Incorporating 'Nudge' in Agri-environmental Program Design to Stimulate BMP Adoption: Does It Work?

by

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Abstract

Sustainable agriculture refers to an environmentally friendly agriculture sector that ensures safe production for both current and future generations. To address climate change's impact on Canadian agricultural production and mitigate the harmful environmental effects of agriculture, promoting Best Management Practices (BMPs) is a proposed strategy by researchers. Agri-environmental programs and policies are used to motivate farmers to adopt BMPs. However, there is still a lack of research on how to design those programs to achieve the optimum level of participation. In this thesis, I use a two-paper approach to analyze whether behavioral nudges can effectively encourage farmers toward adoption.

The first paper (chapter 2) presents an extensive literature review focusing on behavioral factors in BMP adoption and evidence of using behavioral nudges in the agri-environmental sector. The findings reveal that several behavioral factors could impact farmers' decision-making regarding BMPs. It also suggests that applying behavioral nudges might effectively help design agri-environmental policies in Canada.

The second paper (chapter 3) empirically examines whether incorporating different nudges in agri-environmental program designs can influence Saskatchewan farmers' participation in those programs. Data for this paper was collected from a large-scale survey conducted on 500 Saskatchewan farmers in 2021. A vignette experiment is used to investigate how farmers rate different hypothetical programs. The results show that although nudges have some positive influence, monetary incentives significantly impact farmers' decisions to participate in the programs. In this paper, I also analyzed Saskatchewan farmers' current BMP adoption scenario and discussed their participation in the Environmental Farm Plan (EFP).

Preface

This thesis is an original work by Susmita Chowdhury. No part of this thesis has been previously published. The thesis was completed under the ADF project #20200204 ‘Saskatchewan Farmer Adoption and Preferences for Agri-environmental Best Management Practices’, funded by Ministry of Agriculture, Saskatchewan.

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To my beloved father-in-law, who would have been proud to see this.

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Chapter 1: Introduction

1.1 Background

The agriculture sector is integral to the Canadian economy, especially in the prairies. Agricultural productivity is necessary to fulfill the food demands of the rising population in many provinces in Canada (Traxler and Li, 2020; Kulshreshtha, 2011). If agriculture is unsustainable, it will hamper the ability of food production and damage the natural ecosystem (German et al., 2017). Ecosystem services produced by the natural environment are valuable for humans and agricultural production (Banerjee et al., 2015). However, agricultural activities negatively impact ecosystem services, which will, in turn, affect agricultural productivity (Dale and Polasky, 2007). Therefore, to make agriculture sustainable, the quality of the environment (e.g., soil, air, water) needs to be maintained. Agri-environmental economists in Canada are highly concerned about finding solutions that will mitigate the negative environmental impacts of the agriculture sector while keeping its productivity unaffected.

In Canada, Best Management Practices (BMPs) have long been viewed as practical ways to address and minimize the environmental risk from agricultural practices while maintaining productivity (Agriculture and Agri-food Canada, 2000). Non-point source (NPS) pollution can be controlled effectively at desired levels using BMPs (Xie et al., 2015). However, the voluntary nature of adoption creates a barrier to achieving the adoption level expected by the government and policymakers. Researchers all over the world have attempted to identify the factors impacting farmers' BMP adoption, including age, income, and education, but the results primarily do not provide consistent determinants of adoption decisions (Knowler & Bradshaw, 2007; Liu et al.,

2018; Prokopy et al., 2008; Baumgart- Getz et al., 2012). Therefore, designing agri-environmental programs based on these factors might not always increase adoption rates. Other than the observable factors, behavioral factors are considered determinants of adoption in the recent literature that discusses the possible application of behavioral economics insights to encourage adoption (Palm-Forster et al., 2019; Dessert et al., 2019; Streletskaya et al., 2020).

Mullainathan and Thaler (2000) defined behavioral economics as "the combination of psychology and economics that investigates what happens in markets in which some agents display human limitations or complications." This vibrant, quirky, and real-world discipline is rapidly emerging (Cowling, 2014). Neoclassical economic theories dominated the analysis and evaluation of policies that generally aimed to influence or steer individual behavior and decision-making (Dhami, 2016). These models assume that decision-makers are rational (Congiu and Moscati, 2022). However, modern economists find this rationality assumption unrealistic and acknowledge that people can be irrational while making decisions (Leiser and Azar, 2008). This notion was the foundation of this new area of behavioral economics.

The way of modeling and measuring the behavior of economic agents has been fundamentally changed due to developments in behavioral and experimental economics (Hobbs and Mooney, 2016). Behavioral economics models extend the classical models by considering the influence of psychological, cognitive, social, and other noneconomic factors on perceptions, human behavior, and decision-making (Hobbs and Mooney, 2016). Behavioral and experimental economics could be valuable tools for BMP adoption studies as they provide scope to directly measure individual preferences and establish a causal link between behavioral factors and decision-making (Dessart, 2019).

Nudge, a behavioral economics concept, does not consider people as the 'rational economic man' of the classical economic theories; instead, it assumes them as 'social persons' who are not entirely rational (Wu et al., 2021). Nudges aim to redirect peoples' behavior predictably without changing their choice set and economic incentives (Thaler and Sunstein, 2008). Though nudge theory ignores the rationality assumption, it does not create any problem even if people act rationally. Camerer et al. (2003) stated that a well-designed nudge "…creates large benefits for those who make errors while imposing little or no harm on those who are fully rational." Nudge is being used as a new method of public management reform in developed economies, including the United States, the United Kingdom, and Germany (Wu et al., 2021). In recent years, the governments of many countries have started to rely on insights from behavioral economics, including nudges, for more cost-effective agri-environmental programs (Ferraro et al., 2017). This thesis theoretically and empirically attempts to explore the scope of using nudges in the agri-environmental sector in a Canadian context.

1.2: Economic Problem

In economics, externalities are an important concept. Externalities refer to the costs or benefits which are not reflected in the market price of a good or service and, therefore, are not considered by producers in their decision-making (Adde, 2023). Agri-environmental issues often are associated with externalities. For instance, using nitrogen fertilizers may increase crop yields but create negative environmental externalities, including water pollution and GHG emissions (Adde, 2023). These externalities do not reflect in farmers' costs and may require intervention to mitigate the negative impact of their operations. Promoting agricultural BMPs might be the most efficient way to deal with the agriculture sector's negative environmental externalities. Applying behavioral

nudges to engage farmers in agri-environmental programs could be effective. Although nudges are considered behavioral solutions to behavioral problems, in the agri-environmental sector, nudging is a behavioral solution to a conventional economic problem as well (i.e., negative externality) (Carlsson, 2021).

1.3: Thesis Objectives

This thesis aims to provide insights on behavioral interventions that might be applied to remove barriers to BMP adoption in Canadian agriculture. Farmers are responsible for the adoption; therefore, communicating and engaging them is necessary for implementing effective agri-environmental programs (Adde, 2023). The thesis draws on behavioral economics literature to identify effective strategies for agri-environmental policies that farmers will appreciate.

In this thesis, I aim to address the following research questions:

1) What are behavioral nudges? How are they applied in different disciplines?

2) Can nudges be useful in the agri-environmental sector?

3) Which behavioral factors impact farmers' BMP adoption decisions?

4) Why are the behavioral factors important to consider in BMP studies?

5) What is the current scenario of Saskatchewan farmers' participation in BMP adoption and Environmental Farm Plan (EFP)?

6) Can nudges impact the decision of Saskatchewan farmers to participate in agri-environmental programs?

1.4: Thesis Structure and Contribution

In this two-paper approach thesis, the first paper is an extensive literature review that provides an overview of how behavioral intervention might be helpful to increase the pro-environmental behavior of farmers. The review consists of two main sections. One section describes the factors consistently mentioned in literature for impacting farmers' BMP adoption decisions, focusing on behavioral factors. Another section explores the behavioral nudge literature, highlighting the evidence of nudging in agri-environmental settings. The review aims to combine the findings of both sections and discuss recommendations on how different nudges might be applied to address the behavioral factors in Canadian BMP adoption. To my best knowledge, this is the first review in Canada that synthesizes information on the possible application of behavioral nudges in designing agri-environmental programs and policies.

In the second paper, methods from experimental economics are used to examine whether behavioral interventions work in the case of motivating Saskatchewan farmers toward BMP adoption. This paper aims to contribute to behavioral experimental economics by testing the impact of nudges using a vignette experiment. The descriptive analysis of this paper provides information on Saskatchewan farmers' current soil and water-related BMP adoption and Environmental Farm Plan (EFP) participation. The econometric analyses investigate how different forms of nudges impact Saskatchewan farmers' decision to participate in agri-environmental programs. The paper aims to examine the current adoption scenario of Saskatchewan and test whether nudges can be effectively applied to design agri-environmental programs in the province.

This thesis aims to contribute to an emerging field of research, namely 'behavioral agricultural economics.' I used a region-specific approach in the second paper of this thesis by focusing solely

on the BMP adoption and agri-environmental program participation in Saskatchewan province. A region-specific approach is advantageous as it provides the scope to discuss policy recommendations for a specific location. BMPs vary across geographic locations, and generalizing agri-environmental policies is not recommended (Baylis et al., 2008). Since adoption is voluntary, it decentralizes decision-making, and farmers can decide and determine which BMPs are best for their operations based on local conditions (Clement, 2010). Even within Canada, variations in the climate and provincial regulations make it challenging to develop a country-wide plan for agricultural practice adoption. Therefore, the findings of this thesis might specifically help policymakers in Saskatchewan determine the best way to design policies and programs that will motivate farmers toward BMP adoption.

Chapter 2: Behavioral Nudges: A Possible Approach to Addressing Behavioral Factors in Canadian BMP Adoption

2.1: Introduction and Background

Climate change is a major social and political issue. It affects the world predominantly, and the impacts can be seen in research reports and our daily life (Boruchowicz, 2021). Consequently, climate change mitigation programs are included in the political agendas globally (Andor and Fels, 2018). Climate and agriculture have a mutually dependent relationship: agricultural activities can influence the climate through land use changes (Desjardins, 2009), and subsequently, changes in climate affect agriculture (Chen &Gong, 2021). Farmers can become increasingly vulnerable if they fail to adapt to the changing climate (Bogdan and Kulshrestha, 2020). Therefore, finding ways to create an environmentally friendly, sustainable agriculture sector and make it adaptable to climate change is crucial.

Agricultural production practices impact environmental resources, so farmers are often of interest to researchers, non-governmental environmental organizations, etc. (Floress et al., 2018). The practices that help mitigate the environmental risk the agriculture sector poses are commonly known as Best Management Practices (BMPs). BMPs are promoted as practices that can significantly improve the quality of the environment without impacting productivity. However, as most practices are voluntary, farmers must decide whether to adopt BMPs (Tamini, 2011). Since adopting practices is costly to farmers and sometimes requires altering the production process by applying additional technology, they might not always be encouraged to adopt them. Therefore, understanding the factors influencing farmers' BMP adoption is necessary to close the gap between

promotion and adoption (Lang & Rabotyagov, 2022). Over the past decade, researchers attempted to identify and review what factors motivate farmers to participate in adoption programs. Incorporating behavioral factors as a determinant of adoption is comparatively new in the BMP literature. This review will focus on summarizing the impacts of behavioral factors on BMP adoption.

The research question asked here is, 'why are the behavioral attributes important to consider?' Many arguments can be found in the existing literature regarding the need to include behavioral factors in any economic analysis. Though economists generally assume that people are entirely rational (i.e., they have well-defined preferences and always maximize their utility, etc.), evidence from the literature has made economists consider 'full rationality' as a problematic assumption as well as encouraged them to use insights from psychology to understand better economic behavior (Leiser and Azar, 2008). People show complexity in their behavior, and they rarely follow the traditional theories of economics while making decisions (Frederiks et al., 2015). In addition, researchers admitted that preferences can be changed over time and across contexts, and the way decision-makers process information differs from the assumptions of neoclassical economic models (Congiu & Moscati, 2022). This complex and irrational behavior of humans in the economic decision-making context is captured in behavioral economics analyses. Behavioral economics has introduced psychology into economic research while focusing on human behavior, precisely human economic behavior (Wu et al., 2021). Despite being a new discipline, behavioral economics is a part of mainstream economics that draws on insights from economic experiments and psychology to bring a profound understanding of human behavior into economic theory (Reeson and Dunstall, 2009).

Conservation science has mostly ignored the fact that the study of human choice about nature conservation is potentially the most crucial research topic in today's world (Cowling, 2014). However, some recent studies attempted to measure how human behavior or perception generated from unobservable psychological attributes affect conservation practices (e.g., Bennett et al., 2017; Shackleton et al., 2019; Greiner, 2015). Palm-Forester et al. (2019) and Czap et al. (2019) addressed the impact of behavioral factors in agri-environmental policy schemes. Streletskaya et al. (2020) noted that "the behavioral economics and agricultural adoption literature share many common characteristics such as an interdisciplinary nature, a strong empirical basis, and willingness to go beyond traditional economic models when the evidence dictates it, which provides ample scope for cross-fertilization between the two fields." Behavioral economics could be applied to study BMP adoption behavior, which can be valuable for improving policy and increasing BMP adoption (Traxler, Li 2020).

Nudge, a behavioral economics concept, is a form of behavioral intervention rapidly emerging as a public policy tool. A nudge is "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein, 2008). An example is when it is assumed that individuals are willing to donate their organs unless they declare otherwise, the percentage of organ donors increases significantly (Johnson and Goldstein, 2003; Thaler and Sunstein, 2008). Here, the nudge was setting organ donation as the default option so that people must opt-out if they do not want to donate. This example implies that anything that positively impacts peoples' decision-making without affecting their decision rights can be counted as a nudge (Wu et al., 2021). So, nudges could be a behavioral solution to behavioral problems (Carlsson et al., 2019). Most studies that examined nudges were conducted in a health context followed by environment (Hummel and

Maedche, 2019). Agri-environmental policies and programs might be extended cost-effectively if nudges and other behavioral insights are included. (Higgins et al. 2017). This paper aims to synthesize the information in the literature on using different nudges in several disciplines, including agri-environmental studies.

Climate change will influence Canadian agriculture as crop production is affected by temperature and precipitation regimes (Lychuk et al., 2019), and the production practices used in the agriculture sector can adversely affect climate change. Therefore, steering the adoption rate of different BMPs is important for policymakers in Canada. Identifying the most influential factors is necessary to figure out how to encourage Canadian farmers to be more engaged in BMP adoption. Factors consistently found significant in the literature are often used to aid policymakers in creating more effective agri-environmental policies (Pannell, 2008; Pannell et al., 2006). However, designing agri-environmental programs that will help to improve the adoption of BMPs can be challenging due to the heterogeneity among farmers and farming systems (Rolfe and Harvey, 2017). Nudging might be effectively used to design programs that will motivate Canadian farmers to participate more. Therefore, the prime objectives of this review paper are:

1) To summarize which factors impact farmers' BMP adoption, focusing on the unobservable behavioral attributes.

2) Explore the nudge literature and synthesize the evidence on using nudges in various disciplines, including the agri-environmental sector.

2.2: Approach and Structure:

This review focuses on studies that discuss farmers' BMP adoption behavior. By the term BMP, I refer to any environmentally sustainable agricultural practices mentioned in the existing literature. That means any farming practices that help to reduce the negative externalities to the environment from the agriculture sector, no matter whether it is related to soil, water, air, biodiversity, or anything else, will be considered as BMP in this review and there will be no distinction among these practices. BMPs are also known as 'Beneficial Management Practices (BMP)' and 'conservation practices.' Some literature also named them as 'Climate Smart Agriculture (CSA),' 'sustainable agriculture,' and 'climate mitigating technologies.' For simplicity, throughout this review, I will mainly address these practices as BMPs and conservation practices interchangeably.

Since this study is a literature review rather than a meta-analysis, I will not compare effect sizes. Research questions in this review are: 1) What are behavioral nudges? How are they applied in different disciplines? 2) Can nudges be useful in the agri-environmental sector? 3) Which behavioral factors impact farmers' BMP adoption decisions? 4) Why are the behavioral factors important to consider in BMP studies? To find answers, I conducted this review across the disciplines of psychology, economics, health, agriculture, environment, agri-environmental, etc. Regarding the literature search, journal articles and chapters of books were primarily collected from Google Scholar and the University of Alberta's online library. The general exclusion criteria and those specified for nudge literature are described in the following paragraphs.

Both published and working papers are included in this review. Most studies cited here have been published within the last decade to ensure the information is up to date. The review minimally mentions studies published after 2022, as I primarily conducted the literature search in mid-2022.

The targeted topic of this review is the voluntary adoption of BMPs by farmers, regardless of whether it is government-supported or not. Therefore, this review does not consider farmers' decisions to comply with mandatory environmental regulations. In addition, the review focuses on individual decisions; hence, coordinated efforts between farmers to protect the environment are not included here. Including studies that discussed the BMPs related to the residential areas is limited in this review because the practices in the agriculture sector differ from those in the residential sector. However, there are a few examples taken from the residential experiments regarding BMP adoption where it applied to the specific section.

Since this review will include some policy recommendations for motivating Canadian farmers toward BMP adoption, I focused on studies done in developed countries. Although a large portion of agri-environmental adoption literature examines the barriers to adoption in developing countries (example: Lipper, 2014; Pannell et al., 2014; Chandra et al., 2018; Arslan et al., 2015; Murage et al., 2015), challenges faced by farmers in developing nations are different when compared to those in developed ones (Lee, 2005). These include affordability and accessibility to external inputs like fertilizers and machinery (Lee, 2005). Moreover, the policy designs also differ in developing countries, limiting the inclusion of studies done in developing countries in this review.

For the nudge literature, there were a few additional exclusion criteria. For example, studies before 2008 were not considered as the term 'nudging' did not exist before the work of Thaler and Sunstein (2008). In addition, I only included studies that did mention the word 'nudge' or 'nudging,' quoted the origin of this theory (Thaler and Sunstein, 2008), and were linked to the nudge concept. It should be noted that although all types of nudges are considered behavioral interventions, not all types of behavioral interventions are nudges.

The rest of this review is structured as follows: In the next section, i.e., section 2.3, I will discuss the BMPs and the factors that impact BMP adoption. In sub-section 2.3.1, I will review the general observable factors influencing BMP adoption. Though the focus of this study is not to review observable factors, this section is included to justify the importance of including behavioral factors in adoption studies and to complete the review. Sub-section 2.3.2 discusses the behavioral factors that can positively and negatively impact farmers' adoption of BMPs. Moving forward, in section 2.4, I will explore nudge literature. Sub-section 2.4.1 will synthesize the information on the impacts of nudging in various disciplines, while sub-section 2.4.2 will demonstrate examples of nudging in the agri-environmental sector. Section 2.5 is the discussion section summarizing the findings from sections 2.3 and 2.4 and discussing how Canadian policymakers might apply nudges to address the behavioral factors in BMP adoption. Finally, Section 2.6 is the concluding section of this study.

2.3: BMP adoption

BMPs refer to sustainable agricultural production practices (Bechini et al., 2020). The prime reason behind developing BMPs is to achieve the goals of high productivity in the agriculture sector while maintaining a sound environment (Pannel et al., 2006; Shah et al., 2022). While reviewing the literature, several definitions of BMP were identified by me. However, I found a similarity regarding protecting the environment and economic sustainability at the farm level across all these definitions. The following paragraphs summarize some definitions collected from government, academia, and industry.

Across Canada, BMPs are defined in many ways. A BMP is any management practice that reduces or eliminates an environmental risk while covering areas ranging from pesticide handling to energy efficiency to water quality and considers legislation, practicality, and operational needs for a specific operation (Government of Alberta, a). According to the Ontario Ministry of Agriculture, Food and Rural Affairs [OMAFRA] (2020), BMPs improve agricultural sustainability by encouraging producers to conserve soil and water resources, protect agricultural land, and mitigate the release of agricultural pollutants while keeping the productivity same. BMPs are "meant to help maintain or improve a farm's soil, water, air, and wildlife habitat resources, and therefore contribute to the farmstead's overall sustainability and the economic and environmental health of the farm family, as well as the surrounding landscape and community" (AAF, 2018). Agricultural BMPs primarily include managing nutrients, controlling erosion and runoff to prevent soil erosion and reduce the movement of nutrients, and planting barriers and buffers to intercept sediments and nutrients transported from the field (Agriculture and Agri-food Canada, 2000).

BMP adoption provides environmental benefits, including air, soil, and water quality improvements (Lefebvre et al., 2015). BMPs improve end-of-catchment water quality by aiming to reduce diffuse source pollution from agricultural lands (Greiner et al., 2009). Around the world, government agencies, non-governmental organizations, and individuals have been making various efforts to reduce this non-point source pollution (Liu and Ruebeck, 2020). Non-point source implies that tracing the source of pollution is extremely difficult, and agricultural emissions tend to originate from non-point sources of pollution (Weersink et al., 1998; Shortle and Dunn, 1986). The difficulty of finding the sources of emissions makes the policies infeasible, which target reducing emissions. However, the amount of pollution from agricultural non-point sources might

be reduced by different BMPs, including wetland restoration, cover crop planting, and nutrient management (Lang & Rabotyagov, 2022).

Developing universal BMPs is difficult as the agricultural sector operates differently in various countries. According to the Intergovernmental Panel on Climate Change (IPCC), adaptive and mitigative practices and their adoption rely 'on climate, edaphic, social setting, and historical patterns of land use and management (Smith et al. 2007).' However, some common BMPs related to water quality include controlling runoff from manure storage or livestock pens and applying chemical fertilizer at the recommended rate. BMPs used to conserve soil quality include reduced tillage and crop rotation. To protect biodiversity, some examples of BMPs are avoiding draining or filling in natural wetlands/sloughs and managing to graze for wildlife habitat. Air quality-related BMPs usually involve using renewable energy and planting trees for agricultural purposes.

Farmers can receive various long-term and short-term as well as observable and unobservable benefits by adopting BMPs. However, BMPs are considered "beneficial" if farmers find them as economically sustainable practices that will contribute to food quality or quantity and the protection of environmental resources (Canadian Fertilizer Institute, in Brethour et al., 2007). Although adopting BMPs might improve the quality of the environment while maintaining productivity, producers face several barriers when trying to adopt them. Some practices have high uptake costs or long-term maintenance costs, which create a financial barrier and can result in perceived risks to profitability (Prokopy et al., 2019; Pannell et al., 2006; Rodriguez et al., 2009). If BMPs reduce current profitability, farmers will not adopt them unless they recognize the BMPs' contribution to future profitability, which will offset their short-run costs (Frisvold et al., 2009). Moreover, many producers do not have proper access to adequate information about the BMPs

(Baird et al., 2016; Baumgart-Getz et al., 2012), resulting in being unaware of eligible practices for their operation.

Figure 1 depicts farmers' BMP adoption process shown in Weber (2017). Background factors, including demographics and farm characteristics, shape farmers' beliefs regarding BMP adoption, further determining attitudes and perceptions. Intention to adopt BMPs depends on those perceptions, which further determine what actions to take. However, actual control factors such as resources impact the perception and action. This implies that even if farmers are motivated and perceive BMPs as beneficial, other factors might create a barrier to action. Therefore, the observable and behavioral factors are interlinked and impact farmers' adoption decisions.

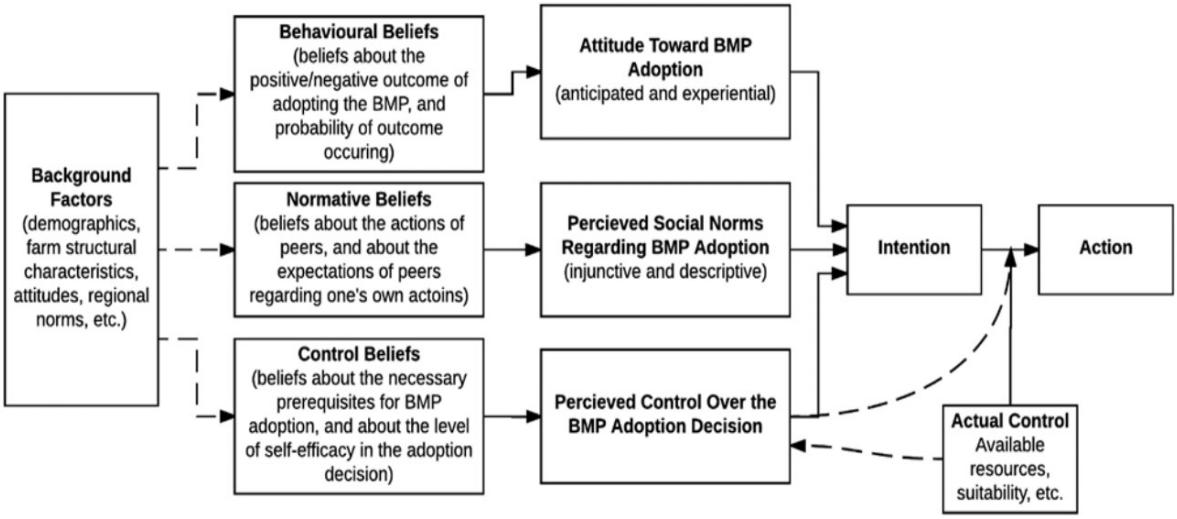


Figure 1: Farmers' BMP Adoption Process (Weber, 2017)[1]

[1] Figure 1 Schematic of the Reasoned Action Model in Weber 2017, adapted from Fishbein & Ajzen (2010) and Jorgensen & Martin (2015).

Since the decision to adopt a BMP depends solely on the producer due to its voluntary nature, Canadian policymakers have developed several financial incentives and education programs to stimulate the adoption process (Traxler and Li, 2020). The Canadian Agricultural Partnership (CAP) is a federal-provincial-territorial government investment that supports cost-share funding, business risk management programs, and educational activities such as workshops and online learning (Government of Canada). In addition, province-based programs such as 'The Canada-Ontario Environmental Farm Plan' are designed to provide voluntary environmental education and awareness programs for encouraging farmers towards BMP adoption in Ontario province (OMAFRA, 2019). MacKay et al. (2010) developed a BMP adoption index that measures a score based on the number of BMPs implemented ranked according to the level of their environmental benefit to examine the extent of BMP adoption in Canada. The average BMP adoption score for producers across Canada was 25-40%, indicating Canadian producers' moderate adoption level (MacKay et al., 2010). Therefore, identifying what factors impact the adoption process and formulating policies and programs based on those findings would help to promote BMPs.

2.3.1: Observable Factors Impacting BMP Adoption:

Previous studies show that a farmer's decision-making process to adopt a BMP is complex, and various factors can influence it (Bogdan and Kulshrestha, 2020). In the literature, several observable factors were examined by researchers that could influence a farmer's decision to adopt BMPs. The meta-analysis by Prokopy et al. (2008), Baumgart-Getz et al. (2012), and a review of literature by Knowler and Bradshaw (2007) all demonstrated the fact that few factors are consistently influential in farmers' adoption of BMPs. Despite contradictory results regarding their impact, some common predictors of BMP adoption mentioned in the literature are described below.

Farm and Farmer characteristics

Farm and farmer characteristics are common additions to a BMP adoption analysis across the agri-environmental literature, though their influence on adoption is often debated, with contradictory results (Baumgart-Getz et al. 2012; Prokopy et al. 2008; Prokopy et al. 2019). Some frequently mentioned characteristics of both farms and farmers that might influence adoption decisions are described in the following paragraphs.

Farm Size

Farm size is found to have a significant positive impact on BMP adoption in the literature (Armstrong et al., 2011; Baumgart-Getz et al., 2012; Liu et al., 2018; Prokopy et al., 2008). Financial incentives influence large farms to adopt early, whereas late adopters get pressure from their peers (Liu et al., 2018). However, some studies have concluded that total farm size is not an essential variable in explaining participation in agri-environmental measures (Comerford, 2014; Nebel et al.,2017).

Land ownership

Agricultural operations decisions might vary between farmers renting and owning the land. The land tenure variable, which is the proportion of land owned to land operated, is often found to be an insignificant factor in BMP adoption (Baumgart-Getz et al., 2012; Knowler & Bradshaw, 2007; Liu et al., 2018; Mishra et al., 2018; Prokopy et al., 2008). However, results by Soule et al. (2000) and Kim et al. (2005) indicated that renters are significantly less likely than owners to adopt BMPs with long-term benefits. Lawin and Tamini (2019) also found that land tenure arrangement significantly influences farmers' decision to invest in agri-environmental practices. Results by

Deaton et al. (2018) suggest that the role of tenure might vary with different types of conservation practices. They found that both renter and owner farmers were equally likely to adopt machinery-related practices (e.g., conservation tillage), while renter farmers were less likely to adopt site-specific practices (e.g., planting cover crops).

Diversity

Farm diversity is another factor mentioned as significantly positive in several BMP adoption studies (Liu et al., 2018; Mishra et al., 2018; Prokopy et al., 2008). Diversified farms are found to adopt BMPs more in a study on cattle producers by Kim et al. (2005). As more practices will apply to diverse farmers, they might be more likely to adopt them at a higher rate.

Education

A positive and significant relationship between farmers' education and BMP adoption is consistently documented in the BMP adoption review literature (Knowler & Bradshaw, 2007; Liu et al., 2018; Mishra et al., 2018; Prokopy et al., 2008). The level of formal education a farmer has attained has been found to have a positive relationship with nutrient management (Gedikoglu et al., 2011), soil management (Barbercheck et al., 2014), and maintaining setbacks (McCann et al., 2015). Frisvold et al. (2009) mentioned 'having more education' as a factor significantly and positively associated with adopting more BMPs. These results intuitively make sense as farmers with higher levels of formal education might acquire more information about the usefulness of management practices, leading to more adoption.

Yet, it has been demonstrated in some studies that more education does not necessarily mean increased pro-environmental behavior (Kollmuss and Agyeman, 2002; Nebel et al., 2017). A

possible explanation can be that farming education may not come from formal education (Goodale et al., 2015). Instead, farmers can acquire agricultural knowledge frequently from sources including family members, neighbors, books, the internet, or even stewardship or government programs (Mobley et al., 2009).

Extension services

Extension services, such as farming education programs and various formal and informal training (Tamini, 2011), also positively impact participation in BMP adoption. It has been found that extension services are vital when it comes to learning new technologies (Krishnan and Patnam, 2013), particularly for the ones that are more complex and demanding (Wuepper et al., 2017). The average effects of agri-environmental extension activities are statistically significant for most BMPs analyzed in the study by Tamini (2011). Baumgart-Getz et al. (2012) indicated in their meta-analysis that extension education (i.e., training) positively influenced BMP adoption.

Age and Farming Experience

The relationship between farmer's age and BMP adoption is consistently negative in the literature, though the results showed both significant and insignificant effects. Generally, age measured in years has been shown to affect adoption negatively (Baumgart-Getz et al., 2012; Mishra et al., 2018; Prokopy et al., 2008). The reason could be that older farmers do not want to consider the long-term benefits of adopting BMPs. However, other studies concluded that the relationship is insignificant, and that age is an ineffective determinant in adoption (Knowler & Bradshaw, 2007; Liu et al., 2018). Surprisingly, results by Kim et al. (2015) showed that older cattle producers were higher adopters of BMPs. Farmers' experience, another variable that is thought to have a positive

impact on BMP adoption, is mainly found insignificant in the existing literature ((Baumgart-Getz et al., 2012; Knowler & Bradshaw, 2007; Liu et al., 2018; Prokopy et al., 2008).

Information and Networking

Access to information and the ability to process it significantly influence BMP adoption (Kim et al., 2005). Access to information is mentioned in the adoption literature frequently as one of the significant factors of BMP adoption (Armstrong et al., 2011; Baumgart-Getz et al., 2012; Prokopy et al., 2008; Boyer et al., 2018), which implies that adoption rate is higher when farmers are aware of the BMPs. Lack of access to information about BMPs can be a significant barrier to adoption (Liu et al., 2018; Mishra et al., 2018). Brehm et al. (2013) found that Knowledge of BMPs is strongly correlated with their use in the case of residential BMP adoption.

Social networks, as mentioned by Prokopy et al. (2008), refer to the combination of different kinds of networks, including local networks (i.e., interaction among neighboring farmers and any grassroots organization), agency networks (i.e., connection to agency personnel and familiar with procedures), and business networks (i.e., agribusiness sector networking). All the networking variables were found as significant determinants of BMP adoption, regardless of the type of BMP (Prokopy et al., 2008). The study by Baumgart-Getz et al. (2012) also found that the connection to local networks of farmers or agencies is one of the most significant variables affecting adoption.

Economic Factors

From an economic perspective, the impact of adopting a practice on a farmer's utility, profitability, and overall operation productivity is a significant concern during the decision-making process (Chouinard et al., 2008; Cary and Wilkinson, 1997). Farmers are assumed to be profit maximizers,

and therefore, they only participate in an agri-environmental scheme if the conservation payment is sufficiently high to deliver a financial advantage that outweighs the lost opportunity and transaction costs (Greiner, 2015). The 2011 Farm Environmental Management (FEM) survey reported that roughly 55% of Canadian farmers selected economic barriers as a reason for not implementing BMPs (Statistics Canada, 2013). A study found that farms with greater financial resources were likely to adopt BMPs more, suggesting that economic assistance is necessary for adoption decisions (Kim et al., 2005).

Financial factors, mainly income, are regularly mentioned as a determinant in the adoption decision. Most BMP adoption review studies reported income to affect adoption significantly (Baumgart-Getz et al., 2012; Boyer et al., 2018; Knowler and Bradshaw, 2007; Liu et al., 2018). Higher income increases the affordability of farmers to invest in BMPs. In contrast, the result by Prokopy et al. (2008) suggests that the ability to afford does not indicate a farmer's willingness to adopt BMPs. Similarly, 'access to capital' has a significant positive effect on adopting BMPs (Baumgart-Getz et al., 2012; Liu et al., 2018). Financial constraints from lower capital levels and high debt are significant barriers to adopting BMPs (Knowler & Bradshaw, 2007; Rosenberg and Margerum, 2008). Costs associated with the BMPs are also mentioned as one of the main barriers in the adoption process (Bechini et al., 2020; Shah et al., 2022).

2.3.2: Behavioral Factors in BMP Adoption

Farmers' behavior regarding BMPs is complex and content-specific; they are a highly diverse group, as their preferences and personalities, environmental motives, and attitudes toward conservation programs differ (Reimer et al., 2014). A better understanding of drivers and barriers to farmers' BMP adoptions may thus be obtained using a behavioral approach, which means

investigating individual farmers' decision-making processes using quantitative methodologies (Burton, 2004; Edwards-Jones, 2006). Experimental and behavioral economics offer valuable tools for studying BMP adoption because they can directly measure individual preferences and establish a causal link between behavioral factors and decision-making (Dessart, 2019). If we can understand how people use or abuse nature and the reason behind it, only then can strategies be designed to influence choice in a way that will positively impact conservation (Cowling, 2014).

Previous studies that tried to investigate the factors influencing farmers' adoption of BMPs mainly focused on how the observable socio-economic factors affect the adoption; they did not emphasize the unobservable behavioral factors. As a result, monetary incentives are thought to be the best option for encouraging farmers to adopt practices. But, if behavioral attributes are considered, non-monetary approaches might also effectively motivate them. Kuhfuss et al. (2016) noted, "motivations other than profit can also be expected to influence farmers' choice to contribute to the provision of environmental services, even without monetary compensation." Therefore, to shift farmers' behavior in a desirable direction, behavioral factors should be included while structuring the incentives (Polasky et al., 2019). Greiner et al. (2009) found that a sound understanding of farmers' motivations and risk attitudes is required to tailor public investments to provide relevant improvements in agriculture's environmental performance.

Economic payoffs may motivate people's behavior, but social and psychological factors impact their decisions. (Carlsson and Johansson-Stenman, 2012). Combining psychology with conservation science will create the behavioral Conservation field, which needs to emerge promptly to solve conservation problems (Cowling, 2014). In this section, I will describe behavioral factors frequently mentioned in the literature as determinants in conservation decisions.

Risk Tolerance

Risk tolerance is often reported in the literature, influencing farmer behavior across many areas, such as signing crop insurance contracts and adopting crop diversification (Hellerstein et al. 2013). Kim et al. (2005) mentioned that risk-tolerant farmers might be more willing to adopt conservation. Liu (2013) elicits risk preferences from Chinese cotton farmers, and they found risk-averse farmers tend to be late adopters of Bt-cotton. However, some authors found that this factor has no direct relationship with BMP adoption (e.g., Trujillo-Barrera et al., 2016). The results found by Reynaud & Couture (2012) indicated that risk preference depends on the context, as farmers in France showed different preferences in different contexts.

A risk-aversion index was developed by Ervin & Ervin (1982) to identify farmers' preferences for avoiding risk. Their results show that the risk-averse farmers hesitate to accept the short-run losses in exchange for the less certain benefits of conservation practices in the long run. They also mentioned that the adoption rate of practices by farmers with higher risk-aversion values is expected to be low (Ervin & Ervin 1982). Baumgart-Getz et al. (2012) presented a different dimension regarding risk perceptions. Their thorough meta-analysis shows that risk was an insignificant factor with minimal heterogeneity, corresponding to their hypothesis that risk has diminished over time as BMPs have become more common.

Farming Values

This factor is not commonly mentioned in BMP literature. However, traditional values used in land management for generations may create a barrier for farmers while adopting BMPs (Armstrong et al., 2011). A recent study examining the role of the status quo bias in the agri-environmental policy

found that many farmers systematically resist any changes in farming practices (Barreiro-Hurle et al., 2018). This resistance to change made conventional hog farmers in Germany avoid investing in an organic barn (Hermann et al., 2016).

Famers' Attitude

The variable attitude is included in several BMP adoption studies and have been found to impact adoption (Prokopy et al., 2008; Prokopy et al., 2019). Farmers' attitudes toward new technologies, risk, and uncertainty might influence their adoption decisions (Tamini, 2011). Adopting new agricultural technologies is dynamic since adoption decisions happen in various stages and can evolve (Streletskaya et al., 2020). Understanding farmers' social preferences and their impact on agricultural technology decisions can help shape agriculture policy and programs and help address problems such as climate change (Ferraro et al., 2017).

Farmers with a positive attitude toward a specific conservation program or practice may also be more likely to adopt conservation practices (Prokopy et al., 2019). Awareness of technical information about BMPs can change farmers' attitudes towards them (Lemke et al., 2010). For example, Ulrich-Schad et al. (2017) found that farmers were significantly less likely to use a Nutrient Management Plan or conduct soil tests when concerned about a lack of access to necessary equipment. The study by Armstrong et al. (2011) shows that farmers' attitude towards conservation policies was one of the strongest predictors of Conservation Reserve Enhancement Program adoption in the USA.

Environmental concerns

Environmental concern influences farmers' adoption of BMPs and has often been documented by researchers as a determinant in BMP adoption (Best, 2010; Läpple and Van Rensburg, 2011). The way farmers view the necessity to make an environment-friendly decision matters in case of adoption. Prokopy et al. (2008) suggested that positive sentiment towards the environment is related to the increasing adoption of BMPs in various geographic contexts of the USA. Lang & Rabotyagov (2022) found that awareness of environmental problems and appreciation of ecosystem services significantly impact landowners' adoption.

Despite the number of studies on environmentally responsible behavior, there is still disagreement on how environmental concerns can predict behaviors (Mobley et al., 2009). Results by Mishra et al. (2018) indicated that producers' concerns toward the environment have an insignificant effect on adopting BMPs. An important thing to note here is that there is often a disconnect between environmental attitudes and pro-environmental behavior (Méthot et al., 2015; Kennedy et al., 2009). Even with a concern for the environment, a range of "demographic, external factors (i.e., institutional, economic, cultural), and internal factors (i.e., awareness, motivation)" can affect how the environmental attitude is turned into action (Kollmuss and Agyeman, 2002).

Self-interest and identity

The challenge with addressing environmental issues in agriculture is that farmers have conflicting interests towards environmental sustainability and often behave in their self-interest (Palm-Forster et al., 2019). Several studies have shown that farmers with positive mindsets regarding stewardship and others' interests may be more likely to adopt practices than those with higher levels of self-

interest (Reimer and Prokopy, 2012; Thompson et al., 2015; Floress et al., 2017). A farmer prioritizing self-interest will want to increase productivity and profit without considering the negative externalities of unsustainable agricultural production that harms society (Lefebvre, 2015).

In contrast, farmers caring for society's interest might be better motivated to eliminate environmental threats and are more likely to support practices such as adopting conservation tillage (Sheeder and Lynne, 2011) and participating in voluntary forest preservation or wetland restoration (Johansson et al., 2013). Chouinard et al. (2008) found that some farmers were ready to forgo profits to engage in BMP adoption.

Self-identity, defined as how humans socially construct themselves, has been found to have a direct relationship with the decision-making process of individuals (Thomas, 2019). This variable is mentioned in recent literature as associated with BMP adoption (Prokopy et al., 2019). Individuals are more likely to engage in pro-environmental behaviors if their identity is strongly linked to their sense of community (Forsyth et al., 2015). In an agricultural context, farmers' willingness to protect the environment might be determined partly by how they define the meaning of being a farmer (Thomas, 2019). Farmers who self-identify as stewardship-motivated are more concerned about BMP adoption and are likelier to adopt practices (Prokopy et al., 2019).

Climate Belief

Farmers' beliefs regarding climate change are documented in recent studies as a factor in adopting conservation practices. For instance, Mase et al. (2016) found that farmers were likelier to adopt in-field conservation practices when they believed the weather changes were damaging their farms. In addition, farmers who believe in human-caused climate change are found to be more likely to support climate-mitigative policies (van Wyngaarden et al.). An Australian study found that people

who believe human actions contribute to climate change have higher WTP for reducing GHG emissions compared to people who do not believe in climate change (Kragt et al., 2016).

Farmers' Perceptions of BMP

Farmers' perception of the benefit of a particular conservation practice may determine their decisions regarding using those practices (Zhang et al., 2016; Shah et al., 2022). The article by Bogdan and Kulasrestha (2020) focused on identifying factors contributing to farmers' perceptions of BMPs as better farm alternatives. The results suggested that farming experience, higher levels of educational attainment, exclusive financial goals, and perceiving the BMPs to be expensive were negatively related to the perception of the proposed BMPs as better alternatives. In contrast, growers gaining a more significant percentage of their revenue from the crop under study, and those who thought making the best use of scarce resources was important were more likely to perceive the proposed BMPs as better alternatives.

The above sub-sections of this section included examples of observable and behavioral factors impacting BMP adoption. Previously, in Fig. 1, it was shown that observable factors might somehow be shaping the behavioral attributes. Fig. 2 depicts a Venn diagram from a study by Mills et al. (2017), who developed a conceptual framework to show the relationship between farmers' willingness, ability, and engagement in BMP adoption and the factors involved with these three determinants.

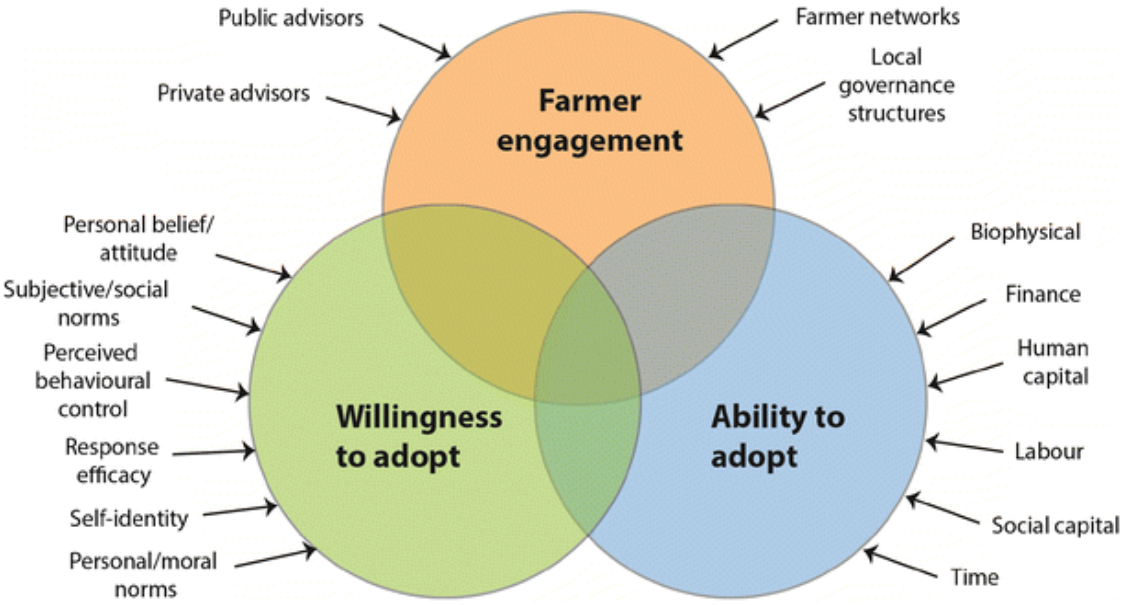


Figure 2: Factors in farmers' environmental decision-making (Mills et al., 2017)

Figure 2 shows that the behavioral attributes mainly determine farmers' willingness to adopt, while the ability depends on observable economic factors. The engagement level is influenced by their networks and the information they receive from various sources. This review attempts to discuss how farmers' willingness might be influenced positively by addressing the behavioral factors using nudges. Nudging could also be a way to increase farmers' engagement in BMP adoption. Discussion section 2.5 will also mention other policies to address the factors impacting farmers' ability to adopt BMPs.

The following sections will explore how different nudges have been applied to different disciplines, including the agri-environmental sector.

2.4: Behavioral Nudges

The concept of nudge, which is based on behavioral economics, was first introduced by behavioral economist Richard Thaler and the legal scholar Cass Sunstein in 2008 in their book titled '*Nudge: Improving Decisions About Health, Wealth and Happiness'* as a policy design that can be used to pursue the socially optimal goals. The original definition of a nudge was "any aspects of the choice architecture that alters people's behavior predictably without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein, 2008). According to the authors, the intervention must be "easy and cheap to avoid," and "nudges are not mandates." Moreover, Thaler and Sunstein added that a nudge "significantly alters the behavior of humans even though it would be ignored by econs (individuals who are consistently rational in the way that they maximize utility)" (Thaler and Sunstein, 2008).

After the book's publication, several authors revised or modified the initial definition of a nudge. According to Hansen (2016), "a nudge is a function of (I) any attempt at influencing people's judgment, choice or behavior in a predictable way (1) that is made possible because of cognitive boundaries, biases, routines and habits in individual and social decision-making posing barriers for people to perform rationally in their own declared self-interests and which (2) works by making use of those boundaries, biases, routines, and habits as integral parts of such attempts". Nudges are also defined as 'liberty-preserving approaches that steer people in particular directions' (Sunstein, 2014). Sunstein further updated his definition of nudges as: "private or public initiatives that steer people in particular directions, but that also *allow them to go their own way"* (Sunstein, 2018).

Nudges can be an effective method for better decision-making in various applications (Ferraro et al., 2017), and many researchers have applied the nudge theory in experiments to improve the decision-making process. A nudge is no longer just a theoretical concept and affects individuals through its influence on political decision-making (Hummel and Maedche, 2019). Literature that explores nudges is often in the health science context (Arno and Thomas, 2016; Adam and Jensen, 2016; Bucher et al., 2016; Cadario and Chandon, 2018). Across the literature, multiple forms of nudging exist. In this review, I will follow the classification of nudges inspired by the "MINDSPACE" framework presented by Dolan et al. (2012), which policymakers use as an accessible summary of the academic literature.

2.4.1: The MINDSPACE Framework

Governments in different countries have adopted nudging techniques to steer citizens toward more thoughtful behaviors (Kankane et al., 2018). An example is the UK's "nudge unit" developed in 2010 to change people's behavior for the public good. That nudge unit created an acronym, MINDSPACE, that lists the most effective, non-coercive nudging strategies for behavior change (Quigley, 2013). Other research also identified effective nudging techniques that confirm those listed in MINDSPACE (e.g., Blumenthal-Barby and Burroughs, 2012). The mnemonic gathers up the nine most robust effects (i.e., Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitment, and Ego) that mainly influence behavior automatically. The following paragraphs will discuss the evidence found in existing literature regarding the application and impact of each nudge in several disciplines, including health and psychology. These findings will be useful in understanding how these nudges may also be applied to promote agricultural BMP adoption by Canadian farmers.

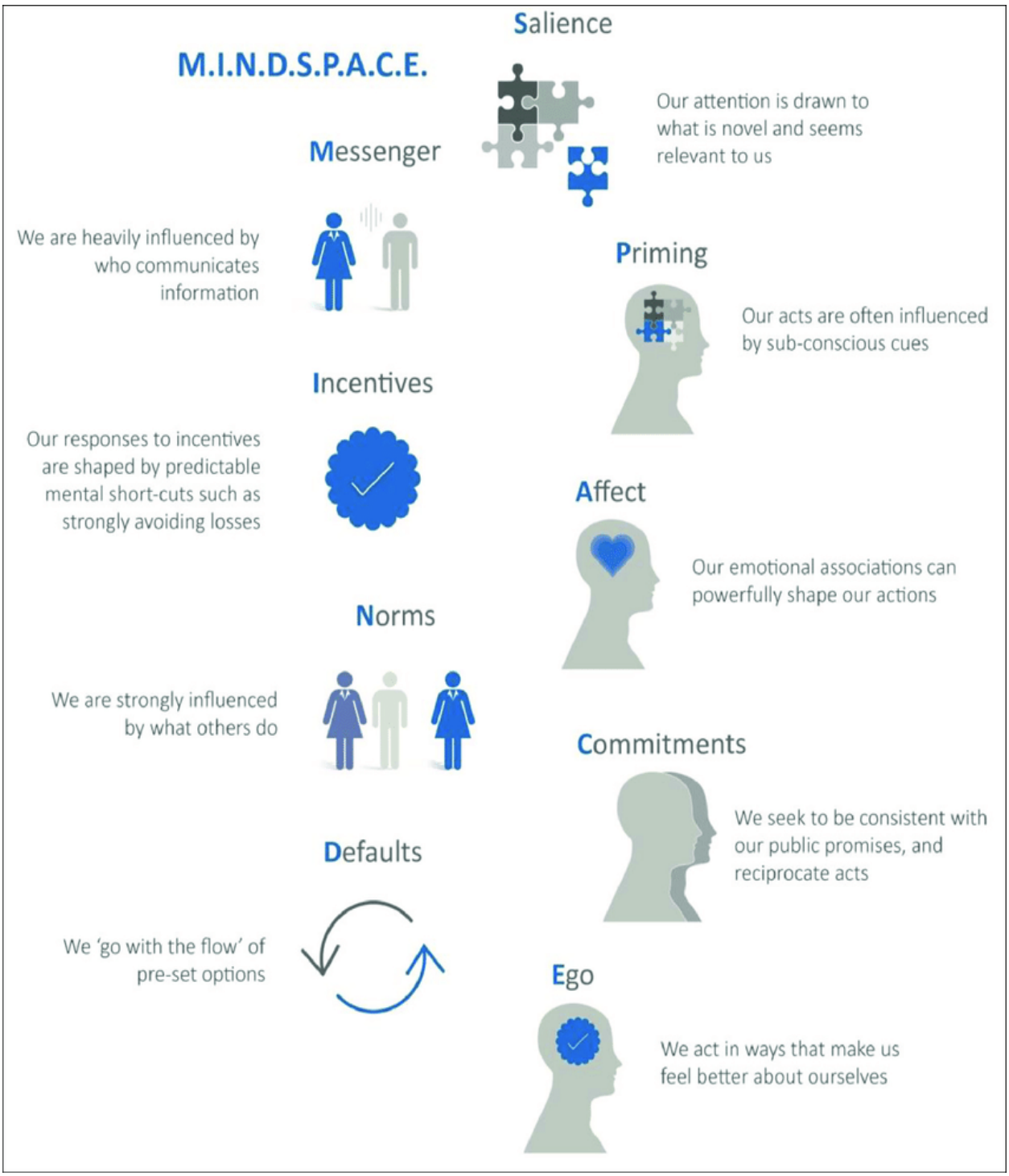


Figure 3: Mindspace influences (Lennox-chhugani, 2018)

Messenger

The value we put on information highly depends on the provider, who can be addressed as a 'messenger.' According to Dolan et al. (2012), "we are heavily influenced by who communicates information to us." Researchers have found that people respond positively when they find messengers having similar demographic and behavioral characteristics to themselves (Durantini et al., 2006). In a study by Hoffner (2009), young adults were nudged to use sunscreen in part by receiving a message from a personal exemplar, and they were more affected if they had a high similarity to the exemplar. People's behavior can also be affected by their feelings for the messenger; for instance, we may ignore the advice given by someone we dislike (Cialdini, 2007).

Incentives

People tend to respond to incentives by nature. Incentives are "rewards or punishments to compel individuals to take an action" (Kankane, 2018). However, the impact of any incentive can be affected by behavioral factors, and understanding them can help create better schemes (Dolan et al., 2012). Though incentives are generally used to motivate people to lose weight, take medications, exercise, stop smoking, etc., there are also novel uses. In Malawi, people were offered an incentive equal to approximately one-tenth of a day's wage for picking up their HIV test results, doubling the pickup rate (Institute for Government and the Cabinet Office, 2010). In another study in the USA, teens already having a baby were paid one dollar a day for each day they were not pregnant, and teenage pregnancies were reduced (Thaler and Sunstein, 2008). Incentive schemes are primarily offered as rewards to participants. Still, a recent review of trials of treatments for obesity involving the use of financial incentives found no significant effect on long-term weight loss or maintenance (Paul-Ebhohimhen & Avenell, 2008).

An alternative may be to frame incentives as a charge imposed if people fail to do something. The theory behind this is the loss aversion theory, which states that 'people value losses more than the equivalent gains' (Kahneman & Tversky, 1979). Put simply, incentives are more effective if they are framed regarding loss. A study on weight loss asked participants to deposit money into an account, which was only returned to them (with a supplement) if they met targets. After seven months, the group showed significant weight loss compared to the participants in control (Volpp et al., 2008). Hossain and List (2012) also used this loss-framing nudging concept. They showed that a loss-framing incentive payment system produced better output than a gain-framing system from employees in a manufacturing company.

Norm

Informing someone about their behavior compared to another individual's behavior as an indication of 'social norm,' also known as a 'social comparison nudge,' can make a difference in their decision-making (Croson and Treich, 2014).). 'Social norm' or 'norm,' a nudge examined in several studies, is described by Ouvrard et al. (2020) as: "…. rules that guide individual behaviors in a given situation, and these rules are influenced by one's perception of what other individuals do." Information nudge is another form of the social norm where the targeted group is provided with the necessary information regarding practice or with general information about their peers without comparing them to each other.

Recent literature has used the concept of information nudges to shape individual behavior (Hotard et al., 2019; Sudarshan, 2017). In the case of providing a public good (i.e., goods accessible by everyone and using them by one person does not reduce the availability to others), the intra-group comparison can significantly improve the level of cooperation (Bohm and Rockenbach, 2013).

Alcott (2011) described that if individuals can be notified about their electricity consumption compared to their neighbors who consume less electricity, this can reduce that individual's electricity consumption. Social comparison nudge was also helpful in decreasing water consumption (Ferraro and Price, 2013; Schultz et al., 2016) and increasing voluntary involvement in green-certified lawn care services (Miao et al., 2017). Despite the positive evidence, the effect of informational nudges[2] on behavior is highly context-specific, and the effect varies with the types of information provided and the individual's ideology (Miao et al., 2017; Costa and Kahn, 2013).

Default

Default is another type of nudge shown to be effective in various contexts. In the decision-making process, defaults are the options that would be enforced automatically if no other choices are made (Dolan et al., 2012). Choice defaults are particularly attractive as they have been shown to strongly affect behavior while being straightforward to implement, cheap to administer, and maintaining people's freedom of choice (Ghesla et al., 2019). People resist change and 'go with the flow' of pre-set options, even if the alternatives may yield better outcomes (Fredericks et al., 2015). Egebark and Ekström (2016) demonstrated how the daily paper consumption rate was reduced due to a change in the default option in the printer at a university. Sunstein and Reisch (2013) provided several other examples of defaults in the context of green energy, paper savings, and smart grids.

[2] It should be noted that the terms' information' and 'social comparisons' are sometimes used as substitutes in the literature. As the nudging concept is still developing, the terminologies vary from study to study and country to country.

A positive effect of defaults on behavior has been observed in a wide range of other settings, including organ donation decisions (Abadie and Gay, 2004; Johnson and Goldstein, 2003), choice of car insurance plan (Johnson et al., 1993), and health care (Halpern et al., 2007).

Salience

Salience nudging includes "novel, personally relevant or vivid examples and explanations used to increase attention to particular choice" (Blumenthal-Barby and Burroughs, 2012). In a randomized control trial, Wisdom et al. (2010) found that overall calories purchased at a fast-food sandwich restaurant were reduced when labels containing either the number of calories in an item or a daily calorie recommendation were displayed. A salience nudge also improves cybersecurity behaviors (Kankane, 2018).

However, mixed results have been found regarding this nudge's effect on improving energy efficiency. Stadelmann and Schubert (2018) found that providing both a label and a visually augmented label that contained monetary and lifetime-oriented information on energy efficiency increased the sales proportion of energy-efficient appliances. In contrast, Allcott and Sweeny (2017) found that information provision did not affect the demand for energy-efficient durable goods. Thunström et al. (2018) highlighted that salience nudges might have unexpected welfare effects, and the direction of their impact can be the opposite of what was intended due to the complexity of consumer emotions and information processing.

Priming

Priming refers to the "subconscious cues which may be physical, verbal or sensational, and are changed to nudge a particular choice" (Blumenthal-Barby and Burroughs, 2012). This nudging

element has provided encouraging results in the nudging literature (Friis et al., 2017; Bimonte et al., 2020). According to the literature, subconscious cues influence our acts and can be strategically used for healthy behaviors. In one study, providing students with a map locating the student health center during the lecture on the risks of tetanus made them nine times more likely to get a tetanus shot (Thaler and Sunstein, 2008). Additionally, simple inquiries about a person's health habits, such as 'whether they intended to floss and how often'; 'whether they planned to consume fatty foods in the next week' made them follow healthy behaviors like increased flossing and less fat consumption (Thaler and Sunstein, 2008).

People can also be primed to make healthier choices by altering the size of food containers (Wansink et al., 2005) and sending reminders about health screening (Fiscella et al., 2010). However, priming also occurs through actual carvings into the environment. In Chicago, architects have painted white lines on the dangerous Lake Shore Drive curve to give drivers the illusion of speeding up. Accidents have since decreased by 36% (Thaler and Sunstein, 2008)

Affect

Affect, the act of experiencing emotion, is considered a powerful force in decision-making (Dolan et al., 2012). The emotional associations elicited by examples and explanations remain readily available in memory and result in powerfully shaping decisions and behaviors (Blumenthal-Barby and Burroughs, 2012). For instance, smokers were shown a video of either themselves or a loved one suffering from a heart attack to increase smoking cessation. More than 50% of study participants reported quitting smoking after three months (May et al., 2010). Radiologists were found to provide extended, more detailed reports and felt more connected to their patients when patients' photographs were attached to X-rays (Turner and Hadas-Halpern, 2008). Gibson (2008)

showed that consumer brand choice can be altered if positive or negative words and images are repeatedly paired with a brand. A campaign in Ghana was started to get people to wash their hands with soap. The campaign provoked the emotion of disgust rather than just promoting soap by using TV commercials. Soap use increased by 13% after toilet use and 41% before eating (Curtis et al., 2007).

Commitment

This form of nudge is strong as it requires people to commit to a behavior. According to Dolan et al. (2012), "We seek to be consistent with our public promises and reciprocate acts." For instance, in a study by Giné et al. (2010), an option of depositing money into an account was offered to those smokers who were willing to quit with the condition that they would get money back if they successfully quit smoking after six months. Failure to fulfill the requirement would result in giving away the money to charity. The result showed that the rate of quitting was approximately 3–6 percentage points higher for those enrolled in the program than the control group. In the study by Baca-Motes et al. (2012), hotel guests asked to behave more sustainably were more likely to reuse their towels than those not asked to commit. Another example is people signing a contract for their exercise program. Eighty-one percent of exercisers who signed the contract met their goal, compared to only 31% in the control group who did not sign a commitment contract (Williams et al., 2005).

Ego

Our behavior is directed toward improving our feelings about ourselves (Kankane, 2018). The effectiveness of many other nudges, such as commitment effect and salience, depends on the ego

of the person (Blumenthal-Barby and Burroughs, 2012). People tend to behave in a way that supports the impression of a positive and consistent self-image Dolan et al. (2012). This nudge is found to be impactful in increasing charity donations (Landry et al., 2006).

From the above paragraphs, it is confirmed that nudges have been found effective in several disciplines to alter peoples' behavior. Nudges might also be useful to redirect farmers' behavior towards more BMP adoption. However, agri-environmental studies that tested nudges are still very few. Therefore, the examples from the literature showing how different nudges are applied in other disciplines might help design agri-environmental policies using nudging attributes. The following section will synthesize the limited evidence of using nudging attributes in agri-environmental settings.

2.4.2: Nudges in Agri-Environmental Sector

When the nudges are implemented to reduce negative environmental externality, they are known as 'Green Nudges' (Carlsson et al., 2021). Schubert (2017) raised the idea of green nudges and considered them "*nudges that aim at promoting environmentally benign behavior*." To encourage eco-friendly behavior and minimize climate change's impacts, insights from behavioral economics are used in this nudging concept (Boruchowicz, 2021). Most studies that have used the green nudge concept relied on the social norm or default form of nudging (Example: Ferraro and Price, 2013; Brent et al., 2016; Egebark and Ekström, 2016; Ghesla et al., 2019).

In agri-environmental economics, a study by Higgins et al. (2017) suggests the policy tool nudge could effectively improve the cost-effectiveness of policies and programs. However, the limited number of studies testing nudges highlight that agri-environmental economists still have not fully

utilized this concept to improve agri-environmental policy and programs despite their possible effects (Palm-Forster et al., 2019; Ferraro et al., 2017). Although Nudging received little attention in promoting agricultural practices' adoption, it could potentially impact farmers' decision-making (Chabe-Ferret et al., 2019). However, it is important to understand that applying nudges directly to encourage BMP adoption may be complicated by barriers to adoption, resulting in personal and economic consequences. These may include large investments, long-term commitments, and significant provisions of public goods (Dessart et al., 2019), all of which may factor into the decision-making process.

To classify behavioral insights that are relevant to agri-environmental programs, Palm-Forster et al. (2019) developed a framework labeled as 'Ag-E MINDSPACE,' which is an extension of the MINDSPACE framework created by Dolan et al. (2012). 'Ag-E MINDSPACE' also comprises categories of nudges related to messengers, incentives, norms, defaults, salience, priming, affect, commitment, and ego, all of which can influence the behavior of farmers. According to this framework, this section will review the application of nudges in agri-environmental studies.

Messenger

Understanding the influence of different information sources, or messengers, on farmers' behavior is important because it affects the optimal public spending on extension services as a range of economic and environmental outcomes (Wuepper et al., 2021). Messengers may be vital in case of unpopular government programs as it would be beneficial to identify the type of information and the information sources that will be most effective in increasing participation and changing targeted farmers' behaviors (Palm-Forster et al., 2019). However, testing messenger impact in adoption literature is limited and do not provide consistent findings. For instance, a study on Swiss

fruit growers found that farmers advised by public extension services are likelier to use non-chemical preventive measures for pest management (Wuepper et al., 2021). In contrast, the findings of Purtaherian (2023) suggest that non-profit organizations have the highest impact on farmers' decision-making for cover crops and BMP adoption.

The farmers' response may also depend on their familiarity with the messenger. For example, Butler et al. (2019) found in an experiment that groups of firms reduce pollution when a community mascot expresses negative emotions regarding poor water quality outcomes. They also mentioned the success rate is expected to be higher when the mascot is more familiar or connected to the community. Reddy et al. (2020) suggest that future experiments should be done to investigate the relative importance of message, messenger, and their interactions.

Incentives

Incentives are commonly used in agri-environmental programs to motivate farmers to participate. Though agri-environmental economists studied the impact of incentives, analysis of how to frame incentives by complementing behavioral nudges has been mostly absent from the literature. Introducing the loss framing concept, that is, telling farmers how much they can lose (e.g., increased fertilizer cost) if a practice is not adopted rather than giving them money for adopting practices, may increase the adoption rate for the programs (Ferraro et al., 2017; Adde, 2023).

Some studies mentioned that farmers prefer instant payoffs relative to more significant yields in the future (Duflo et al., 2011; Duquette et al., 2012). This phenomenon is referred to as "present bias" or "discounting the future" (Dolan et al., 2012; Fredericks et al., 2015). Farmers, like other economic agents, might also avoid actions that offer longer-term benefits but are costly in the short term (Fredericks et al., 2015). Duquette et al. (2012) found that farmers with discount rates higher

than average are typically the "late adopters" of agricultural BMPs. Therefore, promoting the short-term benefits of BMPs and designing incentives to reduce the associated costs is necessary to encourage adoption.

Norms

Information on a social norm can be a powerful behavioral nudge to increase the permanence of pro-environmental activities (Kuhfuss et al., 2016). The experiments done by Banerjee et al. (2014) indicated that if landowners are informed about both their direct and indirect neighbors' actions, they are more likely to produce the socially optimal configuration. Studies mentioned the positive and significant impact of neighboring farmers' viewpoints on the farmers' decision to participate in agri-environmental schemes and adopt conservation practices (Cullen et al., 2020; Gillich et al., 2019). An Italian study found that the main difference between adopters and non-adopters was due to referents' opinions on applying them, which implies that for the adoption of best management practices, it is essential that the community of family members, neighbor farmers, and various advisors, are in favor of adoption (Bechini et al. 2020). These findings will help design the agri-environmental programs better in which farmers' resistance to trying new BMPs creates difficulty in engaging them (Palm-Forster et al., 2019).

Informational nudges have also been mentioned as effective in improving non-point source pollution management programs (Wu et al., 2017) and increasing adoption of smart water meters (Ouvrard et al., 2020). The analysis by My et al. (2022) showed that combining social comparison concerns with information nudge can be an effective method to encourage farmers to move towards environment-friendly agricultural practices. On the contrary, the results by Peth et al. (2018)

implied that the preventive effect of the information nudge was more substantial than the combined effect of both information and social comparison nudge.

Default

In agri-environmental program design, defaults are rarely used strategy (Palm-Forster et al., 2019). One study found that setting the starting point of online slider bar to 100% cost-share instead of 0% in an online auction for conservation contracts, which require farmers to adopt practices, resulted in higher bids (Messer et al., 2015). Ferraro et al. (2017) mentioned that default could be an attractive and powerful tool for agri-environmental programs. They suggested that the USA's Conservation Reserve Program (CRP) might perform better if the default starting point is set to the best practices, allowing farmers to opt out of those practices.

However, defaults have been applied in other environmental or agricultural contexts. For example, a default option could be easy and nearly cost-free to increase the number of enrollments in electricity programs or purchase renewable energy (Fowlie et al., 2017; Pichert and Katsikopoulos, 2008). Default was found as the reason for high voluntary participation in agricultural marketing programs where producers were automatically charged money to support egg marketing unless they requested it back (Messer et al. 2008). Defaults may be highly impactful when choices are complex, and farmers are expected to accept the default option more (Palm-Forster et al., 2019).

Salience

In the context of agri-environmental areas, salience nudge showed mixed effects. Banerjee et al. (2014) found in a laboratory experiment that spatial coordination and efficiency improve if a potential participant receives salient information about their neighbors' behavior. Salience nudge

has a broad subjective scope, and therefore, it can overlap with the other forms of nudges, including norm, priming, and affect, which also require the circulation of information (Palm-Forster et al., 2019).

However, salient information can sometimes have negative impacts as well. For instance, evidence from laboratory experiments tells that producers showed rent-seeking behavior in conservation auctions when they were provided with salient information which gave them a chance to recognize the environmental quality of their lands and the environmental benefits of the auction (Cason et al., 2003; Banerjee et al., 2015; Messer et al., 2017). In a study by Andrews et al. (2013), information about conservation tillage was framed as either profitable or environmentally beneficial to test the salience effect. However, the result concluded that no effect could be detected.

Priming

Czap et al. (2013) found in a laboratory experiment that the conservation behavior of participants increased when priming messages were included in the experiment instructions. Farmers were primed to participate in the 2015 US Department of Agriculture's Farm Service Agency (FSA) county committee elections. The results showed that the nudge increased participation (Higgins et al., 2017). However, a study by Wallander et al. (2017) found that priming farmers by sending reminders made no difference in new enrollment in an agri-environmental program but increased re-enrollment rates. There is also evidence that farmers may show rent-seeking behavior if they get the information about what an agri-environmental program seeks to target for investment and suspect that they are being targeted (Cason et al., 2003; Fooks et al., 2016).

Affect

This nudging element may contribute to changing farmers' views as their emotions can be triggered when shown images or words. Since these changes persist for an extended period (Dolan et al., 2012), this nudge might be helpful in an agri-environmental context as it can help design messages to encourage farmers to connect their actions to the externality they create (Palm-Forster et al., 2019). In their experiment, Czap et al. (2013) used three framings, neutral, empathy, and self-interest, to present instructions on the impact of upstream producers' actions in the social-ecological system. Their result shows that the empathy frame increases pollution reduction. This nudge could be used in the agricultural BMP adoption area to increase participation in different programs by triggering peoples' emotions regarding the need for a healthy environment.

Commitment

Commitments, a cost-effective nudge, might be used in an agri-environmental context by requiring voluntary conservation promises or pledges from agricultural producers (Palm-Forster et al., 2019). Combining commitments with other MINDSPACE nudges could also motivate farmers, such as letting them know about a farm that is maintaining the commitment of being enrolled in a conservation program. However, published agri-environmental experiments that tested this nudge's impact are still rare in the literature. A study by Andrews et al. (2013) mentioned that commitments to dedicate land or time to conservation produced mixed results. There is also evidence of finding mixed results after testing this nudge in a pro-environmental study, which mentioned that a commitment nudge can be more effective when a referee or credible audit is present (Lokhorst et al., 2013).

Ego

The nudge ego might be influential in agri-environmental areas as certain farmers may feel good about being seen as a protector of the environment. However, there is a lack of studies investigating the effect of this nudge in the agri-environmental sector. Ego can also overlap with commitment if a feedback mechanism like a referee or monitor audits an individual's commitment. Though agri-environmental stewardship certification programs can drive behavioral changes by recognizing the farmers who are environmental stewards, it is not certain which benefits provided by these programs work as the most substantial incentive (Palm-Forster et al., 2019). An example is the Michigan Agriculture Environmental Assurance Program (MAEAP), often coupled with benefits, including insurance discounts and legal protections that motivate participation (Stuart et al., 2014).

2.4.3: Criticisms of Behavioural Nudges and Their Application

Overall, the nudge concept has generated an intense debate over its effectiveness across different disciplines while being popular with many policymakers worldwide (Congiu & Moscati, 2022). The idea has been criticized in many dimensions, including the definition, scope of application, and types. All of these critiques are discussed in the following sections.

Criticism of the 'Nudge' Definition

The literature often mentions that nudging is ill-defined (Mongin and Cozic, 2018). According to Thaler and Sunstein (2008), an intervention is considered a nudge if it- [1] does not forbid any options [2] and does not significantly change the economic incentives. [3] is easy and cheap to avoid, and [4] significantly alters the behavior of humans even though econs would ignore it.

These four components are the core of the nudge definition, and each has been discussed and criticized further. For example, though the first component of this definition (i.e., does not forbid any options) implies that a nudge cannot reduce the decision makers' choice set (Saghai, 2013), it is not clarified if an intervention expands the choice set then whether we can consider it as a nudge or not. However, an experiment shows that adding options, mainly dominated ones or decoys, in the choice set can influence a decision-maker. (Hansen, 2016). Kivetz et al. (2004) mentioned an example of how the presence of a decoy significantly altered people's final decision while choosing an option from different annual subscriptions to a journal. In the context of BMP adoption, a nudge would neither reduce the choice set of farmers nor expand it. Therefore, farmers can be nudged into more adoption by fulfilling the first condition of nudge definition.

The second component, which states that nudges do not change economic incentives, was criticized by Hansen (2016), suggesting that these wordings do not consider other relevant incentives, including time, social sanctions, or physical threats. When nudges are used to encourage farmers to adopt BMPs, they do not directly change any economic incentives. However, nudges may sometimes be used as a substitute for monetary payments that farmers are paid to participate in adoption. This means that if nudges work, farmers will not receive the money anymore, which changes their economic incentives. So, in the agri-environmental context, using nudges may violate this condition mentioned in the nudge definition.

The third component suggests that a nudge is not a mandate, and no one is forced to comply. That means one can choose to "accept" the nudging (Sunstein, 2015). The implicit assumption of this component is that the decision-makers have too strong preferences to be influenced by the nudge and that they engage in a deliberation process to choose the course of action to pursue (Hansen & Jespersen, 2013; Saghai, 2013). However, it is unrealistic to imagine that people have clear

preferences over things like the proper allocation rate for their pension fund (Congiu and Moscati, 2022), and that is why there is a tendency to adopt a default allocation option (Thaler & Benartzi, 2004). In addition, whether a nudge is avoidable may also depend on how transparent it is (Bovens, 2009; Hansen & Jespersen, 2013), which means how aware a decision-maker is of a nudge's existence and intention. But this transparency condition is not always met. In the example of arranging food in a cafeteria line, most customers are not expected to know that the food has been placed in a certain way to promote healthy eating. If nudges are used in promoting BMP adoption, it would not force farmers to cooperate, and they can have a strong preference over any practice despite being nudged. However, farmers may not be aware of the existence of a nudge, which violates the transparency condition.

The final component of the nudge definition implies that an intervention is considered a nudge if it affects humans while being ignored by econs (who choose rationally and in a way that maximizes utility). An example is the food arrangement in a cafeteria line, which is a nudge since the order or salience of alternatives would not affect an Econ's choices, but it affects those of a human (Congiu and Moscati, 2022). However, this condition may not always be fulfilled (Homonoff, 2018). Since farmers' decisions regarding BMP adoption are not entirely rational (Dessert et al., 2019), nudges might effectively stimulate adoption by addressing behavioral factors.

The Debate Over Who Benefits from Nudging

'Libertarian paternalism,' the term coined by Thaler and Sunstein, is the political philosophy view that guides and justifies using nudges. This is the approach that "preserves freedom of choice (and in this sense is libertarian) but authorizes both private and public institutions to steer people in directions that will promote their welfare (and in this sense is paternalistic)" (Thaler and Sunstein,

2003). Though there was no specification on who should benefit from nudging, the possible three beneficiaries are the nudged person, the society, and the nudgers themselves (Congiu and Moscati, 2022). According to libertarian paternalism, nudging should make decision-makers "better off, *as judged by themselves*" (Thaler and Sunstein, 2008; Thaler, 2015).

Nudges that aim to benefit the nudged person are referred to as "pro-self" by Hagman et al. (2015) and are defined as nudges that "help individuals steer away from irrational behavior ... which decreases their long-term well-being." Examples of pro-self nudges include the cafeteria food arrangement to promote people's health, a default option for the retirement fund to increase the worker's savings, etc. As libertarian paternalism only authorizes policies that increase the nudged person's well-being, the pro-self nudges are validated by this concept.

In contrast, the second type of nudges, which primarily aim at improving the welfare of society by steering the nudged persons in a certain way, is called "pro-social," "pro-others," or simply "social" nudges (Hagman et al., 2015; Hands, 2020). Energy conservation through the social comparison nudge (Alcott, 2011) can be an example of this type of nudge where the decision maker's well-being is not directly increased. Therefore, they are not justified by libertarian paternalism but rather in contrast with it.

It is argued that if an intervention benefits the nudger, it should never be considered a nudge. If the 'decoy' example (Kivetz et al., 2004) mentioned earlier is taken into account, it can be noticed that the presence of the decoy benefits the company instead of helping the consumer. Therefore, these interventions are simply marketing techniques and should not be counted as nudges according to the libertarian paternalism concept. The definition of nudges provided by Congiu and Moscati (2022) sums up these conditions that are needed to make an intervention counted as a nudge as

they stated, “nudges are interventions that attempt to influence people’s behavior by exploiting, *at least in part*, their rationality failures, and that do not increase, *exclusively*, the well-being of nudgers.”

Nudges used in agri-environmental BMP adoption can be categorized as social nudges, as the primary intention is to benefit society by reducing the negative environmental impacts of agricultural production. However, it can be argued that nudging farmers is an example of pro-self nudging, as farmers also benefit from adopting environment-friendly practices. Although some costs may be associated with the adoption process, farmers will get long-term benefits if they can be nudged into adoption. The traditional practices are harmful to the soil health and water quality, hampering farmers' production process and may reduce productivity. Adopting BMPs will help to reduce soil and water problems while maintaining productivity. Therefore, nudges used in BMP adoption could be considered both a social and pro-self nudge and can be justified by libertarian paternalism.

Is Nudging an Effective Method for Advancing Policies?

Nudging has received widespread popularity, but the conclusions drawn from the existing evidence indicate inconsistent and weak findings regarding the effectiveness of nudging in specific settings (Wu et al.,2021). It is still not confirmed whether nudges work, and if they do, what conditions need to be met (Hummel and Maedche, 2019). For instance, the Science and Technology Committee of the United Kingdom, overseeing the Behavioral Intervention Team (BIT), raised the question of whether appropriate evidence can be provided to support experiments (Hummel and Maedche, 2019; Halpern, 2016). One of the authors who invented the nudging concept has even published a separate journal paper named “Nudges That Fail” (Sunstein, 2017).

In a quantitative review of nudging, Hummel and Maedche (2019) concluded that although nudges seem to work, the application context influences the effect sizes, especially the nudge category. Although nudging is successful in many cases, there might occur a situation where a nudge fails unexpectedly (Sunstein, 2017). For example, the nudge 'default' is considered one of the most influential and robust nudges, but there is evidence that defaults can also fail (e.g., Bronchetti et al., 2013). A recent report also shows that default may be chosen to apply in the wrong environment, which will harm the interests of policymakers (Willis, 2013).

Croson and Treich (2014) reviewed the use of nudging in an environmental context, and they mentioned that although nudges might work effectively, questions can be raised about their manipulative nature. However, a nudge in the environmental sector does not directly manipulate people by correcting mistakes in their decision-making; instead, it aims to refrain them from making choices that negatively affect the environment (Carlsson et al., 2021).

Another concern regarding the effectiveness of nudge is whether the behavioral change generated by a nudge intervention is persistent over time (Marteau et al., 2011; Congiu and Moscati, 2022). However, nudges have been found to have long-term effects in environmental and conservation studies (e.g., Ferraro et al., 2011; Allcott and Rogers, 2014). In addition, concerns have also been raised about the issue of how effective nudges are compared to standard policies. Some researchers have argued that behavioral interventions are less effective than standard policies since the latter influence the decision-maker's costs and incentives more strongly and directly (e.g., Baldwin, 2014; Goodwin, 2012; Marteau et al., 2011). However, there is also evidence which supports the opposite. New literature suggests that nudges can be more effective than standard policy interventions (Benartzi et al., 2017; Sunstein, 2018). Carlsson et al. (2021) did an extensive review of the literature on green nudges, and they showed that nudges can be impactful if complemented

with standard policies such as tax. In the agri-environmental context, a study by Chabe-Ferret et al. (2019) revealed that nudging was not even moderately effective in farmers' water conservation.

The above discussion indicates that there is still debate regarding the effectiveness of the nudge theory, and more substantial evidence is needed to justify the use of nudges instead of the general policies.

2.5: Discussion

In this section, I will summarize the findings and describe their implications for increasing BMP adoption by Canadian farmers. I will start by describing some general policy recommendations to deal with the observable factors affecting the adoption process. After that, I will discuss the possible application of different nudges to address the behavioral factors for stimulating the adoption rate.

Among observable factors in BMP adoption, this review's findings show that farm and farmer characteristics play vital roles in the adoption decision. Farmers would be better motivated to adopt different practices if they have better formal education and extension services. Education can enhance farmers' knowledge and help promote conservation behavior. Therefore, policymakers should use regulatory instruments to promote both formal and extension education, such as including information on agricultural practices in textbooks and funding extension services to increase human resources (Wiedemann and Inauen, 2023). Policy instruments should also be used to engage farmers in training related to BMP adoption. It is generally thought that farmers' age and experience would have some impact on BMP adoption. Still, the mixed results from different studies make it difficult to provide any conclusive statement regarding these two factors. However,

younger farmers might be better encouraged to participate in adoption as they would be less reluctant to try new practices compared to older farmers.

Policy instruments should inform Canadian farmers about safe production practices to increase adoption rates. Farmers often rely on their neighbor farmers for information regarding agricultural practices. The findings of this review suggest that farmers with better social networking with their fellow farmers and agencies are more likely to adopt BMPs. This result implies that providing necessary information regarding BMPs and their adoption process, requirements, etc., to the farmers is essential to increase adopters. Information can be provided by arranging campaigns or distributing written guidelines for voluntary adoption. In addition, encouraging farmers to better networking is needed, which will help to circulate the information provided. Farmers who have larger farms and own the land are found to be better motivated in adoption. Therefore, policymakers should target these farmers to make them more involved in agri-environmental programs. In addition, taking initiatives to engage renters and farmers with smaller production is necessary for optimizing adoption of BMPs. Providing information about positive impacts of adoption specific to their operation can be a way to encourage them.

Since BMPs are sometimes associated with costs, the financial conditions of landowners play vital roles in their decision-making regarding adoption. Farms with higher income or better access to capital are often found as the higher adopters of BMPs. Therefore, it is crucial to help farms overcome their financial constraints regarding adopting BMPs. Policies should focus on making BMPs affordable to farmers to increase participation. Providing various incentives is a standard method to encourage farmers in this aspect. Also, making the existing BMPs less costly or inventing new cost-effective BMPs can be a way to remove the financial barriers of farmers in case of adoption.

Other than observable factors, behavioral factors influence farmers' adoption decisions. The findings of this review reveal that farmers often resist change and show risk-averse behavior, which leads to declining the adoption of any new practice for their agricultural operation. The nudge 'norm' might be effective in addressing this risk averseness. People generally follow their peers, and farmers are no different. Neighbors' viewpoints strongly impact farmers' decision-making (Cullen et al., 2020). Suppose, farmers are shown that the number of practices their neighbors adopt is more than theirs. In that case, they are likely to be more interested in increasing their number of adoptions despite the associated risks. Moreover, the concept of norm can be applied to the design of agri-environmental programs. For instance, if farmers can be provided any certification for adoption that they can display publicly to show their friendly commitment to the environment, the other farmers may be better motivated (Ferraro et al., 2017).

This review found that farmers' perception regarding a BMP affects the adoption rate. Therefore, BMPs must be promoted regularly in Canada so that farmers can learn their benefits and be encouraged to adopt them. The continuous promotion will also help positively change farmers' perspectives regarding the BMPs. The nudging element 'messenger' might positively impact the promotion. For example, farmers are better interested in adopting different practices when the messenger is familiar. Therefore, policymakers should wisely choose the messenger to provide information regarding BMPs to the farmers. Some recommendations include using a community mascot to show the negative externalities of agricultural production to the environment (Butler et al., 2019), selecting any fellow farmer who can lead a group discussion on BMP adoption, and sending information through a trustworthy public organization such as government services rather than private companies (Wuepper et al., 2021).

The finding of this review shows that farmers are more likely to show pro-environmental behavior when they are empathetic about the environment. As farmers' concern for improving the environment is positively related to BMP adoption, it is necessary to make farmers understand the use of environment-friendly practices in their production. Therefore, the 'affect' nudge might effectively be applied to encourage Canadian farmers to engage in BMP adoption. It will help design messages that can connect the farmers' actions to the externality of their production process. In addition, different campaigns can be arranged to show farmers how traditional practices can harm the environment, encouraging them to be more concerned about their surroundings.

Farmers with higher self-interests might not be motivated to adopt BMPs (Lefebvre, 2015). To view the practices as a better alternative to their current production system, farmers need to be compassionate to others. More specifically, they need to understand the negative impacts of their operations to the society. Affect nudge can be applied in this regard as well. For example, workshops can be arranged, or pamphlets can be distributed describing how climate change disrupts agricultural productivity and how farmers can reduce these impacts by adopting BMPs. Moreover, 'commitment' and 'ego' nudges can be combined to get better results in case of self-prioritizing farmers. Canadian farmers might be asked to commit to participation in the adoption of BMPs. They are likely to be motivated by this as it will make them feel good to get recognition as a concerned person for the environment. This feeling is generally generated from their ego.

Farmers who are only concerned about profits might be reluctant to participate in adoption. In this case, providing salient information regarding the practices might be impactful. For instance, presenting the impact of a practice as beneficial to the farmers and focusing on their profitability might be a way to motivate them to participate more (Adde, 2023). Though the results from existing agri-environmental studies that tested salience nudges are mixed, evidence from the other

disciplines suggests that there is a possibility that this nudge can bring expected results when applied to the adoption area properly. In addition to salience, nudge priming is another element in nudge literature yet to be explored in agri-environmental aspects. Presenting any physical or verbal cues that will change the view of farmers regarding the BMP adoption could be a way to prime them. For example, mentioning the adoption's private benefit in the program description might influence the farmers' opinion on the practices. As BMP adoption is voluntary, using this prime nudge may make Canadian farmers act in a way that interests the policymakers.

Introducing incentives in a loss framing method, that is, farmers will lose money if the practice is not adopted rather than receiving money for adopting, might be an influential nudge in BMP adoption (Ferraro et al., 2017). Farmers, like all other economic agents, might prefer immediate returns instead of long-term benefits. Therefore, agri-environmental programs in Canada should be designed considering this factor to offer both short and long-term returns from adopting any practice.

Farmers' attitude toward technologies sometimes creates a barrier to adoption, and they might not voluntarily engage in new technologies. A familiar and impactful nudge 'default' might effectively address this issue. The findings suggest that default could be an easy and cost-effective way to involve farmers in BMP adoption. Agri-environmental programs could be created in Canada with a default option of enrolment to any specific practice adoption, and farmers would need to opt out of it if they do not want to participate. Keeping the default option at 100% cost-share in online auctions of conservation contracts will likely contribute to the adoption of practices positively (Messer et al., 2015). In addition, default can be applied to engage farmers more in any online or in-person technical assistance services regarding conservation practices. For example, if farmers

must opt-out of using those information platforms instead of opting in, participation may increase (Ferraro et al., 2017).

2.6: Conclusions

In this era of climate change, sustainable agriculture is a crucial topic in the research sector, which is emerging rapidly. The scholars have discussed several approaches to making the agriculture sector more sustainable. Among them, agricultural BMPs, invented to reduce the negative externality of agricultural production to the environment, are considered effective solutions. However, due to the voluntary nature of the BMPs, farmers are often less interested in adopting them for their agricultural operations. Consequently, a large body of existing literature tried to find out why farmers adopt less. In addition, discovering various ways to encourage farmers to BMP adoption is also considered necessary in recent research. This review tried to focus on both aspects, and the findings might be helpful regarding increasing the adoption rates by Canadian farmers.

The objectives of this review were: 1) synthesizing the information on factors in BMP adoption and 2) finding evidence of the application of behavioral nudges in agri-environmental areas. To meet the goals, I focused on finding observable and unobservable factors impacting BMP adoption in the third section of this review. I also explored the nudge literature in the fourth section with a separate sub-section on applying nudges in the agri-environmental sector. In the discussion section, I combined all the findings and discussed how policymakers in Canada might apply different nudges to encourage adoption of BMPs.

The research questions asked in this review are: 1) What are behavioral nudges? How are they applied in different disciplines? 2) Can nudges be useful in the agri-environmental sector? 3)

Which behavioral factors impact farmers' BMP adoption decisions? 4) Why are the behavioral factors important to consider in BMP studies?

I found that the literature lists several behavioral factors affecting farmers' decision to adopt BMP and also mentions why behavioral factors should be considered in BMP studies. Identifying the observable factors that play a role in BMP adoption decisions and creating incentives or other programs was insufficient to increase the adoption rate. The number of farmers who adopted the practices is still low, even after years of promotion and incentivization. This failure of the traditional approach led researchers to consider the unobservable factors, the behavioral factors, as a determinant in BMP adoption and include them in their analysis. This behavioral economics approach allows policy analysts to design programs that might motivate farmers to adopt more without providing monetary incentives.

The findings also show various effective uses of nudging in many disciplines, including limited agri-environmental studies. The overall findings suggest that nudges might be an influential and cost-effective way to engage farmers in BMP adoption. However, in an agri-environmental context, nudge application is still not very popular, though it can produce an impactful result. This review focused on nine nudging elements based on the 'MINDSPACE FRAMEWORK' by Dolan et al. (2012). Not all these nudges have been tested in the agri-environmental area, but they might be applied to make farmers interested in the BMP adoption. Therefore, Agri-environmental economists should take this concept seriously and test its effectiveness in different studies so that policymakers correctly understand this non-monetary intervention in motivating farmers toward BMP adoption.

Chapter 3: Can We Nudge Farmers into Agri-Environmental Program Participation? A Vignette Experiment in Western Canada

3.1: Introduction

The term ‘agri-environment’ highlights the fact that agriculture and environment are inseparable, as the agriculture sector will always use a part of our natural surroundings while shaping it in a specific way (Thomas, 2019). However, modern agriculture is often considered a threat to our environment. Agricultural production directly impacts environmental health, so understanding farmers' decision-making processes that can have environmental consequences is necessary (Cowling, 2014). To maintain the productivity of the agriculture sector while mitigating the negative impacts on the environment, regulation of agricultural production practices is also essential.

As agricultural land occupies 6.2% of Canada’s total area (Government of Canada), the impact of conventional agricultural practices on soil productivity and the wider environment is a growing concern. However, there are practical ways, such as Best Management Practices (BMPs), which ensure that the environmental risk from agricultural practices is minimized while keeping the same economic productivity (Agriculture and Agri-food Canada, 2000). A potential solution to risks such as land degradation can be the adoption of these agri-environmental BMPs, which will help to improve soil fertility, water conservation, and crop yields (Lawin and Tamini, 2019). A BMP might be very effective, but the decision of its adoption will depend primarily on the values of the farmers. They also reserve the right to determine whether the practice will be a good fit for their

farming operation. Therefore, it is crucial to consider the farmers' perspective on BMP adoption to increase the adoption rates.

Agri-environmental policies and programs have been developed to help farmers maintain an environment-friendly agriculture sector (Nebel, 2017). Many of these programs are used to motivate farmers to adopt the BMPs while regulating and keeping track of uses as well. An effective way to improve environmental quality is to promote these agri-environmental programs (Palm-Forster et al., 2019). Since the programs are voluntary in structure, an extensive body of research has tried to investigate what factors impact the adoption decision (e.g., Prokopy et al., 2008; Baumgart-Getz et al., 2012). Still, there is a lack of studies demonstrating how to design programs and policies to motivate farmers to participate.

Insights from other behavioral sciences (e.g., psychology), which routinely inform the design of programs and policies in multiple domains, also hold promise for designing more effective agri-environmental programs and policies (Janusch et al., 2017). The program managers have expressed a growing interest in applying the insights from behavioral and experimental economics research to motivate behavioral changes cost-effectively (Higgins et al., 2017). Yet, behavioral economics research related to program and policy design that focuses on agri-environmental issues is few. This study attempts to address the gap by testing whether we can apply the insights from behavioral science, in the form of nudges, to design agri-environmental programs and policies. Nudging is a concept of behavioral economics used to redirect peoples' behavior predictably while keeping their choice options the same (Thaler and Sunstein, 2008). Nudges are proven effective in many disciplines, including health and environment, but agri-environmental studies have not fully explored their uses.

Saskatchewan, a prairie province in western Canada, is facing challenges due to climate change, and among all sectors, agriculture is most sensitive to that (Wu et al., 2021). Saskatchewan is considered an agricultural powerhouse, occupying more than 40% of Canada's farmland (Magnan et al., 2023). Agricultural emissions contribute to GHG emissions, and the GHG emissions of Saskatchewan increased by 8.6% from 2005 to 2014 (Liu et al., 2020). The federal and Provincial government has launched various agri-environmental programs for farmers in the province. These programs aim to mitigate the environmental risks of agricultural production and manage the climate change impacts. However, farmers need to engage in those programs willingly to make them successful. This study uses survey data to investigate Saskatchewan farmers' current scenario of BMP adoption and Environmental Farm Plan (EFP) participation. It will also examine how producers in Saskatchewan rate different agri-environmental programs by doing a vignette experiment analysis. More precisely, this study will estimate how different form of nudges impacts the decision of Saskatchewan farmers to participate in an agri-environmental program. The study uses a region-specific approach, which is beneficial for local policy designs as the agri-environmental programs and policies differ across geographic locations.

3.2: Background

3.2.1: A brief history of Agri-Environmental Programs in Canada

Unlike many other OECD countries, agri-environmental policy in Canada is preferably characterized by stakeholder negotiation and voluntary compliance instead of a strict monitoring system and environmental regulations enforcement (Atari et al., 2009). That is why voluntary environmental programs are essential in Canada (Nebel et al., 2017). In Canada, agri-environmental programs are mainly funded by the government's expenditure for environmental

programs, while a small portion of the agricultural expenditure is also spent on them (Baylis et al., 2022). The governments of Canada have spent large amounts of money to design agri-environmental policies that aim to limit the negative externalities of agriculture while boosting farmers' income (Baylis et al.,2022).

Agri-environmental efforts emerged in Canada as a response to the dust bowl droughts of the 1930s, when farmers in the prairies faced environmental problems and low prices of goods. (Baylis et al.,2022). In 1935, the *Federal Prairie Farm Rehabilitation Act* (now called *Prairie Farm Rehabilitation Administration [PFRA])* was enforced as the first agri-environmental program in Canada, which mandated the reduction of soil erosion and escalated water access in the western provinces (Baylis et al.,2022).

The focus of early agri-environmental programs in Canada was limited to land retirement, and other forms of income support were included later (Baylis et al.,2022). The federal and provincial governments started to fund education and extension programs aimed at conservation in the 1970s (Baylis et al., 2022). Those programs primarily provided technical support and demonstration plots for promoting the adoption of conservation practices and offered some small cost-sharing grants targeting soil erosion and water quality as well (Cressman et al. 2000). In 1987, the federal-provincial cost-share program named *National Soil Conservation* was established which provided support for technology development, education, land conversion, research, and monitoring (Cressman et al. 2000). The *Permanent Cover Program (PCP)* in western Canada was introduced in 1989 due to the repeated concern regarding soil erosion in prairies, which aimed to remove highly erodible land from crop production including some exceptions (Vaisey et al., 2000). The Pest Control Products Act of 2000 set tolerance levels for sensitive groups (Baylis et al. 2022), and

using that new tolerance levels, Canada started to reregister all pesticides and still requires re-registration every 15 years (Badulescu and Baylis, 2006).

The *Agricultural Policy Framework (APF)*, an agreement signed by federal and provincial ministries of agriculture in 2003, included environmental goals such as soil, water, and water quality improvement and the promotion of environmentally beneficial practices (Baylis et al., 2022; Draper and Reed, 2009). APF is the first national agricultural policy framework in Canada (Office of the Auditor General of Canada, 2008), which initiated two mutually dependent programs named *Environmental Farm Planning (EFP)* and the *Farm Stewardship Program* to be implemented in each province and territory (Basset, 2013). The stewardship programs, which aim to mitigate many impacts from agriculture to the environment, are common amongst all four APFs to date (2003-2023) (van Wyngaarden, 2021). On the other hand, EFP is a voluntary self-assessment tool that guides farmers in identifying and reducing environmental risks their farms pose, which needs to be completed to get support from the stewardship programs. Some other programs launched under APF include The *Greencover Canada* (2003–2007) and the *Cover Crop Protection Program* (Eagle et al., 2015).

After the first APF ended in 2008, three additional APFs were implemented: 1) Growing Forward (2008-2013), 2) Growing Forward 2 (2013-2018), and 3) Canadian Agricultural Partnership (2018-2023) (Van Wyngaarden, 2021). The *Canadian Agricultural Partnership (CAP)* was a $3 billion five-year (2018-2023) investment by federal, provincial, and territorial (FPT) governments, which ended on March 31, 2023 (Government. Of Canada, b). The current and most recent framework is the *Sustainable Canadian Agricultural Partnership (Sustainable CAP)*. The Sustainable CAP, which is replacing the Canadian Agricultural Partnership, is a "new $3.5-billion, 5-year agreement (April 1, 2023, to March 31, 2028) between the federal, provincial, and territorial governments to

strengthen the competitiveness, innovation, and resiliency of the agriculture, agri-food and agri-based products sector (Government of Canada, b)."

3.2.2: Agriculture sector issues and current programs in Saskatchewan

The economy of Saskatchewan, a prairie province in western Canada, is primarily based on agriculture and resources (Wu et al., 2021; Liu et al., 2020). By area, agriculture is the dominant form of land use in southern Saskatchewan. Agricultural lands – or lands used to produce crops and livestock occupy most of the province's south of the commercial forest (Government of Saskatchewan, b). Having 60.2 million acres of cultivated farmland (Statistics Canada), the province accounts for more than 40% of Canada's cultivated farmland and some of the world's most productive lands (Government of Saskatchewan, a)**.** While the primary intent of farming is food or forage production, land management impacts biodiversity and natural processes necessary to sustain clean adequate water supplies, a stable climate, and other values important to people and the economy (Govt. of Saskatchewan,b). Saskatchewan is facing challenges related to soil health and water quality that affect and are affected by agricultural practices.

The soils of Saskatchewan are fragile, and tillage operations have contributed largely to some of the environmental problems facing agriculture. (Encyclopedia of Saskatchewan). Research since the 1990s has identified soil erosion by tillage as a significant source of human-induced soil change on the Canadian Prairies, including Saskatchewan (Soils of Saskatchewan). However, Recent reports show that approximately 78% of cropland in Saskatchewan uses some form of conservation tillage (Adde, 2023). Crop rotations are also widely used in the province, as many farmers rotate crops like wheat, canola, and pulses for managing pests and improving soil health (Adde, 2023). Wind and water erosion, which have long been recognized as another major cause of soil

degradation in Saskatchewan, have been substantially reduced in rate due to the improved residue management practices adopted by Saskatchewan farmers (Soils of Saskatchewan). The SSHRC Urban Best Management Project, which focuses on Best Management Practices (BMP) in water governance and climate change adaptations in Saskatchewan, asserts that the province is greatly affected by floods and droughts, and the condition will be further exacerbated by the increasing climate variability (Saskbmp.com).

Saskatchewan agriculture is a strategic asset in addressing global climate change since the province's cropland is estimated to sequester 8.5 mega tonnes of carbon each year through improved agricultural practices (Agricultural Producers Association of Saskatchewan). The province has been implementing '*Prairie Resilience: A Made-in-Saskatchewan Climate Change Strategy'* since its launch in December 2017. The *Prairie Resilience strategy "*takes a system-wide approach and includes more than 40 commitments designed to make Saskatchewan more resilient to the effects of a changing climate." (Government of Saskatchewan, f) Implementing Saskatchewan's agricultural water management framework is one of the actions outlined in the Prairie Resilience Strategy. Agricultural water management, released in 2016, supports the continued growth of a sustainable and resilient agricultural sector in Saskatchewan by providing a strategic direction to guide responsible drainage activities in Saskatchewan (Sask. Water Security Agency). The strategy focuses on managing four vital agri-environmental priorities: 1) flood mitigation, drought response, and adaptation; 2) water quality; 3) wetland habitat; and 4) soil health and greenhouse gas management (Sask. Water Security Agency).

As Saskatchewan has a long history of climate variability and episodic droughts (Marchildon et al.,2009), different agri-environmental programs have emerged over time, which assist agricultural producers and communities with agricultural practice change or infrastructure development.

(Hurlbert, 2014). The Government of Saskatchewan defines a beneficial management practice, or BMP, as any agricultural practice that 1) ensures the long-term health and sustainability of agricultural land; 2) positively impacts the long-term economic and environmental viability of agricultural production; and 3) minimizes negative impacts and risk to the environment. (Government of Saskatchewan, 2023). The federal and provincial governments recently took strategic initiatives for Saskatchewan agriculture by investing $485 million in the five-year project 'Sustainable Canadian Agricultural Partnership (Sustainable CAP)' (Govt. of Saskatchewan,c). One of the five priorities of the partnership is climate change and the environment. (Govt. of Saskatchewan,c). The following paragraphs briefly mention some current agri-environmental programs and related initiatives implemented in Saskatchewan.

Agri-Environmental Risk Assessment: An Agri-Environmental Risk Assessment is an environmental program that evaluates practices in soil and nutrient management; crop and pest management; water, biodiversity, and land use; handling and storage of farm inputs; waste, by-products, pollution and energy efficiency and livestock and feed management. (Govt. Saskatchewan,e). Producers can Identify and address agri-environmental risks and opportunities by using it to improve farm health and safety. (Govt. of Saskatchewan, e)

Environmental Farm Plan: The Environmental Farm Plan (EFP) is a free, online self-assessment tool designed to help producers identify areas of environmental risks or concerns and create realistic action plans to address those (Govt. Saskatchewan, e). EFP has been the most effective driver in Saskatchewan for identifying and preventing environmental impacts from farm operations (Basset, 2013). Since 2005, producers used EFP as the primary way to access funds from the Canada- Saskatchewan Farm Stewardship Program (CSFSP) for BMP implementation. (Basset, 2013)

Farm and Ranch Water Infrastructure Program: The Farm and Ranch Water Infrastructure Program (FRWIP) provides rebates to support 1) development of secure and sustainable water sources for agricultural use in Saskatchewan and 2) reduction of potential groundwater contamination through well decommissioning (Govt. Saskatchewan, e). The FRWIP potentially reduces producers' vulnerability to climate and environmental change by assisting them in responding to environmental risk and water supply threats (Hurlbert, 2014).

Irrigation program: Irrigation programming supports sustainable agriculture water management and adaptation to climate change by providing funding support for 1) development of new irrigation acres; and 2) improved efficiencies in irrigation systems. (Govt. Saskatchewan, e).

The Resilient Agricultural Landscapes Program (RALP): This program provides producers funding to increase agricultural land's environmental resiliency and helps producers achieve outcomes related to water quality, soil health, and biodiversity through adopting BMPs. (Govt. Saskatchewan, d).

Livestock Facility Emissions Program: The program supports intensive livestock facilities to adopt practices and technologies that will improve the environmental performance of intensive hog operations, including adaption to climate change and reduction of Greenhouse Gas (GHG) emissions (Govt. Saskatchewan, e).

3.3: Literature Review

Literature on BMP adoption mainly focuses on finding factors impacting the farmers' adoption process. The most known literature on this topic was by Prokopy et al. (2008) and Baumgart-Getz

et al. (2012), as both analyzed and synthesized more than 50 articles that modeled conservation practice adoption. But those reviews mainly took the observable factors into account.

Dessart et al. (2019) reviewed findings from 1999 to 2018 in 16 developed countries of Europe, Australia, and the USA and solely focused on behavioral factors influencing farmers' decisions to adopt environment-friendly measures. Their results indicate that farmers do not make entirely rational decisions while adopting sustainable agricultural practices, and the behavioral factors significantly impacting decisions are often culture-specific. A systematic review by Schaub et al. (2023) explored the role of behavioral factors and opportunity costs in farmers' decisions to participate in Agri-Environmental Schemes (AES) in Australia, Europe, and North America. They found that behavioral factors such as advice and positive attitudes towards AESs are consistently connected to participation.

Studies that have examined factors influencing Canadian farmers' BMP adoption are comparatively few in the literature, and they were mainly conducted in specific regions or small watersheds (Liu and Brower, 2022). For instance, by analyzing survey data from a watershed in Quebec, Ghazalian et al. (2009) found that farmers with larger cultivated areas or large animal production are more likely to apply BMPs, including crop rotation and riparian buffers. Filson et al. (2009) conducted a survey on BMP adoption in five southern Ontario watersheds in 2006, and their results show that only farm size has a positive and significant effect on BMP adoption.

In addition to finding factors, few studies analyzed what motivates Canadian farmers to participate in adoption. For example, a study done in watersheds in southern Ontario mentioned that financial incentives play an essential role in BMP adoption decision-making (Lamba et al., 2009). Dupont (2010) analyzed farmers' decisions to participate in BMP programs and the participation rate in

the Grand River watershed in southern Ontario. She found that the maximum percentage of costs covered by the grant available to farmers increases the likelihood of a farmer's BMP adoption. A recent and comprehensive review of factors affecting Canadian farmers' BMP adoption by Weber (2017) mentioned some key motivators for adoption, including regulatory pre-emption such as the Environmental Farm Plan, program flexibility, and funding.

The literature provides evidence on factors impacting or motivating farmers towards BMP adoption. Still, there is a lack of studies that discuss ways to design agri-environmental programs and policies to encourage participation. To make the agri-environmental programs successful, using limited resources to motivate farmers to change their behavior in ways that support environmental benefits is important (Palm-Forster et al., 2019). In recent years, the governments of many countries have started to rely on insights from behavioral economics and psychology for more cost-effective agri-environmental programs (Ferraro et al., 2017). Using behavioral tools such as nudges to influence farmers' adoption behavior is a new approach in the adoption literature. The nudge that has been tested in most agri-environmental studies is 'norm.' For example, a study by Wu et al. (2021) assessed the impact of peer comparison on NPS water pollution, and their results suggest that policy efficiency can be improved using nudges. Information on a social norm has been found to positively impact farmers' decisions regarding conservation (Banerjee et al., 2014; Cullen et al., 2020; Ouvrard et al., 2020). Other nudges that have been tested in agri-environmental settings include messenger (Wuepper et al., 2021; Butler et al., 2019), priming (Czap et al., 2013), salience (Cason et al., 2003; Banerjee et al., 2015; Messer et al., 2017).

Although behavioral factors have been recently considered in the BMP adoption literature, we can see the connection between environmental economics and behavioral economics from the much earlier environmental valuation studies that were inspired by the research in psychology and

behavioral economics (e.g., List, 2006; Carlsson, 2010). Scholars and policymakers welcome behavioral environmental research due to the increasing awareness of environmental problems and the failure to solve them by traditional methods. (Croson and Treich, 2014). However, it is still not known if agri-environmental programs and policies can be designed using behavioral approaches (Palm-Forster et al., 2019; Streletskaya et al., 2020).

Experiments in behavioral economics primarily focus on consumer decision-making, with very few exceptions that study producers' behavior (Pourtaherian, 2023). Ferraro et al. (2022) state that "the evidence in support of behavioral economic theories among producers is almost exclusively non-experimental." A lab-in-the-field experiment with commercial agricultural producers in the US measured the impact of price anchoring on conservation contracts related to pest and nutrient management. Their result shows that farmers' cost-share bids were 46% higher when the starting value was 100% instead of 0% (Ferraro et al., 2022).

BMP adoption studies primarily use choice experiments (e.g., stated preference methods) to examine farmers' preferences regarding agri-environmental programs and BMPs (e.g., McGurk et al., 2020; Hasler et al., 2019; Lin, 2019). The stated preference method is advantageous for measuring preferences and estimating welfare, but it is less suitable for measuring attitudes, beliefs, and perceptions (Liebe and Dobers, 2020). The latter concepts are examined in social science research using the vignette experiment method, first introduced in Sociology (Rossi, 1979). This method has become an important tool for research in the context of social norms, justice concerns, and perspectives (Auspurg and Hinz, 2015; Liebig et al., 2015; Liebe et al., 2020; Chewinski et al., 2023). The vignette method employs multiple factors, and respondents must make trade-offs, which lowers the social desirability bias (Auspurg et al., 2015). Studies on renewable energy expansions regularly use this method (e.g., Liebe et al., 2017; Parkins et al.,

2022). The Vignette experiment might also be effectively used to examine farmers' adoption behavior. For example, a recent study in the UK used the vignette analysis to examine what choices farmers would make when they decide between better environmental conservation and higher farm profits (Ocean and Howley, 2023).

Behavioral economics research related to program and policy design focusing on agri-environmental issues is rare. Palm-Forster et al. (2019) mentioned two characteristics unique to the agri-environmental context that are absent in contexts focused on broader behavioral science literature. These characteristics could be the reasons behind the absence of studies specifically testing the impact of behavioral nudges in agri-environmental policy settings. "First, agri-environmental programs aim to affect long-term voluntary behaviors of agricultural producers often acting in competitive markets. Second, the long-term decisions being targeted are ones regarding producing impure public goods" (Palm-Forster et al., 2019). This gap highlights the need for ongoing research that applies behavioral science findings in the agri-environmental sector.

This study aims to contribute to the literature in several ways. Firstly, it will be one of the few Canadian studies testing nudges in agri-environmental settings. It will add to the nudge literature by testing the effect of different nudges on farmers' decision-making processes. In addition, it aims to contribute to behavioral agricultural economics literature by incorporating behavioral intervention tools in agri-environmental settings. BMP adoption studies that analyzed nudge impacts mostly applied nudges to motivate farmers in any specific practices. In contrast, this study will examine the impact of nudges on farmers' decisions to participate in agri-environmental programs. Moreover, using vignette experiment approach makes this study unique from all other studies that examined nudging in BMP adoption. Though some studies in other disciplines, including psychology and sociology, examined the impact of nudges using vignette experiments

(e.g., Aharoni et al., 2022, Dimant and Gesche, 2023), no agri-environmental studies, to my best knowledge, have done that yet.

3.4: Approach

This study used survey data to analyze the current BMP adoption scenario in Saskatchewan and to examine the impact of different nudge elements on Saskatchewan farmers' decision to participate in various agri-environmental programs. The survey included a vignette experiment portion to get farmers' responses on rating different hypothetical programs. The details of the data and methods used are described in this section.

3.4.1: Survey Design

Data used in this study is collected from the Environmentally Sustainable Agriculture Tracking Survey (ESATS), 2021. The survey was done on Alberta and Saskatchewan farmers, and there were 1001 respondents, including 501 farmers from Alberta and 500 farmers from Saskatchewan. Most of the questions were same for participants from both provinces except for the province-specific questions. This study only used the Saskatchewan portion of the data. The following paragraphs provide a brief description of the survey's background. Details of the ESAT Survey are summarized from the Government of Alberta's website and project report by Anders et al. (2021).

The Environmentally Sustainable Agriculture Tracking Survey (ESATS)

Every two years, the Environmentally Sustainable Agriculture Tracking Survey (ESATS) is administered by Alberta Agriculture, Forestry and Rural Economic Development (AFRED) to monitor farm-level awareness and adoption of environmentally sustainable agriculture (ESA)

practices in Alberta. The survey results are used to aid the Alberta government in improving the ESA programs and activities to encourage farmers further to adopt ESA practices. For the first time, Saskatchewan farmers were also included in the survey of 2021 with the collaboration of the Saskatchewan Ministry of Agriculture. In this paper, the focus will be solely on the Saskatchewan portion of the survey. Therefore, the findings of this study will be helpful to the Govt. Of Saskatchewan in promoting the BMP adoption in the province.

AFRED collaborated with researchers at the University of Alberta to update the ESA practices and survey objectives of the 2021 ESAT survey, retaining questions and practices that were determined to reflect current environmental conditions. The survey kept many objectives shown in the past surveys, with an added objective to examine current and emerging initiatives in the agricultural industry. This led to the development of questions that elicited producers' opinions on soil and water quality monitoring programs, the environmental farm plan, sustainable sourcing, and economic, conservation, and lifestyle values.

The survey was done during the spring and summer of 2021 and asked respondents about their 2020 production year practices. The full survey can be found in the Appendix. Table 1 shows the names of survey sections and a brief description of what each section contains.

It is uncertain whether the Covid-19 pandemic influenced decisions as producers may make practice decisions the year prior in preparation for the forthcoming production year. For instance, a producer may have made fertilizer purchases in 2019 to prepare for 2020. Investigating the effect of the Covid-19 pandemic was not an objective of this survey, but it is noteworthy that there may be some influence.

Table 1: Brief Descriptions of Survey Sections

Sections	Components
SECTION 1: FARM OPERATIONS	Contains questions about farm operations and production systems.
SECTION 2: VIGNETTE EXPERIMENT	Farmers were asked to rate soil and water quality monitoring programs based on described scenarios.
SECTION 3 - SOIL QUALITY	Contains questions about land use and soil management.
SECTION 4: AIR QUALITY	Contains questions about fertilizer and manure management that can impact air quality.
SECTION 5: BIODIVERSITY	Contains questions about natural habitat and biodiversity management on their farmland.
SECTION 6: WATER QUALITY	Contains questions about manure management that can affect water quality.
SECTION 7: ENVIRONMENTAL FARM PLAN	Contain questions regarding their opinions on the Environmental Farm Plan (EFP).
SECTION 8 – SUSTAINABLE SOURCING	Farmers were asked to provide opinions on sustainable sourcing standards and their general approach to farming.
SECTION 9 – ECONOMIC, CONSERVATION AND LIFESTYLE MEASURE	Farmers were asked to indicate their level of agreement with statements about lifestyle, along with economic and conservation facts.
SECTION 10 - RESPONDENT PROFILE	Contains questions about farm and farmer characteristics.

3.4.2: Experimental approach

Farmers' decision to participate in agri-environmental programs is influenced by factors other than quantitatively measurable attributes, including income and farm size. Farmers differ in many ways, such as having different attitudes towards environment-friendly practices and not having identical

preferences for the requirements of Agri-environmental programs. Their willingness to cooperate with organizations providing the programs may also vary as they have different views and experiences regarding them. So, these behavioral and social factors are considered important determinants in their decision-making process. However, Incorporating the behavioral and social factors into any traditional choice-experiment study and inferring the preferences is not straightforward (Parkins et al., 2022). Therefore, this study will use vignette analysis, an alternative method, to determine the impact of different behavioral nudges on agri-environmental program participation.

A vignette study is a non-monetary valuation technique that measures participants' preferences when choices have multiple and complex options. A vignette experiment, or a factorial survey experiment, consists of multiple vignettes: a carefully constructed short description of a person, object, or situation representing a systematic combination of characteristics (Atzmüller and Steiner, 2010). The core difference between a vignette study and a choice experiment is that the participants do not get to choose from different options in a vignette experiment. Instead, they provide an evaluation based on their level of support or acceptability, on a scale ranging from completely acceptable to completely unacceptable (Chewinski et al., 2023) or on a numeric scale of 1 to 10, for example. Typically, respondents are shown multiple vignettes in the form of between-subject designs and are asked to assess each scenario (Parkins et al., 2022). Vignette experiments provide the opportunity to indirectly measure individuals' evaluations of vignette attributes as part of a scenario, where the possibility of social desirability bias decreases through attribute trade-offs. (Auspurg and Jäckle, 2017).

The quantitative vignette studies in the social sciences have been mostly done according to the factorial survey, mainly characterized by randomly selecting vignette sets (Atzmüller and Steiner, 2010). This study also uses a factorial survey for the vignette experiment. Along with the other simple measurements in surveys, factorial survey experiments also allow to identify causal effects because of the experimental setup (Auspurg and Hinz, 2015; Liebig et al. 2015). The details of the experiment design are provided in the following paragraphs.

Priming

A prime is any subconscious cue that impacts people's decision-making. Priming shows that people's behavior may be altered if they are first exposed to certain words or scenarios (Bargh, 2006; Williams & Bargh, 2008). More precisely, people tend to behave differently when 'primed' by specific cues beforehand (Dolan et al., 2012). A laboratory experiment showed that including priming messages increased conservation behavior (Czap et al., 2013).

In this study, two primer messages were constructed, which were shown before starting the experiment. Half of the respondents were shown a social primer, and the other half were shown a private primer. The messages indirectly informed farmers how they or the society would benefit from conservation practices. Instead of describing what could be gained from adopting practices, the text mentioned the social loss and farmers' own loss because of the agricultural operation. The intention was to determine if providing these subconscious cues at the beginning impacted farmers' decision to participate in hypothetical agri-environmental programs. Both primer's text is included below.

Table 2: Primer Message for Sub-Sample 1, Environment (Social Benefits)

Land degradation of soil and water resources costs Canadian farmers $3+ billion a year. Measuring, maintaining, and improving soil and water quality have been identified as key priorities by scientists and policy makers in Saskatchewan. Access to detailed monitoring data and web-based tools help policymakers in designing new programs that advance the management of soil and water resources in your province.

Table 3: Primer Message for Sub-Sample 2: Productivity (Private Benefits)

The degradation of soil and water resources on your farm is likely to result in significant losses in productivity and may cost you cost you $1,000's of dollars over time. Measuring and improving soil and water quality should therefore be a key priority to you. Access to detail monitoring data and web-based tools will help you to developed and implement computer aided land management and production decisions to harvest the full potential of your land.

Shortened Cheap Talk

All respondents read a brief text before the vignette experiment started, a shortened version of cheap talk commonly used in choice experiments to reduce hypothetical bias (Penn and Hu, 2019). The script was used to inform respondents about the hypothetical nature of the task and to set a baseline of understanding (Penn and Hu, 2018; Parkins et al., 2022). The table shows the cheap talk shown to the participants.

Table 4: Shortened Cheap Talk Text

The next section presents you with six [6] scenarios of soil and water quality monitoring programs offered in your area. Although these are hypothetical scenarios, please evaluate each scenario as if it was a real option that could affect your on-farm decision making. Please carefully read each scenario and rate it based on how likely you would be to participate in this program.

Vignette Attributes

The vignettes contained systematically varying attributes/details about program design and features of a hypothetical agri-environmental program. The responses of participants are further used to determine preferences for each attribute. The attributes chosen for the experiment include program, messenger, privacy, ego, norm, and cost-share incentive. Table 5 contains details about the levels of the attributes.

The programs that were included in the experiment were soil and water programs. Respondents were shown three randomly chosen water-related vignettes and three soil-related vignettes for rating. The reason for choosing these two types of agri-environmental programs is the importance and relevance of soil and water quality to agricultural production.

Agricultural operations cause soil erosion, which further reduces farms' productivity. Agricultural lands lose their nutrients and water storage capacity due to erosion, leading to reduced soil productivity and increased water runoff, which in turn contributes to nutrient pollution. (Montgomery, 2007; Pimentel and Burgess, 2013). Healthy soils are also essential for reducing greenhouse gas emissions and other negative environmental impacts from agriculture (Shah et al.,

2022). Therefore, promoting BMPs that mitigate harmful environmental impacts while improving soil quality and increasing agricultural productivity is necessary.

Good-quality water is a must for safe agricultural production. However, surface and groundwater supplies are at risk of contamination from agricultural practices (Corkal et al., 2011). Nutrient pollution entering river systems from agricultural areas is putting water quality increasingly at risk (Hassanzadeh et al., 2019). As an essential source of nutrients, agricultural activities contribute to issues of water pollution (Chapra, 2008) and are typically considered the largest non-point source of polluting water (Hassanzadeh et al. 2019). Applying BMPs to reduce the amount of nutrients entering watercourses is the usual method to protect water quality in agricultural sectors (Ji, 2017).

Four types of nudging elements were present in the experiment as attributes, including messenger, privacy, ego, and norms. All of them had three levels except the norm, which had four levels. Application of nudges is popular in many disciplines; however, agri-environmental researchers are yet to explore the effect of nudging. Dolan et al. (2012) developed a framework named MINDSPACE, an abbreviated form of nine nudging elements: messenger, incentive, norm, default, salience, priming, affect, commitments, and ego. Based on this framework, Palm-Forster et al. (2019) created an agri-environmental version called Ag-E MINDSPACE. The nudges messenger, ego, and norm are adapted from the study by Palm-Forster et al. (2019) to be used in this vignette experiment.

Messenger and norm are the nudges that are frequently mentioned in the literature (Whiting et al., 2019), including agri-environmental studies (Arbuckle et al., 2015; Pourtaherian, 2023; Wuepper et al., 2021; My et al., 2022). In contrast, to my knowledge, no agri-environmental study has tested nudge ego. The messenger attribute has three levels: the government of Saskatchewan (status quo)

and two private organizations. The base is set to the government to test farmers' preferences for private organizations compared to the government. For the nudge norm, the base is set to none, which refers to the status quo in the province. The other three levels include comparison with peers and approval by municipalities or organizations. Comparing these levels against the status quo will show if the information impacted farmers' decisions. In Saskatchewan, farmers do not receive any award or certificate for conservation participation. Therefore, adding them as the two levels of ego nudge will help identify if any inspire farmers to participate.

Privacy nudge is generally considered a digital nudging element, mainly tested in online applications or social media platforms (Kankane et al., 2028; Kroll and Stieglitz,2021; Wang et al., 2014). This study includes a privacy nudge in the context of sharing farmers' data publicly or with other institutions. The aim of testing this nudge is to find out whether there is an impact on the decision taken by farmers to participate in agri-environmental programs based on the disclosure of their information. The status quo for disclosing survey results is keeping them private. Adding two levels named 'partially available' and 'public' in the experiment with the base as 'private' will allow to compare farmers' preferences for the two levels against the status quo.

The final attribute of the experiment is a cost-share incentive, a conventional element used to motivate farmers to be engaged in agri-environmental BMP adoption**.** This attribute has three levels in this study: 25% (status quo), 50%, and 75%. Setting the base as 25% allows the identification of how an increase in cost-share impacts farmers' decisions. Testing the impact of this cost-share attribute along with the nudging attributes will allow to compare the effect of monetary and non-monetary interventions in the case of promoting agri-environmental programs.

Table 5: Vignette Attribute Levels

Attributes	Levels
Program	• **Soil:** Soil Quality Monitoring • **Water**: Water Quality Monitoring
Messenger	• **Govt.**: The government of Saskatchewan* • **SSCA**: The Saskatchewan Soil Conservation Association • **Groups**: A group of conservation and watershed associations across Saskatchewan
Privacy	• **Private**: The resulting data will be kept confidential and not made available outside of the leading organization.* • **Partially available**: Only aggregate data resulting from the program will be added to a new Saskatchewan soil/ water quality database. A webtool based on the database will only be made available to participating Saskatchewan producers. • **Public**: All data resulting from the program and their GPS coordinates will be added to a new Saskatchewan soil /ground water quality database. A webtool based on the database will be made publicly available to help all Saskatchewanians to improve their land.
Ego	• **None*** • **Award**: Participating producers qualify for a stewardship award for sustainable agricultural practices in your community. • **Certificate**: Participating producers receive a certificate that may provide access to attractive premiums and benefits from their financial and/or insurance provider.
Norm	• **None*** • **Comparison:** Several producers in your area have already signed up for the [soil, water] program. • **Municipal approval**: The program has received a strong endorsement by your rural municipality. • **Organization approval**: The program has received a strong endorsement by your local producer organization.
Cost-share Incentive	• **25%**: Participating producers can get access to detailed [soil, water] test results for their land at 25% of the cost of comparable commercial testing services.* • **50%**: Participating producers can get access to detailed [soil, water] test results for their land at 50% of the cost of comparable commercial testing services. • **75%**: Participating producers can get access to detailed [soil, water] test results for their land at 75% of the cost of comparable commercial testing services.

*Status quo for the province

Vignette Experiment Design

Based on the six attributes and their levels, a full factorial design of 648 unique vignettes was generated (2*3*3*3*4*3=648). After that, an orthogonal design was used with two-way interactions to reduce the number of vignettes, as the full factorial contains a large number. The two-way interactions, which were created using the fold-over technique, allowed the attributes to vary independently of each other within and across vignettes (Parkins et al., 2022; Liebe et al., 2017). The final design included 144 vignettes. Six vignettes were randomly drawn (without replacement) out of these 144 for each respondent to avoid learning and order effects in the vignette rating (Auspurg and Jackle, 2017). 500 Saskatchewan farmers participated in the survey, resulting in a total of 3000 evaluations. Therefore, each vignette was evaluated approximately 21 times ([500*6]/144=20.8).

Vignette texts described a scenario of hypothetical agri-environmental programs and asked producers to provide evaluations by giving a rating. Rating was given on an 11-point numeric scale ranging from 0 to 100. Here, 0 represented the response as ‘definitely no’ and 100 represented ‘definitely yes.’ Such scales are frequently used in vignette experiment studies as they give sufficient possibilities for respondents to express differences in vignette judgments, while preventing risks of censored responses (Wallander, 2009; Auspurg and Hinz, 2015). The following tables show examples of vignette text for soil and water programs separately. The attributes are written in italics in the texts.

Table 6: Example of Soil Monitoring Vignette Text

The [*Govt. of Saskatchewan]* invites farm operators to participate in a new [*soil quality monitoring*] program. The program requires you to commit to random soil sampling on your land. [*All data and their GPS coordinates*] will be added to a new Saskatchewan soil quality database. A webtool based on the database will be made [*publicly available to help all Saskatchewanians*] to improve their land. Participating producers qualify for [*a stewardship award for sustainable agricultural practices in their community*]. The program already has received strong endorsement by [*some producers in your rural municipality*]. Participating producers can get access to detailed soil and water test results for their land at [*25%*] of the cost of comparable commercial testing services.
Rating: Given this program design and the features described above, how likely are you to participate in this program?
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Definitely no Probably no Maybe Probably yes Definitely yes

Table 7: Example of Water Monitoring Vignette Text

[*The Saskatchewan Soil Conservation Association*] invites farm operators to participate in a new [water *quality monitoring*] program. The program requires you to commit to random water sampling on your land. [Only anonymous aggregate data] will be added to a new Saskatchewan water quality database. A web tool based on the database will be made [*available only to participating* Saskatchewan producers to improve their land. Participating producers qualify for [*NONE, dropped*]. The program already has received strong endorsement by [*your industry organization*]. Participating producers can get access to detailed soil and water test results for their land at [*75%*] of the cost of comparable commercial testing services.
Rating: Given this program design and the features described above, how likely are you to participate in this program?
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Definitely no Probably no Maybe Probably yes Definitely yes

3.4.3: Data collection

The 2021 ESAT survey used both online and telephone methods. Researchers at the University of Alberta recruited 464 Saskatchewan farmers for an online survey, and Kynetec was commissioned to recruit the remaining 36 producers using a telephone survey. While the survey was mainly similar for all respondents, the online survey differed in two ways:

1. Online respondents participated in a vignette experiment eliciting Saskatchewan farmers' thoughts on soil and water quality monitoring programs.
2. Online respondents could pause the survey and complete it at their own pace. This option was meant to reduce respondent fatigue.

A random and representative sample of 500 Saskatchewan farmers were created who responded to either the online or telephone survey between March 23, 2021, and August 6, 2021. The target population was primary agricultural operators in Saskatchewan who 1) had gross farm sales of at least $10,000 in 2020, 2) had at least 10 acres of land, and 3) were mainly involved in making decisions about the practices and operations used on their farms. The following figure shows the weighted data distribution from Saskatchewan's six census agricultural regions (CAR). There was no observation for CAR 7 in this survey.

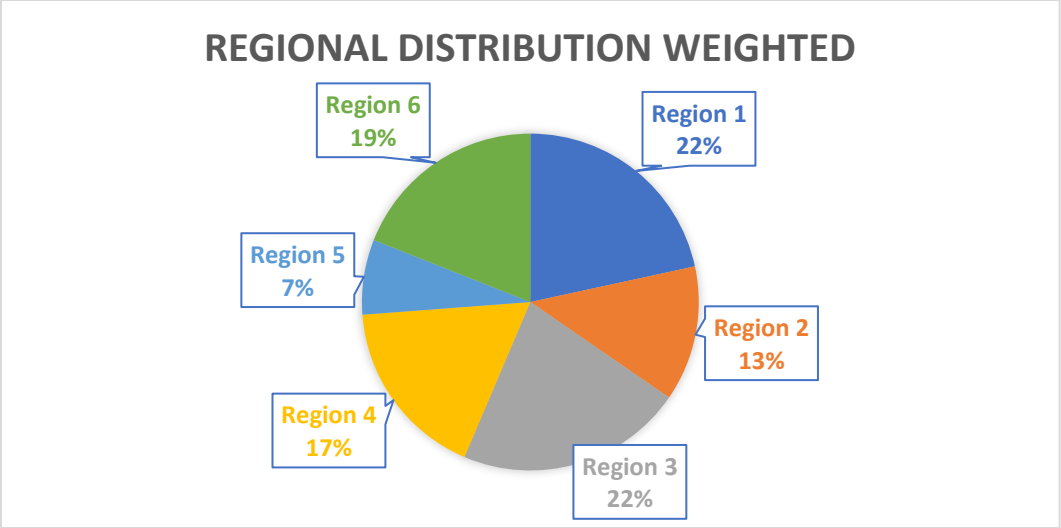


Figure 4: Regional Distribution of Data

The survey included respondents from 225 municipal districts of Saskatchewan, with at least one respondent from each. The summary statistics at the *municipal level* are presented in the table below.

Table 8: Summary Statistics at Rural Municipal Level

Summary Statistics	Value
Mean	2.22
Standard Deviation	1.44
Minimum	1
Maximum	9

The final data were weighted to ensure the overall sample's regional and gross farm sales composition reflects the actual distribution of farms in Saskatchewan based on the 2016 Census of Agriculture. Details of the weighting used in this survey can be found in the appendix.

3.4.4: Econometric Methods

In vignette experiments, researchers distinguish two types of independent variables. The experimental setup defines the first type, the vignette variables, which vary in their levels. The second type of independent variable is the respondents' characteristics. The assumption of independent observations on vignette variables is violated because each respondent evaluates multiple vignettes (Auspurg and Hinz, 2015). More precisely, the judgments per individual are probably correlated (Liebe et al., 2017). In this case, using the well-known ordinary least squares [OLS] method is not recommended. In OLS, the estimation of the regression coefficients will be unbiased, but the standard errors of the coefficients will be biased (they are typically underestimated) (Auspurg and Hinz, 2015; Snijders and Bosker, 2012; Parkins et al., 2022). This means the null hypothesis of no relationship between the independent and outcome variables might be too easily rejected.

To analyze vignettes that are clustered within respondents, different approaches are used by researchers (Liebe et al., 2017). One of them is using multilevel regression models that explicitly focus on the multilevel structure of error terms. Among multilevel models, random intercept models are a type that attempt to "express different (individual) thresholds of the outcome(s)" (Auspurg and Hinz, 2015). As the structure of data used in this study is multilevel and the focus is on vignette ratings as the dependent variable, a random intercept model is used to account for the nested structure of the data at the respondent level and the presumed heterogeneity among respondents (Atzmüller and Steiner, 2010; Liebe et al., 2017).

The random intercept model is a random effect (RE) model in contrast to fixed effect (FE) model. The FE approach is less than ideal for vignette data analyses as it restricts us to comparisons of

different models over groups of respondents (Auspurg and Hinz, 2015), while RE model specification allows for including second-order respondent characteristics (Parkins et al., 2022) Vignette data presumes that the randomization of vignettes to a random sample of respondents was effective, which fulfill the main prerequisite for the use of random effects models (i.e., there is no correlation between covariates and the error terms (Cameron and Trivedi, 2010). For vignette variables, this assumption is automatically fulfilled by design.

The Hausman test was done to ensure that the RE model best fits this study. The result is reported in the appendix. The result confirms the use of RE models. Therefore, with successful randomization, RE models are estimated to find out the impacts of vignette dimensions in this study using the statistical software package 'Stata.'

Attribute Only Model:

In this first model, the primary purpose is to determine the impact of vignette attributes on the farmers' rating of different programs. The general econometric model with only vignette attributes is:

$$Y_{ij} = \beta_0 + \beta_1 X_{ij1} + \beta_2 X_{ij2} + \ldots + \beta_\rho X_{ij\rho} + u_j + \varepsilon_{ij}$$

With, $i = 1, \ldots, n_d$; $j = 1, \ldots, n_r$

Here, Y_{ij} = Ratings for the single vignettes i from respondents j

X = vignette attributes

p = vignette dimensions

β = regression coefficients

ε_{ij} and u_j = random errors [The error term is decomposed into two components because each respondent evaluates more than one vignette]

n_d = number of vignettes presented to single respondents

n_r = number of respondents

The specific econometric model for this study with only vignette variables is:

$$Y_{ij} = \beta_0 + \beta_1 \text{Program}_{ij1} + \beta_2 \text{Messenger}_{ij2} + \beta_3 \text{Privacy}_{ij3} + \beta_4 \text{Ego}_{ij4} + \beta_5 \text{Norm}_{ij5} + \beta_6 \text{Cost-Share Incentive}_{ij6} + u_j + \varepsilon_{ij}$$

Farmer Characteristics Model:

The respondents' characteristics are added in this second model, extending the attribute-only model. The general formula for the model is:

$$Y_{ij} = \beta_0 + \beta_1 X_{ij1} + \beta_2 X_{ij2} + \ldots + \beta_\rho X_{ij\rho} + \gamma_1 Z_{j1} + \gamma_2 Z_{j2} + \ldots + \gamma_q Z_{jq} + u_j + \varepsilon_{ij}$$

With, $i = 1, \ldots, n_d$; $j = 1, \ldots, n_r$

γ= Coefficient for respondent level

Z= respondent variable

The specific farmer characteristics model for this study is:

$$Y_{ij} = \beta_0 + \beta_1 \text{Program}_{ij1} + \beta_2 \text{Messenger}_{ij2} + \beta_3 \text{Privacy}_{ij3} + \beta_4 \text{Ego}_{ij4} + \beta_5 \text{Norm}_{ij5} + \beta_6 \text{Cost-Share Incentive}_{ij6} + \gamma_1 \text{Age1844}_{j1} + \gamma_2 \text{Age4564}_{j2} + \gamma_3 \text{Degree}_{j3} + \gamma_4 \text{Training}_{j4} + \gamma_5 \text{EFP}_{j5} + \varepsilon_{ij}$$

The farmer characteristics variables added in the model are age, degree, training, and EFP. The reason behind including these specific variables is their possible impact on the rating. Literature often mentions all these variables to be impactful in case of farmers' decisions regarding agri-environmental program participation or BMP adoption. For example, age, education, and training are frequently documented determinants of BMP adoption (Baumgart-Getz et al., 2012; Mishra et al., 2018; Prokopy et al., 2008; Knowler & Bradshaw, 2007). In addition, EFP has also been found to impact BMP adoption and agri-environmental risk areas positively (Plummer et al., 2008; van Wyngaarden, 2021).

3.5: Results

3.5.1: Descriptive Results

This section starts with the descriptive statistics of the survey respondents. After that, the current BMP adoption rates for soil and water in Saskatchewan are discussed. In Saskatchewan, EFP is considered an essential factor in adopting BMPs. Therefore, the third component of this section is the EFP analysis for farmers of Saskatchewan. Descriptive results related to the primer message and nudging attributes are reported next. A distribution of vignette ratings by farmers is also included in the analysis.

Overview of Respondent Characteristics

The table below provides the descriptive statistics of respondent characteristics (n=500). Most producers were between the ages of 45 to 64 (46%) or over the age of 65 (42%), with only a small

portion of producers being younger than 45 (12%). These results correspond to the 2016 census of agriculture, where the average age of Saskatchewan farm operators was 55 (Statistics Canada,b).

Table 9: Descriptive Statistics of Farm and Farmer characteristics

Type	Variable	Description	Mean	Std. Dev.
Farmer Characteristics	*Age*	18-44	.119	.324
		45-64	.457	.499
		65+	.424	.495
	Degree	Had a Degree in Agricultural related area	.384	.487
	Training	Attended Agriculture Training Sessions	.137	.344
	EFP	Has an Environmental Farm Plan (EFP)	.444	.497
Farm Characteristics	*Land Ownership*	Own land	.456	.499
		Rent Land	.017	.129
		Both Own and Rent Land	.527	.499
	Farm Revenue	Gross Farm Revenue> $250,000	.417	.494
	Farm Size	Acres of Cropland (n=482)	2458.05	3622.44
	Farm Type	Primarily Crop	.819	.385
		Primarily Livestock	.069	.255
		Mixed	.111	.315
	Farm's State	Planning to Expand	.131	.337
		Planning to Reduce	.352	.478
		Planning to Sell	.018	.133
		Planning to Maintain	.499	.501

Only 14% of farmers had attended conservation training within the past two years, while 38% had a degree. 44% of farmers had an Environmental Farm Plan (EFP), while the Farm Management Survey (2017) shows that 28% of Saskatchewan farmers had completed EFP (van Wyngaarden,

2021). Further, 42% had gross farm revenue greater than $250,000. More than half of all respondents owned and rented land (53%), and 46% primarily owned land. A large portion (82%) of respondents identified themselves as primarily crop farmers based on gross farm receipts in 2020, with only 7% primarily livestock farmers. Most of these values closely match the results of the Alberta portion of the survey (Anders et al., 2021). The only noticeable difference was having more livestock farmers in Alberta (24%).

Respondent Characteristics Across Different Farm Types

Some respondent characteristics were similar across farm types, but some showed huge differences. The largest and most significant difference was the mean percentage of farmers who had attended training, as livestock farmers showed a very high percentage (82%).

Table 10: Respondent Characteristics Across Different Farms

	Crop	**Livestock**	**Mixed**
Farmer Characteristics			
Age 18-44	12%	3%	13%
Age 45-64	51%	18%	21%
Age 65+	37%	79%	66%
Has a degree	38%	76%	12%
Attended Conservation Training	8%	82%	12%
Environmental Farm Plan	42%	88%	37%
Farm Characteristics			
Gross Farm Revenue > $250,000	47%	20%	19%
Primarily Owns Land	44%	55%	53%
Primarily Rents Land	2%	0%	0%
Both Owns and Rents	54%	45%	47%
Planning to Expand	14%	9%	10%
Planning to Reduce	34%	68%	24%
Planning to Sell	2%	0%	0%
Planning to Maintain	49%	23%	67%

Compared to primary livestock or mixed farmers, primary crop farmers were more likely to have higher gross farm revenue (47%). Most livestock producers had EFP (88%) and a degree (76%). Only a few crop producers (2%) planned to sell, while mixed producers mainly maintained (67%).

Current BMP Adoption Scenario in Saskatchewan

The ESAT survey included questions regarding adopting different soil and water quality-related BMPs by Saskatchewan farmers. An Environmentally Sustainable Agriculture (ESA) adoption score, developed to analyze the current adoption scenario of Saskatchewan producers, can be described as: '*the average percentage of* improved *environmentally sustainable agriculture practices adopted by producers.'* The formula for calculating the ESA adoption score is as follows:

$$ESA\ Score_{jf} = \frac{Number\ of\ Practices\ Adopted_{jf}}{Number\ of\ Practices\ Eligible_{jf}}$$

Where j represents the risk area for farmer f. All farmers were not eligible for all practices. Therefore, eligibility was determined by asking questions regarding the farm operations. Only those who were eligible were further asked questions about ESA practices to measure adoption correctly. Details about determining the eligibility and example can be found in the appendix.

There were 21 ESA practices in total, and among them, 12 were related to soil and water quality with the following breakdown:

- Water Quality – 7 performance measures
- Soil Health – 5 performance measures

The following paragraphs demonstrate the descriptive results for Saskatchewan farmers' soil and water-related BMP adoption. The adoption rates are compared to the results derived from the

Alberta portion of the data reported by Anders et al. (2021), where applicable. All results in this portion are weighted against the 2016 census data.

Soil Health Adoption

The mean soil health adoption score for 2020 was 62%, higher than Alberta's (44%). The most adopted practice was the frequency of applying manure more than every two years (89%), with the least adopted practice being sampling and analyzing manure for nutrient content (9%). The most and least adopted practice in Alberta was the same, though the percentage varied. 77% of respondents used reduced tillage, while 56% used pulse crops in rotation, and only crop producers were eligible for these two practices. Only livestock producers were eligible for the other three practices related to manure.

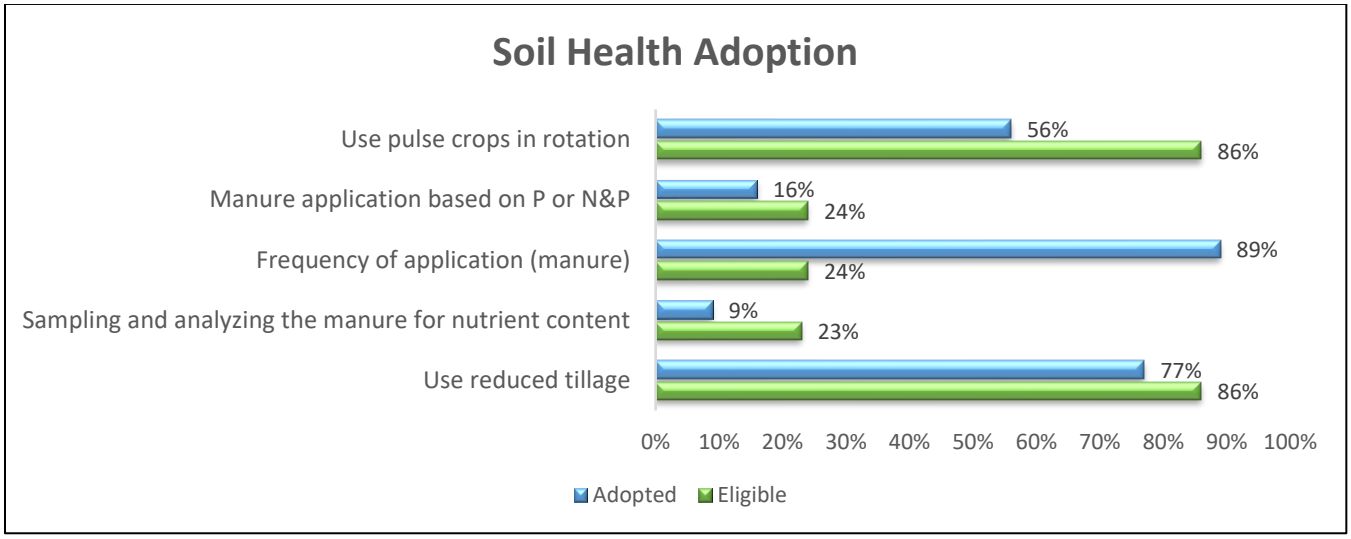


Figure 5: Soil Health Related Practice Adoption Rates

Soil Health Adoption Analysis

- Respondents from region 2 held the highest soil health adoption scores (79%), with respondents from region 5 having the lowest scores, on average (47%).
- An EFP and higher gross farm revenue were also indicators of higher adoption scores (67% and 73%, respectively).
- Livestock producers had, on average, lower adoption scores (41%) than crop producers (65%).
- Respondents planning to expand their operation presented higher scores, on average (69%).

Water Quality Adoption

The mean Water Quality adoption score for 2020 in Saskatchewan was 70%, while it was 76% in Alberta. Overall, almost all practices were highly adopted. The practice with the highest adoption rate was 'avoiding applying compost on frozen or snow-covered ground (100%),' while the least adopted practice was 'avoiding applying manure close to waterways to minimize increased nutrient runoff (45%).' Only livestock producers were eligible for all the water-related practices.

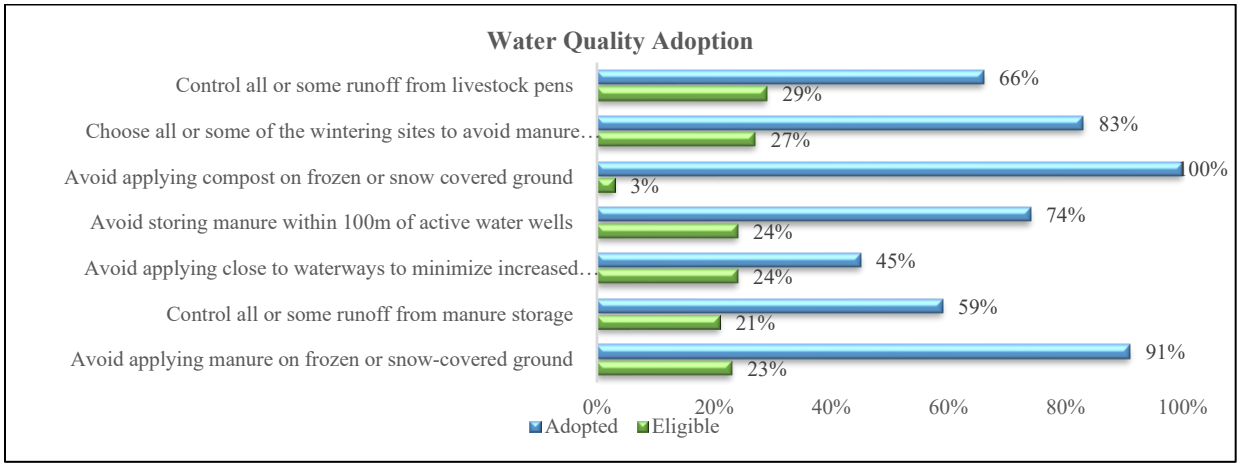


Figure 6: Water Quality Related Practice Adoption Rates

Water Quality Adoption Analysis

- The adoption score was highest for region 1 (93%), while region 6 presented the lowest (50%).
- A degree and an EFP were indicators of higher water quality adoption scores (84% and 78%, respectively).
- The most significant difference in adoption score was between respondents who attended conservation training (86%) and those who had not attended (66%).
- On average, crop producers were slightly less likely to adopt water quality practices (75%) than livestock producers (90%).

EFP Participation in Saskatchewan

The survey contained questions about Saskatchewan producers' opinions and knowledge about the Environmental Farm Plan (EFP). The EFP is a voluntary, whole-farm self-assessment tool that helps producers identify environmental risks on their farms. The EFP forms an integral component of agri-environmental policy as it is a requirement for producers to participate in almost all cost-share programs under agricultural policy frameworks. Studies highlighted the importance of the EFP, mentioning that producers who had completed an EFP were significantly more likely to adopt practices (van Wyngaarden, 2021)**.** In this study, out of all farmers, 44% had completed an EFP, while 47% completed it in Alberta in 2020.

EFP Participation: Overview

91% of farmers found the EFP process valuable, and by completing an EFP, they learned something about environmental risks in their operation. Out of farmers who did not have an EFP,

only 21**%** indicated they would consider completing one in the future, 50**%** stated they did not know if they would consider completing one, and 29**%** said they would not be willing to complete one.

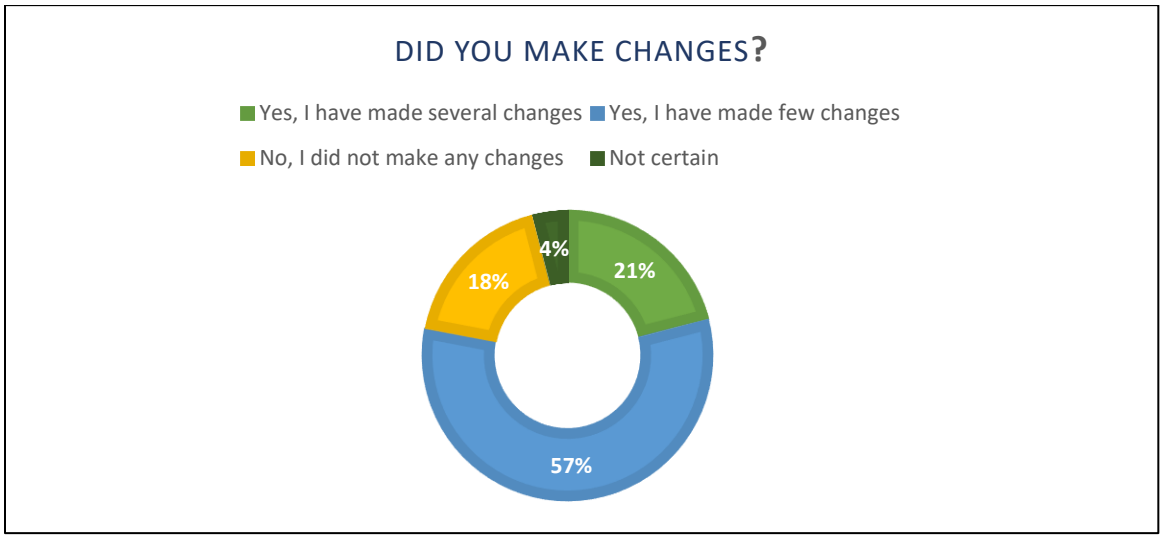
The survey asked respondents to identify the statement that best described the EFP. This question examined whether farmers understood or held knowledge about the EFP program. The response indicating a producer fully understood the program was, *'The EFP helps farmers identify environmental risks and provides suggestions to mitigate them.'* Producers who responded, *'The EFP is a tool for identifying environmental risks on your farm,'* were also deemed knowledgeable and informed regarding the EFP.

Table 11: Farmers' Responses to EFP Statements

Statement	Responses (%)
The EFP is a tool for identifying environmental risks on your farm	80%
The EFP gives farmers money to complete environmental projects on their land	11%
The EFP is required by some commodity organizations	2%
The EFP is only for large commercial farms	7%
The EFP helps farmers identify environmental risks and provides suggestions to mitigate them	0%

Most farmers properly could describe the EFP (80%). However, no farmers (0%) selected the best statement to describe the EFP, corresponding to the Alberta results. Only 11% of farmers believed the EFP gave farmers money to complete environmental projects on their land. While the EFP does not provide monetary funds, this response may be attributed to the EFP being a requirement to access financial support through environmental stewardship programs.

In the survey, respondents with an EFP were asked whether they had changed their operation based on their EFP workbook. Most farmers said they had made a *few* changes (57%), which is similar for Alberta farmers (64%), with 21% stating they had made several changes. These results imply that EFP helps farmers to identify the risks of their operations and motivates them to change their operations according to the guidelines. Further, 18% of farmers indicated they did not make any changes based on their EFP. It should be noted these farmers may have only recently completed an EFP, which would provide a shorter time horizon to make changes.

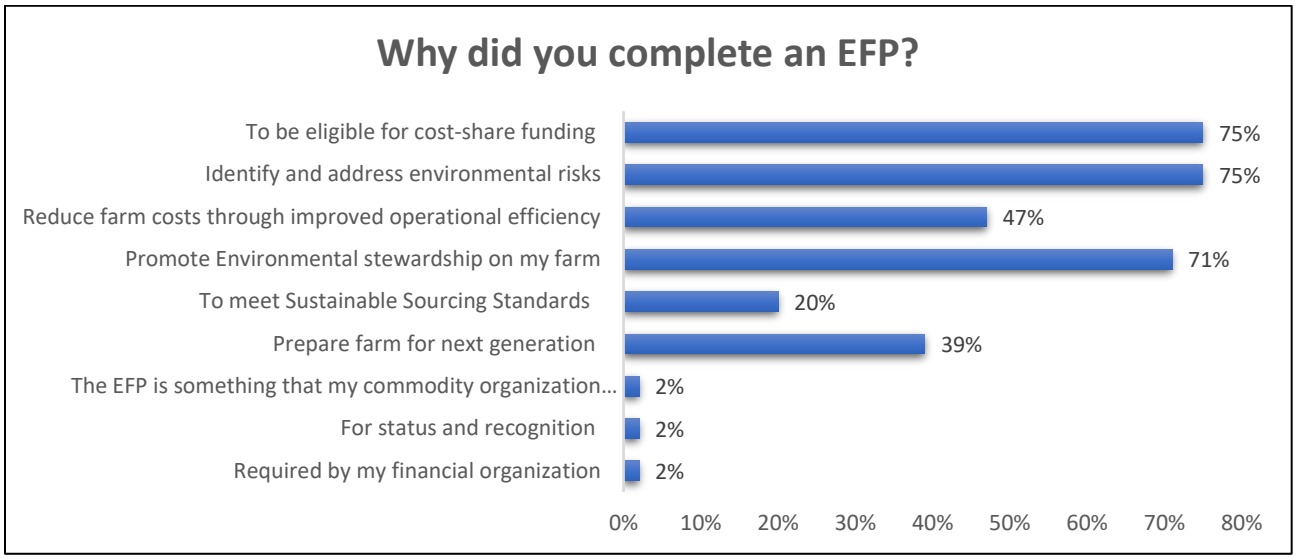


[Base: Has an Environmental Farm Plan (n=289]

Figure 7: Changes in Farm Operation Based on EFP

Respondents were also asked to state why they decided to complete an EFP. 75% of farmers completed the EFP to be eligible for cost-share funding and to identify and address environmental risks on their farms. This result highlights the fact that farmers are highly motivated to complete an EFP when it is tied to monetary incentives. 71% wanted to promote environmental stewardship, reflecting that farmers who completed EFP are also concerned about environment. Only a small

portion of farmers (2%) stated they completed an EFP for status and recognition or that they were required by their financial organization (2%).

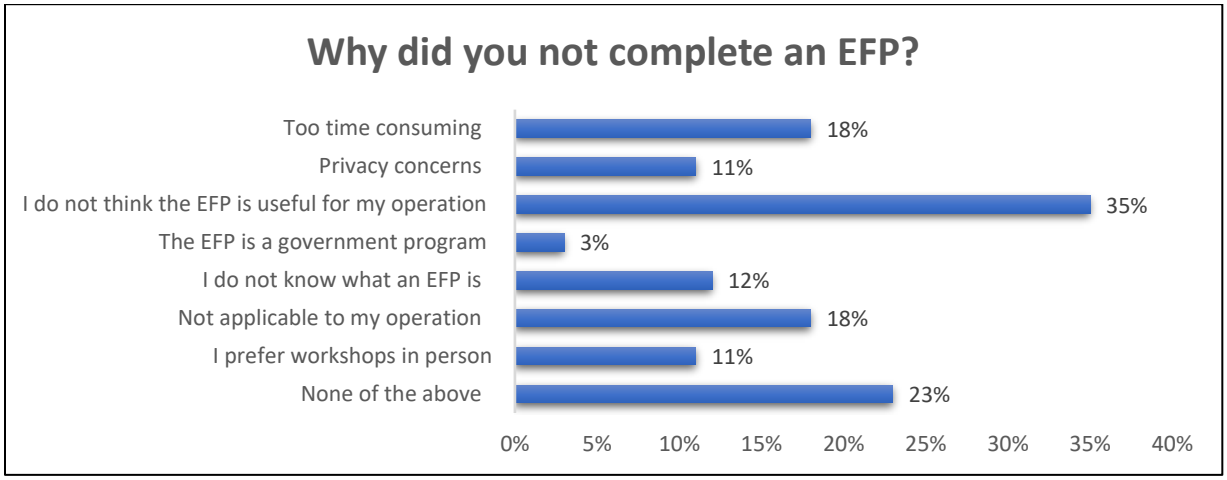


Base: Has an Environmental Farm Plan (n=289)

Figure 8: Reasons Why Farmers Completed EFP

Lastly, farmers who had not completed an EFP were asked to state the reasons for their decision. The most common reason they stated for not completing an EFP was that they did not think it was useful for their operation (35%), similar to the Alberta producers (26%). This result implies that farmers need to be informed about the importance of EFP and its usefulness in their operation. Literature often mentions the inadequate monitoring and assessment of the EFP (Smith et al. 2020; Atari et al. 2009), which can result in less participation. 18% of farmers said it was too time-consuming and it was not applicable to their operation. Privacy concerns and preferring in-person workshops were why 11% of producers did not do it. Privacy concerns have been a consistent reason for producers choosing not to complete an EFP, even with the current confidentiality allotted towards the program (Atari et al. 2009; Smithers & Furman 2003). 12% stated they did

not know what an EFP was (22%). Though private organizations run EFP, 3% of producers avoided it thinking it was a government program.



Base: Do not have an Environmental Farm Plan (n=211)

Figure 9: Reasons Why Farmers Did Not Complete EFP

Farmer Characteristics and EFP

Having a degree (or diploma) and attending an environmental agricultural training session are associated with higher rates of EFP participation. Having a degree and attending conservation training can increase awareness about environmental risks, which may correspond to an increased interest in completing an EFP. Being a livestock farmer and having higher gross farm revenue increased the EFP completion rate, which corresponds to the results by Atari et al. (2009) who found that these two factors were significantly related to completing an EFP by Nova Scotia farmers.

Table 12: Farmer Characteristics and EFP Participation

		Degree		Training		Livestock		Crop		GFR>250K		Own Land	
	Total	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Environmental Farm Plan	**44%**	50%↑	41%	79%↑	39%	88%↑	41%	42%	57%	56%↑	36%	35%↓	52%

↑ indicates participation increased by at least 5% for these characteristics.

↓ indicates participation decreased by at least 5% for these characteristics.

Farm Expansion Plans and EFP Participation

Farmers planning to expand their operation had the highest percentage of producers who completed an EFP (60%). Farmers who were planning to sell their operation had the lowest participation rates on average at 5%. These result makes sense as those farmers most likely did not find value in completing an EFP as they would not continue caring for the land.

Table 13: Farm Expansion Plans and EFP Participation

	Total	Beginning or Maintaining	Expanding	Reducing	Selling
Environmental Farm Plan	**44%**	34%	**60%**	55%	**5%**

[1]Red indicates the farm expansion plan with the lowest EFP score; green represents the highest.

Primer Messages and Rating

The priming message shown to farmers before participating in the vignette experiment included either social or private benefits of agri-environmental program participation. The intention was to identify which benefits better motivate farmers to participate in programs. Literature mentions that farmers who are already adopters of BMPs are more likely to continue adoption (Liu and Brower, 2022). As there is data for the current adoption level of the farmers (ESA Score), descriptive statistics were run to check if higher adopters rate programs higher than the lower adopters regardless of the different primer messages. The estimation was done based on the average ESA score, which is .6.

Table 14: Impact of Primer Messages on Rating

	Adopters above mean (ESA Score >.6)	**Adopters below mean (ESA Score <.6)**	**Highest Adopters (ESA Score >.8)**	**Lowest Adopters (ESA Score <.4)**
Primer 1: Social Benefit	48.36	41.50	51.63	34.94
Primer 2: Private Benefit	47.23	44.51	49.30	38.75

Note: Green refers to the highest rating, while red indicates the lowest.

The result shows adopters having a score above mean rated programs almost similarly, though they received different priming, and the rating was higher than the overall mean rating (45.85). In contrast, adopters below the mean rated programs lower in both cases, and the rating was much lower for those who received social benefit messages. The table shows that rating was highest when the ESA score was highest and the farmers received the social benefit message, while the

rating was lowest for the farmers who had the lowest ESA score and received the social benefit message.

This implies that the current adopters are more inclined to participate, even if they do not receive any private benefit. It makes sense intuitively, as the higher adopters of BMPs are considered more concerned about their operation's social and environmental impacts (Liu and Brower, 2022). Farmers who have already adopted other practices are more likely to adopt new practices (Prokopy et al., 2019). However, promoting private benefits may work better than social benefits to motivate non-adopters. Reviews of adoption practices often mention net private returns as an important motivator (e.g., Pannell et al., 2006). If farmers make production decisions based solely on private benefits, they could under-invest in conservation practices if the costs of implementing and managing are higher than incentives (Kara et al., 2008). However, if they are informed that there will be cost associated with not implementing BMPs, they may be better interested in adoption.

As the ESA score seems to impact the rating from these descriptive results, an OLS regression with cluster robust standard error was done on rating with the ESA score as the independent variable. The result can be found in the appendix. The regression result showed that the rating increased by 17.90 points with a .1 increase in the ESA score.

Nudging Attributes and Respondents' Characteristics

This section describes how rating changes when farmers with the same characteristics receive different levels of nudging attributes. The table's descriptive statistics show different groups of farmers having different preferences for nudge attribute levels and rated accordingly. This implies that the impact of a specific nudge on rating can differ with the different characteristics of the participants when all other things are constant. For example, younger farmers rated the highest

when the vignette contained Saskatchewan Soil Conservation Association (SSCA) as the messenger. In contrast, the older ones rated highest when the messenger was the government. Farmers having training and EFP also preferred the government as a messenger. Findings of a study suggest that the messenger is likely more important than the message itself in influencing farmers' decision-making for adopting BMPs (Pourtaherian, 2023)

Table 15: Nudge Attributes and Respondent Characteristics

		Age		***Have a degree***	***Have Training***	***Have EFP***
		Age 18-44	**Age 45-64**			
Messenger	Government	44.13	48.18	50.06	50.89	49.67
	SSCA	47.14	45.12	48.87	51.42	47.77
	Groups	44.01	43.61	49.37	52.99	46.52
Privacy	Private	46.82	47.58	51.28	51.93	48.78
	Partially Available	47.40	45.04	48.22	55.20	50.20
	Public	41.69	44.23	46.73	48.45	45.08
Ego	None	42.29	45.28	49.45	53.52	48.12
	Award	46.38	45.90	49.18	50.00	47.96
	Certificate	46.39	45.68	47.70	51.35	47.90
Norms	None	45.36	42.85	47.77	50.25	45.38
	Comparison	45.59	47.39	50.67	51.23	50.84
	Municipal Approval	45.50	44.97	48.51	53.13	47.61
	Organization Approval	44.03	47.31	47.86	52.33	48.11

Note: Values colored in green indicate the highest ratings for each nudging category

Farmers, regardless of their characteristics, rated the program lowest when privacy was set as public. The younger farmers and those with training rated highest when the vignette text mentioned

that the data would have been made partially available. All other groups preferred to keep the resulting data private. For nudge ego, younger farmers are found to rate highest when they would receive a certificate for participation. This nudge seems to have little impact on rating for all other groups.

In case of the norms nudge, all groups of farmers rated highest when there was a comparison statement in the vignette text, except those with training who preferred the program to be approved by the municipality. This result indicates that farmers, as other people, tend to follow their peers' activities. This result corresponds to the literature findings, which mentioned social comparison as an effective way to motivate farmers to BMP adoption (e.g., Wu et al., 2017; Cullen et al., 2020). Results from the study by Sherren et al. (2023) suggest that fenceline neighbour dynamics might indeed be related to the adoption of a practice.

Rating Distribution of Vignettes

The graph shows the distribution of ratings given to the vignettes by Saskatchewan farmers. The highest percentage of farmers (27.69%) rated the programs at a level of 50, which is equivalent to the response 'maybe.' This result reflects that almost one-third of farmers were moderately willing to participate in the programs. However, rating a program at the level of 50 might also refer to the fact that farmers were not very sure about participating, resulting in choosing the average rating.

Figure 10: Vignette Rating Distribution

Almost 20% of farmers rated programs higher than 80, with 6.9% giving a rating of 100. This implies that only a few numbers of farmers were highly encouraged to participate. In contrast, 16.3% gave a rating of 0 to the programs, demonstrating many farmers' reluctance to participate. These farmers were not motivated by monetary incentives or non-monetary nudging elements. Therefore, this result highlights the fact that it is still unknown what would motivate all farmers towards agri-environmental program participation.

3.5.2: Econometric Results:

This section presents the results of different econometric models, which demonstrate the impact of different program, nudging, and respondents' characteristics on the rating of vignettes.

Attribute-only model:

Three different models were estimated that included only vignette variables and aimed to determine their impact on the rating. The first is an aggregate model that included the program as a variable, whereas the second and third models were run separately for soil and water programs. The overall results of all models do not show expected outcomes. Nudge attributes show minimal significant impact on farmers' decision to rate the vignettes. In addition, some nudge variables show negative signs implying that those attributes impacted farmers' decision negatively, which contradicts the assumptions regarding the effectiveness of nudges.

The interpretation of the coefficients is not straightforward, like general regression coefficients. In statistical analysis of vignette models, we get estimates for all levels of an attribute except for the benchmark or base level. The coefficients of the attribute levels are interpreted against the base level of the attribute. For instance, the coefficient of water monitoring program being 8.44 implies that the farmers rated vignettes 8.44 points higher on average when the vignette text contained water programs instead of soil programs, which is highly significant.

Similarly, the coefficient of the SSCA being .095 indicates that farmers' rating of vignettes was .095 points higher on average if SSCA was present as the messenger in the vignette than if the government was present. However, this value is not statistically significant. None of the nudging attribute coefficients were statistically significant except the attribute level 'public' for the privacy nudge.

Table 16: Attribute-Only Model Results

	Aggregate (N=2784)	Soil (N=1392)	Water (N=1392)
Program: base: Soil			
Water	8.447***		
	(0.85)		
Messenger: base: Government			
SSCA	.095	.871	-.826
	(0.83)	(1.204)	(1.191)
Groups	-.733	-.055	-1.653
	(0.86)	(1.213)	(1.038)
Privacy: base: Private			
Partially Available	-.735	-.606	.709
	(0.92)	(1.173)	(1.172)
Public	-1.791*	-2.228*	-.197
	(0.96)	(1.343)	(1.202)
Ego: base: None			
Award	-.795	.701	-2.312*
	(0.81)	(1.241)	(1.309)
Certificate	-1.064	.85	-2.046*
	(0.80)	(1.215)	(1.205)
Norms: base: None			
Comparison	1.222	.266	1.519
	(0.97)	(1.289)	(1.298)
Municipal Approval	-.07	.636	-.178
	(0.97)	(1.38)	(1.274)
Org. Approval	1.028	-.336	.806
	(0.94)	(1.237)	(1.198)
Cost-Share Incentive: base: 25%			
50%	-2.075**	-1.582	-2.492**
	(0.93)	(1.294)	(1.222)
75%	-2.517**	-2.33	-2.498*
	(1.03)	(1.423)	(1.33)
Constant	44.287***	51.391***	44.86***
	(1.77)	(2.07)	(2.107)

Standard errors in parenthesis
**** p<.01, ** p<.05, * p<.1*

The coefficient of the level ‘public’ being -.17 implies that farmers rated the vignettes .17 units less on average when the vignette text mentioned the resulting data would be made public instead of private. This result was significant at 10% level. The coefficient of ‘public’ was significant in the soil model as well, where the value was -.23. No other vignette attribute’s coefficient was statistically significant in the soil model.

Among the nudge attributes in the water model, only the two levels of ego nudge yielded significant results. The negative sign in both coefficients indicates that farmers rated the vignettes less when an award or certificate was mentioned in the vignette text than when the statement did not mention any of them. The coefficients of two levels of cost-share incentive variable are significant at 5% level in the first and third models, while the values are insignificant in the second model. Coefficients of the incentive variable had negative signs in both first and third models, implying that farmers preferred programs when their cost-share portion was stated lower. For instance, the value -2.49 for the attribute level ‘75% cost-share means that farmers rated the vignette 2.49 points less on average when the vignette text contained 75% cost-share compared to when it said 25%.

Farmer Characteristics Model:

In the second step, farmer characteristics variables were added alongside the vignette variables, and three different models were again estimated.

Table 17: Farmer Characteristics Model Results

	Aggregate (N=2730)	Soil (N=1365)	Water (N=1365)
Program base: Soil			
Water	4.634***		
	(1.147)		
Messenger: base: Government			
SSCA	.284	.77	-.724
	(.916)	(1.368)	(1.193)
Groups	-1.151	-.324	-3.023***
	(1.048)	(1.576)	(1.153)
Privacy: base: Private			
Partially Available	-.51	.644	.99
	(1.083)	(1.255)	(1.271)
Public	-2.672**	-2.163	-.077
	(1.164)	(1.797)	(1.067)
Ego: base: None			
Award	-.664	2.369	-2.626**
	(1.147)	(2.017)	(1.251)
Certificate	-2.443**	.165	-2.373*
	(1.077)	(1.424)	(1.239)
Norms: base: None			
Comparison	.582	-1.479	.729
	(1.047)	(2.13)	(1.554)
Municipal Approval	-.108	-.234	-.695
	(1.13)	(1.794)	(1.477)
Org. Approval	2.23*	.778	.623
	(1.224)	(2.146)	(1.252)
Cost-Share Incentive: base: 25%			
50%	-3.706***	-2.077	-2.215*
	(1.153)	(1.477)	(1.249)
75%	-3.527***	-2.365	-2.575*
	(1.15)	(1.516)	(1.354)
Farmer's Characteristics			
Age18-44	.096	2.199	-2.862
	(10.376)	(8.945)	(11.421)
Age 45-64	-10.45	-9.939	-11.133
	(7.815)	(7.949)	(7.917)
Have Degree	-3.564	-3.663	-4.514
	(6.068)	(6.001)	(6.117)
Have Training	7.284	1.277	10.76*
	(6.075)	(6.529)	(6.05)
Have EFP	-1.09	-3.414	-.566
	(5.697)	(5.67)	(5.709)
Constant	55.093***	44.979***	55.562***
	(10.415)	(14.581)	(10.83)

*Standard errors in parenthesis, *** p<.01, ** p<.05, * p<.1*

Against the expectation, the farmer characteristics variables do not yield any significant results in all three models except the training variable, which is significant in the third model. The coefficient of training being 10.76 implies that farmers who had training rated the vignettes 10.76 points higher on average than those without training. However, adding the characteristics variables made some nudge attributes significant in the first and third models. For example, in model one, the level certificate of the ego nudge and the level public of privacy nudge is now significant at 5% level along with the level organizations approval of the norm nudge being significant at 10% level.

In the third model, the variable 'groups' of the messenger attribute is now highly significant with a value of -3.02. This means that farmers' rating was 3.02 points lower on average when the vignette mentioned groups of conservation and watershed associations across Saskatchewan as the messenger compared to when it mentioned the government. The levels of cost-share incentive variable are highly significant in model one. Surprisingly, model two, the soil model, does not yield any significant results when farmers' characteristics variables are added.

Since the farmers' characteristics variables are insignificant in these models, an OLS regression with cluster robust standard error was done on rating with farmers' characteristics as independent variables. The results are reported in the appendix, which shows that EFP is positively related to rating, and the result is significant at a 10% level.

The overall result of the econometric models suggests that cost-share incentives were most effective in impacting ratings.

3.6: Discussion

The primary purpose of this study was to examine the impact of behavioral nudges on Saskatchewan farmers' decisions to participate in agri-environmental programs. In addition, I analyzed the current BMP adoption and EFP participation scenario in Saskatchewan, which was another objective. I will combine the results of the descriptive analysis of current adoption and the econometric analysis of vignette ratings wherever applicable to discuss their implications regarding policy and programs in Saskatchewan.

The descriptive results of this study show that the adoption rates for water quality-related BMPs were higher than soil health-related BMPs. In addition, the econometric results showed that farmers rated vignettes higher when they contained information regarding water programs. If both results are considered, it refers to the fact that farmers are currently adopting water-related BMPs more and are better inclined to participate in future water programs. These results imply that Saskatchewan farmers might value water more than soil in their agricultural operations. Moreover, literature mentions that water-related problems are worse in Saskatchewan agriculture as the province is greatly affected by wetland drainage issues (Breen et al., 2019; Hassanzadeh, 2019), which could be the reason behind the higher adoption. These results also highlight the fact that soil programs need to be promoted more to Saskatchewan farmers as both the current adoption rates and the ratings of programs are comparatively lower.

The regional impact on adoption was notable as some regions had much higher adoption rates while some had lower. This result indicates the fact that farming strategies might vary with the location. In a specific location, farmers tend to make decisions as a group (Liu et al., 2018). So, when they adopt a practice and find it valuable, they may recommend it to others (Liu and Brower,

2022). Moreover, the impacts of climate change may differ from region to region, which can cause variability in adoption rates. Therefore, programs should be designed considering these regional inconsistencies.

Different characteristics of farms and farmers also impacted the adoption rates. For example, livestock producers highly adopted water-related BMPs, while crop producers adopted both soil and water BMPs at similar rates. These results correspond to the different types of operation in both farming processes, referring to the importance of soil and water in crop production. In addition, education and training are found to be associated with higher adoption, corresponding to the literature (Baumgart-Getz et al., 2012; Liu et al., 2018). I also found that farmers with different characteristics view the nudge attribute levels differently. For example, the descriptive analysis shows that younger farmers rated vignettes differently than older ones based on different messengers. This result highlights farmers' age's impact on BMP adoption decisions. Therefore, when communicating with farmers about the agri-environmental programs, the messengers should be chosen according to the farmers' age for optimum participation. However, adding farmers' characteristics in econometric analysis yields no significant result.

This study's descriptive and econometric analysis highlights the importance of an Environmental Farm Plan (EFP). EFP is found to be positively related to 1) soil and water BMP adoption and 2) rating in the vignette experiment. For this reason, a separate analysis of EFP participation by Saskatchewan farmers was done in this study. The results show that most of the farmers who had completed an EFP found it valuable as it helped them identify their operation's environmental risks. The Majority also stated that they made changes based on the EFP workbook. However, only a few of those who did not complete the EFP were positive for completing one in the future. In addition, many of them stated that they did not complete one because they did not think it useful

for their operation. These results highlight that farmers find EFP useful once they participate and will prefer to continue participating. However, none of the Saskatchewan farmers could properly identify what an EFP is. Therefore, promoting the advantages of EFP participation in Saskatchewan is crucial to make all farmers interested.

The findings of this study indicate that the current adopters of BMPs are more likely to participate in agri-environmental programs and are better concerned about the social benefit of adoption. This result corresponds to other studies that mentioned that farmers' experience with BMPs might change their attitudes toward their future adoption (Liu and Brower, 2022). It implies that BMP adoption will sustain over time as the adopters are expected to continue the adoption. However, to encourage non-adopters, different measurements should be taken such as highlighting the private benefits of BMPs instead of their public benefits (Pourtaherian, 2023). The results also suggest that non-adopters are better motivated if they understand how much loss they will incur if they do not adopt.

The econometric results for privacy nudge show that farmers will be less likely to participate in agri-environmental programs if the resulting data is shared publicly. The descriptive results reveal that farmers prefer the data to be shared only with participating farmers. This finding could be important in the context of designing agri-environmental programs in Saskatchewan. The nudge norm, which has been mentioned as one of the influential nudges in the agri-environmental literature (Banerjee et al., 2014; Cullen et al., 2020), does not yield much significant impact in this study. Although the descriptive results show that social comparison positively impacted farmers' decision to rate, econometric results found organizational approval statistically significant in only one model. Similarly, the messenger effect was minimal in this study as only one econometric model yielded significant results suggesting that the government is preferred as a messenger. In

addition, although ego nudge has a positive impact in literature, it negatively impacted Saskatchewan farmers' decisions in the vignette experiment. However, the descriptive results suggest that younger farmers might be interested in receiving certificates in exchange for participation.

Although the nudge attributes did not yield expected results, the cost-share incentive attribute was highly significant in most models. This implies that Saskatchewan farmers might prefer incentives rather than non-monetary motivation to participate in the agri-environmental programs, which corresponds to the results of other studies that mentioned that farmers thought incentives as the best option to motivate BMP adoption (Hassanzadeh, 2019). Moreover, it could also be the fact that farmers already have reached a private optimum and are not encouraged enough to change their behavior following a non-monetary incentive (Chabe-ferret et al., 2019). Therefore, this result suggests that policymakers in Saskatchewan should focus on monetary incentives to encourage farmers to participate in programs more.

3.7: Conclusion

This study aims to contribute to the agri-environmental literature in a Canadian context. Saskatchewan, a prairie province in western Canada, is dealing with agricultural sector issues related to soil and water. Various agri-environmental programs are launched in Saskatchewan to help farmers attain the goal of a sustainable agriculture sector. Still, it is unknown how to encourage farmers to participate more in those programs. Agri-environmental programs are important and complex, making them crucial topics for academic research (Baylis et al., 2022). In recent years, the governments of many countries have started to rely on insights from behavioral economics and psychology for more cost-effective agri-environmental programs (Ferraro et al.

2017). However, few behavioral economics research related to program and policy design focuses on agri-environmental issues. This study tried to address this gap by testing if behavioral nudges can be effectively applied as a non-monetary policy to promote agri-environmental programs in Saskatchewan. The results will help policymakers in the province to decide between monetary and non-monetary interventions to get the best outcomes.

This study aims to contribute to the behavioral agriculture literature by exploring the result of incorporating nudging elements in the design of various agri-environmental programs in Saskatchewan. The research questions this study tried to address were: 1) what is Saskatchewan farmers' current BMP adoption scenario? 2) can nudges impact the decision of Saskatchewan farmers to participate in agri-environmental programs? After performing both descriptive and econometric analyses, I found that Saskatchewan farmers are adopting water-related BMPs at a higher rate than soil-related BMPs. Regarding the nudges' impact, the results of this study suggest that monetary incentives might work better than behavioral nudges to motivate Saskatchewan farmers in agri-environmental program participation.

Behavioral nudges have been effectively applied in several disciplines. However, application of nudges in redirecting farmers' adoption behavior is still very few, which makes it challenging to understand the effectiveness of nudges in motivating farmers towards BMP adoption. The result of this study adds to the nudge literature and adoption literature by testing the impact of four different forms of nudging elements on farmers' adoption behavior. In addition, by using a vignette experiment to analyze the effects of nudging, the study aims to contribute to the behavioral experimental economics literature. To my knowledge, this is the first study using vignette analysis in the agri-environmental BMP adoption context.

The conclusion drawn from this study is that although cost-share incentives highly impact farmers' decisions, nudges might still be effective in some cases. Therefore, nudging should be further tested in the agri-environmental sector to understand their impacts better. There are other forms of nudges beyond those tested in this study, which might show better effects. In addition, only soil and water-related adoption is considered here, limiting the opportunity to provide any statement on nudges' impact on all other BMP areas. That is why further research should be conducted by testing more nudging elements and adding other programs to address this limitation. A region-specific approach obtains the results of this study. Since the factors of adoption vary between different technologies, regions, and individuals, the result of this study may not be applicable universally. Even in Canada, these results might not be helpful for other provinces due to the variation in climate and agricultural practices. Moreover, the study used a survey with only 500 respondents from Saskatchewan farming populations, which limits the scope to show the actual scenario of the whole province.

Chapter 4: Conclusions

This thesis used a two-paper approach to investigate whether behavioral nudges can effectively be applied to increase Canadian farmers' participation in BMP adoption and agri-environmental programs. I attempted to answer the following six research questions in this thesis to meet the objectives:

1) What are behavioral nudges? How are they applied in different disciplines? 2) Can nudges be useful in the agri-environmental sector? 3) Which behavioral factors impact farmers' BMP adoption decisions? 4) Why are the behavioral factors important to consider in BMP studies? 5) What is the current scenario of Saskatchewan farmers' participation in BMP adoption and

Environmental Farm Plan (EFP)? 6) Can nudges impact the decision of Saskatchewan farmers to participate in agri-environmental programs?

The first paper, a broad literature review, explored the nudge literature by documenting examples of using different forms of nudges in many disciplines, including a separate section on nudging evidence in agri-environmental settings. The conclusion drawn in that paper was that nudges might work positively in agri-environmental settings despite having some concerns about their effectiveness. The review also identified that several behavioral factors might impact a farmer's decision regarding BMP and mentioned the importance of considering these factors in the adoption studies. The overall findings of the review suggest that nudges might be considered as the behavioral solution to address the behavioral factors in BMP adoption decisions. I discussed how different forms of nudges might be applied by policymakers to deal with different behavioral factors of Canadian farmers to increase adoption rates. However, due to the lack of adequate evidence in the literature on using nudges in the agri-environmental sector, the policy recommendations are often based on general nudge literature. Therefore, nudges should be examined further in agri-environmental studies to better understand their influence in this sector. The review followed a theoretical approach to synthesize the findings, which limits the scope to provide empirical analysis on nudges' effectiveness in literature.

The second paper presented an empirical analysis of incorporating nudges in agri-environmental program design. The vignette experiment analysis examined how different nudging attributes impact Saskatchewan farmers' decision to participate in agri-environmental programs. The results indicate that the nudge elements minimally influenced farmers' ratings for the programs. However, the monetary incentive attribute yielded a highly significant and positive result in the econometric models, implying that Saskatchewan farmers might be better motivated by cost-share incentives

instead of the nudge interventions. In that paper, I also analyzed Saskatchewan farmers' current BMP adoption situation and participation in the Environmental Farm Plan (EFP). The findings show that farmers are adopting water-related practices more, and their EFP participation decision depends on various factors. However, those currently adopting practices and those who have implemented EFP wish to continue in the future. These results highlight the need to promote BMPs in Saskatchewan more efficiently. The paper used a region-specific approach; therefore, the findings should not be generalized for any location. In addition, I only focused on BMPs related to soil and water, which limits the scope of providing any recommendations regarding other BMPs.

Application of behavioral nudges to design agri-environmental programs is still very few. This study aims to contribute to the behavioral agriculture literature by exploring the result of incorporating nudging elements in the design of agri-environmental programs in Saskatchewan. The results of this thesis could be useful to aid the government and policymakers in Saskatchewan to develop policies and programs for agri-environmental BMP to encourage farmers better. Saskatchewan has implemented several programs to motivate farmers into conservation. However, the participation rate is still not very high. Therefore, this thesis's findings might help change the structure of current programs to achieve higher participation as well.

Although the empirical results of this thesis show that farmers would prefer monetary incentives to engage in adoption, the findings of the theoretical review suggest that nudges might still be effective in motivating participants if appropriately applied. This thesis only tested the impact of four nudging elements, limiting the scope to provide any statement as other forms of nudges might work better. Therefore, future research should include more nudging elements and conduct studies in other provinces in Canada to better understand the influence of nudges in the agri-environmental sector.

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Appendix 1: 2021 ESATS On-Line Survey Questionnaire

Below is a copy of the 2021 ESAT survey for online participants. Phone respondents answered all the same questions **except** section 2, the vignette experiment.

2021 Environmentally Sustainable Agriculture Tracking Survey (on-line)

S2. Do you currently own or rent your farmland or both?
Own land only
Rented land only
Both own and rented land
Don't know

S3. What was your gross farm revenue in 2020?
Under $10,000
$10,000 to under $25,000
$25,000 to under $50,000
$50,000 to under $100,000
$100,000 to under $250,000
$250,000 to under $500,000
$500,000 to under $1,000,000
$1,000,000 to under$2,000,000
$2,000,000 or more
Don't know

S4. In order to ensure we have representation from all regions of the province, could you please select in which "municipality" the majority of your farm is located.

Abernethy No. 186	Gravelbourg No. 104	Paddockwood No. 520
Antelope Park No. 322	Grayson No. 184	Parkdale No. 498
Antler No. 61	Great Bend No. 405	Paynton No. 470
Arborfield No. 456	Griffin No. 66	Pense No. 160
Argyle No. 1	Gull Lake No. 139	Perdue No. 346
Arlington No. 79	Happy Valley No. 10	Piapot No. 110
Arm River No. 252	Happyland No. 231	Pinto Creek No. 75
Auvergne No. 76	Harris No. 316	Pittville No. 169
Baildon No. 131	Hart Butte No. 11	Pleasant Valley No. 288
Barrier Valley No. 397	Hazel Dell No. 335	Pleasantdale No. 398
Battle River No. 438	Hazelwood No. 94	Ponass Lake No. 367
Bayne No. 371	Heart's Hill No. 352	Poplar Valley No. 12
Beaver River No. 622	Hillsborough No. 132	Porcupine No. 395
Bengough No. 40	Hillsdale No. 440	Prairie Rose No. 309
Benson No. 35	Hoodoo No. 401	Prairiedale No. 321
Big Arm No. 251	Hudson Bay No. 394	Preeceville No. 334

Big Quill No. 308	Humboldt No. 370	Prince Albert No. 461
Big River No. 555	Huron No. 223	Progress No. 351
Big Stick No. 141	Indian Head No. 156	Reciprocity No. 32
Biggar No. 347	Insinger No. 275	Redberry No. 435
Birch Hills No. 460	Invergordon No. 430	Redburn No. 130
Bjorkdale No. 426	Invermay No. 305	Reford No. 379
Blaine Lake No. 434	Ituna Bon Accord No. 246	Reno No. 51
Blucher No. 343	Kellross No. 247	Riverside No. 168
Bone Creek No. 108	Kelvington No. 366	Rocanville No. 151
Bratt's Lake No. 129	Key West No. 70	Rodgers No. 133
Britannia No. 502	Keys No. 303	Rosedale No. 283
Brock No. 64	Kindersley No. 290	Rosemount No. 378
Brokenshell No. 68	King George No. 256	Rosthern No. 403
Browning No. 34	Kingsley No. 124	Round Hill No. 467
Buchanan No. 304	Kinistino No. 459	Round Valley No. 410
Buckland No. 491	Lac Pelletier No. 107	Rudy No. 284
Buffalo No. 409	Lacadena No. 228	Saltcoats No. 213
Calder No. 241	Laird No. 404	Sarnia No. 221
Caledonia No. 99	Lajord No. 128	Saskatchewan Landing No. 167
Cambria No. 6	Lake Alma No. 8	Sasman No. 336
Cana No. 214	Lake Johnston No. 102	Scott No. 98
Canaan No. 225	Lake Lenore No. 399	Senlac No. 411
Canwood No. 494	Lake of the Rivers No. 72	Shamrock No. 134
Carmichael No. 109	Lakeland No. 521	Shellbrook No. 493
Caron No. 162	Lakeside No. 338	Sherwood No. 159
Chaplin No. 164	Lakeview No. 337	Silverwood No. 123
Chester No. 125	Langenburg No. 181	Sliding Hills No. 273
Chesterfield No. 261	Last Mountain Valley No. 250	Snipe Lake No. 259
Churchbridge No. 211	Laurier No. 38	Souris Valley No. 7
Clayton No. 333	Lawtonia No. 135	South Qu'Appelle No. 157
Clinworth No. 230	Leask No. 464	Spalding No. 368
Coalfields No. 4	Leroy No. 339	Spiritwood No. 496
Colonsay No. 342	Lipton No. 217	Spy Hill No. 152
Connaught No. 457	Livingston No. 331	St. Andrews No. 287
Corman Park No. 344	Lomond No. 37	St. Louis No. 431
Cote No. 271	Lone Tree No. 18	St. Peter No. 369
Coteau No. 255	Longlaketon No. 219	St. Philips No. 301
Coulee No. 136	Loon Lake No. 561	Stanley No. 215
Craik No. 222	Loreburn No. 254	Star City No. 428
Cupar No. 218	Lost River No. 313	Stonehenge No. 73
Cut Knife No. 439	Lumsden No. 189	Storthoaks No. 31

Cymri No. 36	Manitou Lake No. 442	Surprise Valley No. 9
Deer Forks No. 232	Mankota No. 45	Sutton No. 103
Douglas No. 436	Maple Bush No. 224	Swift Current No. 137
Duck Lake No. 463	Maple Creek No. 111	Tecumseh No. 65
Dufferin No. 190	Mariposa No. 350	Terrell No. 101
Dundurn No. 314	Marquis No. 191	The Gap No. 39
Eagle Creek No. 376	Marriott No. 317	Three Lakes No. 400
Edenwold No. 158	Martin No. 122	Tisdale No. 427
Elcapo No. 154	Maryfield No. 91	Torch River No. 488
Eldon No. 471	Mayfield No. 406	Touchwood No. 248
Elfros No. 307	McCraney No. 282	Tramping Lake No. 380
Elmsthorpe No. 100	McKillop No. 220	Tullymet No. 216
Emerald No. 277	McLeod No. 185	Turtle River No. 469
Enfield No. 194	Meadow Lake No. 588	Usborne No. 310
Enniskillen No. 3	Medstead No. 497	Val Marie No. 17
Enterprise No. 142	Meeting Lake No. 466	Vanscoy No. 345
Estevan No. 5	Meota No. 468	Victory No. 226
Excel No. 71	Mervin No. 499	Viscount No. 341
Excelsior No. 166	Milden No. 286	Wallace No. 243
Eye Hill No. 382	Milton No. 292	Walpole No. 92
Eyebrow No. 193	Miry Creek No. 229	Waverley No. 44
Fertile Belt No. 183	Monet No. 257	Wawken No. 93
Fertile Valley No. 285	Montmartre No. 126	Webb No. 138
Fillmore No. 96	Montrose No. 315	Wellington No. 97
Fish Creek No. 402	Moose Creek No. 33	Weyburn No. 67
Flett's Springs No. 429	Moose Jaw No. 161	Wheatlands No. 163
Foam Lake No. 276	Moose Mountain No. 63	Whiska Creek No. 106
Fox Valley No. 171	Moose Range No. 486	White Valley No. 49
Francis No. 127	Moosomin No. 121	Willner No. 253
Frenchman Butte No. 501	Morris No. 312	Willow Bunch No. 42
Frontier No. 19	Morse No. 165	Willow Creek No. 458
Garden River No. 490	Mount Hope No. 279	Willowdale No. 153
Garry No. 245	Mount Pleasant No. 2	Wilton No. 472
Glen Bain No. 105	Mountain View No. 318	Winslow No. 319
Glen McPherson No. 46	Newcombe No. 260	Wise Creek No. 77
Glenside No. 377	Nipawin No. 487	Wolseley No. 155
Golden West No. 95	North Battleford No. 437	Wolverine No. 340
Good Lake No. 274	North Qu'Appelle No. 187	Wood Creek No. 281
Grandview No. 349	Norton No. 69	Wood River No. 74
Grant No. 372	Oakdale No. 320	Wreford No. 280

Grass Lake No. 381	Old Post No. 43	None of the above
Grassy Creek No. 78	Orkney No. 244	Don't know

In this first section, we will ask you questions about your farm operation and production system

1. In 2020, did the area you farmed include acres in any of the following? (Please select all that apply). **Note:** 'Area you farmed' includes both land that is owned, as well as land that was rented from someone else
Crop production
Summerfallow
Forages or hay
Improved land used for pasture or grazing
Undisturbed wetlands
Unimproved land in bush, native grasses, etc.
Anything else (please specify)
None of the above

[ASK Q2 IF EITHER CROP PRODUCTION OR SUMMERFALLOW SELECTED IN Q1]

2. Approximately how many acres of cropland seeded to annual crops did you have on your farm in 2020?

[ASK Q3 IF "FORAGES OR HAY" OR "IMPROVED LAND" OR "UNDISTURBED WETLANDS" OR "UNIMPROVED LAND IN BUSH" SELECTED IN Q1]

3. Approximately how many acres of perennial cover did you have on your farm in 2020?

[ASK Q4 IF CROP PRODUCTION SELECTED IN Q1]

4. Did you have any irrigated cropland last year?
Yes
No

[ASK Q5 IF "FORAGES OR HAY" OR "IMPROVED LAND USED FOR PASTURE OR GRAZING" SELECTED IN Q1]

5. Did you have any irrigated pasture, forages or hay last year?
Yes
No

6. Has the percentage of acres in summerfallow on your farm increased, decreased, or remained the same in the past two years?
Increased
Remained the same/ had none
Decreased

7. Thinking about your total farm area, has the percentage of acres in unimproved land increased, decreased or remained the same in the past two years? **Note:** By unimproved land, we mean land not under production, excluding summerfallow.
Increased
Remained the same/ had none
Decreased

8. In 2020, did you have any of the following?
Beef cattle
Dairy cattle
Pigs
Broiler chickens
Layer chickens
Turkeys
Sheep or lambs
Horses
Bison
Any other livestock
None of the above

[IF NONE OF THE ABOVE IN Q8, SKIP TO INSTRUCTION BEFORE Q11]

9. Do you graze any livestock on land you own or rent?
Yes
No

[ASK Q10 IF YES TO BEEF CATTLE OR BISON IN Q8, OTHERWISE SKIP TO Q11.]

10. Do you operate a feedlot?
Yes
No

[ASK Q11 IF "CROP PRODUCTION" OR "FORAGES OR HAY" SELECTED IN Q1 AND YES TO ANY ITEM IN Q8.]

11. Was the main source of your gross farm revenue in 2020…
Crops
Livestock
Equal mix of both

12. In 2020, which of the following was applied to your land? (select all that apply)
Commercial fertilizers
Solid manure
Liquid manure
Compost manure – that is, manure that is actively managed, not manure that has been piled and left

Crop protection products such as herbicides, insecticides and fungicides
None of the above

[ASK Q13 IF YES TO SOLID MANURE OR LIQUID MANURE OR COMPOST IN Q12]

13. Did you have any custom manure application in 2020?
Yes
No

14. Which of the following types of manure did you store on your farm last year?
Solid manure
Liquid manure
Compost manure
None of the above

15. Are there any natural rivers, streams, wetlands or sloughs on the property that you farm?
Yes
No

[ASK Q16 IF YES TO Q15]

16. Do you have any drained wetlands or sloughs on your land?
Yes
No

[SECTION 2: VIGNETTE EXPERIMENT]

[SECTION 3 - SOIL QUALITY]

In this section, we will ask you questions about your land use and soil management

[IF CROP PRODUCTION OR SUMMERFALLOW SELECTED IN Q1 CONTINUE OTHERWISE SKIP TO Q20]

18. Please indicate which of the following best describes how you seeded the majority of your crop acres in 2020.
Direct seeding into the stubble of the previous crop (this may include use of harrows)
Minimum till with one tillage pass, completed either in the spring or fall prior to seeding
Seeding with two or more tillage passes were completed either in the spring or fall prior to seeing

19. Did you use any of the following in your cropping rotation in 2020? (Select all that apply)
Perennial forages
Pulse crops
Winter cereals
None of the above

[IF YES TO Q9 CONTINUE OTHERWISE SKIP TO Q22]

20. Which, if any, of the following do you typically do on your farm?
Annually consider or adjust your stocking rate to balance livestock forage demand with the available forage supply
Rotate use of your pastures as part of your grazing management
Avoid or minimize grazing in riparian and/or bush areas in the late summer or autumn
Move livestock away from riparian areas using tools and methods such as salt blocks, windbreaks and herding
Time the grazing of riparian areas to avoid grazing during spring and early summer
Manage native rangelands – that is, those lands on which the vegetation is mostly native grasses in a way that improves rangeland health and/or biodiversity (e.g., allowing adequate rest throughout the growing season, timing grazing to avoid impacting species at risk, controlling invasive species, avoiding overutilization).
None of the above

[IF SELECTED MANAGE NATIVE RANGELANDS IN Q20 CONTINUE OTHERWISE SKIP TO Q22]

21. On your farm do you typically time the grazing of native rangelands
Yes
No

22. Do you retain woodlands, bush or native grassland?
Yes
No
Not applicable – my farm does not have woodlands, bush or native grassland

[IF ANY OF SOLID MANURE, LIQUID MANURE OR COMPOST MANURE SELECTED IN Q12 CONTINUE OTHERWISE SKIP TO Q24]

23. On the fields that you have manure applied, how frequently do these fields typically receive manure?
One or more times a year
Once every two years
Once every three years
Less frequently than once every three years

[ASK Q24 IF YES TO COMPOST, SOLID MANURE OR LIQUID MANURE IN Q12]

24. Do you typically apply any of the following based on a soil or tissue test, manure nutrient test or book values? (select all that apply)
Compost *[INSERT IF YES TO COMPOST IN Q12]*
Manure – either, solid or liquid *[INSERT IF YES TO SOLID OR LIQUID MANURE IN Q12]*
[DOWN SIDE – DO NOT RANDOMIZE]

Soil or tissue test
Manure nutrient test
Book values
None of the above

[ASK Q25 IF YES TO COMPOST, SOLID MANURE OR LIQUID MANURE IN Q12]

25. Are your manure application rates typically based on crop nitrogen requirements, crop phosphorus requirements or neither? (Please select one response – the best one that applies)
[ACCEPT ONE RESPONSE ONLY]
Crop nitrogen requirements
Crop phosphorus requirements
Neither

26. For each of the following, please indicate how familiar you are with these resources or if you've used any of them to help you make soil quality related management decisions.
[ACROSS TOP]
You have not heard of it
You are aware, but have not used it
You have used it
[DOWN SIDE - RANDOMIZE ORDER]
Requirements and standards provided in the Weed Control Act or Pest Control Act when making management decisions.
Saskatchewan Soil Information System (SKSIS) for soil information and planning
The Saskatchewan Crop Planning Guide and/or Crop Planner
Consulted an agronomist or used VRM to make soil fertility and application decisions.
The 4R Nutrient Stewardship Principles when applying manure or fertilizer on your farm (the 4R's are defined as: the right product, at the right rate, right time and right place)

[SECTION 4: AIR QUALITY]

In this section, we will ask you questions about fertilizer and manure management.

[IF COMMERCIAL FERTILIZER SELECTED IN Q12 CONTINUE OTHERWISE SKIP TO Q32]

27. Did you apply commercial fertilizer based on the results of a soil or plant tissue test?
Yes
No
Sometimes

28. Thinking about the total amount of commercial fertilizer you applied or had applied in 2020, about what percentage was applied in each of the following?
Spring
Fall
Other time of year

29.Which of the following application methods were used for the fertilizer you applied or had applied in 2020? (Select all that apply)
Banded
Broadcast and incorporated
Broadcast but not incorporated
In furrow with the seed
Fertigation (injection of fertilizer into an irrigation system)
Other (Please specify)

30. Did you use any Nitrogen Use Efficiency products in 2020, for example, products such as ESN, Super U, Urea with Agrotain, Anhydrous Ammonia with N-serve, etc. – that is, products that are nitrogen inhibitors or stabilizers that reduce nitrogen loss?
Yes
No

[IF YES IN Q30 CONTINUE OTHERWISE SKIP TO Q32]

31. Of all the acres that you could use Nitrogen Use Efficiency products on, on your operation, what percentage of your acres are you using them on currently?

[IF ANY OF LIQUID MANURE, SOLID MANURE OR COMPOST MANURE SELECTED IN Q12 CONTINUE OTHERWISE SKIP TO Q34]

32. On annually cropped fields that are not direct seeded, do you typically incorporate …?
[DOWN SIDE]
Solid manure
Compost manure
Liquid manure

[ACROSS TOP]
Yes
No

[ASK Q33 IF YES TO ANY ITEM IN Q32]

33. How long after seeding do you typically incorporate each of the following?
[DOWN SIDE]
Solid manure *[INSERT IF YES TO SOLID MANURE IN Q32]*
Compost manure *[INSERT IF YES TO COMPOST MANURE IN Q32]*
Liquid manure *[INSERT IF YES TO LIQUID MANURE IN Q32]*
[ACROSS TOP]
Within 24 hours
Within 48 hours
Greater than 48 hours

[ASK Q34 IF YES TO LIQUID MANURE IN Q12, OTHERWISE SKIP TO Q35]

34. Thinking about liquid manure, do you typically…? (Please select one response)
Inject – that is, shank or disc – the manure into the ground
Broadcast the liquid manure with no incorporation – incorporation means cultivation, discing or harrowed after application
Broadcast with incorporation within 24 hours after application
Broadcast with incorporation within 48 hours after application, OR
Broadcast with incorporation greater than 48 hours after application

35. Do you produce grid-connected electricity using any of the following sources of renewable energy (excluding electrical company leases)?
Solar panels, not counting for water pumping or electric fencing
Wind turbine generator on a tower
Biogas generator using farm waste

Yes
No

36. Have you planted trees on your farm in the past two years for agriculture purposes? (Examples; Shelterbelts/windbreaks, Wildlife habitat, soil conservation, odour control, etc.)
Yes
No

[SECTION 5: BIODIVERSITY]

In this section, we will ask you questions about natural habitat and biodiversity management on the land you farm.

37. Did you drain or fill in any natural wetlands or sloughs since 2018?
Yes
No

[ASK Q38 IF YES TO Q9]

38. In 2020, did you actively manage your livestock grazing land to create wildlife habitat, such as delaying grazing until after nesting, etc.?
Yes
No

39. For each of the following, please indicate which statement best describes how familiar you are with these resources or if you've used any of them to help you make biodiversity related management decisions.
Requirements and standards provided in the Saskatchewan Weed and/or Pest Control Act when making management decisions.
Saskatchewan government sources of information on current and new environmentally sustainable agricultural practices, including extension specialists.

[ACROSS TOP]
You have not heard of it
You are aware, but have not used it
You have used it

[SECTION 6: WATER QUALITY]

In this section, we will ask you questions about your manure management

[ASK Q40 IF ANY ITEM OTHER THAN NONE OF THE ABOVE SELECTED IN Q8 OR ANY ITEM OTHER THAN NONE OF THE ABOVE SELECTED IN Q14, OTHERWISE SKIP TO Q41]

40. Did you control runoff from all, some or none of if each of the following on your farm
[DOWN SIDE]
Manure storage
Livestock pens
Silage piles, pits or bunkers
[ACROSS TOP]
All
Some
None
Not applicable – do not have this

[ASK Q41 IF YES TO Q9 AND YES TO Q15]

41. Did you select the location of all, some or none of your in-field winter feeding and bedding sites to prevent runoff from manure entering natural water bodies or leaching into shallow groundwater or aquifers?
All
Some
None

[ASK Q42 IF SELECTED ANY OF LIQUID, SOLID OR COMPOST MANURE IN Q12]
42. Do you typically need to apply any of the following on frozen or snow-covered ground?
Manure [SHOW IF YES TO LIQUID OR SOLID MANURE IN Q12]
Compost *[SHOW IF YES TO COMPOST IN Q12]*
Yes
No

[ASK Q43 IF YES TO LIQUID, SOLID OR COMPOST MANURE IN Q14]

43. Did you store manure within 100 meters of each of the following?

Active water wells
Abandoned, inactive or unused water wells that have not been properly plugged, or sealed
Yes
No
Not applicable – do not have this type of well.

[ASK Q44 IF YES TO COMPOST MANURE SOLID MANURE OR LIQUID MANURE IN Q12]

44. Do you typically consider any of the following factors when applying either solid or liquid manure? (Select all that apply)
Distance between manure application and waterways – that is, low lying paths where surface water collects and flows
Slope of land
Application method
None of the above

45. For each of the following, please indicate which statement best describes how familiar you are with these resources or if you've used any of them to help you make water quality related management decisions.

Requirements and standards provided in the Agriculture Operation Act –when making management decisions.
Farming and Agricultural Calculators provided online by the Saskatchewan Ministry of Agriculture.
Agri Environmental Technical Services provided by the Watershed Stewardship Associations and /or other community group.
Manure storage and management plan review services offered by the Ministry of Agriculture.
Manure Production Model and the Nutrient Production Models offered online by the Ministry of Agriculture.
[ACROSS TOP]
You have not heard of it
You are aware, but have not used it
You have used it

46. For each of the following, please indicate which statement best describes how familiar you are with these resources or if you've used any of them to help you make general farm management decisions.
Local extension personnel for information or events – for example, local newsletters, workshops or tours, Regional Stay Connected email, webinars
Crop Report– website for weather information
AAFC Drought Watch Website
Ministry of Ag extension specialists
Agri-ARM sites and staff
Government of SK Website
Canadian Field Print Calculator (for cropping and mixed operations)
Cool Farm Tool (both crop and livestock)
HOLOS, the whole farm greenhouse gas emissions calculator (both crop and livestock)

[ACROSS TOP]
You have not heard of it
You are aware, but have not used it
You have used it

[SECTION 7: ENVIRONMENTAL FARM PLAN]

This section is to better understand your opinions on the Environmental Farm Plan (EFP) process.

47: Please tell me which statement you think best describes the Environmental Farm Plan.
The EFP is a tool for identifying environmental risks on your farm
The EFP gives farmers money to complete environmental projects on their land
The EFP is required by some commodity organizations
The EFP is only for large commercial farms
The EFP helps farmers identify environmental risks and provides suggestions to mitigate them

48: Do you have an Environmental Farm Plan?
Yes
No

[IF NO IN Q48 CONTINUE OTHERWISE SKIP TO Q51]

49: What reason(s) made you not complete an EFP? Select all that apply.
Too time consuming
Privacy concerns
I do not think the EFP is useful for my operation
The EFP is a government program
I do not know what an EFP is
Not applicable to my operation
I prefer workshops, in person, or an EFP binders instead of online
None of the above

50. Would you consider completing an EFP in the future?
Yes
No
Don't Know

[IF YES IN Q48 CONTINUE OTHERWISE SKIP TO NEXT SECTION Q55]

51. Select all reasons for why you completed an Environmental Farm Plan.
To be eligible for government cost-share funding
Identify and address environmental risks on my farm
Reduce farm costs through improved operational efficiency
Promote Environmental stewardship on my farm
To meet Sustainable Sourcing Standards

Prepare farm for next generation
The EFP is something that my commodity organization requires me to do
For status and recognition (ex. Adding to business cards, product packaging)
Required by my financial organization and/or insurer
Other (please specify)

52: How did you learn about the Environmental Farm Plan? (Please select all that apply)
Saskatchewan Ministry of Agriculture website
Agri-Environmental Technical Services (Technician)
Saskatchewan Ministry of Agriculture extension specialist
Neighbors and friends
In person workshop
Local municipal website or event
Newspaper
Social Media
Market requirements
From commodity organization(s)
Local agriculture/producer organization
None of the above

53: Have you made changes to your operation based on what you learned through completing an EFP?
Yes, I have made several changes
Yes, I have made a few changes
No, I did not make any changes
Not Certain

54: Was the process valuable and did you learn something about environmental risks on your farm?
Yes
No
Prefer not to answer

[SECTION 8 – SUSTAINABLE SOURCING]

In this section, we will ask for your opinion about Sustainable Sourcing Standards and about your approach to farming in general.

55. Sustainability standards are becoming more important to buyers across agri-food supply chains and increasingly influence production decisions of both livestock and crop producers. We would like to better understand your thoughts and opinions on sustainability standards for sourcing agriculture products. For each of the following, please indicate how import each factor is towards motivating your participation.
[ACROSS TOP]
Not important at all
Slightly important

Moderately important
Very important
Extremely important
[DOWNSIDE – RANDOMIZE]
Access to new markets
Maintaining access to existing markets
To receive a premium
Receive recognition for stewardship practices
Increase consumer confidence
Increase public trust in the agriculture industry
Industry setting their own standards
Neighbours discuss benefits of programs
Other (Specify)

56 Now, we would like to understand why someone may not participate in sustainable standards and sourcing programs. Please indicate how important the following barriers are in your opinion.
[ACROSS TOP]
Not important at all
Slightly important
Moderately important
Very important
Extremely important
[DOWNSIDE – RANDOMIZE]
Costs are too high
Too difficult to change current farm practices
Access to markets for my commodity
Does not provide a premium
Need more information
Privacy concerns
The time it takes
Audits and record keeping requirements
Other (Specify)

57. Which of the following factors would assist you in accessing sustainable standards and sourcing programs more readily. Please indicate how important the following facilitating factors are in your opinion.
[ACROSS TOP]
Not important at all
Slightly important
Moderately important
Very important
Extremely important
[DOWNSIDE – RANDOMIZE]
If Government provides incentives to producers
If Retail and Food Companies provide incentives to producers
Access to attractive/premium Agricultural Financial Services or Incentives

Commodity organization provide information and training
Government provide information and training
Other (Specify)

[SECTION 9 – ECONOMIC, CONSERVATION AND LIFESTYLE MEASURE]

58. Please indicate your level of agreement with each of the following statements:
[ACROSS TOP]
Strongly disagree
Disagree
Neutral
Agree
Strongly Agree
[DOWNSIDE – RANDOMIZE]
Dollars and cents is what farming is all about
I view my farm as first and foremost a business enterprise
When planning future farming activities, I only focus on how profitable they will be
A maximum annual return from my property is my most important aim
Money and profit are not the most important things about farming
The lifestyle that comes with being on the farm is very important to me
Farming communities are a great place to live
I enjoy the peace and quiet that comes with farming
A rural environment is a great place to raise children
We do not make a fortune from farming, but the lifestyle is great
Good farmers regularly make land stewardship improvements to their land
The most important thing is leaving my property in better shape than I found it
Land stewardship by farmers is more important than anything else about farming
Managing environmental problems on my farm is a very high priority
I like to look after my land, making it work for me, without damaging it

[SECTION 10 - RESPONDENT PROFILE]

I just have a few final questions about you and your farm. Your responses will be used for classification purposes only and only aggregate results will be used for reporting purposes.

59. Have you attended a degree or diploma program, specifically in an agriculturally related area?
Yes
No

60. Have you attended any environmental agriculture training sessions in the past two years?
Yes
No

61. Which of the following best describes the current state of your farm operation?
I am just getting my farming operation established

I am maintaining my farming operation at a steady level
I am expanding my farming operation
I have started to reduce or scale down my farming operation
I plan to sell my farming operation

62. What is your age?
18 to 24
25 to 34
35 to 44
45 to 54
55 to 64
65 to 74
75 or older
Decline to respond

63. At any time, have you received funding or payments to introduce more sustainable practices on your land (for example, introducing wetlands on your land, riparian fencing) from any of the following sources? (Select all that apply)
Ducks Unlimited
Alternative Land Use Sources (ALUS)
Saskatchewan Ministry of Agriculture
Your local municipality or county
Other Environmental Organization
None of the above

"That is all of the questions we have for you today. Thank you very much for your time."]

Appendix 2: Weighting

Region & Gross Farm Sales	# of 2016 Census Farms with $10+ In Gross Farm Sales	2016 Census Distribution (Weights)	Survey Count Unweighted	Survey Distribution Unweighted	Weighting Factor	Survey Count Weighted
CAR1 $10K to $25k	1544	0.046	1	0.002	23	23
CAR1 $25k to <50K	920	0.027	1	0.002	13.5	14
CAR1 $50K to <$100K	1005	0.029	6	0.012	2.42	15
CAR1 $100K to <$250K	1536	0.044	17	0.034	1.29	22
CAR1 $250K to <$500K	1061	0.031	13	0.026	1.19	15
CAR1 $500+	1413	0.041	69	0.138	0.30	21
Total CAR1	7479	0.217	107	0.214	1.01	108
CAR2 $10K to $25k	920	0.027	0	0	0	0
CAR2 $25k to <50K	501	0.015	0	0	0	0
CAR2 $50K to <$100K	588	0.017	3	0.006	2.83	8
CAR2 $100K to <$250K	896	0.026	6	0.012	2.17	13
CAR2 $250K to <$500K	631	0.018	11	0.022	0.82	9
Central $500+	958	0.028	44	0.088	0.32	14
Total CAR2	4494	0.130	64	0.128	1.01	65
CAR3 $10K to $25k	977	0.029	0	0	0	0
CAR3 $25k to <50K	735	0.021	3	0.006	3.5	11
CAR3 $50K to <$100K	986	0.029	9	0.018	1.61	15
CAR3 $100K to <$250K	1622	0.047	10	0.02	2.35	24
CAR3 $250K to <$500K	1296	0.038	24	0.048	0.79	19
CAR3 $500+	1915	0.056	67	0.134	0.42	28
Total CAR3	7531	0.218	113	0.226	0.964	109
CAR4 $10K to $25k	1089	0.032	2	0.004	8	16

CAR4 $25k to <50K	609	0.018	0	0	0	0
CAR4 $50K to <$100K	796	0.023	4	0.008	2.88	12
CAR4 $100K to <$250K	1070	0.031	11	0.022	1.40	15
CAR4 $250K to <$500K	882	0.026	13	0.026	1	13
CAR4 $500+	1546	0.045	57	0.114	0.39	22
Total CAR4	5992	0.174	87	0.174	1	87
CAR5 $10K to $25k	476	0.014	0	0	0	0
CAR5 $25k to <50K	266	0.008	3	0.006	1.33	4
CAR5 $50K to <$100K	360	0.010	3	0.006	1.67	5
CAR5 $100K to <$250K	490	0.014	2	0.004	3.5	7
CAR5 $250K to <$500K	342	0.010	8	0.016	0.63	5
CAR5 $500+	524	0.015	20	0.04	0.38	8
Total CAR5	2458	0.071	36	0.072	0.99	36
CAR6 $10K to $25k	1506	0.044	1	0.002	22	22
CAR6 $25k to <50K	788	0.023	0	0	0	0
CAR6 $50K to <$100K	932	0.027	2	0.004	6.75	14
CAR6 $100K to <$250K	1297	0.038	16	0.032	1.19	19
CAR6 $250K to <$500K	842	0.024	24	0.048	0.5	12
CAR6 $500+	1184	0.034	50	0.1	0.34	17
Total CAR 6	6549	0.190	93	0.186	1.02	95
CAR7 $10K to $25k	8	0.0002	0	0	0	0
CAR7 $25k to <50K	3	0.000009	0	0	0	0
CAR7 $50K to <$100K	3	0.00009	0	0	0	0
CAR7 $100K to <$250K	4	0.0001	0	0	0	0
CAR7 $250K to <$500K	1	0.00003	0	0	0	0
CAR7 $500+	1	0.00003	0	0	0	0
Total CAR7	20	0.001	0	0	0	0
Total	**34,523**	**1.00**	**500**	**1.0**		**500**

Appendix 3.1: ESA Adoption Eligibility and Practice Adoption

An eligible practice for the base calculation was one where the respondent was asked the question, it was applicable to their operation, and was answered. Responses of "not applicable" or "don't know" were excluded from the base calculation.

For example, the 2020 survey includes 5 practices for the water quality risk area which were included in the overall water quality ESA adoption score. One such practice is 'Avoid applying close to waterways to minimize increased nutrient runoff.'

- All respondents (n=500) were asked: '*In 2020, which of the following was applied to your land? (Select all that apply)'*
    - 90% applied commercial fertilizer, 17% applied solid manure, 7% applied liquid manure, 3% applied compost manure, 79% applied crop protection products, with 6% applying *none* of the above.
- Those who had applied solid manure, liquid manure or compost manure were then asked the following question: '*Do you typically consider any of the following factors when applying either solid or liquid manure? (Select all that apply).'*
    - 47% considered the distance between manure application and waterways, 35% considered the slope of the land, 45% considered application methods, and 20% considered *none of the above.*
    - Adoption was saying 'yes' (n=43) to any option, other than none of the above.
    - Eligible respondents were those who answered the question (n=117)
- Adoption of this practice is 43/117=37% as a raw score, once weighted, the score becomes 45% to reflect the true sample population.

Adoption of all 21 ESA practices were calculated for each risk area, as well as an overall ESA adoption score. In all cases (where applicable), the eligible base was defined as those respondents asked the question excluding "not applicable" and "don't know" responses.

The table below provides a summary of all 21 ESA practices and the question(s) used to measure each practice, and how adoption was defined in the 2020 survey.

ESA Practice	Question	Adoption =
Water Quality (7 Practices)		
Control runoff from manure storage	Q40. Did you control runoff from all, some or none of your Manure Storage?	All or Some
Control runoff from livestock pens	Q40. Did you control runoff from all, some, or none of your Livestock Pens?	All or Some
Choose wintering site to avoid manure contamination	Q41. Did you select the location of all, some or none of your in-field winter feeding and bedding sites to prevent runoff from manure entering natural water bodies or leaching into shallow groundwater or aquifers?	All or Some
Avoid applying manure or compost on frozen or snow-covered ground	Q42. Do you typically apply manure on frozen or snow-covered ground?	No
	Q42. Do you typically apply compost on frozen or snow-covered ground?	

Avoid storing manure near active water wells	Q43. Did you store manure within 100m of Active water wells?	No
Avoid applying close to waterways to minimize increased nutrient runoff	Q44. Do you typically take into account any of the following factors when applying either solid or liquid manure? Distance between manure applications and waterways – that is low lying paths where surface water collects and flows, slope of land, application method	Yes to any item
Soil Health (5 Practices)		
Used reduced tillage	Q18. Please indicate which of the following best describes how you seeded the majority of your crop acres in 2020.	The seeding operation into the stubble of the previous crop was the only tillage pass completed.
Use pulse crops in rotation	Q19. Did you use pulse crops in your cropping rotation in 2020?	Yes
Frequency of application	Q23. On the fields that you have manure applied, how frequently do these fields typically receive manure?	Once every two years, three years or less
Sampling and analyzing the manure for nutrient content	Q24. Do you typically apply manure – either solid or liquid, based on a soil or tissue test, manure nutrient test or book values?	Yes to soil or tissue test OR manure nutrient test OR book values
Manure application based on P or N&P	Q25. Are your manure application rates typically based on crop nitrogen requirements, crop phosphorus or neither?	Crop nitrogen or phosphorus requirements
Biodiversity (5 Practices)		
Protect riparian areas from grazing to prevent overuse	Q20. Which of the following do you typically do on your farm? Avoid or minimize grazing in riparian and/or bush areas in the late summer or autumn	Yes
Time grazing to avoid vulnerable times of the year for riparian areas	Q20. Which of the following do you typically do on your farm? Time the grazing of riparian areas to avoid grazing during spring and early summer	Yes
Retain bush or native grassland	Q22. Do you retain woodlands, bush or native grassland?	Yes
Avoid draining or filling in natural wetlands/sloughs	Q37. Did you drain or fill in natural wetlands or sloughs?	No
Manage grazing for wildlife habitat	Q38. In 2020, did you actively manage your livestock grazing land to create wildlife habitat, such as delaying grazing until after nesting, etc.?	Yes
Air Quality (4 Practices)		
Apply chemical fertilizer at recommended rate	Q27. Did you apply commercial fertilizer based on the results of a soil or plant tissue test?	Yes
Incorporate manure after applying	Q33. Do you typically incorporate Solid manure with 24 hours, 48 hours or greater than 48 hours?	Within 24 or 48 hours
Renewable Power	Q35. Do you produce grid-connected electricity using any of the following sources of renewable energy (excluding electrical company leases)?	Yes to any
Trees for agricultural purposes	Q36. Have you planted trees on your farm in the past two years for agriculture purposes? (Examples; Shelterbelts/windbreaks, Wildlife habitat, soil conservation, odour control, etc.)	Yes

Appendix 3.2: Questions Determining Eligibility for ESA Practices

This section provides an overview of respondent characteristics that were used to determine eligible ESA practices:

Livestock

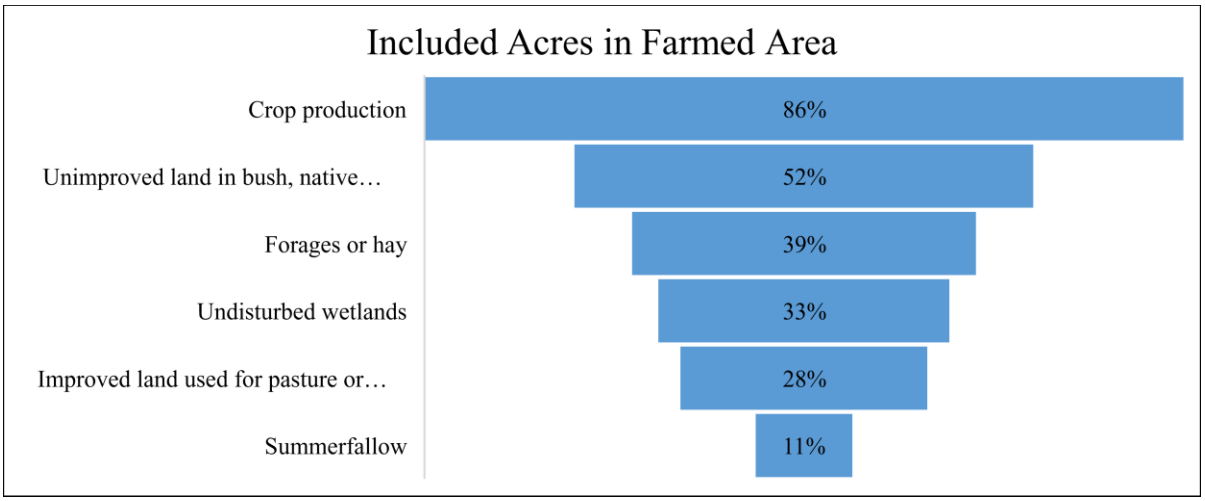
Did you have any….?	Yes (%)
Beef Cattle	31%
Dairy Cattle	1%
Pigs	5%
Broilers	5%
Layers	9%
Sheep/Lamb	5%
Horses	14%
Bison	2%

Base: All respondents (n=500)

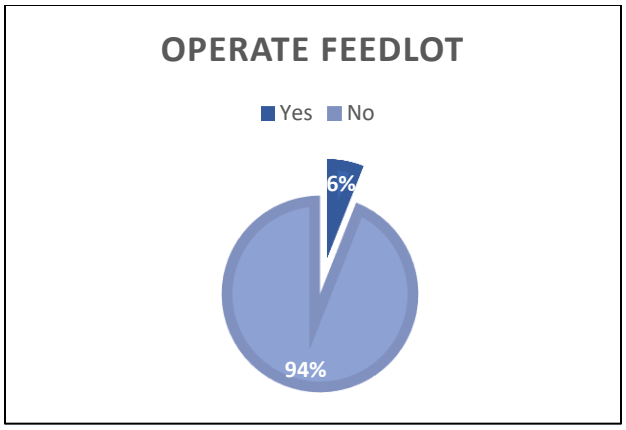
Applied to Land

In 2020, did you apply…?	Yes (%)
Commercial Fertilizer	90%
Solid Manure	17%
Liquid Manure	7%
Compost Manure	3%
Crop Protection Products (i.e., Herbicides)	79%
None of the above	6%

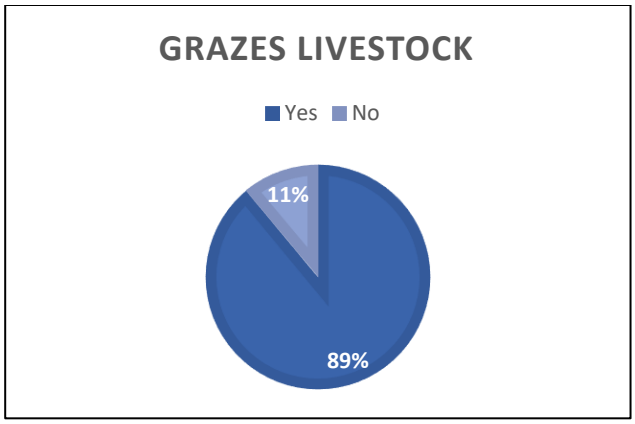
Base: All respondents (n=500)



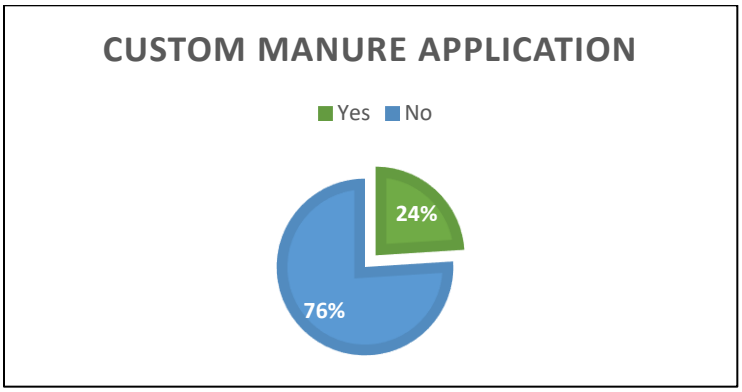
Base: All respondents (n=500)



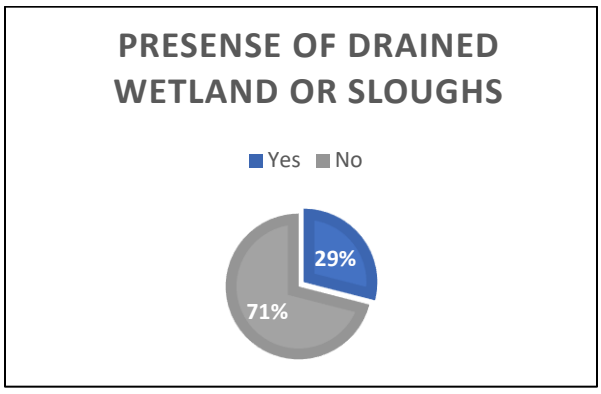
Base: Has Beef Cattle or Bison (n=127)



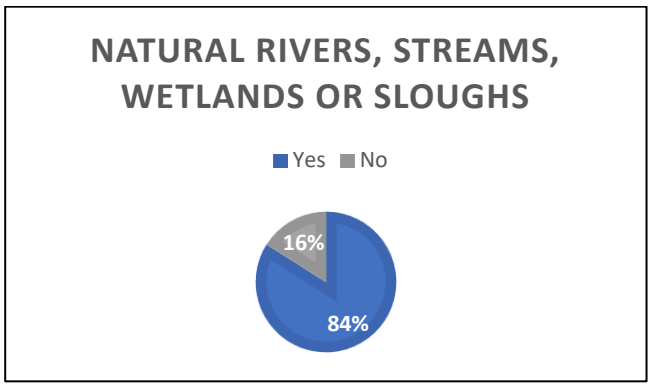
Base: Has Livestock (n=154)



Base: Base: Applied solid/liquid/compost manure on farm (n=117)



Base: Has natural rivers, streams, wetlands, or sloughs (n=408)



Base: All respondents (n=500)

Appendix 4: Hausman Test for FE vs RE

	Coefficients (b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
1.alt1prog~m	8.44727	8.447041	.0002289	.0186119
alt2messen~r				
1	.1798654	.0948067	.0850587	.0869071
2	-.5957463	-.7328467	.1371004	.0884007
alt3privacy				
1	-.76129	-.7351875	-.0261025	.099393
2	-1.70107	-1.790517	.0894473	.0971378
alt4ego				
1	-.8723036	-.7953715	-.0769321	.0918958
2	-1.116541	-1.064363	-.0521781	.0904192
alt5norms				
1	1.080648	1.221917	-.1412682	.1068646
2	-.1141558	-.0699384	-.0442174	.1115127
3	.9849391	1.02763	-.0426904	.1115645
alt6cost				
1	-2.140177	-2.075118	-.0650592	.0921977
2	-2.591698	-2.516681	-.0750172	.0896145

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(12) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 7.82
Prob>chi2 = 0.7987

Fail to reject null hypothesis, confirms use of random effects.

Appendix 5: Additional Regression Results

1) OLS VCE Cluster on Rating with Farmer Characteristics

Linear regression

rating	Coef.	St.Err.
age1844	-4.172	3.769
age4564	-3.23	2.974
degreeyn	4.053	2.543
trainyn	4.841	3.823
efpyn	4.451*	2.472
Constant	44.078***	2.934

2) Ols VCE Cluster on Rating with ESA Score

Linear regression

rating	Coef.	St.Err.
esascore	17.9**	7.156
Constant	34.742***	4.58