge, and resources to implement NMPs successfully. When farmers perceive NMPs as compatible and feel they have control over their implementation, they are more likely to adhere to its guidelines, leading to better compliance. This result can also be explained by the fact that NMPs have been around for some time; hence, farmers have changed their farming operations to align with NMPs. For example, NMPs became legally required for agricultural operators in 1997 in Maryland and 1999 in Delaware and Virginia (Perez, 2015).

Findings also indicate a positive relationship between observability and subjective norms. When farmers can easily see positive results such as improved soil health, reduction in input cost, and increased crop yield, it can influence subjective norms, which are the perceived social pressure farmers feel when engaging in NMPs concerning this study. Farmers observing their colleagues successfully implementing NMPs and witnessing tangible results can be a form of social learning. Visible positive outcomes can influence farmers' subjective norms by providing evidence of the NMP's effectiveness and acceptability within the farming community. Regional stakeholders can capitalize on the positive relationship between subjective norms and observability as a strategy to accelerate reception and compliance among farmers. For example, emphasizing the importance of social norms surrounding NMPs and showing evidence of successful implementation and positive outcomes from other farmers can help accelerate compliance and reception among the farming population.

Stakeholders can also use various communication avenues such as seminars, workshops, and field demonstrations to reach a wider audience of farmers, as it has been shown to increase farmers' adoption of BMPs (Singh et al., 2018). For example, Ulrich-Schad et al. (2017) found that farmers who seek information in workshops, such as meetings or demonstration sites, significantly increase their adoption of soil tests and NMPs. Farmers belong to a social group; therefore, if other farmers have good testimonies concerning NMPs and share their positive experiences, they will be more interested in adhering to their plans. However, in communities like the CBW, where water quality issues have persisted for decades, farmers might normalize non-compliance with NMPs. If their colleagues and respectable or influential farmers do not prioritize NMPs, others may feel less social pressure to adopt and adhere to the plan.

It was also surprising that the three TPB constructs were not statistically significant even though they had a positive relationship with the intention to adopt NMPs. Past studies have found that the three constructs of the TPB significantly and positively influence farmers’ decision to adopt various BMPs, specifically NMPs (Wauters et al., 2010; Avemegah et al., 2024; Daxini et al., 2019). One possible reason why the three constructs of the TPB were not statistically significant in predicting intention could be the result of social desirability bias that can affect how individuals report their attitudes, norms, and control beliefs. Over many decades, the prevalence of water quality issues in CBW can also influence the TPB constructs, which do not predict the intentions. Several years of ongoing water quality issues can lead to skepticism about the effectiveness of NMPs, especially if previous efforts to address nutrient pollution are perceived as ineffective. Farmers may develop a negative attitude towards new plans, doubting their potential to make any significant impact.

Conclusion

This study contributes relevant insights into how the attributes of NMPs and farmers' perceptions regarding NMPs influence their attitudes and future intention to continue using them. Integrating the TPB and DOI attributes illuminates or throws more light on the social and psychological aspects influencing farmers' decisions about NMPs' future usage. Findings suggest that perceived relative advantage and compatibility influence farmers' positive attitudes toward NMPs. When farmers see or view NMPs as offering tangible benefits and aligning well with their current farming operations, they are more likely to develop a positive attitude. The attitude of farmers regarding NMPs was the strongest predictor of farmers' behavior toward adopting BMPs in the U.S. (Prokopy et al., 2019). Some of the positive attitudes farmers indicated were the reasons for engaging in various BMPs, including perceived financial gain and farm environmental benefits such as improved air and water quality (Prokopy et al., 2019). It is, therefore, essential to focus on the benefits or advantages and compatibility of NMPs to promote acceptance and regulatory compliance among farmers in the CBW. Findings also showcase the negative effect of complexity on farmers' attitudes towards NMPs. For example, writing an NMP costs money, and following a plan is also time-consuming, and the data requirements (for example, conducting soil tests) make it complex for many farmers to adopt (USDA NRCS 2013;

Perez, 2015; Daxini et al., 2019; Osmond et al., 2015). Perceived complexity can result in resistance and lack of compliance among farmers, emphasizing the importance of simplifying and providing the necessary technical and financial support for farmers. However, the positive relationship between compatibility and perceived behavioral control suggests that NMP is compatible with some farmers' current farming systems, and they have the knowledge and skills to implement them successfully. Furthermore, the positive relationship between observability and subjective norms stresses the role of visible outcomes and social influence in forming farmers' attitudes and future intentions to continue using NMPs. Past studies have found that farmers' social networks, such as their colleagues, crop consultants, fertilizers, and chemical dealers, play a role in their decision to adopt various conservation practices or BMPs (Ranjan et al., 2019; Prokopy & Babin 2014).

The results of this study provided insight that can help conservation professionals, agencies, and policymakers aiming to promote NMP adoption and compliance among farmers in the CBW. By illuminating or throwing more light on the advantages of adopting and complying with NMPs, ensuring NMPs are compatible with farmers' current practices, making NMPs less complex, and leveraging social norms and observable outcomes, stakeholders can promote a positive reception and adherence to NMPs. This can help reduce nutrient pollution of various water bodies in local streams and the Chesapeake Bay. Studies have shown that farmers are more likely to comply with NMPs prepared by fertilizer dealers and crop consultants than university extension agents (Osmond et al., 2015). Therefore, to ensure NMPs are widely adopted and followed, crop consultants, fertilizer dealers, and extension agents must collaborate and work with farmers to prepare the plan. Collaboration can lead to trust and acceptance of NMPs within the farming community, resulting in farmers' compliance and adherence to NMPs. Future research should focus on understanding how public (university extension agents) and private (crop consultant and fertilizer dealer) collaboration in NMP preparation can influence farmers' decisions to comply and adhere to the plan.

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CHAPTER 5

CONCLUSION

The CBW is increasingly becoming more urbanized, posing different challenges to residents living within that region, ranging from water quality problems to tensions among residents and regulations likely to be tightened. Agriculture remains a significant land use activity crucial to the regional economy and food production (Ribaudo, Savage, and Aillery 2014). However, agricultural activities create problems such as nutrient runoff in local waterways and the Chesapeake Bay, and the nuisance generated by farming sometimes leads to tensions among residents living close to farms. The activities of nonfarming residents, such as urban lawn runoff, industrial pollution, sewage treatments, and suburban storm runoff, also create water quality problems in local waterways and the Chesapeake Bay. All these issues must be addressed to create an economically thriving and environmentally beneficial agricultural system in an urbanized landscape like the CBW. The three papers of this dissertation contribute to the literature regarding residents' views on water quality, agriculture-related conflicts, and farmers' adoption of NMPs in the CBW. Each of the papers is briefly reviewed below.

Review of Chapter 2

In Chapter 2, I examine agricultural and non-agricultural actors' perceptions of water quality issues and interventions in the CBW. To be specific, I examine agricultural and non-agricultural residents' concerns about water quality issues, their perception of water quality issues, who they think is responsible for water quality issues, and their support for various policy tools to reduce urban lawn and farm runoff in their local streams and the CBW in general. Survey data collected from agricultural and non-agricultural residents were analyzed quantitatively. The non-agricultural resident survey was conducted from May to July 2021 by Qualtrics through an online panel. The agricultural resident survey was conducted from March to June 2022 using an online and mail survey. Three statistical tests were employed in this study. One was a t-test to understand whether the perceptions and concerns regarding current water quality and support for various policies varied between the two groups. Pearson’s chi-square test to determine if there were significant differences between agricultural and non-agricultural residents on crucial contributors to water quality issues in their local streams and waterways and the CBW in general. A logistic regression model was also run on farmers' and non-farming residents' data separately to understand how various socio-demographic and economic variables are related to support for policy tools to control farm and urban lawn runoff.

Findings from this study suggest that agricultural residents expressed significantly more concern about poor water quality in local streams and the CBW than non-agricultural residents. However, farmers were less likely to see the water as poor quality than nonfarming residents at both scales. To address both urban lawn and farm nutrient runoff, utility and tax credits were highly supported by both farmers and nonfarming residents, while both groups were least supportive of laws and litigation that would require behavior change. A binary logistic regression also indicated that education, age, income, gender, and the level of urban and suburban development where respondents reside are related to residents' support of utility and tax credits.

Review of Chapter 3

In Chapter 3, I assess urban-agricultural tensions in the CBW. Specifically, I examine nonfarming residents' and farmers' concerns about their proximity due to nuisance generated by farming activities and complaints by nonfarming residents in CBW. This paper further explores whether these concerns have led to conflict between farmers and nonfarming residents in CBW, including potential solutions. For Chapter 3, I used mixed methods, quantitatively analyzing survey data from non-agricultural and agricultural residents and qualitative data (key informant interviews) from Howard County. For the quantitative analysis, I employed a chi-square test to understand the relationship between various socioeconomic and demographic variables and the top concerns of residents and nonfarming residents (i.e., legal action by new residents from the farmers' survey and exposure to chemicals and pesticides from the nonfarming residents' survey). Key informant interviews were coded (thematic coding), and major themes were identified.

I found that CBW nonfarming residents were primarily concerned about exposure to chemicals/pesticides. Farmers, on the other hand, were more concerned about new residents' legal actions against them due to the nuisance generated by their activities. The findings from the qualitative interviews indicate that addressing the concerns requires multifaceted strategies focused on education, communication, and policy development. Efforts to integrate agricultural education into school curricula, organize farm tours and farmers' markets, and foster better relationships between farmers, nonfarming residents, and elected officials can help reduce tensions or conflict at the rural-urban interface and promote more sustainable and resilient communities in CBW.

Review of Chapter 4

In Chapter 4, I examine how the constructs of the TPB (attitude, subjective norms, and perceived behavioral control) and DOI attributes (relative advantage, compatibility, complexity, observability, and trialability) are related to farmers' adoption of NMPs. I proposed a conceptual framework integrating the TPB and DOI attributes to understand farmers' future intention to adopt NMPs in the CBW. To do this, I analyzed survey data from an online and mail survey of agricultural producers in the southern part of the CBW (Maryland, Virginia, and Delaware). The survey targeted crop producers (corn and soybeans), livestock producers (beef and dairy), and farmers who produce crops and livestock, but not hobby farmers or those with livestock only. I employed Structural Equation Modeling (structural regression) to test my proposed conceptual framework for the quantitative analysis.

This analysis shows the three constructs of the TPB were positively related to farmers' future intention to adopt NMPs, but the relationship was not statistically significant. I also found that relative advantage and compatibility positively influence attitudes toward NMPs, while complexity negatively influences them. There was also a positive relationship between compatibility and perceived behavioral control and observability, and subjective norms related to NMPs.

Limitations

There are some limitations of this dissertation. One of the limitations of this study is the survey data. The goal was to survey farmers and nonfarming residents in all the states that align with the CBW. However, with the farmer survey, most of the sample purchased from a private vendor was from Maryland, Virginia, and Delaware, making the study focus on the southern part of the CBW. Therefore, to some extent, the result from this dissertation cannot be generalized to the entire CBW but to the southern part of the watershed. The non-agricultural resident survey was also non-probability and did not proportionately capture metro and non-metro areas. About 90% of responses came from metro areas; hence, the data did not capture the diversity of the population within the CBW.

Secondly, for Chapter 3, I could only interview three nonfarming residents. This skewed the result toward more perspective and insight from agricultural producers regarding the pathways for farmers and nonfarming residents to coexist peacefully. Even though some of the suggestions from the nonfarming residents align with farmers regarding how they can peacefully coexist, having more responses from nonfarming residents could have brought up a more nuanced and diverse viewpoint.

Positionality

My position as a researcher (how I approach the research topic, interact with study participants, interpret the data, and present the findings) may also present some limitations that need to be recognized. The attributes and viewpoints of a researcher can affect the research process (Babbie 2020; Holmes 2020; Foote and Bartell 2011; Baca Zinn 1979). I am interested in issues that affect farmers and how they can be supported to stay in business. I know how my standpoint and personal biases can impact the interpretation and conclusion of the result. Therefore, I consciously tried to remain reflexive throughout the research process and not be biased towards farmers. In my writing, I made sure I reflected on my values, beliefs, and assumptions and continuously questioned my positionality and potential biases. I know some farmers also engage in unsustainable practices that are not good for the environment; hence, they should be encouraged to do so. My study is in CBW, where I don't live, giving me an "outsider" status in the study region. My position as someone originally from Ghana and not American conducting research in the U.S. further emphasizes my "outsider" status.

Implications

The extent of attributing blame and its relationship to subsequent inaction regarding water quality remains uncertain within the context of the CBW. Chapter 2 of my dissertation offers insights and an up-to-date understanding of the alignment between agricultural and non-agricultural stakeholders concerning water quality issues in the CBW. This study also explored their perspectives on attribution and support for the interventions suggested in prior studies on water quality policy tools. Although previous research (Church et al. 2021; Gasteyer 2008; Hu and Morton 2011) has delineated the effects of tackling water quality problems on urban-agricultural dynamics, this study sought to shed light on areas of consensus and divergence regarding water quality concerns and interventions. The study reveals that blame-shifting is still prevalent, offering insights crucial for shaping policies addressing nutrient pollution from diverse sources in the CBW. This study provided knowledge regarding where nonfarming residents and farmers agree on strategies to reduce urban lawn and farm runoff, which policymakers can adopt to reduce the pollution of streams and the Chesapeake Bay in general.

Chapter 3 of my dissertation provides current knowledge on the CBW's conflict between farmers and nonfarming residents. Some current studies have shown the tension between farmers and nonfarming residents. However, they mostly focused on disagreement regarding water quality issues and how policy choice in addressing issues impacts urban-agricultural relationships (Armstrong 2019; Armstrong 2022; Church et al. 2021). Nonetheless, a lack of related investigation exists into conflicts between farmers and nonfarming residents within the CBW, stemming from issues such as odor, chemical usage, theft, property vandalism, trespassing, and more. Most of the available research was conducted two or more decades ago. Consequently, this current research in the region addresses the contemporary challenges linked to the urbanization of agriculture prevalent in the CBW. The study provides some pathways farmers and nonfarming residents think will help address the conflicts and ensure they peacefully coexist at the rural-urban interface.

Chapter 4 of my dissertation also provides insight into social psychological factors related to farmers' future intention to adopt NMPs. This study provides both theoretical and practical implications. Understanding the TPB and DOI attributes provides a comprehensive and multi-faceted understanding of farmers’ intention to adopt NMPs. These two theories offer distinct perspectives illuminating the complex factors influencing farmers’ decisions regarding NMP adoption. Based on my knowledge, the approach of using both theories has not previously been explored to understand farmers’ intentions to adopt NMPs in the CBW voluntarily. Therefore, this study will provide current knowledge to help conservation practitioners develop more effective strategies to promote sustainable agricultural practices and address the environmental challenges of nutrient pollution.

Conclusion

This dissertation draws upon quantitative and qualitative data collected from farmers and nonfarming residents in the southern part of the CBW (Maryland, Virginia, and Delaware) to understand residents' views on water quality, agriculture-related conflicts, and farmers' adoption of NMPs. My dissertation concludes that water quality problems spanning multiple jurisdictions, such as the CBW, need to use a collaborative governance approach by exploring both the convergence and divergence in perceptions between farmers and nonfarming residents, emphasizing shared values and targeted education campaigns to improve the watershed's health. Due to rapid urban development, the tensions between farmers and their nonfarming residents at the rural-urban interface can be reduced through educational initiatives that bridge the knowledge gap between farmers and nonfarming residents. To encourage farmers to adopt NMPs and comply with regulations, it is essential to highlight the importance of perceived benefits, compatibility, simplicity, and social influence. Stakeholders - including farmers, nonfarming residents, planners, policymakers, government and nongovernmental officials, and environmental organizations - can adopt these strategies to ensure agriculture is environmentally sustainable and economically viable and promote the wellbeing of residents within the CBW.

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APPENDICES

Appendix: Interview Protocol

1. How would you describe Howard County to someone who has never been there?
2. How would you say people in Howard County view farming or agriculture?
3. What would you say is the relationship between the non-farming residents and agriculture or farming?
4. How, if at all, has farming changed here over the last 10 years?
5. How do you feel about the growing population? Have you noticed if there has been a loss of farmland? What do you think of that?
6. Have these changes in population or land use led to any conflicts? What were the sources of conflict? Who or what groups have been involved in these conflicts?
    a. If there is no conflict, why do you think there haven't been conflicts?
7. Have there been any successful approaches to mitigating these conflicts in Howard County and do you think these could be applied to the CBW region?
    a. What approaches, if any, were unsuccessful?
8. What role do you think the local government, community organizations, farmers, or individual residents can play in addressing these conflicts?
9. Finally, what do you believe is the best path forward to address this conflict and promote sustainable agriculture *and* community development in your area and the CBW as a whole?

Demographic and Background Questions

10. What is your occupation?
11. In what year were you born?
12. What is the highest level of formal education have you completed?

13. Do you have any formal or informal leadership roles here?

14. How long have you lived in Howard County?

15. Is there anyone else that would be good for me to talk to about this topic? If so, can you share their name and contact information?

EDEM AVEMEGAH
CURRICULUM VITAE

Education

Ph.D., Sociology (Community and the Environment), *Utah State University*, expected Spring 2024

Dissertation topic: Agriculture in the Chesapeake Bay Watershed: Views on Water Quality, Agricultural-related Conflict, and the Adoption of Nutrient Management Plans
Committee: Dr. Jessica D. Ulrich-Schad, Dr. Jennifer Givens, Dr. Courtney Flint, Dr. Sarah Church, and Dr. Mehmet Soyer

M.S., Applied Sociology, *South Dakota State University*, 2020

Thesis: Understanding South Dakota Farmers' Intentions to and Adoption of Conservation Practices: An Examination of the Theory of Planned Behavior
Committee: Dr. Candace K. May, Dr. Jessica D. Ulrich-Schad, and Dr. Maaz Gardezi

B.A., Social Work with Information Studies. *University of Ghana*, 2012

Research Interests

Community; Environment/Natural Resources; Survey Methodology; Agricultural Conservation Practices

Awards and Grants

- College of Humanities and Social Sciences, Summer Research Grant, 2023 ($4000)
- Graduate School Travel Award, 2022 ($600)
- Diversity Travel Award, Rural Sociological Society Annual Conference, 2022 ($900)
- Travel Award, Alpha Kappa Delta International Sociological Honor Society, 2022 ($300)
- Diversity Travel Award, Rural Sociological Society Annual Conference, 2020 ($300)
- Travel Award, Alpha Kappa Delta International Sociological Honor Society, 2019 ($400)

Peer-Reviewed Publications

- **Avemegah, E.**, E. Bennett, J. D. Ulrich-Schad, T. Wang, W. M. Eaton, H. L. Sieverding, S. Westoff, and D. E. Clay 2024. "Understanding Farmers' Adoption of Diversified Crop Rotations in South Dakota, USA: An Examination of the Roles of Sense of Place and Social Responsibility" *Journal of Agroecology and Sustainable Food Systems*
- **Avemegah, E.,** C. K. May, J. D. Ulrich-Schad, P. Kovács & J. D. Clark. 2024. "Understanding Farmers' Adoption of Conservation Tillage in South Dakota: A Modified Application of the Theory of Planned Behavior." *Journal of Soil and Water Conservation* 79(1):31-42.
- Shuang L., J. D. Ulrich-Schad**,** J. Leffler, **E. Avemegah** and L. Perkins. 2023. "Dewormers, Dung Beetles, and Decision-Making: Understanding Rangeland Livestock Producers' Parasiticide Use." *Rangeland Ecology & Management* 90:13-21.

- Clark, J. D., J. D. Ulrich-Schad, P. Kovács, A. Bly, and **E. Avemegah.** 2022. "Farmer adoption of efficient inorganic nitrogen fertilizer management practices in South Dakota" *Journal of Soil and Water Conservation* 77(6):568-578. doi:10.2489/jswc.2022.02152

- Ulrich-Schad, J. D., S. Li, J. G. Arbuckle, **E. Avemegah**, K. J. Brasier, M. Burnham, A. Kumar Chaudhary, W. M. Eaton, W. Gu, T. Haigh, D. Jackson-Smith, A. Metcalf, A. Pradhananga, L. S. Prokopy, M. Sanderson, E. Wade, A. Wilke, A. 2022. "An inventory and assessment of sample sources for survey research with agricultural producers in the U.S." *Society & Natural Resources* 35(7):804–812. doi: 10.1080/08941920.2022.2081392.

- **Avemegah, E**., W. Gu, A. Abulbasher, K. Koci, A. Ogunyiola, J. Eduful, S. Li, K. Barington, T. Wang, D. Kolady, et al. 2021. An examination of best practices for survey research with agricultural producers. *Society & Natural Resources* 34 (4):538–79. doi:10.1080/08941920.2020.1804651

Non-Peer-Reviewed Research Briefs and Reports

- **Avemegah, E.** and J. D. Ulrich-Schad. "Chesapeake Bay Watershed Residents' and Farmers' Concerns and Perceptions of Water Quality" (2023). *Publications.* Paper 1. https://digitalcommons.usu.edu/canri_publications/1

- **Avemegah, E.** and J. D. Ulrich-Schad. "Chesapeake Bay Watershed Residents' and Farmers' Views on Water Quality" (2023). *Publications.* Paper 2. https://digitalcommons.usu.edu/canri_publications/2

- **Avemegah, E.** and J. D. Ulrich-Schad. "Chesapeake Bay Watershed Residents' and Farmers' Views on Urban and Suburban Growth" (2023). *Publications.* Paper 3. https://digitalcommons.usu.edu/canri_publications/3

Course Taught

Introduction to Sociology (Summer 2022)

Research Presentations

- **Avemegah E.,** & J. D. Ulrich-Schad **"**Farmers' Intention to Voluntarily Adopt Nutrient Management Plans in the Chesapeake Bay Watershed Student Rural Sociological Society conference, Madison, Wisconsin, July 2024.

- **Avemegah, E.,** and J. D. Ulrich-Schad. "Residents' Support for Varied Scenarios for Agricultural Systems in Urbanized Landscapes" Chesapeake Community Research Symposium, June 2024.

- **Avemegah, E., "**Farmers' Adoption of Nutrient Management Plans in the Chesapeake Bay Watershed." Student Research Symposium, Utah State University, March 2024.

- **Avemegah, E.,** and J. D. Ulrich-Schad. "Addressing Urban-Agricultural Tension in the Chesapeake Bay Watershed: Perspective on Concerns and Remedies." Rural Sociological Society conference, The University of Vermont Burlington, Vermont, August 2023.

- Kovacs, P., J. D. Clark, J. D. Ulrich-Schad, & **Avemegah E.,** "Decision-Making Factors of Precision Agricultural Practices in South Dakota. ASA, CSSA, and SSSA International Annual Meeting, Baltimore, Maryland November 2022.

- **Avemegah E.,** C. K. May, J. D. Ulrich-Schad, P. Kovács, & J. D. Clark. "Understanding Farmers' Adoption of Conservation Tillage in South Dakota: A Modified Application of the Theory of Planned Behavior. Rural Sociological Society conference, The Westin Westminster, Colorado, August 2022.

- **Avemegah E.,** & J. D. Ulrich-Schad. "Understanding South Dakota Farmers' Adoption of Diversified Crop Rotation: An Examination of the Role of Sense of Place and Sense of Responsibility" Pacific Sociological Association Conference, Sacramento, April 2022.

- Ulrich-Schad J. D., Westhoff S., **Avemegah E.**, Wang T., Sieverding H. L., & Clay D. E. "Sense of Place and Responsible Management of Working Lands in Eastern South Dakota. ASA, CSSA, and SSSA International Annual Meeting, Salt Lake City Utah, November 2021.

- Emery M., **Avemegah E.**, Ogunyiola A., Kwarisima C., Eduful J. "Evaluation of the graduate school's professional development program. Great Plains Sociological Association. November 2019.

- **Avemegah E.,** "The Impact of Agricultural value chain on poverty reduction among farmers in developing countries: A Meta-Analysis. Great Plains Sociological Association. November 2019.

- Meredith R., Emery M., Eduful J. & **Avemegah E.** "Evaluating equity change initiatives in a high administrative turnover environment: A case study [updated]. Midwest Sociological Society Annual Meeting. Chicago, IL, March 2019.

- Meredith R., Emery M., Eduful J. & **Avemegah E.** "Equity change initiatives in a higher education Administrative Turnover Environment: A case study." Association of Behavioral and Social Sciences, Las Vegas, February 2019.

Professional Employment and Experience

Graduate Research Assistant to Dr. Jessica D. Ulrich-Schad. Utah State University. 2020 – present.

- Designed and implemented online and mail surveys for agricultural producers and residents to understand their views on farming and its future and water quality issues in the Chesapeake Bay Watershed.
- Designed, organized, and implemented qualitative and quantitative research projects related to the assessment of interdisciplinary research teams' organizational efficacy and

interdisciplinary team collaboration of the Thriving Agricultural System in Urbanized Landscape Project.

- Designed and implemented qualitative and quantitative research projects related to the assessment of the interdisciplinary research team's interactions with various stakeholders including the stakeholder advisory board of the Thriving Agricultural System in Urbanized Landscape Project.
- Designed and implemented qualitative and quantitative assessments of workshops organized by the Thriving Agricultural System in Urbanized Landscape research team with stakeholders.
- Conducted data management and analysis using Excel and STATA and R Software.

Graduate Research Assistant to Dr. Jessica D. Ulrich-Schad & Dr. Redlin Meredith. South Dakota State University. August 2018 – August 2020.

- Designed and implemented online and mail surveys for agricultural producers in South Dakota to understand their current nutrient management practices.
- Conducted data management and analysis using Excel and Stata.
- Prepare manuscripts for publication.

Project Administrator. Cell Construction Limited. Accra, Ghana. July 2013 – July 2018.

- Supervised effective use of resources on the project (labor, material, time, etc.) and budgeting.
- Prepared project-based, weekly, and monthly financial records, including accounting for employees' salaries and wages.
- Provided quality assurance of company safety measures.

Information System Support Associate (National Service). Ghana Cocoa Board Head Office. August 2012 – July 2013.

- Installations of hardware and peripherals (printers, keyboards, scanners, etc.) on personal computers.
- Troubleshooting problems on windows operating system.
- Drafted hardware and spice work reports for my supervisor's attention.

Supervising Assistant. Farmers Credit Groups (student internship/ fieldwork) Centre for Agriculture and Rural Development (CARD International). May 2011 – August 2011.

- Organized the farmer's forum to discuss credit loan and organizational policies, including general office administration and project/business proposal writing.
- Managed credit records, task planning, and the distribution of farm input credit and monitoring of their use and application.
- Prepared presentations on community profiles.

Membership /Service

- Rural Sociological Society (RSS). 2018 – present.
- American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America (ASA, CSSA, SSSA). 2021 – present.
- International Association for Society and Natural Resources (IASNR) 2021 – present.

- Pacific Sociological Association (PSA). 2021 – present.
- Alpha Kappa Delta Member, International Sociological Honor Society (AKD). 2018 – present.
- American Association of Behavioral and Social Science (ABSS). 2018 – 2020.
- Midwest Sociological Society (MSS) 2018 – 2020.

Technical Knowledge

Proficient Knowledge in R, STATA SPSS, ArcGIS Online, and Qualtrics Online Survey Design