An Examination of the Environmental Farm Plan and its Role in Agri-Environmental Policy and Programs in Alberta

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Agricultural and Resource Economics

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Abstract

The Environmental Farm Plan (EFP) program has been the cornerstone of Canada's agricultural policy frameworks since 2003. It is a voluntary, self-administered program designed to help agricultural producers assess and mitigate environmental risks on their farms. The EFP program has seen varied levels of adoption across the country, with notably lower uptake in Western provinces. This research provides a comprehensive examination of the EFP program at both farm and municipal levels using a case study of Alberta. Key areas of investigation include the historical development and current processes of the EFP program, the impact of agri-environmental extension efforts, and the influence of farm and producer-specific characteristics and industry standards. We employ a range of econometric models to assess data from various sources, including government databases, the Environmentally Sustainable Agriculture Tracking (ESAT) survey rounds from 2014 to 2023, and direct communications with stakeholders to explain the low adoption rates in the province. At the municipal level, given the unique agronomic conditions, information exchange methods, and varying levels of agri-environmental and EFP extension services and funding in each municipality, we utilize the two-way fixed effects approach to control for time and municipality-related unobserved heterogeneity to determine the factors affecting EFP completion. Our findings reveal that agri-environmental extension efforts are crucial in increasing program adoption. The role of industry standards and collaborative efforts among agricultural organizations are also emphasized as significant factors in driving program participation. Additionally, municipalities with a high proportion of large farms, earning annual gross farm receipts exceeding $250,000, exhibited higher EFP completion rates. At the farm level, we employ the logit model to determine the factors influencing the adoption decisions of agricultural producers. Factors such as conservation training attendance and farm income over $250,000 positively influenced EFP adoption. The positive impact of the farm income over $250,000 in both farm and municipality level analyses suggest that most of Alberta's agricultural land might be covered by an EFP, as producers operating larger farms have adopted the program. Furthermore, we investigate the impact of EFP completion on BMP adoption across several agri-environmental risk areas as indicated by the ESAT survey. Given that EFP completion is required to access BMP cost-shared funding in Alberta, we assume that the EFP is endogenous in the BMP adoption process. Employing the two-step control function and instrumental variables (IV) approaches, we find that the EFP is endogenous in the overall, water quality and quantity, and energy and climate change related BMPs adoption.

Preface

This thesis is an original work by Kamola Abdurasulova. No part of this thesis has been previously published. This research project received ethics approval from the University of Alberta Research Ethics Board, Project Name “Role of extension services in explaining Environmental Farm Plan and Best Management Practices Adoption in Alberta at the county level”, No. Pro00125683, November 7, 2022.

In loving memory of my grandmothers and grandfather, who would have been so proud to see me earn my master's degree.

Acknowledgements

I would like to extend my deepest gratitude to everyone who has supported me throughout the journey of completing this thesis.

First, I would like to thank my supervisor, Dr. Peter Boxall, for his unwavering guidance, patience, and encouragement. Peter, your profound knowledge, insightful and prompt feedback, and consistent support have been instrumental in shaping the direction and quality of my research. I am immensely grateful and fortunate to have learned from and worked with you. I could not have asked for a better supervisor for my master's thesis. I would also like to express my sincere gratitude to Dr. Sven Anders, who introduced me to this topic and to Dr. Boxall. Sven, thanks a lot for your insights, encouragement, and continuous support.

To other professors of the Department of Resource Economics and Environmental Sociology - Dr. Vic Adamowicz, Dr. Sandeep Mohapatra, and Dr. Bruno Wichmann — thank you for your invaluable advice and guidance. To a former graduate student of our department and my friend Sarah Van Wyngaarden — thank you for sharing your knowledge and experience. I must also extend my gratitude to the individuals at Alberta Ministry of Agriculture and Irrigation, Alberta EFP, and the Agricultural Research and Extension Council of Alberta for their cooperation with the necessary data, their time, and valuable and insightful feedback for several chapters of my thesis. Also, I am grateful to the Alternative Land Use Services team for being responsive to my emails and sharing needed information.

I am eternally grateful to my mom and dad for their unconditional love and support. Everything I am today is because of them. To my husband Ulugbek, thank you for always believing in me, listening to me, empowering me, and encouraging me to get the best life has to offer. Without your support and encouragement, my master’s journey would not have been possible. A special thanks to my siblings, Shakhnoza, Sitora, and Nodirbek, for always rooting for me and checking up on me. I am also profoundly grateful to my parents-in-law for their continuous support and understanding throughout this journey. Lastly, a big shoutout to all my friends — coffee meetups and late-night conversations with you kept me sane through this journey.

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Chapter 1. Introduction

1.1. Introduction

Agricultural activities pose several environmental risks, including soil degradation, water contamination, greenhouse gas emissions, and loss of biodiversity. The intensive use of fertilizers and pesticides can lead to nutrient runoff, contaminating water bodies and affecting aquatic ecosystems (Yang et al., 2007). Livestock operations contribute to significant methane emissions, a potent greenhouse gas, while improper manure management can result in both air and water pollution (Desjardins et al., 2001). Additionally, the handling, storage, and field application of manure are major sources of nitrous oxide (N_2O) emissions, which can affect the soil quality (Smith et al., 2008). Furthermore, the agricultural intensification significantly reduces biodiversity and disrupts ecosystems (Pywell et al., 2012).

In developed countries, the environmental implications of agriculture are well-recognized. To address these concerns and promote sustainable agricultural practices, agri-environmental schemes (AES) were introduced in several countries. One of the main AES in Canada is the Environmental Farm Plan (EFP) program, a cornerstone of federal and provincial governments' agri-environmental policies. It is a voluntary, confidential, self-assessment process aimed at assisting producers in improving their environmental stewardship by increasing their knowledge and awareness of the agri-environmental risks on their farms (Hobbs et al., 2005; AAFC, 2011, Clearwater et al., 2016). The EFP program emerged in Ontario in the 1990s by the Ontario Farm Environmental Coalition (OFEC), a group of farm organizations in Ontario with the aim of addressing key environmental issues related to farming practices. (OFA, 2023; Robinson, 2006a; Yiridoe, 2000). The program started gaining popularity across the country and in 2003, it was incorporated into the first Canadian national Agricultural Policy Framework (APF), which is a federal-provincial/territorial initiative. This initiative was part of a broader strategy to integrate environmental considerations into agricultural policies and practices across Canada (Boxall, 2018; AAFC, 2007). Since then, the EFP has served as a vital informational and educational resource for Canadian producers.

Canada's EFP program slightly diverges from the AES of other developed nations. While it encourages the farmers to act on their action plans, it does not bind them contractually. Instead, separate subsidized programs, based on a cost-share approach, support the implementation of beneficial management practices (BMPs).[1] This Canadian program framework is considered voluntary, and contrasts with certain agri-environmental programs in the USA and the EU, which can emphasize cross-compliance (Baylis et al., 2022; Barrerio-Hurle et al., 2023; Robinson, 2006b). Also, in the EU's AES, farmers are encouraged to address environmental concerns using less-intensive forms of agricultural production. Conversely, in Canadian AES programs, farmers' primary focus on food and fibre production is not altered and intensive farming remains prevalent, with farmers adopting more environmentally friendly practices to reduce environmental risks stemming from production (Atari et al., 2009). Another distinctive feature of Canada's AES is its bottom-up approach, with farmers being the principal investigator and central decision-makers. The program is tailored to individual farms, allowing farmers to adopt conservation practices that align with their goals and specific environmental conditions of their farms. The program's administration also differs, being overseen by individual provinces largely due to the provincial governments holding the primary jurisdiction over agriculture, natural resources, and environmental management (Smithers & Furman, 2003; Yiridoe, 2000).

Participation in the EFP program involves several stages including workshops, risk assessments, and the creation of detailed action plans (e.g. adoption of BMPs) which are tailored to each farm's unique environmental conditions and challenges. These plans address a variety of environmental concerns, such as soil management, water quality, and the storage and disposal of agricultural waste (Smith et al., 2020; Yiridoe, 2000; Baylis et al., 2022). In addition, the producers who complete an EFP can access the cost-share funding through the agri-environmental stewardship programs at the provincial level under each agricultural policy framework to adopt the BMPs outlined in their EFP action plans (Boxall, 2018; Rollins & Boxall, 2018).

[1] These are farm management operations, that once adopted, serve to reduce or eliminate environmental risks ranging from pesticide handling to energy efficiency to water quality. BMPs take into consideration legislation, practicality and operational needs for a specific farm operation (Government of Alberta, 2023).

1.2. Economic Problem

Nationally, the EFP program has seen significant evolution. All 10 Canadian provinces and the Yukon have developed and implemented their own EFP programs, reflecting the distinct nature of their provincial and territorial agricultural industries (Wilton et al., 2022; Morrison & Fitzgibbon, 2014). Despite its popularity in Eastern Canada, the program's uptake in Western Canada remains low (Statistics Canada, 2023). Since participation in the program is voluntary, enhancing its effectiveness and increasing farmer participation requires tailoring support and resources to meet the specific needs of different farmers and maximize environmental benefits. Understanding the factors influencing EFP adoption decisions among potential participants is crucial. Insights into these factors can guide future policy development, making the program more accessible and extending its reach to more farms (Smith et al., 2020; Smithers & Furman, 2003; Atari et al., 2009).

Farmers' decisions to complete an EFP in Canada are influenced by several factors. Farm and farmer characteristics such as income, age, and education impact the propensity to adopt an EFP (Yiridoe et al., 2010; Smith et al., 2020; Van Wyngaarden, 2021). Non-financial motivations, such as enhancing public perceptions and improving community relations, often drive participation (Atari et al., 2009). Positive program perceptions and social influences also play crucial roles (Smithers & Furman, 2003). Also, in the western provinces, producers' decisions to complete an EFP are influenced by economic concerns, risk perceptions, and governmental trust (Harney, 2024). Moreover, agricultural extension services provide essential training and advisory support, significantly enhancing farmers' capacity to implement environmental practices (Yiridoe et al., 2010; Tamini, 2011).

To the best of our knowledge, most existing studies focus on the EFP in Ontario and other eastern provinces (Atari et al., 2009; Yiridoe et al., 2010; Robinson, 2006a; Smithers & Furman, 2003; Smith et al., 2020; Morrison & Fitzgibbon, 2014). This leaves a research gap, with only two studies by Van Wyngaarden (2021) and Harney (2024) on EFP completion in the western region, specifically in Alberta. In both studies, the development of the EFP program in Alberta, the implementation process, adoption rates at the municipality level, and the efforts to enhance program adoption through extension activities, along with other agri-environmental outreach efforts, have not been thoroughly examined. Building on this foundation, this study aims to provide a comprehensive review of the EFP program, process, agri-environmental extension efforts, adoption determinants at both farm and municipal levels, and the role of EFP adoption in the implementation of BMPs at the farm level in Alberta during the last two agricultural policy frameworks, Growing Forward 2 (2013-2018) and the Canadian Agricultural Partnership (2018-2023).

1.3. Thesis Objectives

The purpose of this thesis is to provide a comprehensive examination of the Environmental Farm Plan (EFP) program in Alberta, focusing on the program's evolution, processes, and extension efforts to increase its uptake. It will also examine the determinants of program adoption at both the municipal and farm levels, as well as the role of EFP completion in the adoption of BMPs. Drawing on the literature related to conservation practices adoption, economic theory, and econometric methods, this thesis seeks to better understand the reasons for the low EFP uptake in the province and the factors influencing farmers' decisions regarding EFP and BMPs adoption. Throughout the thesis, the following research questions will be addressed:

1. What are the historical and policy developments that have shaped the EFP program in Alberta? What are the key components and processes of the program, and how have they evolved over time?
2. What is the agri-environmental extension process in Alberta, and who are the key players?
3. How effective are agri-environmental extension efforts in increasing the completion rates of the EFP at the municipal level in Alberta?
4. How do agricultural industry standards facilitate the adoption of the EFP at the municipal level in Alberta?
5. What are the key determinants affecting the EFP adoption at the farm level in Alberta?
6. How does the completion of the EFP influence the adoption of BMPs by agricultural producers in Alberta?

1.4. Thesis Structure and Contributions

This thesis is structured into three papers, each addressing different aspects of the Environmental Farm Plan program in Alberta.

Leading up to the papers, Chapter 2 outlines the program's history, processes, current status, and significance in promoting sustainable agricultural practices (BMPs) in Canada. Chapter 3 provides a comprehensive overview of the program's evolution, processes, key components, and current status in Alberta. It also explores the agri-environmental and EFP extension processes in the province. This chapter lays the groundwork for understanding the context in which the EFP operates, highlighting its significance in promoting sustainable agricultural practices in the province.

The first paper, Chapter 4, delves into the determinants of EFP completion at the municipal level. The primary goal of this chapter is to assess the impact of agri-environmental extension efforts, agricultural industry standards, and farm income on EFP completion rates using econometric methods. This chapter provides insights into the effectiveness of agri-environmental and EFP program extension services by the provincial government, municipalities, and program managers. This analysis is crucial for policymakers, program stakeholders, and Agricultural Service Boards aiming to enhance the reach and impact of the EFP program.

The second paper, Chapter 5, shifts focus to the farm level, examining the determinants of EFP adoption among individual farmers using data from the Environmentally Sustainable Agriculture Tracking survey of Alberta. This chapter investigates the effects of farm and producer characteristics, along with access to extension services, on a producer's decision to adopt an EFP. The findings offer valuable insights for designing targeted support and extension activities to increase EFP uptake among producers in the province and contribute to the limited research on EFP adoption in western provinces.

The last paper, Chapter 6, investigates BMP adoption across several agri-environmental risk areas. The main objective of the chapter is to understand the impact of the EFP completion on BMPs adoption at the farm level. We also analyze the other farm and producer characteristics, along with access to extension services on BMP adoption. We use various econometric methods in our analysis utilizing the data from the first two papers. This chapter provides evidence on the effectiveness of the EFP in promoting environmentally sustainable agricultural practices among farmers. Also, the insights gained offer valuable guidance to policymakers and extension agents in identifying which BMPs should be targeted in future agri-environmental policy and programs.

Finally, the thesis concludes with a summary of key findings, policy implications, and an examination of study limitations.

Chapter 2. Background

2.1. Evolution of the Environmental Farm Plan in Canada

The development of the EFP program in Canada dates back to the early 1990s. The original EFP program was adapted from the US Farm A System program. The first Canadian EFP program was formulated in Ontario in 1991 by the Ontario Farm Environmental Coalition (OFEC), a group of farm organizations in Ontario. Their aim was to create a framework for the farming community to address the key environmental issues related to farming practices. (OFA, 2023; Robinson, 2006a; Yiridoe, 2000). The program identified key issues involving water quality, soil quality, air quality, wetlands, and woodlots, and recommended that all Ontario farmers develop an EFP tailored to the needs of their farms and to adopt BMPs suggested in their plans (Robinson, 2006a).

The pilot program was launched in 1993 in seven selected counties in Ontario with funding support from Agriculture and Agri-Food Canada's Green Plan Program (Robinson, 2006a). The EFP concept gained popularity across Eastern Canada, and provincially led EFPs or EFP-like programs were soon operating in Ontario, Quebec, and Atlantic Canada by the end of 1990s. In April 2003, under the APF, the National EFP Initiative was established with a set of principles and program components for EFP programs across Canada. This led to the creation of a federal/provincial/territorial partnership that designed and supported the launch of an EFP program in every Canadian province and the Yukon Territory by 2005 (Clearwater et al., 2016; AAFC, 2005).[2]

To this day, the EFP program serves as a leading instrument for agri-environmental stewardship in Canada (Smith, 2015; Statistics Canada, 2023). The program operates in all 10 provinces and the Yukon and is tailored to the unique nature of their agricultural industries. Meanwhile, the Northwest Territories are in the process of establishing their own EFP program (Wilton et al., 2022).

2.2. The Role of the Environmental Farm Plan in Beneficial Management Practice Adoption in the Context of Canadian Agri-Environmental Incentive Policy/Programs.

Since 2003, the Canadian government has implemented five agricultural policy frameworks, collaborative federal-provincial/territorial (FPT) initiatives designed to support and advance the agriculture and agri-food sector. The first Agricultural Policy Framework (APF) introduced elements of agri-environmental policy, allocating approximately $600 million to environmental programs from 2003 to 2008 (Office of the Auditor General of Canada, 2008; Boxall, 2018).

During the second APF, Growing Forward (2008-2013), $296.6 million was spent by FPT governments on environmental programming (AAFC Office of Audit Evaluation, 2012). The third framework, Growing Forward 2 (2013-2018), dedicated roughly 49% of the Non-Business Risk Management cost-shared funding—around $2 billion—to 'Innovation' programs, which included research and environmental initiatives (AAFC Office of Audit and Evaluation, 2017). Annual funding for environmental programs during this period ranged from $148 to $253 million (Boxall, 2018).

The most recent framework, the Canadian Agricultural Partnership (2018-2023), concluded on March 31, 2023. According to the AAFC Office of Audit and Evaluation (2024), spending data for environmental programs under this framework was available for the first two years only, amounting to approximately $190.8 million.

[2] See Table 1.1A in Appendix 1 for the history of EFP programs across Canada.

The current Agricultural Policy Framework, Sustainable Canadian Agricultural Partnership (Sustainable CAP) (2023-2028), was rolled out on April 1, 2023 (AAFC, 2023). Due to its recent implementation, data on environmental spending is not yet available. However, the cost-shared funding amount has increased by 25% compared to the previous framework, reflecting a continued commitment to enhancing environmental sustainability and innovation in the agriculture sector.

Producers across Canada can access cost-shared funding for Best Management Practices (BMPs) through environmental stewardship programs available in their respective provinces. To be eligible for this funding, producers must obtain an Environmental Farm Plan (EFP) completion certificate, which helps them identify and manage potential environmental risks on their farms. Typically, cost shares for BMPs range from 25% to 75%, with funding maximums varying between $2,000 and $100,000, depending on the specific BMP (Rollins & Boxall, 2018). For those who prefer not to apply for government cost-share funding, alternative funding sources are available through organizations such as Alternative Land Use Services (ALUS), Ducks Unlimited Canada (DUC), or other agencies (Van Wyngaarden, 2021).

Figure 2.1 illustrates the possible pathways a producer could follow leading to adoption of BMPs within the Canadian agri-environmental policy and programs framework:

1. Complete an EFP and Access Government Cost-Share Funding: A producer completes an EFP, uncovers the environmental risks on their farm in the process, and develops an action plan that is a list of potential BMPs that can be adopted. Then the producer applies for government cost-share funding to implement these BMPs.
2. Complete an EFP and Access Alternative Programs: A producer completes an EFP, which helps them identify the environmental risks on their farms and develops the list of potential BMPs in their action plan. Instead of opting for government provided cost-share funding, the producer can choose to seek funding through alternative programs offered by ALUS, DUC, or other agencies to implement BMPs.
    a. Complete an EFP and Self-Fund BMPs Projects: A producer completes an EFP which educates them about the environmental risks associated with their farming operations. As they progress through each EFP chapter relevant to their activities,

they develop action plans to mitigate the identified risks. Instead of reaching out to funding sources, the producer chooses to directly adopt the BMPs using their own financial resources.

3. Do Not Complete an EFP and Access Alternative Programs: A producer opts not to complete an EFP and seeks funding from alternative sources such as ALUS and DUC, which do not require an EFP for cost-share funding. The decision to forego an EFP may stem from various reasons, including privacy concerns, a lack of information about the EFP process, or perceptions that the EFP is too time-consuming or complex to complete (Statistics Canada, 2023; Yiridoe, 2000; Smithers & Furman, 2003).
4. Do Not Complete an EFP and Self-Fund BMPs Projects: A producer decides not to complete an EFP, not to access funding sources, and adopts BMP projects at their own expense. This decision to self-fund BMP adoption may be influenced by factors such as guidance from extension personnel, promotional efforts, social networks, and memberships in advisory clubs or agricultural organizations (Pannell et al., 2006; Tamini, 2011).

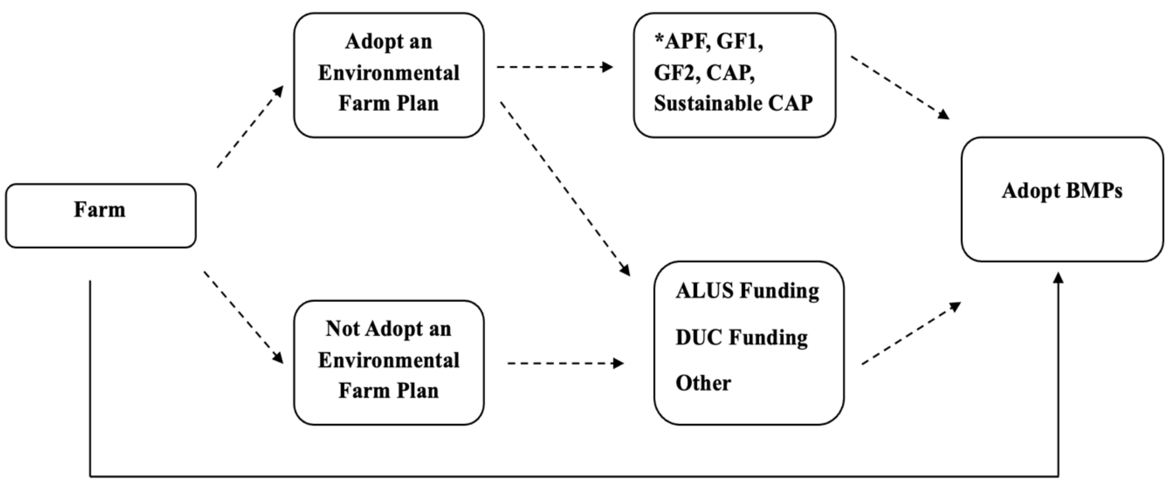

Figure 2.1. Beneficial Management Practices Adoption in the Context of Canadian Agri-Environmental Incentive Policy/Programs.

As we can see, completing an Environmental Farm Plan (EFP) could play a significant role in promoting sustainable agriculture and environmental stewardship in Canada, particularly if adopters are interested in accessing government provided cost-share funds to assist in adopting BMPs.

2.3. EFP Process in Canada

The Canadian EFP program is funded through collaboration among federal, provincial, and territorial governments. Since agricultural production, soil quality, landscape, weather, and other factors vary across the country, farm management practices and their environmental effects also diverge regionally. Consequently, agricultural and environmental regulations are distinct across the provinces (AAFC, 2011). The EFP programs are unique in each province and tailored to fit their own regional and agronomic situations (Boxall, 2018; AAFC, 2011). The administration and execution of the program differs across the provinces and the Yukon. In Saskatchewan, Quebec, New Brunswick, and the Yukon, a single government department, typically the ministry of agriculture, is responsible for both monitoring and implementing the program. However, in other provinces, a government ministry oversees the program, and an external agency delivers it (Wilton et al., 2022).[3]

While the EFP process differs across provinces, most tend to align with the initial EFP process established in Ontario. This initial EFP process consisted of six stages, starting with participation in an introductory workshop and ending with the implementation of the individual farm plan. (Robinson, 2006a; Morrison & FitzGibbon, 2014).[4] Throughout the process, farmers received guidance from facilitators who come from local farming organizations, notably the Ontario Soil and Crop Improvement Association (OSCIA), the Ontario Federation of Agriculture (OFA) and the Christian Farmers Coalition (CFC). These organizations also played a role in creating 23 advisory worksheets. Using these worksheets farmers identified the environmental risks in their farms (Robinson, 2006a). Farmers employed a four-point scale to conduct environmental assessments of specific scenarios outlined in the worksheets, from 4 (best- conditions that protect the environment or have low environmental risk) to 1 (poor- conditions with high environmental risk), with intermediary points of 3 (good) and 2 (fair) (Robinson, 2006b).

[3] See Table 1.1A in Appendix 1.

[4] See Figure 2.2. The six-stage sequence of Ontario's initial EFP process.

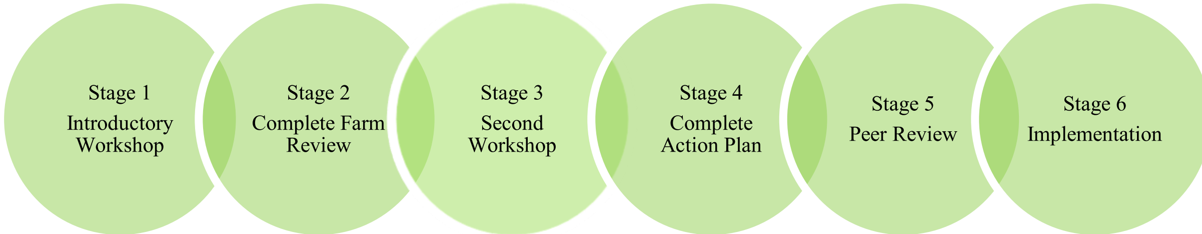

Figure 2.2. The six-stage sequence of Ontario's initial Environmental Farm Plan process.
Source: Robinson (2006a); OFEC (1999).

As each province and territory has their unique approach to EFP programming, the process a farmer undergoes to complete an EFP and the criteria for EFP renewals differ based on their farming location. Generally, the EFP process in all provinces encompasses a mix of the six-stage sequence above. After completing the EFP, farmers have the opportunity to seek cost-shared funding to implement any BMPs listed in their action plans (Wilton et al., 2022).

2.4. Environmental Farm Plan Uptake in Canada

The EFP program has become a foundational piece of agri-environmental stewardship in Canada. The program seems to be accepted and the participation rate can be high in some provinces (Statistics Canada, 2017, 2023). Table 2.1 below displays the percentage of producers in Canada, by province, who have completed the EFP, based on data from the Farm Environmental Management Surveys (FEMS) of 2006, 2011, and the Farm Management Surveys (FMS) of 2017 and 2021.[5]

Table 2.1. Percentage of producers who held a completed Environmental Farm Plan across the 10 Canadian provinces from 2006-2021.

Provinces	Completed EFPs FEMS 2006 (%)	Completed EFPs FEMS 2011 (%)	Completed EFPs FEMS 2017 (%)	Completed EFPs FEMS 2021 (%)
Prince Edward Island	39.6*	53*	66	68

[5] The survey is released every five years and represents 90 % of the Canadian agricultural production in 7 production subsectors: beef, dairy, poultry, pigs, field crops, forage crops, fruit, vegetables, berries and nut production. Only the provinces with significant national production in one of the 7 subsectors are included in the sampling. Therefore, Newfoundland and Labrador are not included in the table (Statistics Canada, 2022).

Nova Scotia	39.6*	53*	63	59
New Brunswick	39.6*	53*	74	63
Quebec	73.2**	72	81	76
Ontario	34.7	38	46	42
Manitoba	15.4	28	28	27
Saskatchewan	10.7	26	28	23
Alberta	13.4	23	25	25
British Columbia	10.8	21	28	28
Canada	**27.6**	**35**	**40**	**37**

Source: Farm Environmental Management and Farm Management Surveys from Statistics Canada (2013, 2017, 2023) and AAFC (2013).
**EFP completion rate for the three marked provinces was calculated jointly in FEMS 2006 and 2017 surveys.*
*** Numbers represented for Quebec might be over-reported and include the farms with environmental programs other than EFP.*

Table 2.1 indicates that the national EFP adoption average gradually increased from 27.6% in 2006 to 37% in 2021. However, the 2021 FMS provided information suggesting a 3% decline in EFP adoption compared to 2017. This decrease could be attributed to different factors influencing farmers' decisions to adopt an EFP (see Table 2.2). The 2021 survey highlighted that a primary reason for farmers not adopting the EFP was the perception that the EFP was time-consuming. Additionally, 28% of the farmers cited other reasons for not adopting the EFP. We assume that the global Covid-19 pandemic could have been one of the contributing factors. Moreover, 24% of the farmers declared that they had insufficient information about the EFP (see Table 2.2).

Table 2.2. Factors affecting non-adoption of the Environmental Farm Plan in Canada.

Reasons why farmers did not complete an EFP	Statistics from Farm Management Survey 2021 in %
EFP is too complicated	22
EFP is too time consuming	32
Lack of information on EFP	24
Participating in other environmental initiatives	10
Other reasons	28

Source: Statistics Canada (2023).

The 2021 FMS also revealed that 18% of the Canadian farmers had outdated EFPs, while 8% of farmers were developing their EFPs that year. A significant portion, over half of the Canadian farmers, still do not have an EFP (see Figure 2.2). Mainly, this could be due to the low EFP adoption rate in the four western provinces — Manitoba, Saskatchewan, Alberta, and British Columbia. As Table 2.1 shows, these provinces had modest adoption rates below 30% over the period from 2006 to 2021. In contrast, eastern provinces exhibited considerably higher adoption rates, particularly Quebec, which had an adoption rate of over 70% across the years.

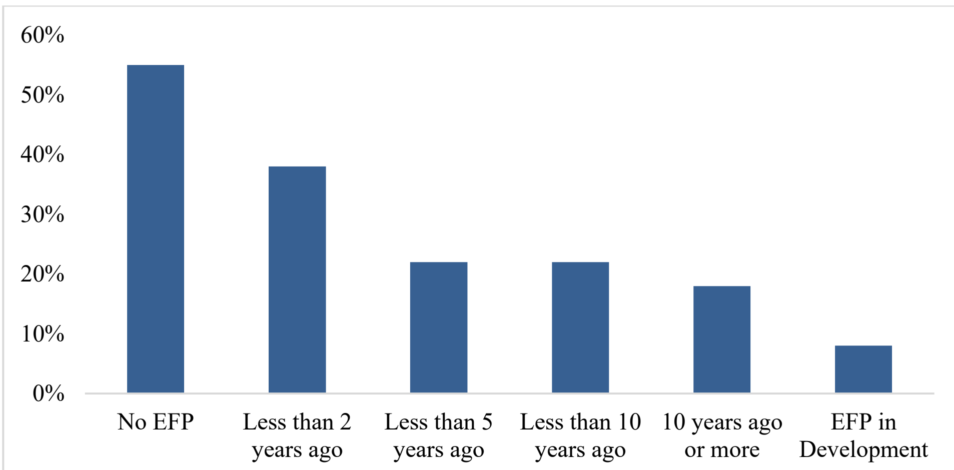

Figure 2.3. The EFP Status in Canada based on the Farm Management Survey 2021.
Source: Statistics Canada (2023).

Various reasons can be suggested for this disparity. For instance, Quebec's high adoption record over the years is likely due to cross-compliance policy measures, where certain agricultural financial assistance programs are tied to meeting some specific environmental standards. These standards, in turn, are associated with having adopted an EFP (Van Wyngaarden, 2021; AAFC, 2011). The fewer number of farms in eastern provinces might also correlate with a high EFP uptake (Statistics Canada, 2023). It is also worth noting that the EFP program was launched later in the western provinces than eastern provinces (Wilton et al., 2022; AAFC, 2011).

Chapter 3. Overview of the Environmental Farm Plan and Agri-Environmental Extension in Alberta

3.1. Evolution of the Environmental Farm Plan in Alberta

The EFP in Alberta is a similar voluntary self-assessment tool that helps the identification of agri-environmental risks on farms and the development of plans to alleviate them. It allows Alberta producers[6] to access funding sources to help them implement on-farm BMPs through agri-environmental policies stemming from Growing Forward 1, Growing Forward 2, the Canadian Agricultural Partnership, and the Sustainable Canadian Agricultural Partnership. In addition to reducing environmental risks and preserving a healthy farm for future generations (AEFP, n.d.), producers holding an EFP may have access to new market opportunities through signaling to consumers their production of sustainably sourced products and the potential of reducing farm input costs.[7]

Looking back at the Alberta EFP program's evolution, it was initially developed by farmers, for farmers, in response to regulations as an early attempt to secure social license commonly referred to as public trust. Farmers, farm organizations, and the federal and municipal governments swiftly recognized the EFP's value as an educational and planning tool. In the early 2000s, the Government of Alberta, with the industry organizations, united under the banner of the Alberta Environmentally Sustainable Agriculture (AESA) Council and began assessing the feasibility of adopting Ontario's EFP. Alberta's EFP program version was reviewed by the experts and tailored to the specific farm-based environmental risks in the province (AEFP, 2023; Moskal-Hébert T., ARECA, personal communication, May 3, 2023).

After signing the first national agricultural policy framework in 2003, simply called the APF, Alberta formed a non-profit organization — the Alberta Environmental Farm Plan Company (AEFP Co.). The AEFP Co. was a tripartite partner with Agriculture and Agri-Food Canada and

[6] From this chapter on, we will use the term "producer" when referring to participants of the program in Alberta. The EFP is intended for both farmers and ranchers.
[7] Note that not every producer will have reduced input costs.

Alberta Agriculture, Food and Rural Development, delivering programs in the Environmental Chapter of the APF. The AEFP Co. was responsible for the delivery of the Alberta EFP program from 2003 to 2009. In 2003, AEFP Co. signed a contract with federal and provincial governments to carry out preliminary producer outreach and to design a delivery model in Alberta. The delivery model included peer-to-peer workshops by trained producers and field support from AESA municipal conservation coordinators who offered technical support for BMPs adoption. As a result, the EFP program significantly increased on-farm environmental awareness and helped the producers identify and assess the environmental risks on their farms. Throughout 2003-2009, AEFP Co. managed to engage with more than 13,000 producers and developed EFPs with approximately 8,000 producers (Moskal-Hébert T., ARECA, personal communication, May 3, 2023; Government of Alberta, 2007).

In 2009, the AEFP Co. was dissolved, and the EFP program was coordinated by the provincial government through the Alberta Ministry of Agriculture and Rural Development. The ministry entrusted the EFP program delivery to AESA program partners. During that year, a total of 35 EFP plans were generated, representing 88,312 acres of farms assessed for environmental risks (Government of Alberta, 2010). The Alberta EFP program remained under the provincial government management until 2013, and in that period, approximately 1000 EFP workbooks were delivered to producers. In 2013, the provincial government contracted out the delivery of the Alberta EFP program to the Agricultural Research and Extension Council of Alberta (ARECA), marking a pivotal moment in the program's trajectory. Since then, ARECA has been developing and delivering the program to Alberta's producers and supply chains on behalf of the Government of Alberta. The financial support for the program delivery comes from provincial and federal governments through environmental elements of the quinquennial agricultural policy frameworks (Moskal-Hébert T., ARECA, personal communication, May 3, 2023). Also, in addition to the program funding, the provincial government continues to provide subject matter expertise and technical support to help advance the EFP program.

Under ARECA's leadership, the Alberta EFP program has developed significance and gained broader recognition. The establishment of the Alberta EFP Stakeholder Advisory Committee in 2015 highlighted a commitment to collaboration and strategic guidance. The Committee is comprised of representatives from the various agricultural sectors affected by the environmental risks. The committee's primary responsibilities are to provide advice and guidance on the program activities, outputs, and future enhancements. The current members of the committee are the provincial government, Agriculture and Agri-Food Canada, ARECA, Alberta Barley, Potato Growers of Alberta, Alberta Beef Producers, Alberta Agriculture and Irrigation, Alberta Wheat, Rural Municipalities of Alberta, Alberta Federation of Agriculture, Alberta Milk, and Canadian Federation of Agriculture (AEFP, n.d.; Moskal-Hébert T., ARECA, personal communication, May 3, 2023; AEFP, 2023).[8]

Also in 2015, in response to the international market demands for sustainable sourcing standards, ARECA collaborated with Alberta Barley to initiate a benchmarking project aimed at comparing Alberta's EFP against three globally recognized sustainability standards or initiatives: The Sustainable Agriculture Initiative Farmer Self-Assessment (SAI FSA v2.0), International Sustainability & Carbon Certification (ISCC) and Unilever's Sustainable Agriculture Code (ULSAC). According to the results, Alberta's EFP addressed numerous criteria covered by most sustainable sourcing frameworks, such as water management, energy use/efficiency, climate change, soil management, waste management, crop protection management, nutrient management, and biodiversity conservation. A few gaps still existed in biodiversity sections, and in response, the development of the species at risk (SAR) component to the EFP started in 2016 (Control Union, 2015; Global Ecologic Environmental Consulting and Management Services, 2016).[9]

Alberta EFP's evolution with ARECA resonated through partnerships with Canada's and Alberta's key agricultural associations, fostering a united approach to sustainability (AEFP, 2017, 2018). In 2014, one of the partners, the Potato Growers of Alberta, became the first agricultural industry group to consider requiring an EFP for membership in response to requests from one important potato buyer, McCain Foods, who was requiring sustainable sourcing of potato in their supply chains.[10] In the same year, Alberta EFP worked with the Egg Producers of Alberta to incorporate EFP into their new assessment tool called Producer Environmental Egg Program (PEEP) (AEFP,

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[8] Note that Alberta Agriculture and Irrigation acts as an observing role. They do not offer guidance on final decisions.
[9] The Habitat and Biodiversity Assessment Tool (formerly called the SAR tool) was not available for broad use until the launch of EFP version 3.1 in 2021.
[10] Note that the producers need an EFP if they want to sell their products to the buyers.

2023). Starting in September 2021, Dairy Farmers of Canada included the EFP completion requirement in the Environmental Module section of their proAction program for dairy producers (Dairy Farmers of Canada, 2023). These partnerships have exemplified the influence of Alberta's EFP program in shaping industry practices.

Along with local efforts to advocate sustainable sourcing among producers, ARECA has also taken a proactive role in endorsing the National EFP program. To elaborate, Canadian provincial governments and agricultural organizations came together in 2015 to establish the National EFP steering committee, with the goal of harmonizing EFP practices nationwide and building national credibility within the agricultural sector and global markets. Since then, Alberta EFP has emerged as a crucial collaborator in shaping the trajectory of the National EFP initiative (AEFP, 2017, 2023).

From its grassroots origins to its current status, Alberta's EFP program exhibits a journey of progress, collaboration, innovation, and responsible stewardship. The program has actively involved producer groups and stakeholders with less administrative burden, enhanced ecosystem management, and increased sustainable sourcing opportunities. Also, Alberta EFP enhanced its role in shaping sustainable agricultural practices in the province and across Canada. As the program evolved, its impact steadily grew, hoping to shape promising environmental improvements for farming communities and the lands they utilize.

3.2. The Environmental Farm Plan Process and Workbook in Alberta

Over the years, the Alberta EFP Workbook has undergone multiple upgrades and transitions. Initially, it existed as a 4-inch hard copy binder during the early 2000s (AEFP, 2023). In 2012, Alberta EFP introduced the online EFP Webbook (version 2.1), followed by its advancement to version 3.01 in 2015.[11] Progressing to 2018, the updated EFP Webbook (version 3.01) was launched with a refreshed look, minor content modifications, and user-friendly features (Moskal-Hébert T., ARECA, personal communication, February 10, 2023). In the following year, the most

[11] The term "webbook" is used when referring to the online system that producers can access to complete their workbook. The term "workbook" is used to refer to the self-assessment questionnaire and action plan the producer completes.

recent EFP Webbook, in conjunction with local legislation, was benchmarked against the Farm Sustainability Assessment (FSA) 2.1 and received a Silver content equivalency rating. Responding to the FSA 2.1 outcomes as well as to support Alberta producers' market access, the new "Habitat Management" chapter, which employs the use of the Habitat and Biodiversity Assessment Tool (HBAT, previously known as SAR), was added to the Alberta EFP in 2021. Simultaneously, the EFP webbook version was updated to version 3.1. In the same year, alongside local legislation, the Alberta EFP submitted the EFP+ webbook version 3.1 to the Sustainable Agriculture Initiative (SAI) Platform for a Silver equivalency assessment concerning content, governance, and verification of components of FSA 2.1. In 2022, a new version 4.0 of the EFP + webbook was developed with the help of content experts to assess alignment with most up-to-date BMPs and to streamline content within the workbook. The version 4.0 of the EFP+ webbook also included an optional "Beekeeping" chapter. Taking into account the federal legislation, which was benchmarked to the FSA 3.0, as of now, the Alberta EFP 4.0+ is aligned to FSA Gold Level (Nadeau, L., ARECA, personal communication, November 24, 2023; Moskal-Hébert T., ARECA, personal communication, February 10, 2023).

Currently, the Alberta EFP webbook comprises 25 chapters encompassing various environmental risk categories. Producers complete the chapters that are relevant to their farm operations using a four-point scale that is similar to that described by Robinson (2006b). The scale is used to evaluate the on-farm agri-environmental risks across several risk categories specified in the worksheets. Unlike the scale used by Robinson (2006b), the natural risk rating of "1" and "2" suggest "low environmental impact", "3" – "moderate environmental impact", and "4" – "high environmental impact". Thus, producers self-evaluate the environmental risks on their farms, and the ones with "3" - moderate environmental impact" and "4" - "high environmental impact" develop action plans (AEFP, 2023). While certain chapters are optional, seven are mandatory to complete:

- Soil and site characteristics (Chapter 1)
- Water sources (Chapter 2)
- Environmental emergency planning (Chapter 4)
- Habitat management (Chapter 5)
- Disposal of farm waste (Chapter 8)

- Energy efficiency (Chapter 9)
- Management of household wastewater (Chapter 10).

Also, any chapter that is relevant to the producer's operation needs to be completed. For instance, if a producer has livestock, they have to complete livestock chapters such as manure management. Otherwise, a technician will not approve their EFP (Nadeau, L., ARECA, personal communication, November 24, 2023).

Shedding light on the Alberta EFP process, there are several steps producers must take to navigate the completion of an EFP. As illustrated in Figure 3.1, at the initial stage, producers fill out the online form to answer questions about their farming operations, and they receive an emailed link to activate their account. An EFP technician contacts the producer shortly to offer guidance through the EFP process by addressing their questions. Throughout the workbook, after completing each chapter, the producers create an action plan if there are environmental risk(s) identified in that chapter. In the action plan, they are to identify either an action to address the risk (adopting a BMP), compensating factors that mitigate the risk (e.g., the well is upslope from the source of contamination and is unlikely to flow into the well), or a monitoring plan (e.g., if moving the well is not feasible in the short term, they will conduct regular water tests) (Nadeau, L., ARECA, personal communication, November 24, 2023).

Even though there is no deadline to complete the EFP, producers are encouraged to do it within a short period of time. In the next stage, producers will submit the completed EFP with action plans to an EFP technician for review. If the EFP needs more work, the technician will provide recommendations on how to proceed, and if it is complete, then the technician will approve and arrange a certificate of completion. However, it is important to emphasize that obtaining a completion certificate does not initiate monitoring for executing the plans or action items developed in the workbooks (AEFP, 2023).

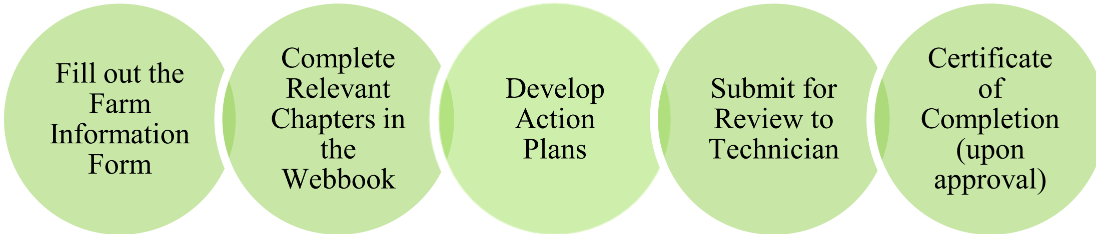

Figure 3.1. Environmental Farm Plan Completion Process in Alberta.[12]

In addition, the users of the EFP 4.0+ Webbook receive an official FSA score upon completion of the workbook which they can submit to their Farm Management Group for verification. Once the verification is complete, the Farm Management Group can make sustainability claims on their product based on the results (Nadeau, L., ARECA, personal communication, November 24, 2023).

It is important to highlight that, Alberta EFP has a mandatory renewal period. Until 2018, Alberta remained the only province in the country without a renewal date for the EFP. However, driven by the desire to increase the producers' access to policy incentive cost-share programs, enable producers to align with the evolving upgrades in the EFP workbooks, and empower them to better meet global sustainable sourcing standards, the Alberta EFP introduced a mandatory 10-year EFP renewal period starting April 1, 2018 (AEFP, 2018).

3.3. Agri-Environmental Extension in Alberta

Agricultural environmental extension plays a vital role in promoting sustainable farming methods and tackling environmental issues within the agricultural sector. In Alberta, the province's approach to agri-environmental extension involves collaboration with producers, research and farming organizations, and other stakeholders. The province directs its research and extension efforts, along with incentive-based programs, towards promoting the adoption of BMPs. Figure 3.2 below describes the agri-environmental extension process in Alberta.

[12] Developed by authors using the information on ARECA's website.

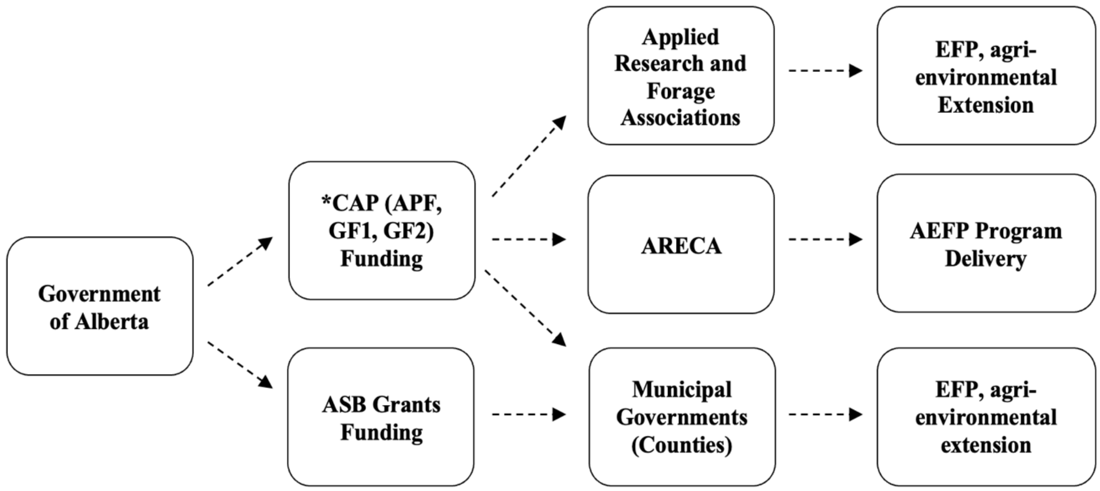

Figure 3.2. An Overview of the Agri-environmental extension process in Alberta.[13]
*Government BMP cost-share funding through the agricultural policy frameworks that have been running since 2003.

The Government of Alberta allocates funds to support agri-environmental extension efforts in the province through two primary funding streams. In the first stream, the provincial government receives funding from the federal government via the environmental components of the agricultural policy framework (CAP, GF1, GF2 etc.) usually called stewardship programs (Boxall, 2018). Applied Research and Forage Associations and the Agricultural Service Boards (ASBs) of the municipal governments can apply for funding through this stream. To illustrate, during the CAP 2018-2023 period, several research associations, agricultural organizations and municipalities received funding through the Environmental Stewardship and Climate Change programs. This funding was used to conduct applied research and provide extension services related to new technologies and practices. In 2019, the Cows and Fish organization utilized funding received from this stream to implement a project focused on delivering training and resources to primary producers in support of assessing riparian areas and implementing riparian area BMPs. Additionally, in 2020, the Ministry of Agriculture and Forestry provided a $350,000 grant to ARECA to deliver the EFP program through the Environmental Sustainability priority area of CAP (Government of Alberta, 2021, 2022).

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[13] Source: Developed using information from the Alberta Ministry of Agriculture and Irrigation's annual reports, ARECA, and applied research and forage associations' websites.

In the second funding stream, the Government of Alberta offers funding through the Environmental Funding stream of the ASB grant to the ASBs of municipal governments. One of the primary objectives of the ASB grant program is to support the development and delivery of environmental extension programs in the municipal governments. The ASB grant is offered on an annual basis, and eligible applicants are municipal governments that have established an ASB in accordance with the ASB Act. These municipal governments must also have appointed an Agricultural Fieldman as mandated by the ASB Act, and they should have primary producers actively engaged in farming agricultural land that yields agricultural commodities within the municipality (Government of Alberta, 2016, 2022). Some ASBs provide their grant funding to applied research and forage associations to deliver extension programs on their behalf (Ung, L., Government of Alberta, personal communication, November 15, 2023).

3.4. Key Players of Agri-Environmental Extension in Alberta

The Alberta Ministry of Agriculture and Irrigation[14] is the main entity in funding and monitoring the agri-environmental extension in the province. Ensuring a consistent source of funding for agricultural research and extension is a top government priority. Until 2020, the agricultural research and environmentally sustainable agriculture extension programs and services were delivered under the AESA program with the help of 12 applied research and forage associations and the majority of ASBs of the municipalities. However, in 2020, the provincial government shifted their approach, emphasizing agricultural producers led research. The introduction of this new approach, known as Results Driven Agriculture Research (RDAR), was announced at the end of March 2020 (Government of Alberta, 2018, 2020). RDAR is a non-profit corporation at arm's length from the provincial government. One of the primary focuses of RDAR is to streamline the adoption of new technologies in Alberta's agriculture through extension and knowledge transfer (Government of Alberta, 2021; RDAR, 2023). In 2022, a committee sponsored by the provincial government and RDAR evaluated Alberta's agricultural extension system, recommending a new enhanced extension model, the Cooperative Extension Model (CEM) (ASB, 2023).

[14] Ministry of Agriculture and Irrigation of Alberta has been renamed several times over the years. In 2002-2005: Ministry of Agriculture, Food, and Rural Development; in 2006-2007: Ministry of Agriculture and Food; in 2008-2014: Ministry of Agriculture and Rural Development; in 2015-2020: Ministry of Agriculture and Forestry; in 2021-2022: Ministry of Agriculture, Forestry and Rural Economic Development; in 2023: Ministry of Agriculture and Irrigation.

Another key player in Alberta's agri-environmental extension is the Agricultural Research and Extension Council of Alberta (ARECA). This organization delivers the province's main extension program, the Alberta EFP, at arm's length from the provincial government. To promote the uptake of the EFP program, ARECA offers extension services to Alberta producers regarding the program. They develop the EFP workbook and update the website, how-to-do videos, and extension materials. Through the EFP program, producers are connected to EFP extension agents, known as EFP technicians, who often connect producers with other environmental programs and resources in their area. The EFP technicians are employed by municipalities and the local agricultural and forage research associations. Furthermore, ARECA supports their members in delivering innovative research and extension to Alberta agricultural producers. (Hall, A., ARECA, personal communication, May 15, 2023; Nadeau, L., ARECA, personal communication, November 24, 2023).

Applied research and forage associations also play a vital role in Alberta's agricultural extension. They facilitate the transfer of information among research institutions, the industry, and agricultural producers. Their aim is to achieve sustainable agriculture in the municipalities they partner with. They disseminate information and expertise on new technologies and BMPs through seminars, demonstrations, workshops, newsletters and other available mediums (SARDA, n.d.). There are 12 applied research and forage associations in Alberta[15] and they are considered local non-profit organizations directed by the producers of the municipalities they partner with. Also, technicians from these associations volunteer to support ARECA with EFP program extension. Currently, eight of these organizations collaborate with ARECA (ARECA, 2023).

Agricultural Service Boards (ASBs), unique to Alberta for over 50 years, are another cornerstone of agri-environmental extension. Appointed by the local municipal councils and mandated by the ASB Act, these boards develop policies and programs for the local agricultural sector. There are 69 ASBs in the province and their core focus areas are weed control, soil and water resource conservation, and pest management (ASB, 2023; Government of Alberta, n.d.). By the ASB Act, each ASB employs an agricultural fieldman to oversee programs reflecting their board's priorities (AAAF, n.d.; Government of Alberta, 2022). ASBs support the delivery of the environmental

[15] See Table 2.1A in Appendix 2 for the list of research associations and their member municipalities.

extension programming in their local communities. The agricultural fieldmen, who largely have a comprehensive background in applied agricultural or environmental science, offer environmental extension services to local producers (AAAF, n.d.; Government of Alberta, 2022).

One more organization that supports environmental stewardship in the province is Alternative Land Use Services Canada, a national charitable organization that administers the ALUS program across the country. This program was initiated as a pilot project in Manitoba in 2006 by the Keystone Agriculture Producers, a farm group, and the Delta Waterfowl Foundation, a non-profit conservationist organization (ALUS, 2023; France & Campbell, 2015). ALUS helps agricultural producers become more sustainable through cost-sharing on BMP implementation, providing annual payments for ongoing management that produces increased ecosystem services, and by providing extension services for the implementation of the program projects. ALUS projects focus on different agri-environmental risk areas such as water quality and quantity, carbon sequestration, soil health, flood and drought mitigation, and pollinator and wildlife habitat (ALUS, 2023). The first ALUS program in Alberta was launched in the county of Vermilion River in 2010 and since then the program has supported several local producers in establishing and maintaining stewardship projects (County of Vermilion River, 2023). Currently, ALUS operates in 21 municipalities in Alberta (Lewis, K., Red Deer County, personal communication, November 18, 2022). An operational hypothesis might be that the program may have gained popularity among producers who do not want to complete an EFP, as ALUS does not require an EFP completion certificate from the producers to access funds for the implementation of their BMPs projects.[16]

In addition to these entities, research institutions, federal government agencies, and commodity groups are also involved in promoting agri-environmental extension in Alberta. Their collective efforts ensure that Alberta's agricultural producers receive the knowledge and resources they need to implement environmentally sustainable farming practices.

[16] Many producers who are involved with ALUS also have an EFP. Having an EFP is not a requirement for ALUS, but ALUS is one of the environmental programs an EFP technician may direct a producer to when reviewing their EFP workbook. Some producers apply for both ALUS and government grant programs.

3.5. Environmental Farm Plan Extension Process and Efforts in Alberta

As discussed in the previous sections, the Alberta EFP has emerged as a pivotal component of province's agri-environmental extension. Boxall et al. (2013) describe the program as emphasizing education and moral suasion, resonating with the principles of stewardship. Also, MacKay and Hewitt (2010), note the EFP's role as a primary educational and informational resource for producers.

Extension efforts in support of EFP adoption are carried out by ARECA with the help of ASBs, applied research and forage associations, and individuals from several other groups. The EFP technicians from the ASBs provide individual support to producers guiding them in tailoring the EFP to their specific farming conditions. While completing the EFP workbooks, producers gain insights about the potential environmental risks associated with their farming operations. Moreover, through the process of developing action plans, they learn about the environmentally sustainable practices that may need to be adopted on their farms. The EFP program supports the producers by offering one-on-one support through workshops, EFP technician, and staff support. As the program switched to online workbooks, known as webbooks in 2012, ARECA developed digital tools and resources for producers. Throughout the EFP process, producers can also access on-demand EFP technician support (AEFP, 2023; ARECA, 2023).

To highlight the EFP extension efforts in the province, before 2018, the Alberta EFP had a network of over 50 technicians in the province to help the producers through the process (AEFP, 2018). However, between 2018 and 2023, this network experienced a 17% contraction. Nevertheless, the Alberta EFP has maintained the network of 40+ technicians annually and continually train new technicians. According to the Alberta EFP, there is a higher uptake of the program in the regions where technicians are present and active (AEFP, 2023). The Alberta EFP remains committed to the professional development of EFP technicians, providing annual training through webinars, workshops, mentorship programs, and networking events. This ongoing commitment provides producers with support they need to complete an EFP (AEFP, 2023).

To promote ongoing EFP education, the Alberta EFP hosts regular in-person and virtual workshops, providing producers an opportunity to address their questions with EFP technicians, staff, and fellow producers. Over the past five years, Alberta EFP has organized 98 workshops which has led to a 130% increase in the number of producers in the online system (AEFP, 2023). ASBs, the provincial government, and applied research and forage associations support Alberta EFP promoting the uptake of the EFP program by offering trainings and workshops to the producers in their municipalities. To illustrate, from 2018 to 2020, over 200 workshops were hosted across 69 municipalities.[17] Moreover, during 2020-2021, Alberta EFP delivered 6 training programs and 19 workshops to producers throughout the province, despite the COVID-19 pandemic (Government of Alberta, 2021, 2022; Nadeau, L., ARECA, personal communication, December 7, 2023). However, despite these rigorous extension efforts, the levels of EFP adoption in the province remain modest over the years.

3.6. The Rate of Environmental Farm Plan Completion in Alberta

The EFP adoption rate has been assessed historically through two surveys in Alberta. One is the Farm Environmental Management Survey (FEMS) renamed the Farm Management Survey (FMS) in more recent years. This survey is conducted every five years by Statistics Canada and Agriculture and Agri-Food Canada. The other is the Environmentally Sustainable Agriculture Tracking Survey (ESAT) conducted by the Alberta provincial government biennially. According to the FEMS 2011-2017 and FMS 2021 surveys, the EFP adoption rate in the province increased from 23% in 2011 to 25% in 2017 and has remained at that level until 2021 (see Table 2.1). In the survey rounds from 2017 and 2021, approximately 8-9% Alberta farms had an EFP under development or renewal (see Figure 3.3). Among the Alberta producers who held an EFP, 17-18% of them completed their EFP in less than two years prior, while 21-25% of the producers have held their EFP for more than 10 years. It is important to highlight that in 2018, the Alberta EFP changed the EFP renewal period to 10 years (AEFP, 2018). This may imply that 25% of the producers had an expired EFP in 2021.

[17] Data received from ARECA.

On the contrary, the adoption rate in the 2021 ESAT survey is approximately 47% (Anders et al., 2021). This discrepancy could be due to possible self-selection bias since participation in the survey is voluntary and focuses on environmentally sustainable agriculture. Therefore, producers with EFPs may be more apt to self-select into participating in the survey.

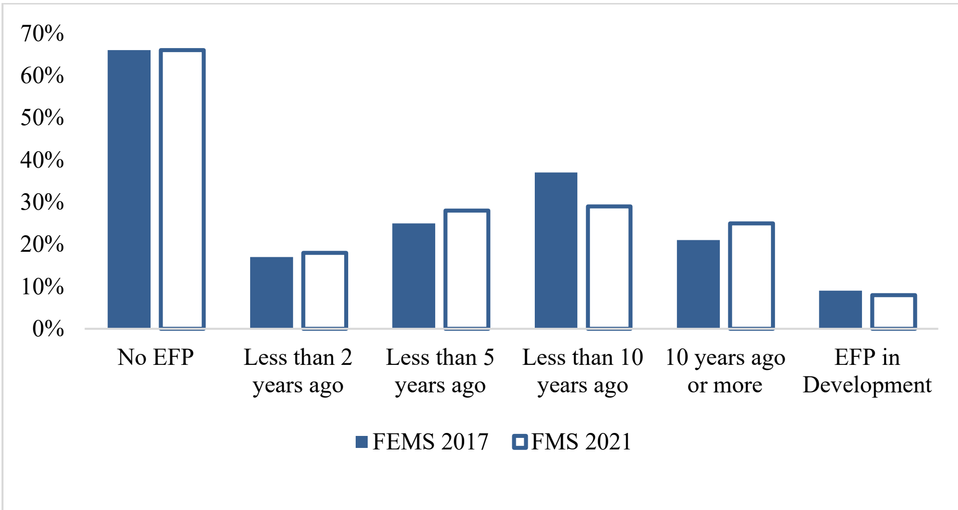

Figure 3.3. Status of Environmental Farm Plan Adoption in Alberta based on the Farm Management Survey 2021.

Source: Statistics Canada (2013, 2017, 2023).

To delve deeper into Alberta EFP adoption rates, we obtained data from ARECA on the number of EFP completions by producers for each municipality and for calendar years from 2013 to 2022. Using the information from FEMS 2011, 2017, and FMS 2021 and the data on the number of farms from the Census of Agriculture from 2011-2021, we calculated the completion rate per 100 farms (see Figures 3.4 and 3.5). Given that FEMS 2011 showed a 23% adoption rate and FEMS 2017 and FMS 2021 suggested adoption rates of 25%, we inferred that 77% in 2013-2016 and 75% in 2017-2021 of Alberta farms did not have an EFP. Our calculations for the completion rates are focused on the pool of producers without an EFP. Our data and calculations reflect the changes in the EFP completion rate and EFP completion numbers during the existence of two Canadian agricultural policy frameworks, GF2 (2013-2018) and CAP (2018-2023).

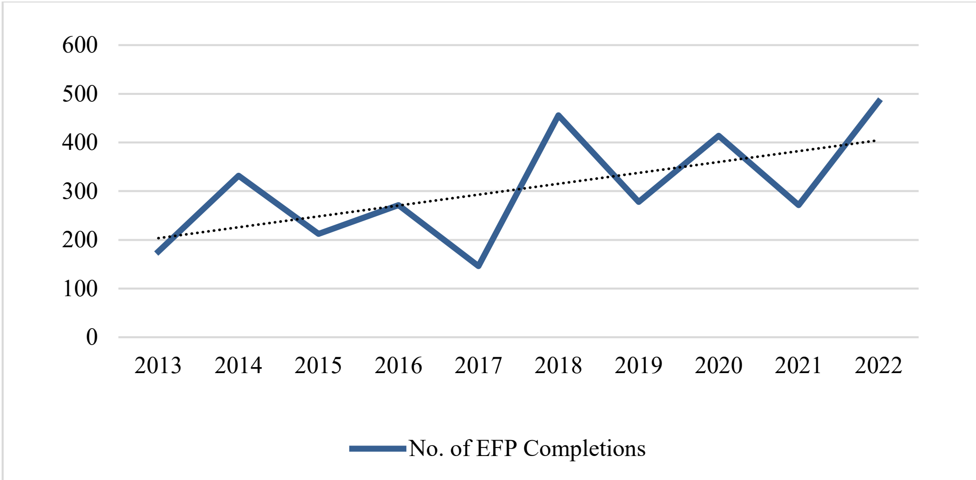

Figure 3.4. Number of Environmental Farm Plan Completions in Alberta between 2013-2022.
Source: ARECA (2023); AARD (2014); AAF (2020); Statistics Canada (2013, 2017, 2021, 2023).

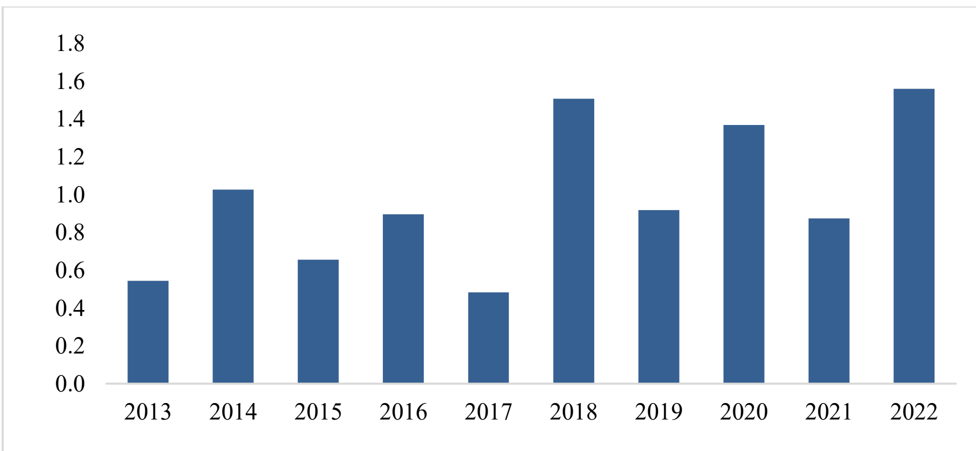

Figure 3.5. Estimated Completion Rate of the Environmental Farm Plan per 100 farms in Alberta in 2013-2022 (per 100 farms in %).
Source: ARECA (2023); AARD (2014); AAF (2020); Statistics Canada (2013, 2017, 2021, 2023).

As illustrated in Figures 3.4 and 3.5, there was an upward trend in the adoption rate between 2013-2022. Overall, the number of EFP completions and the adoption rate per 100 farms were lower in the GF2 period (2013-2018) than the CAP period (2018-2023). This discrepancy could be due to administrative and system changes in the Alberta EFP in 2013. ARECA took over the administration of the program in that year and later in 2015 introduced an online version of the EFP workbook. In 2016, the EFP workbook was fully digitalized (Moskal-Hébert T., ARECA, personal communication, February 10, 2023). This transition may have required additional extension efforts and time allowing producers to adapt to the new EFP webbooks. Notably, EFP adoption was at its lowest in 2017 with a 0.5% adoption rate per 100 farms and fewer than 150 completions. The Alberta EFP's 2017-2018 annual report indicated that 22 producer workshops were conducted across Alberta during this time (AEFP, 2018). Despite these workshops, the adoption rate remained low. Personal communications with ARECA revealed that there was a transition in EFP management in that year, which could have contributed to the low adoption rate. Between 2018 and 2023, in the CAP period, the adoption rate experienced some fluctuations but stayed above the levels seen in the 2013-2018 GF2 period. This upward trend in adoption could be linked to increased environmental awareness and EFP recognition among the Alberta producers. As mentioned in the Foothills Forage and Grazing Association's annual report, several producers completed their EFP to access the CAP's cost-share BMP programs (FFGA, 2020). However, there were noticeable declines in adoption rates in 2019 and 2021, potentially due to a 17% reduction in the number of EFP technicians in the network and the impact of the global COVID-19 pandemic. In 2021, Dairy Farmers of Canada started requiring an EFP from dairy producers as a part of their proAction program (Slomp M., Alberta Milk, personal communication, June 26, 2023). Collectively, these initiatives may have contributed to a boost in EFP completion in the following year.

As seen from above, it is evident that despite ongoing extension efforts, the EFP adoption rate still remains below 2% per 100 farms, with only a quarter of Alberta's producers holding an EFP. The FMS 2021 disclosed the factors affecting the non-adoption decisions of the producers in the province. As shown in the Figure 3.6, in the pool of the producers who did not have an EFP in 2021, over 30% found the EFP process too time-consuming, and 23% deemed it to be too complicated. Additionally, 23% of the producers mentioned they did not have enough information about the EFP. Even though the EFP program is highly confidential, many producers still have privacy concerns fearing the potential negative consequences of identifying specific environmental risks on their farms (Smithers & Furman, 2003; Atari et al., 2009). As the survey reveals, 20% of the producers chose not to complete an EFP due to concerns related to data privacy and enforcement.

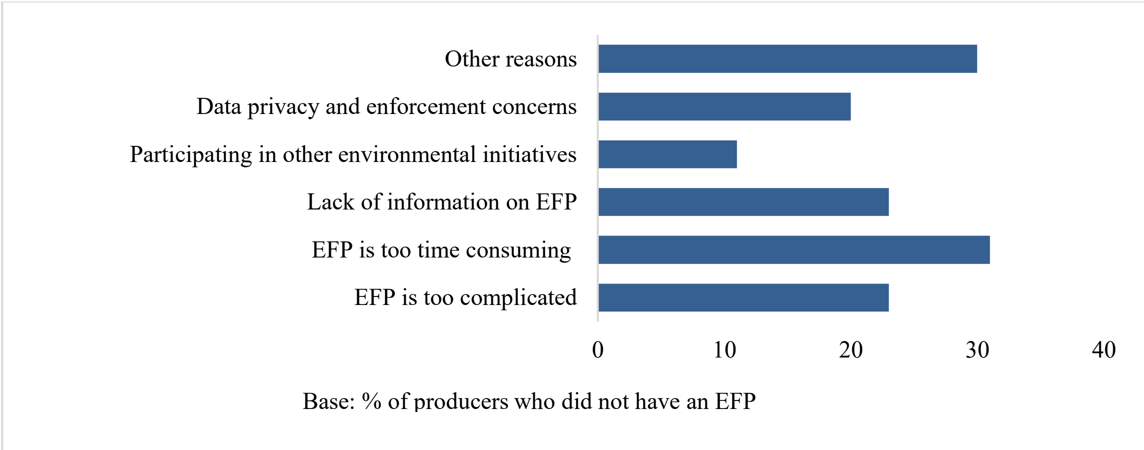

Figure 3.6. Factors affecting Environmental Farm Plan non-adoption in Alberta based on the Farm Management Survey 2021 (in %).
Source: Statistics Canada, (2023).

Chapter 4. Environmental Farm Plan Completion Determinants in Alberta at the rural municipal level. Role of Agri-Environmental Extension Efforts.

4.1. Introduction

The EFP program is considered a leading agricultural extension initiative by Canada's Agricultural Policy Framework for environmental education. In Alberta, it is acclaimed as an educational and planning instrument, contributing to environmental outcomes, and fostering public trust in agriculture. Participation in the program allows producers to positively impact ecosystems by understanding the possible environmental risks on their farms and developing action plans. In addition, it supports sustainable sourcing in supply chains (ARECA, 2023; Wilton et al., 2022).

The preceding chapters highlighted the program's evolution nationwide, with a specific focus on the agri-environmental extension process in Alberta and its relationship with the EFP. Chapter 3 outlined the promotion and delivery of agri-environmental extension efforts through collaboration among the Agricultural Research and Extension Council of Alberta (ARECA), Agricultural Service Boards (ASBs) of the municipalities, the Applied Research and Forage Associations, producer groups, and the provincial and federal governments. As discussed in Chapter 3, a key delivery arm of extension to the agricultural communities are the ASBs of the municipalities who carry out agri-environmental extension programs and activities in collaboration with the federal government, agricultural organizations, some applied research and forage associations, and post-secondary institutions. The extension activities of the ASBs are funded through the Resource Management funding stream of the ASB grants provided by the Government of Alberta.[18] However, other financial supports for ASB extension activities could also come from funds raised from municipal property taxes, user fees, and other funding streams (ASB, 2023).

In this chapter, we examine the role of agri-environmental extension efforts by the ASBs of municipal governments and ARECA in explaining the EFP completion rate at the municipal level in Alberta from 2014 to 2022. We will also explore the impacts of industry standards and the Applied Research and Forage Associations on EFP completion rates, as well as other crucial farm characteristics like farmland acreage and the number of producers with annual gross farm revenues exceeding $250,000 within each municipality. The primary goal of this chapter is to assess the impact of agri-environmental extension efforts by ARECA and ASBs on EFP completion rates at the municipal level in Alberta. This will also contribute to the sparse and relatively limited body of literature on agri-environmental extension efforts and municipal-level EFP completion in Alberta. Our analysis will draw on data from various sources, including the Government of Alberta, the Ministry of Municipal Affairs, ARECA, the Census of Agriculture, producer groups, and the Applied Research and Forage Associations.

4.2. A Brief Literature Review on the Agri-Environmental Extension Efforts in Canada.

Available adoption studies consider the lack of information and awareness as one of the significant barriers to adoption of new practices (Rogers, 2003; Baird et al., 2016). Agricultural extension is a commonly recognized strategy to promote the voluntary adoption of new practices (Rollins et al., 2018). Extension is defined as 'public and private sector activities relating to technology transfer, education, attitude change, human resource development, and dissemination and collection of information' (Marsh & Pannell, 2000, p.607). Initially, agricultural extension followed a top-down approach in which extension agencies served as the sole information providers and farmers were viewed as passive receivers of this information. In this model, the failure to adopt new practices was often attributed to a failure in the extension communication

[18] Previously known as the Environmental Funding stream.

process (Pretty & Chambers, 1993; Rogers, 1995; Vanclay & Lawrence, 1994; Vanclay, 2004). Recent research, however, moves away from viewing landholders as passive information receivers towards recognizing the necessity for diverse extension models that incorporate producer knowledge, addressing the varying needs and learning styles of farmers, and to focus on the key factors influencing adoption decisions (Black, 2000; Vanclay, 2004; Pannell et al., 2006). Effective tools of extension agents now involve multiple channels, repetition, various deliverers of the message, and leveraging peer pressure. Relying on one particular extension approach is less effective than employing a diverse portfolio of approaches and channels (Vanclay, 2004).

In Canada, agricultural extension and advisory services have undergone several structural changes to integrate more bottom-up (also known as participatory) approaches (Rivera, 1998; Gosselin, 2009; Chowdhury et al., 2021a & 2021b; Hambly, 2020). Gosselin (2009) stated that even though policy changes and budget cuts in agricultural extension in the 1990s in Alberta led to the closure of extension offices and the re-centralization of staff, the adoption of new extension service delivery methods like call centres, in some cases, was found to be efficient. Similarly, budget cuts in agricultural extension in Ontario prompted producer organizations, private consultants, and commercial input dealers to participate in delivering extension services (Hambly, 2020). As several studies noticed, agricultural extension and advisory services in Canada had been experiencing ‘plurality’ — acknowledging the presence and contribution of other organizations and sources of knowledge; and ‘disruption’ — recognizing the need for extension services to adapt to changing technologies and visions in agricultural production. Now, agricultural extension services are shifting from one-to-one individual contacts to broader group interactions and digital delivery methods (Klerkx, 2020; Chowdhury et al., 2021a & 2021b; Hambly, 2020; Brewin et al., 2022).

Few studies examine how different extension methods and information channels influence farmers’ decisions to voluntarily participate in agri-environmental programs and adopt beneficial management practices (Yiridoe et al., 2010; Van Wyngaarden, 2021; Smith et al., 2020). For example, Yiridoe et al. (2010) found that newsletters and agricultural magazines were important communication channels for the farmers participating in the Nova Scotia Environmental Farm Plan program. Additionally, program-specific workshops, information sessions, and farm stewardship demonstrations were key participation drivers. Smith et al. (2020) highlighted that technical advice from the government agriculture staff and other organizations, agri-business advisors, and publications affected positively the EFP participation rate among Ontario farmers. A study by Tamini (2011) through farm-level interviews revealed that agri-environmental extension activities and advisory clubs positively affected the adoption of beneficial management practices by farmers in Quebec.

Thus, the current literature on agricultural extension in Canada primarily focuses on the structural changes in the delivery of extension and advisory services, and how different extension methods and information channels influence agricultural producers' decisions to engage in agri-environmental initiatives and implement beneficial management practices voluntarily. However, to the best of our knowledge, research on the agricultural extension's role in adoption of agri-environmental policy programs such as an EFP at the municipal level in Canada, and especially in Alberta, remains scarce. Our study aims to fill this gap.

4.3. Data Sources, Description, and Exploratory Analysis

Alberta's rural municipalities consist of 63 municipal districts (M.D.), also known as counties, which are regional governments in the rural areas of the province.[19] These municipalities encompass agricultural lands and unincorporated communities like hamlets and rural residential subdivisions. Additionally, the province is home to 6 specialized municipalities designed to integrate urban and rural communities under a unified municipal government framework. Examples of these specialized municipalities include Strathcona, Mackenzie, and Lac La Biche municipalities. Furthermore, there are three rural areas in southeast Alberta which are known as Special Areas (Special Area 2, Special Area 3, and Special Area 4) (Government of Alberta, 2023).[20] The Rural Municipalities of Alberta (RMA) represents 64 municipalities, 4 specialized municipalities, and the Special Areas promoting effective and robust local government (RMA, 2023). Altogether, these 69 municipalities, along with the Special Areas Boards have Agricultural

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[19] Throughout the thesis we use the term "Municipality" when referring to counties and municipal districts.

[20] See Table 3.1A in Appendix 3 for a list of rural municipalities and Special Areas in Alberta.

Services Boards (ASBs) that deliver and develop the environmental extension programming in their municipalities.[21]

Since our study's main purpose is to examine the impact of municipal level extension, industry standards, along with other Agricultural Census indicators on the EFP completion rates at the municipal level in Alberta, we collected available data from each municipality for the period of 2014-2022. Unfortunately, the municipal level data is not accessible for the years prior to 2014. A brief description of the data on the variables of our interest and their sources are explained below.

4.3.1. Data on Municipal Level Environmental Farm Plan completion

To find data on EFP completion for each municipality, we reached out to the Agricultural Research and Extension Council of Alberta (ARECA). They provided annual EFP completion numbers at the municipal level for the period of 2014-2022. Our completion numbers are slightly different from the reported ones in ARECA's annual reports as our data is for each calendar year, while they report information for each fiscal year.

We have consistent data on EFP completion numbers for 67 municipalities, except Acadia and the Municipality of Crowsnest Pass. To calculate the EFP completion rate per municipality, we used the number of farms in each municipality from the Agricultural Census rounds. We also employed data on the number of farms, agricultural farmland acreage, and the number of farms reporting gross farm receipts over $250,000 for each municipality from the Census to incorporate some agricultural characteristics of the municipalities and their impacts on the EFP completion rate. For the period of 2014-2015, we used information from the Agricultural Census 2011; for the 2016-2020 period from the Agricultural Census 2016; and for the 2021-2022 period from the Agricultural Census 2021 (AARD, 2014; AAF, 2020; Statistics Canada, 2021).

In our data, there were 99 municipalities during the period of 2014-2022 with zero EFP completions. Figure 4.1 represents the distribution of those zero completions over the years. From 2014 to 2017, the occurrences of zero EFP completions increased steadily. The introduction of the

[21] See Figure 3.1A in Appendix 3 for ASBs coverage map in Alberta.

10-year EFP renewal period in 2018 may have impacted the completion numbers, as previously, an EFP completion certificate was considered valid indefinitely. This may suggest that Alberta EFP had reached a different point on the adoption bell curve, with the majority of early adopters having already participated. Consequently, ARECA had to shift their messaging to appeal to the late majority. In addition, the rise in zero completions could also be due to a series of administrative factors such as the program delivery transition to ARECA in 2013 and the digitalization of the EFP workbooks in late 2015. Furthermore, our personal conversations with ARECA staff revealed that in 2017, there was a transition in EFP management, which may have contributed to the lowest EFP adoption rate that year.

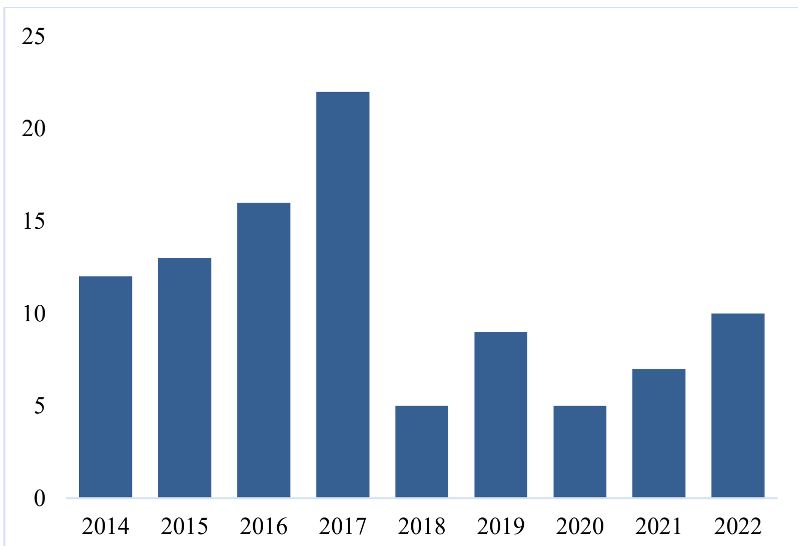

Figure 4.1. The number of Alberta Municipalities with zero Environmental Farm Plan completions over the period of 2014-2022.
Source: ARECA (2023).

We examined the municipalities with the most frequent zero EFP completions by counting the number of occurrences of municipalities with zero EFP completions in 2014-2022. No municipality had a consistent zero completion rate for the period of our interest. Six municipalities — M.D. of Lesser Slave, M.D. of Big Horn, M.D. of Ranchland, M.D. of Birch Hills, Woodlands, and Northern Sunrise — appeared more than five times with annual zero completions in 2014-2022. As shown in Table 4.1, most of these municipalities had a small number of farms, and their agricultural land acreage decreased significantly from the Agricultural Census 2011 through 2021. They also had fewer farms accumulating annual gross farm receipts over $250,000.

Table 4.1. Characteristics of Alberta Municipalities with the most frequent zero Environmental Farm Plan completions in 2014-2022.

Municipalities	*No. of Farms*		*Agricultural Land Acreage (in acres)*		*No. of Farms with Gross Farm Receipts over $250,000*	
	Census 2011	*Census 2021*	*Census 2011*	*Census 2021*	*Census 2011*	*Census 2021*
Lesser Slave, M.D. of	160	127	125,019	128,247	5	14
Big Horn, M.D. of	44	106	203,627	47,352	4	3
Ranchland M.D. of	78	42	465, 727	267,455	9	13
Birch Hills, County of	195	182	560,111	463,260	99	88
Woodlands, County of	294	188	206,132	153,858	21	24
Northern Sunrise, County of	181	149	286,913	289,048	42	52

Source: ARECA (2023); AARD (2014); Statistics Canada (2021).

As discussed in the previous chapter, the provincial EFP completion rate per 100 farms is below 2% in the province. To explore the municipal-level EFP completion rate, we divided the EFP completion numbers by the number of farms in line with the Agricultural Census years mentioned earlier. Excluding municipalities with the most frequent zero completions, we tracked the frequency of municipalities recording a completion rate below 0.25% over nine years. During the 2014-2022 period, none of the municipalities had a consistently low EFP completion rate. Nevertheless, Brazeau, Clear Hills, M.D. of Greenview, Strathcona, M.D. of Wainwright, and Yellowhead were noted more than five times with a low completion rate. In almost all these municipalities, there was a significant decline in the number of farms and agricultural land over the Census periods. Moreover, they had fewer farms with gross farm receipts over $250,000. On the contrary, the M.D. of Wainwright, despite having a higher number of farms accumulating gross farm receipts over $250,000, still had a low EFP completion rate (see Table 4.2). Regarding completion numbers, the County of Big Lakes, M.D. of Fairview, M.D. of Smoky River, and M.D. of Spirit River appeared more than five times between 2014 and 2022 with EFP completion numbers less than five.[22] These municipalities had similar characteristics as those municipalities

[22] See Table 3.2A in Appendix 3.

with low EFP completion rates, except the M.D. of Smoky River. In Smoky River, there was a higher proportion of farms generating gross farm receipts above $250,000 compared to others.

Table 4.2. Characteristics of Alberta Municipalities with most frequent low Environmental Farm Plan completion rates in 2014-2021.

Municipalities	*No. of Farms*		*Agricultural Land Acreage (in acres)*		*No. of Farms with Gross Farm Receipts over $250,000*	
	Census 2011	*Census 2021*	*Census 2011*	*Census 2021*	*Census 2011*	*Census 2021*
Brazeau, County of	487	429	289,674	231,444	11	22
Clear Hills, County of	443	457	585,129	550,075	46	87
Greenview, M.D. of	639	492	734,790	547,624	50	61
Strathcona, County of	658	501	220,184	235,066	70	69
Wainwright, M.D. of	501	568	865,627	807,696	148	200
Yellowhead, County of	695	673	480,869	431,222	43	51

Source: ARECA (2023); AARD (2014); Statistics Canada (2021).

Employing the same approach, we discovered that six municipalities — Kneehill, Lethbridge, Warner, Wheatland, and Willow Creek — frequently achieved the highest completion rates, surpassing 1% between 2014 and 2022 (see Table 4.3). In terms of completion numbers, Red Deer, Mountain View, and Vermilion River municipalities were also identified as having consistently high EFP completion numbers.[23] Relative to municipalities with low EFP completion rate and numbers, all the municipalities with high completion rates and numbers had a greater number of farms, more agricultural land, and a higher count of farms earning gross farm receipts exceeding $250,000.

[23] See Table 3.3A in Appendix 3. Also, to highlight, these municipalities have other environmental programs in place and highly involved technicians in environmental programing outside of the EFP program.

Table 4.3. Characteristics of Alberta Municipalities with most frequent high Environmental Farm Plan completion rates in 2014-2021.

Municipalities	*No. of Farms*		*Agricultural Land Acreage (in acres)*		*No. of Farms with Gross Farm Receipts over $250,000*	
	Census 2011	*Census 2021*	*Census 2011*	*Census 2021*	*Census 2011*	*Census 2021*
Kneehill, County of	686	751	832,411	943,858	259	318
Lethbridge, County of	933	1014	701,095	1,150,044	350	432
Warner, County of	488	489	1,112,336	1,205,193	154	186
Wheatland, M.D. of	782	825	1,121,462	1,315,866	278	339
Willow Creek, M.D. of	772	833	1,126,368	1,262,951	184	249

Source: ARECA (2023); AARD (2011); Statistics Canada (2021).

4.3.2. Data on Agri-environmental Extension Funding

One of the main financial sources of the Agricultural Service Boards (ASBs) in the municipalities has been the ASB grants program, which comes from the Ministry of Agriculture and Irrigation of Alberta. Until 2020, the program supported ASBs to administer the legislative requirements as outlined in the ASB Act, in addition to developing and implementing environmental extension programs via two funding streams: the Legislative and Environmental. For the 2020-2024 program, the funding framework for ASBs included the Legislative, Resource Management, and Rat and Rabies Control Program funding streams (AAF, 2016; Government of Alberta, 2020).

The provincial government discloses grant payment transactions every year. We collected data under the ASB grants transactions for the rural municipalities over the period of 2014-2022. Data prior to 2014 is not available. In some of the years, there was a single payment labelled as the ASB program payments to the municipalities. Conversations with a staff member from the provincial government's ASBs unit revealed that from 2014 to 2019, each municipality received $168,359 under the Legislative Stream, and starting in 2020, budget cuts meant the amount was adjusted downwards to $123,907. Anything above these levels was directed towards environmental programs (Macaulay, D., Government of Alberta, personal communication, February 2, 2023). The agri-environmental extension activities in the province are supported through the Environmental (now labelled as Resource Management) funding stream of the ASB grants program. It is important to mention that some municipalities jointly apply for funding under the Environmental Funding Stream of the ASB grant (Ung, L., Government of Alberta, personal communication, April 18, 2023; March 4, 2024). For our analysis, we deducted the legislative funding portion from the ASB transactions to get the environmental programs stream funding and then distributed the amount equally among those municipalities who applied for those funds as partners.

Furthermore, we gathered data on the funding incentives offered to ASBs by the Agricultural Policy Framework (APF), Growing Forward 2 (2014-2018), and the Canadian Agricultural Partnership (2018-2023) under the Environmental Stewardship and Climate Change program umbrellas (Government of Alberta, 2023). Additionally, we compiled data on the funds allocated to the provincial agricultural research organizations and forage associations through the Environmental Programs and Environmental Stewardship funding streams. We assumed that this funding was used to conduct applied research and provide extension services related to the adoption of new technologies and practices in their partner municipalities. Thus, the funds were equally allocated among their partners.[24] We also assumed that all these environmental funds discussed above were used for the delivery of agri-environmental extension programs in the province.

The annual distribution of total agri-environmental extension funding levels in the province through the funding channels specified above is presented in Table 4.4 for the years 2014-2022. The data reveal that each year, the municipalities were allocated more than $1.5 million through the Environmental Programs Funding Stream of the ASB grants program. However, only a select number of municipalities were beneficiaries of the Canadian Agricultural Partnership Environmental Stewardship and Climate Change funding streams. In 2018, Wheatland and Red

[24] Note that the members of research organizations and forage associations change yearly. We collected data on their yearly members and allocated the funding accordingly among the members for each year. For the current members of research organizations please see Table 2.1A in the Appendix 2.

Deer municipalities received a total of $303,125 under the Environmental Stewardship stream, with Wheatland County securing this funding on behalf of the Red Bow Agricultural Partnership (RBAP) (Ung, L., Government of Alberta, personal communication, April 17, 2023). This partnership represents a municipal initiative aimed at resource sharing, knowledge exchange, and promoting sustainable agriculture across rural communities (RBAP, 2023).[25] In 2019, an allocation of $24,395 was made to Warner County under the same funding stream. Regarding the Climate Change program, Lamont and Mountain View municipalities were the sole recipients of funding in 2018.

Table 4.4. Total annual agri-environmental extension funding levels at the municipal level in Alberta in 2014-2022.

Year	*ASB Grant Environmental Programs Funding Level (N=69)*		*CAP* Environmental Stewardship and Climate Change Programs Funding Level*	*Applied Research Organizations and Forage Associations' Environmental Programs Funding Level*
	Total	Average	Total	Total
2014	$1,775,000	$25,725	-	$450,000
2015	$1,775,000	$25,725	-	-
2016	$1,775,000	$25,725	-	-
2017	$1,735,300	$25,149	-	-
2018	$1,735,000	$25,145	$303,125	$824,448
2019	$1,735,200	$25,148	$24,395	$785,949
2020	$1,684,000	$24,406	-	$350,000
2021	$1,812,085	$26,262	-	$350,000
2022	$1,924,064	$27,885	-	$262,500
Total	$15,950,649		$327,520	$3,022,897

Source: Government of Alberta (2023).

* Canadian Agricultural Partnership.

[25] Current members of the Red Bow Agricultural Partnership are Clearwater County, Kneehill County, M.D. of Bighorn, Mountain View County, Red Deer County, Rocky View County, and Wheatland County (RBAP, 2023).

Further, we investigated the number of municipalities that did not apply for the ASB grants program's Environmental funding stream.[26] Until 2019, 62 to 64 municipalities were beneficiaries of the environmental program's funding through the ASB grants. Yet, from 2019 onwards, there was a noticeable increase in the number of municipalities not seeking funds from this program. For instance, in 2021, 12 municipalities did not secure funding through this stream. Also, we examined those municipalities that consistently did not apply for this funding stream (see Table 4.5). Notably, the M.D. of Taber and the County of Vulcan did not claim environmental funding from the ASB grants program between 2014 and 2022. The M.D. of Provost was an exception, having received funding through this stream for the first time in 2022. Several other municipalities also showed a pattern of not receiving environmental program funding. Among these, the M.D. of Ranchland and Bighorn have a small number of farms, and for that reason they might have applied for the funding occasionally, while other municipalities might have sought financial support from different agricultural organizations.

Table 4.5. Characteristics of Alberta Municipalities most frequently receiving no ASB Environmental Programs Grant in 2014-2022.

Municipalities	*No. of Farms*		*Agricultural Land Acreage (in acres)*		*No. of Farms with Gross Farm Receipts over $250,000*	
	Census 2011	*Census 2021*	*Census 2011*	*Census 2021*	*Census 2011*	*Census 2021*
Big Horn, M.D. of	44	106	203,627	47,352	4	3
Northern Lights, County of	446	344	614,873	546,152	70	86
Provost, M.D. of	425	473	885,276	852,466	113	173
Ranchland, M.D. of	78	42	465, 727	267,455	9	13
Taber, M.D. of	652	610	1,031,225	944,373	269	295
Vulcan, County of	603	607	1,354,405	1,284,191	279	279

Source: ARECA (2023); AARD (2014); Statistics Canada (2021).

[26] See Figure 3.2A in Appendix 3 for the annual distribution of municipalities without the Environmental funding stream of the ASB grants.

Our analysis also extended to identifying the municipalities that received the highest amount of environmental funding through ASB grants. To simplify the presentation of our findings, we aggregated our data into two APF periods — Growing Forward 2 (2014-2018) and Canadian Agricultural Partnership (2018-2023).[27] Six municipalities, Lethbridge, Mountain View, Red Deer, Rocky View, Warner, and Wheatland secured the highest level of environmental funding between 2014 and 2022 (see Figure 4.2). These municipalities, which are among the largest by the number of farms and agricultural land acreage, also recorded the highest rates and numbers of EFP completions in the province. Regarding the municipalities with the lowest level of environmental funding, almost 35% of municipalities received $15,000 annually, which was the basic funding stream of the Environmental Funding program of the ASB grant. This funding amount was aimed at supporting the communication of environmental information and tools, including the EFP program.

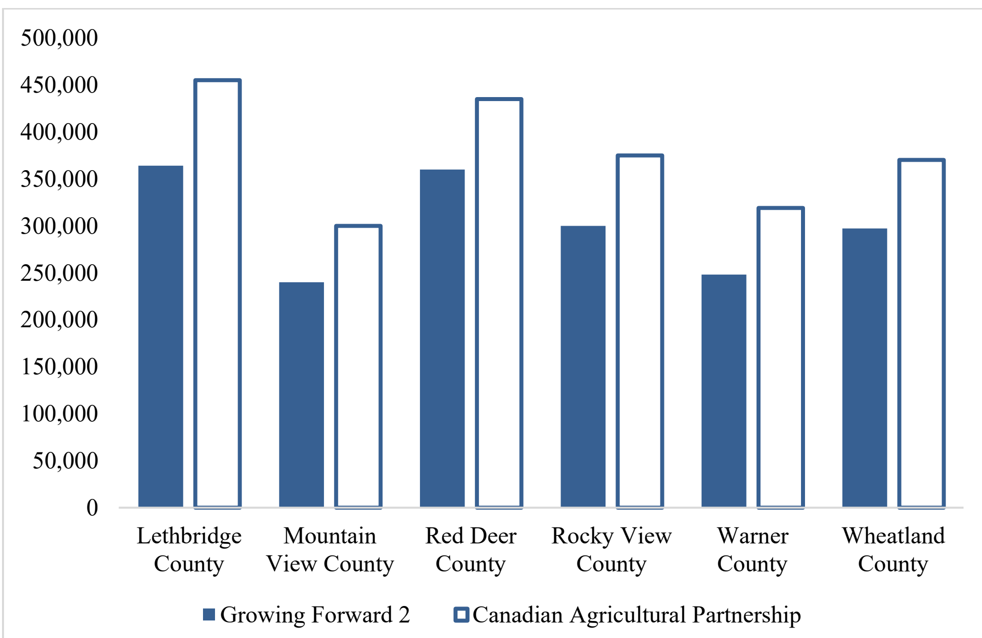

Figure 4.2. Alberta Municipalities with the highest levels of ASB Environmental Programs Grant Funding during Growing Forward 2 (2014-2017) and Canadian Agricultural Partnership (2018-2022).
Source: Government of Alberta (2023).

[27] Note that ASB grants come from the Ministry, not from the Agricultural Policy Framework. For simplicity, we just included these two periods.

4.3.3. Tax Base

Historically, the majority of funding for ASBs came from provincial grants. However, this is no longer the case and most ASBs fund their programs through property taxes, user fees, and other funding sources (ASBs, 2023). Therefore, we accessed the municipal financial and statistical data for each municipality available through the provincial government's database and extracted data for economic and agricultural development tax revenues of municipalities for 2014-2022 to use as a proxy for the "tax base". As outlined in the Financial Information Manual (FIR), the funding under this function should be used to enhance local economic and agricultural development (Alberta Municipal Affairs, 2022). We encountered difficulties in isolating the funding for the development and delivery of agri-environmental extension activities and programs from the aggregate totals. It is worth mentioning that ASBs grant payments could also be included in this funding category, but we are uncertain due to the limited information provided by the data we could obtain.

4.3.4. Industry Standards

Since ARECA was responsible for leading the delivery of the Alberta EFP program in 2013, they started building partnerships with national and local agricultural associations and commodity groups to promote a collective commitment to sustainability. One of these, the Potato Growers of Alberta, was the first Alberta agricultural industry group to require an EFP completion certificate from producers for membership in response to the requirement for sustainable production by McCain Foods.[28]

In 2015, ARECA partnered with Alberta Barley to initiate a benchmarking project to compare Alberta's EFP against globally recognized sustainability standards in response to growing demands for sustainable sourcing in supply chains. In 2019, the most recent EFP Webbook + was benchmarked against the Farm Sustainability Assessment (FSA) 2.1 and received a Silver content equivalency rating on the Sustainable Agriculture Initiative Platform (SAI Platform)[29] (Moskal-

[28] Note that, the EFP is required by a buyer, McCain Foods, if the potato growers want to sell potato to them.

[29] SAI platform was created by the food and drink industry to develop, maintain, and enhance Farm Sustainability Assessment (FSA), which is used to evaluate on-farm sustainability performance, foster sustainable supply chains, encourage improvement in farming practices, and benchmark existing standards, codes and legislation (AEFP, 2023).

Hébert T., ARECA, personal communication, May 3, 2023). Later, in 2021, the Dairy Farmers of Canada mandated an EFP requirement for dairy producers in the country as a part of their proAction program's Environmental Module (Dairy Farmers of Canada, 2023; Slomp M., Alberta Milk, personal communication, June 26, 2023). Further emphasizing the importance of sustainable farming practices, the latest version of Alberta's EFP workbook was benchmarked in conjunction with Canadian legislation to the SAI Platform's FSA 3.0. As of 01 May 2023, the Alberta EFP is aligned with SAI Platform's FSA Gold Level (100% essential, 100% intermediate, 96% advanced), considering Canadian Federal legislation, and allows producers to receive an official FSA score (AEFP, 2023).

To account for the impact of the EFP mandate by the producer groups on the EFP completion rates at the municipal level, we reached out to agricultural industry groups such as Alberta Milk and Potato Growers of Alberta to obtain data on the yearly number of their members between 2014-2022 at the municipal level. Unfortunately, we could not access the necessary data, and instead used the number of dairy and potato farms in the province given by the Census of Agriculture 2011, 2016, and 2021 for each municipality.[30] As Figure 4.3 shows, the number of both potato and dairy farms decreased substantially in Alberta from the 2011 and 2021 rounds of the Census of Agriculture. The number of potato farms decreased from 149 to 123, and dairy farms saw a reduction from 485 to 393.

[30] See Table 3.4A in the Appendix 3 for the number of potato and dairy farms in the province from 2011 to 2021 Census periods.

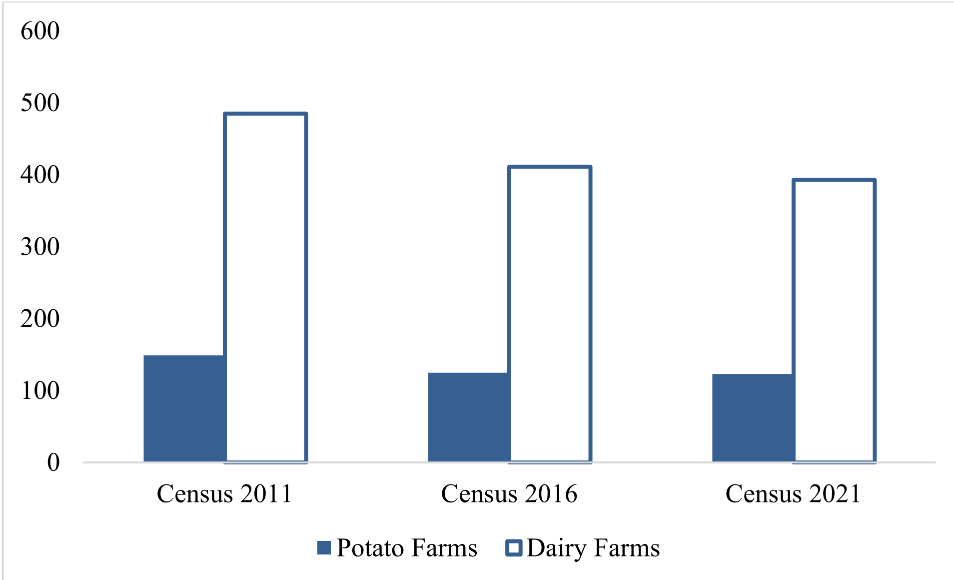

Figure 4.3. Number of dairy and potato farms in Alberta across the Census of Agriculture 2011, 2016, and 2021.
Source: AARD (2014); AAF (2020); Statistics Canada (2021).

Next, we explored those municipalities with the highest number of potato farms across the census rounds and their EFP completion numbers (see Table 4.6). Our analyses revealed that the majority of potato farms in the province are located in the M.D. of Taber. According to the Census of Agriculture 2021, approximately 42% of the province's potato farms were located there. Other municipalities — Forty Mile, Lethbridge, and Parkland — had a relatively high number of potato farms across census periods compared to other municipalities. As we have seen earlier in this section, among these municipalities, only Lethbridge appeared frequently with yearly high EFP completion rates in 2014-2022. However, other municipalities had high EFP completion numbers in certain years only. For instance, the numbers were high in the M.D. of Taber in 2017 and 2022.[31]

[31] See Figure 3.3A in Appendix 3 for the EFP Completion numbers in the M.D. of Taber in 2015-2022.

Table 4.6. Alberta Municipalities with consistently high numbers of potato farms based on the Census of Agriculture 2011, 2016, 2021.

	Census 2011	*Census 2016*	*Census 2021*
Forty Mile County	11	10	7
Lethbridge County	5	5	15
Parkland County	9	8	7
Taber, M.D. of	53	56	51

Source: AARD (2014); AAF (2020), Statistics Canada (2021).

Regarding dairy farms, we assumed that the industry requirement would take a year to affect EFP completions and reported our analysis only for the Census 2021 period. All the municipalities presented in Table 4.7 had the majority of dairy farms in the province. Among them, Lethbridge and Ponoka municipalities had the highest EFP completion numbers. The other municipalities also had higher completion numbers than the ones with fewer dairy farms.

Table 4.7. Alberta Municipalities with the highest number of dairy farms based on the Agricultural Census 2021.

Municipalities	*Number Dairy Farms*	*Number of Farms*	*Number of EFP completions in 2022*
Barrhead, County of	20	725	13
Camrose, County of	11	986	15
Lacombe, County of	44	1010	20
Leduc, County of	35	977	17
Lethbridge, County of	54	1014	31
Mountain View, County of	23	1576	18
Ponoka, County of	44	1067	26
Red Deer, County of	33	1510	23
Wetaskiwin, County of	17	888	14

Source: AARD (2014); AAF (2020); Statistics Canada (2021); ARECA (2023).

4.3.5. Environmental Farm Plan Technician Coverage

EFP technicians assist producers through the completion of their EFPs. After a producer completes their EFP, the assigned technician examines the finished workbook to offer feedback and suggest resources. If a producer needs more support, technicians may choose to host online or in-person meetings with them (AEFP, 2023). EFP technicians are important for promoting EFPs in their area. They are often employed through their municipality or local applied research and forage association (AEFP, 2023; Hall, A., ARECA, personal communication, May 15, 2023).

We reached out to ARECA to obtain municipal-level data on the number of EFP technicians in Alberta. We could only access data on the total numbers of EFP technicians in the province for 2018-2022.[32] At the municipal-level, we only have data for 2014, 2016, 2018, and 2022. According to the data, certain municipalities have one technician, while others might have several. For example, in 2022, Red Deer, Rocky View, and Grande Prairie municipalities had more than one EFP technician helping producers in completing their EFPs and reviewing their action plans. Regarding the number of EFP technicians, until 2018, over 50 EFP technicians were actively engaged in promoting the EFP completion throughout the province. Nonetheless, between 2018 and 2022, the number of technicians decreased by 17% (see Figure 4.4). Despite this reduction, the Alberta EFP maintained a network of more than 40 technicians each year (ARECA, 2023).

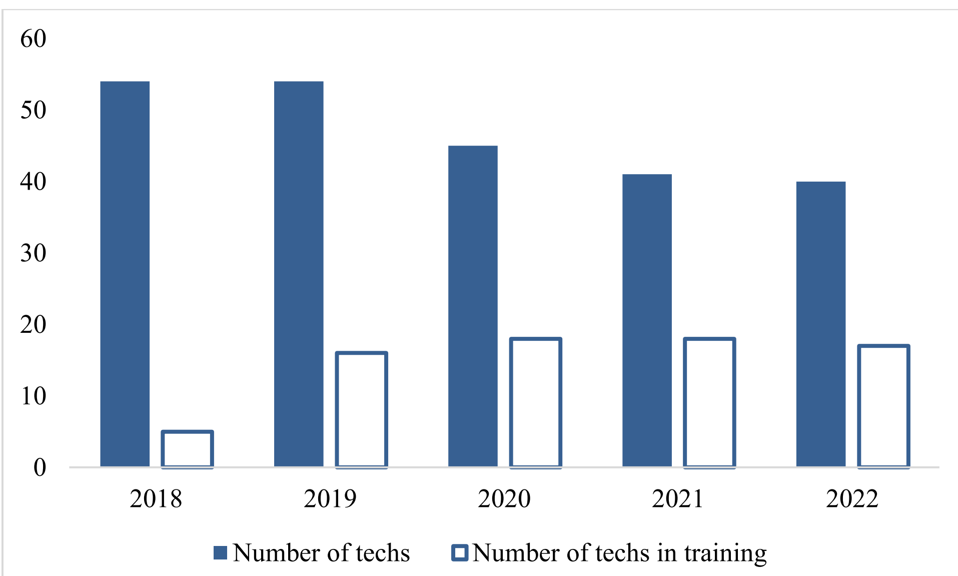

Figure 4.4. Number of full-time and in-training Environmental Farm Plan Technicians in Alberta between 2018-2022.
Source: ARECA (2023).

[32] Number of technicians may change every month. Thus, we received data for each October from 2018 to 2022.

4.3.6. Applied Research and Forage Associations' Partner Municipalities and Extension Efforts by Agricultural Service Boards

As highlighted in the previous chapter, the Applied Research and Forage Associations are one of the main partners in delivering agri-environmental extension activities in the province. Some of them also host EFP workshops for the producers in their partner municipalities. The majority of the research associations partner-up with one or multiple municipalities. Some of the municipalities allocate their ASB Environmental Program grant funding to these associations to conduct agri-environmental extension activities on their behalf (Ung, L., Government of Alberta, personal communication, November 18, 2023; Nadeau, L., ARECA, personal communication, July 14, 2023). Currently, Alberta is home to 12 Applied Research and Forage Associations. The partner municipalities of research associations have changed over the years.[33] To get the annual count of partner municipalities for each research association, we reviewed their annual reports from 2014 to 2022. Our analysis revealed that every year at least 40 municipalities were affiliated with these associations over nine years.[34] Only the following municipalities did not partner up with them during this period:

- Athabasca, County of
- Lamont, County of
- Lesser Slave River, M.D. of
- Minburn, County of
- Strathcona, County of
- Sturgeon, County of
- Two Hills, County of
- Vermilion River, County of
- Wainwright, M.D. of

Among these municipalities, Strathcona, Lesser Slave River M.D., and Wainwright M.D. were associated with low rates of EFP completion.

Additionally, we obtained data from the Government of Alberta regarding the extension efforts of ASBs in the municipalities for the years 2021 and 2022. Figures 4.5 and 4.6 illustrate

[33] See Table 2.1A in Appendix 2 for the list of research associations and their partner municipalities.

[34] See Figure 3.4A in Appendix 3.

municipalities that offered the highest number of written and event-based extension activities provided to their agricultural producers. A significant portion of municipalities, where their ASBs delivered a high number of written extension materials such as comprehensive guides on beneficial management practices, workshop materials, and newsletters, had high numbers of EFP completions in 2021-2022. These municipalities frequently had high EFP completion rates and numbers in the previous years as well. Given that we have data on ASBs' extension activities only for 2021-2022, we assume that these municipalities have consistently engaged in a higher volume of extension activities relative to others in the previous years as well. Despite substantial written extension efforts, the M.D. of Ranchland recorded only a single EFP completion during 2021-2022, potentially due to a small number of farms, with only 42 farms reported in the 2021 Census of Agriculture.

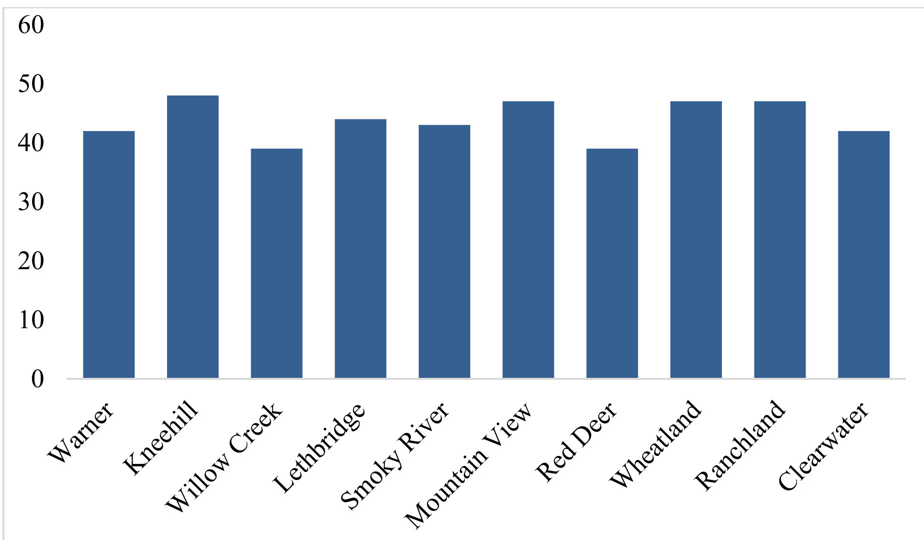

Figure 4.5. Alberta Municipalities with the highest number of written extension activities in 2021-2022.
Source: Government of Alberta (2023).

Regarding the municipalities where their ASBs hosted a high number of extension events such as workshops, on-farm demonstrations and one-on-one training sessions, Mountain View, Lethbridge, and Warner municipalities had the highest number of EFP completions. These municipalities generally maintained high EFP completion numbers in the previous years as well. The County of Mountain View experienced high EFP completion numbers in 2022 only. It is important to note that not all extension activities provided by ASBs are directly related to the EFP;

many could be specifically aimed at promoting agri-environmental beneficial management practices adoption.

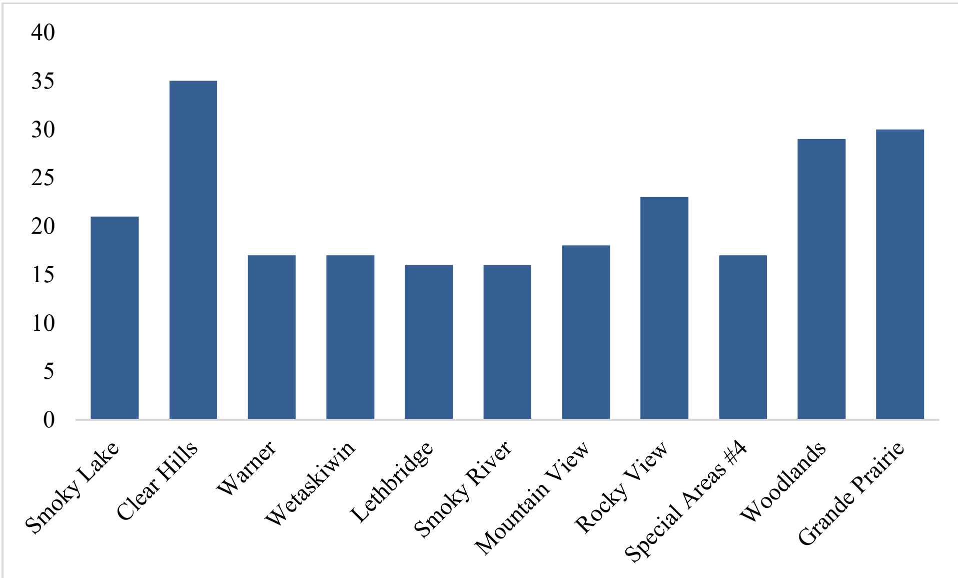

Figure 4.6. Alberta Municipalities with the highest number of extension events in 2021-2022.
Source: Government of Alberta (2023).

4.4. Methods

4.4.1. Econometric Model Identification Strategy

In the preceding section, we described the data we collected on agri-environmental and EFP extension in Alberta across 69 municipalities over nine years. The data were collected from different sources, and some of the EFP extension-related data was lost during the transition to the online system in 2015. Also, the data on extension funding (ASBs grants, CAP programs, Applied Research and Forage Associations) are unavailable for the years prior to 2014. For our analysis, we merged the available data across 67 municipalities for the period of 2014-2022. During the merging process, the M.D. of Acadia and the Municipality of Crowsnest Pass were excluded as these municipalities were not represented in the Census of Agriculture. Data on the EFP technician coverage and the extension efforts by the ASBs was available only for a few years. Therefore, we only merged the data that is available for the period of 2014-2022. Subsequently, our data is a strongly balanced panel data with cross-sections of 67 municipalities over 9 years.

The choice of our econometric modelling approach is guided by the nature of our dependent variable and the characteristics of our data. Our dependent variable is the EFP completion rate, which represents the proportion of farms with an EFP relative to the total number of farms in the municipality *i* in the year *t:*

$$EFP\ completion_{it} = \frac{Number\ of\ EFP\ completions_{it}}{Number\ of\ farms_{it}}$$

Our response variable is fractional and bound within the [0,1] interval as a municipality could theoretically reach a 100% completion rate. Overall, we have 99 instances of zero completions in our dataset annually across some municipalities, indicating that the value of our dependent variable lies on the lower boundary for some municipalities and years.

Various econometric models exist for estimating fractional response variables, each with strengths and challenges. The traditional approach is the log-odds ratio model, which assumes that the log-odds transformation of y, log $[y/(1-y)]$, has a conditional expectation of the form $x\beta$. However, this approach fails when the fractional response is observed near the boundaries of the data distribution which in our case is zero and one. Also, even when the variable is strictly inside the unit interval, without stringent independence assumptions, the expected value of the fractional response from a linear model for the log-odds ratio cannot be recovered (Papke & Wooldridge, 1996; Wooldridge, 2010). The two-limit Tobit model can also be applied for fractional response models when the limits are zero and one. However, this approach has notable limitations. First, it is only suitable when there is a significant mass of data points exactly at the minimum (zero) and maximum (one) values. The fractional responses that have continuous distribution in (0,1) and the responses that have a mass point at zero or one (but not both) cannot be modelled using a two-limit Tobit. Secondly, the model assumes a parametric model for how the fractional responses depend on the explanatory variables. If we are interested in the effects on the conditional mean, then the two-limit Tobit will generally produce inconsistent estimates of expected outcome (Wooldridge, 2010).

The conditional beta distribution model offers an alternative for continuous fractional responses and can be estimated using the standard Maximum Likelihood Estimation (MLE) (Kieschnik & McCullough, 2003; Wooldridge, 2010). Similar to the two-limit Tobit, this approach fails if any aspect of the distribution is misspecified and if some portion of the sample lies at one of the maximum points, zero or one (Wooldridge, 2010). In the presence of the extreme values, the zero or one inflated beta models can be utilized. These models can estimate the maximum values and the bounded proportions. Although, these models rely on specific assumptions about the distribution of the data and the process generating the extreme values. If these assumptions do not hold, for instance, if the zeros are not generated by a separate process other than the proportions, or if the data do not follow a beta distribution, the model may produce biased or inaccurate estimates (Buis, 2010).

An alternative and widely used method for estimating a fractional dependent variable is the fractional logit model which was first proposed by Papke and Wooldridge (1996). The authors specified a logistic functional form to model the conditional mean of a fractional dependent variable. They estimate the model by applying a quasi-maximum likelihood method proposed by Gourieroux et al. (1984) and McCullagh and Nelder (1989) and maximize the Bernoulli log-likelihood function. This method is straightforward and provides a consistent quasi-maximum likelihood estimator even when the actual distribution of the dependent variable does not strictly follow a Bernoulli distribution (Papke & Wooldridge, 1996).

In panel data contexts, the estimation of the fractional response variable becomes more complex as we observe unobserved heterogeneity that can be correlated with the explanatory variables. To account for unobserved heterogeneity using nonlinear fractional response functions such as the fractional logit could lead to more substantive issues such as the incidental parameters problem. When the number of cross-sectional observations is large while the number of time periods (T) remains small, adding many cross-sectional fixed effects (N) facilitates the inclusion of unobserved heterogeneity to the model in a flexible way. Consequently, the model will encounter the incidental parameters problem. Specifically, when T is fixed, the estimators for the fixed effects become inconsistent as $N \rightarrow \infty$ and this inconsistency affects the estimates of the common slope coefficients (Papke & Wooldridge, 2008). Employing Mundlak's (1978) version of Chamberlain

(1980) approach, which treats the unobserved heterogeneity as a random effect, Papke and Wooldridge (2008) modelled the distribution of unobserved heterogeneity conditional on strictly exogenous variables. This strategy incorporated the inclusion of time averages of time-varying explanatory variables into the model allowing the unobserved effects to be correlated with the explanatory variables. By accounting for this correlation, they effectively reduced the bias from the omitted variable effects, which is a common problem in panel data analyses where unobserved heterogeneity exists. Then they estimated average partial effects using a pooled fractional probit regression (Papke & Wooldridge, 2008).

In the context of our study, our panel data is at aggregated levels for 67 municipalities across 9 years. We want to include both municipality and time fixed effects to our model to account for time-invariant unobserved heterogeneity in municipalities and time trends in the economic environment. The conventional method for estimating such models involves applying within transformation with respect to the fixed effects with more categories and including a dummy variable for each category of existing fixed effects (Wooldridge, 2010). However, adding a dummy variable for 67 municipalities and 9 years into a nonlinear model can lead to inconsistent estimates due to the incidental parameters problem as discussed above. On the other hand, applying a linear method to fractional response models cannot ensure that the estimated probabilities fall within the [0,1] interval and the linear functional form may not effectively capture the potential nonlinear relationship between explanatory and response variables (Papke & Wooldridge, 1996, 2008; Horrace & Oaxaca, 2006). Thus, the drawbacks of using linear models for fractional response variable are similar to the ones applying linear probability model for binary data (Papke & Wooldridge, 1996). Nevertheless, in situations where the appropriate model is uncertain, adhering to a linear regression function is preferable over arbitrarily selecting a non-linear option (Angrist & Pischke, 2009). Using robust standard errors can enhance the reliability of linear probability models (Lewis & Linzer, 2005). Our objective is to estimate the causal impact of several explanatory variables on the EFP completion rate at the municipal level, rather than focusing on generating predictions. Moreover, we want to incorporate fixed effects and account for both unit and time-level unobserved heterogeneity. Thus, we will utilize a two-way fixed effects linear model with robust standard errors.

4.4.2. The Two-Way Fixed Effects Linear Model

Several studies have attempted to develop an estimator that is both practical and computationally efficient, and capable of handling models with multiple levels of fixed effects. The estimators proposed by many of these studies suffered from poor and slow convergence rates (Koutis, Miller, & Peng, 2012; Guimarães & Portugal, 2010; Gaure, 2015; Bauschke et al., 2003). Also, other estimators were limited to only one high-dimensional fixed effect level (Cornelissen, 2008; Somaini & Wolak, 2015). Correia (2016) introduced a method that significantly reduces the computational complexity of estimating linear models with multiple levels of fixed effects and enhances the convergence rates. The proposed estimator has the fastest asymptotic running time and performs well with large datasets with high-dimensional fixed effects. We will adopt Correia's (2016) method for our analysis.

The authors derive the two-way fixed effects estimator in several steps using the approaches by Guimarães and Portugal (2010), Frisch and Waugh (1933) and Lovell (1963). First, they derive $\hat{\beta}$, the Ordinary Least Squares (OLS) estimator of β that incorporate the high-dimensional fixed effects. The linear model under consideration is:

$$Y = X\beta + Z\gamma + e$$

where *Y* represents the vector of outcomes, *X* denotes the matrix of covariates $n \times k$, Z is a matrix $n \times h$ representing fixed effects across multiple dimensions, and e is the unobserved error term. The fixed effects matrix Z has a block representation $Z = [Z_1 Z_2 \dots . Z_F]$, each corresponding to a specific level of fixed effects *F*. The number of fixed effects levels for the f-th dimension is denoted as $h = \sum_{f=1}^{F} h_f$ (Guimarães & Portugal, 2010). To make the process of deriving $\hat{\beta}$ with partialled-out fixed effects simpler, the Frisch-Waugh-Lovell Theorem is applied. This theorem requires generating residuals by regressing each independent variable in the *X* matrix and the dependent variable *Y* against all fixed effects in the *Z* matrix. This process effectively controls for the fixed effects by isolating the impact of $\hat{\beta}$ on the dependent variable. Mathematically, the residual generating process utilizes projection with respect to fixed effects *Z*, $P_D = Z(Z'Z)^{-1}Z'$, and annihilator (residual-maker), $M_z = I - P_Z$, matrices. The annihilator matrix M_z is applied to both to X and Y to partial out the unobserved heterogeneity:

$$Y^* = M_Z Y$$
$$X^* = M_z X$$

where Y^* and X^* are the partialled-out residuals of X and Y with respect to the fixed effects. According to the theorem, the OLS estimated $\hat{\beta}$ and the error term $\hat{\varepsilon}$ are then[35]:

$$\hat{\beta} = (X^{*\prime}X^*)^{-1}(X^{*\prime}Y^*)$$
$$\hat{\varepsilon} \equiv Y - X\hat{\beta} + Z\hat{\gamma} = Y^* - X^*\hat{\beta}.$$

After obtaining the partialled-out residuals X^* and Y^*, the method focuses on the linear system $(Z'Z)\ \hat{g} = (Z'Y)$ that arises from the normal equations of the regression model. Further steps involve applying this linear system to a graph Laplacian, which allows employing combinatorial algorithms. This graph representation approach includes graph pruning, applying the Reverse Cuthill-McKee algorithm for reordering, constructing a low-stretch-spanning tree, and solving the electrical flow problem. This method significantly reduces the computational complexity and improves the convergence for high-dimensional fixed effects, especially in large datasets (Correia, 2016). The 'reghdfe' package by the author is available in Stata, a statistical software, for estimating models with high-dimensional fixed effects.

4.4.3. Selection of Key Variables and the Empirical Model

Publicly available data to examine the agri-environmental extension and factors affecting the EFP completion rate at the municipal level in Alberta are limited. We attempted to collect and combine data from various sources. Moreover, empirically, agricultural extension is often examined within the context of new technology adoption. In Canada, and specifically in Alberta, there are no directly comparable studies on the role of municipal level agri-environmental extension efforts on

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[35] See Correia (2016) for the formal explanation of generating $\hat{\beta}$ using Frisch-Waugh-Lovell Theorem.

EFP completion rates to which we can relate our methodology and results. Also, the majority of studies in the adoption literature are at the farm level. Given that EFP completion rates in municipalities highly depend on the adoption decisions of individual producers, our study will rely on the municipal level data we have collected and studies on adoption determinants to select key variables for our analysis.

In the adoption literature, extension services play a crucial role in fostering the adoption of beneficial management practices among farmers by providing essential education and resources. Studies have indicated that extension programs, whether delivered by government personnel or the private sector, are positively correlated with adoption (Pannell et al., 2006). Also, farmers' involvement in advisory clubs and associations significantly impact their adoption decisions (Pannell et al., 2006; Tamini, 2011; Rollins et al., 2018; McKenzie et al., 2018; Chowdhury et., 2021a). Hence, we assume that the number of EFP technicians in the province and the municipality's membership in the Applied Research and Forage Associations positively influence the EFP adoption rate at the municipal level as well. Moreover, extension funding plays a crucial role in shaping the capacity of extension services to adapt to changing agricultural landscapes and effectively support farmers in adopting sustainable farm practices. Effective extension requires that farmers have sufficient and timely access to relevant advice and information (Anderson & Feder, 2004). Since the 1980s, there has been a continued reduction in funding for public extension services in Canada (Milburn et al., 2010; Hambly, 2020; Wilton et al., 2022). In 2020, Alberta experienced not only a reduction in the budget for public agricultural extension services but also a decrease in staff numbers (Macaulay, D., Government of Alberta, personal communication, April 13, 2023). Given that agri-environmental extension funding mainly comes through provincial grants and the taxes generated by the municipalities in the province, we hypothesize that the amount of grants and tax revenue affects the EFP program uptake.

Extension activities such as workshops, on-farm demonstrations, meetings, and seminars are also correlated with improved adoption rates (Reimer et al., 2012). Marsh et al. (2004) suggest that cumulative extension activities accelerate earlier adoption of new practices. Thus, we anticipate that municipal level extension events by the ASBs will have a positive impact on EFP adoption.

There is limited literature incorporating industry standards as an explanatory variable in EFP adoption studies. Only a farm-level study by Van Wyngaarden (2021) included industry standards and found that dairy producers in Alberta were more likely to complete an EFP. Following their idea, since EFP completion is a requirement for membership in Alberta's dairy and potato industries, we assume that municipalities with more potato and dairy farms have better EFP completion rates. We also presume that municipalities with a greater proportion of farms generating income over $250,000 annually will have better completion rates. In the adoption literature, many studies hypothesize that the income variable has a positive influence on adoption (Kim et al., 2005; Baumgart-Getz et al., 2012).

Since we could not get consistent and complete data at the municipal level on the extension events by the ASBs and EFP Technician Coverage for some years, we will estimate two models: the linear two-way fixed effects model for 2014-2022 and the Ordinary Least Squares (OLS) model for 2022 using the variables given in Table 4.8:

$$
\begin{aligned}
EFP\ Completion\ Rate_{\ it} = \beta_0 + \beta_1 Grants\ funding\ perfarm_{\ it} + \\
\beta_2\ Tax\ funding\ perfarm_{\ it} + \beta_3\ GFR > \$250K_{\ it} + \\
\beta_4\ Potato\ Farms\ in\ 2015_{\ it} + \ \beta_6\ Dairy\ Farms\ in\ 2022_{\ it} + \\
\beta_7\ RA\ partnership_{\ it} + \ \alpha_i + \gamma_t + \varepsilon_{it}
\end{aligned}
$$

where β_0 is the intercept, β_1 to β_7 are the coefficients of the independent variables, representing the impact of each unit change in the respective variable on the EFP completion rate holding other variables constant, α_i captures all time-invariant unobserved characteristics of each municipality; γ_t denotes the time fixed effects, and ε_{it} is the error term for municipality *i* at time *t*, capturing the unobserved factors that affect EFP completion rate beyond the variables included in the model.

For the 2022 OLS models, we will estimate the models with and without grants and tax funding, as theoretically, the number of extension events and EFP technicians could be correlated with the funding:

$$EFP\ Completion\ Rate_{\ i} = \beta_0 + \beta_1 Grants\ funding\ perfarm_{\ i} + \beta_2\ Tax\ funding\ perfarm_{\ i} + \beta_3\ GFR > \$250K_{\ i} + \beta_4\ Potato\ Farms\ in\ 2015_{\ i} + \beta_6\ Dairy\ Farms\ in\ 2022_{\ i} + \beta_7\ Extension\ Events_i + \beta_7\ EFP\ Technician\ Coverage_i + \varepsilon_i.$$

$$EFP\ Completion\ Rate_{\ i} = \beta_0 + \beta_1 GFR > \$250K\ + \beta_2\ Potato\ Farms\ in\ 2015_{\ i} + \beta_3\ Dairy\ Farms\ in\ 2022_{\ i} + \beta_4\ Extension\ Events_i + \beta_5\ EFP\ Technician\ Coverage_i + \varepsilon_i.$$

It is important to note that as we have municipal-level data, we have a single observation for each municipality in one year. Therefore, accounting for municipal-level unobserved heterogeneity is not viable.

Table 4.8. Description of the Key Variables used in the Econometric Analysis of the Municipal Level Adoption of the Environmental Farm Plan in Alberta.

Variables	***Description***
Dependent Variable:	
EFP Completion Rate	Proportion of farms with an EFP in a municipality relative to the total numbers of farms in a municipality; bounded between 0 and 1.
Independent Variables:	
Annual Municipal Environmental Extension funding per farm	Sum of ASB grants Environmental Program Funding Stream, Canadian Agricultural Partnership Funding through Environmental Stewardship and Climate Change programs, and Applied Research and Forage Associations funding through Environmental programs in a municipality divided by the number of farms in a municipality; note that the funding level is scaled by 10,000.
Annual Municipal Tax Revenue per farm	Economic and Agricultural Development Revenue in a municipality divided by the number of farms in a municipality, as a proxy to municipality's tax funding; note that the funding level is scaled by 10,000.

%Gross Farm Revenue>$250K	Proportion of farms in a municipality with Gross Farm Receipts (GFR) exceeding $250,000 relative to the total number of farms in a municipality.
%Potato Farms in 2015	Percentage of potato farms in a municipality multiplied by 2015-year dummy variable.
%Dairy Farms in 2022	Percentage of dairy farms in a municipality multiplied by 2022-year dummy variable.
If the municipality is a part of RA (dummy)	If the municipality is a part of one of the Applied Research and Forage Associations ('1' if 'Yes', and '0' if 'No').
Extension Events	Number of Extension Events by the ASB in the municipality; scaled by 100.
EFP Technician Coverage	Number of EFP Technicians full-time and in training per municipality; if the technician is responsible for 2 municipalities their efforts were divided by 2 and each municipality had 0.5 technician coverage.

4.5. Results

4.5.1. Descriptive Statistics

Table 4.9 presents the descriptive statistics for key variables used in the analysis of the determinants of EFP completion rates across municipalities in Alberta from 2014 to 2022. The average EFP completion rate was 0.8%, with a standard deviation of 1%, indicating some variability among municipalities. The average annual municipal environmental extension funding per farm, scaled by $10,000, was $60, with values ranging from $0 to $740, suggesting differing levels of support across municipalities. The average annual municipal tax revenue per farm, also scaled by $10,000, was $700, with values ranging from $0 to $11,160. On average, approximately 26.4% of the farms in a municipality had gross farm revenue exceeding $250,000.

The average percentage of potato farms in 2015 and dairy farms in 2022 was 0.2%, but with notable maximums of 35.6% and 13.7%, respectively. Additionally, approximately 77% of municipalities were part of the applied research and forage associations.

Regarding extension efforts variables, from 2014 to 2022, the average number of extension events by the ASBs in the municipalities was 4, with a maximum of 18. Furthermore, each municipality had approximately one EFP technician assigned on average, with some municipalities having up to three technicians.

Table 4.9. Descriptive Statistics of Key Variables.

Key Variables	*Mean*	*St. Dev.*	*Minimum*	*Maximum*	*No. of Obs.*
EFP Completion Rate	0.008	0.010	0	0.14	603
Annual Municipal Environmental Extension funding per farm (scaled by 10,000)	0.006	0.007	0	0.074	603
Annual Municipal Tax Revenue per farm (scaled by 10,000)	0.070	0.088	0	1.116	603
%Gross Farm Revenue>$250K	0.264	0.125	0.023	0.585	603
%Potato Farms in 2015	0.002	0.016	0	0.356	603
%Dairy Farms in 2022	0.002	0.011	0	0.137	603
If the municipality is a part of RA (dummy)	0.769	0.422	0	1	603
Extension Events (scaled by 100)	0.040	0.046	0	0.18	67
EFP Technician Coverage	0.845	0.720	0.03	3.03	67

4.5.2. Regression Results and Discussion

Since we have incomplete data for some of the variables at the municipal level for the period of 2014-2022, we analyzed the 2014-2022 and 2022 models separately. Before estimation, we tested for multicollinearity within our independent variables using the Variance Inflation Factor (VIF) analysis. As suggested by textbooks (Wooldridge, 2018; Verbeek, 2017), a VIF value of 10 is preferred. For our models, the VIF values were below 2. Following the recommendations by the literature and discussions on the use of linear probability models (Angrist & Pischke, 2009; Lewis & Linzer, 2005), we used heteroskedasticity-robust standard errors in our models.

For the 2014-2022 data, we implemented the two-way fixed effects linear estimator method by Correia (2016) using the 'reghdfe' statistical Stata package. In this model, we controlled for both year and municipality-related unobserved heterogeneity.

For the year 2022, due to the correlation between the technician coverage and extension events variables, we opted to estimate two separate models: one incorporating the extension events and the other with the technician coverage. Also, even though the annual municipal environmental extension and tax funding variables were not correlated with the extension events and technician coverage variables, they could theoretically be correlated. Thus, we estimated both models with and without the funding variables. It is important to mention that controlling for municipality fixed effects was not feasible. We performed both linear and fractional logit regression analyses without accounting for municipal-level unobserved heterogeneity. To select a model that explains our 2022 data better, we employed Akaike's Information Criterion (AIC) and the Schwartz Bayesian Information Criterion (BIC). Verbeek (2017) suggests that in small samples AIC works better, and models with less AIC and BIC values are preferred[36]. Given that our sample size is small, our decision was based primarily on AIC scores. Thus, the linear models having lower AIC scores were selected for reporting.[37]

The 2014-2022 Two-Way Fixed Effects Linear Model Results Discussion

The regression analysis presented in Table 4.9 provides essential insights into the factors influencing the EFP completion rate at the municipal level in Alberta over the period from 2014

[36] The F-test and LR tests are not appropriate in our case as they are used to compare the nested linear models within the same family (Verbeek, 2017; Wooldridge, 2018). We cannot also directly compare R-squared from the linear models with the pseudo-R-squared from the fractional logit ones. Thus, we rely on the AIC and BIC values.
[37] Refer to the Table 3.5A and Table 3.6A in Appendix 3.

to 2022. The analysis employs a two-way fixed effects linear model, absorbing municipality and year fixed effects, and incorporating robust standard errors (SE) to address potential heteroskedasticity. This approach allows us to control for both municipality and time-specific factors that are not directly observed but could influence the EFP completion rates. It is important to note that the coefficients for municipality and year fixed effects are not directly reported but rather absorbed in the model to isolate the true relationship between the independent variables and the EFP completion rate. The model accounts for 29% of the variation in the EFP completion rate across municipalities and over time. Given the small sample size, our model may not have enough power to detect the statistical significance of all the explanatory variables in our models. We assume that a larger sample size could potentially reveal statistically significant relationships, as the variables we include in the models are important in explaining the municipal-level EFP completion rate. Thus, we will provide a discussion on the magnitude of the statistically insignificant results as well.

Our results revealed that the extension funding municipalities receive through the ASB Grants' Environmental Programs stream and the Canadian Agricultural Partnership's Environmental Stewardship and Climate Change programs significantly enhanced their EFP completion rate. Each $10,000 increase in extension funding increased the EFP completion rate by approximately 0.60 percentage points. Moreover, according to our qualitative exploratory analysis, the municipalities with higher levels of environmental extension funding had higher numbers of EFP completions. The negative coefficient of the tax revenue under the economic and agricultural development stream in the municipalities indicates that each $10,000 increase in tax revenue per farm is associated with a 0.008 percentage point decrease in the EFP completion rate. However, the coefficient is statistically insignificant, suggesting that this relationship is not robustly supported by the data. This could stem from our inability to isolate the agricultural extension funding amount from the tax revenue, as it was not reported in the financial statements of the municipalities. Similarly, the negative sign of the coefficient of the membership to the Applied Research and Forage Associations variable contradicts our hypothesis. We anticipated that these associations assisted municipalities in delivering various extension activities, and the member municipalities were expected to have higher EFP completion rates. Nonetheless, the coefficient is statistically insignificant. However, some municipalities that are members of the research associations also have an EFP technician on their staff who delivers EFP-related extension activities. Therefore, they might not require the assistance of research associations for the specific delivery of EFP extension activities.

Furthermore, even though the coefficient of the proportion of farms accumulating annual gross farm receipts over $250,000 is statistically insignificant, it has a positive magnitude as we expected. Our exploratory analysis showed that most of the municipalities with a high number of large farms,[38] such as Red Deer, Vermilion River, Kneehill, Mountain View, and Wheatland had frequently high EFP completion rates and numbers in 2014-2022. This suggests that the many of the large farms already have an EFP, implying that a substantial portion of Alberta's agricultural land could be covered by an EFP.

Regarding industry standards, after a year an EFP was mandated by Dairy Farmers of Canada in the Environmental Module of the proAction program in 2021, each percentage point increase in the proportion of dairy farms within a municipality was associated with a 0.119 percentage point rise in EFP completion rates. This implies that municipalities with a large proportion of dairy producers[39] were more likely to have higher EFP completion rates. Particularly, in 2022, the municipalities of Barrhead, Lacombe, Leduc, Lethbridge, Ponoka, and Red Deer had high EFP completion numbers compared to others. On the contrary, despite the Potato Growers starting to require an EFP for membership in 2014, the coefficient for the variable associated with municipalities having a large proportion of potato farms was negative and statistically significant at 10%, contradicting our expectations of a positive influence on EFP completion rates. This outcome may be attributed to a 17.5% decline in the number of potato farms in the province since 2011, according to the 2021 Census of Agriculture. Furthermore, the majority of potato farms were clustered in a few municipalities over the census periods. As per the 2021 Census of Agriculture, approximately 42% of the potato farms in Alberta were located in the M.D. of Taber, and 24% were in the municipalities of Forty Mile, Lethbridge, and Parkland. Among these, only the County of Lethbridge frequently achieved high EFP completion rates from 2014 to 2022. Other

[38] We consider farms generating Gross Farm Receipts exceeding $250,000 as 'large' farms.

[39] See Table 3.4A in Appendix 3 for the distribution of dairy farms in the province across Agricultural Census 2011, 2016, and 2021.

municipalities had high EFP completion rates in certain years only. This suggests that an EFP requirement by the Potato Growers of Alberta might have influenced EFP completion rates in different years in these municipalities.[40]

Table 4.10. Two-way Fixed Effects (Time and Municipality) Linear Model Results for the Environmental Farm Plan Completion Rate at the municipal level in Alberta in 2014-2022.

Independent Variables	*Coefficients (robust SE)*
Municipality Funding:	
Annual Municipal Environmental Extension	0.604**
funding per farm	(0.282)
Annual Municipal Tax Revenue per farm	-0.008
	(0.009)
Farm Income:	
%Gross Farm Revenue>$250K	0.020
	(0.044)
Industry Standards:	
%Potato Farms in 2015	-0.035*
	(0.021)
%Dairy Farms in 2022	0.119***
	(0.019)
Municipality's ARFA partnership:	
If the municipality is a part of RA (dummy)	-0.002
	(0.003)
Observations	603
R-squared	0.29
Absorbed FE (Categories - Redundant = Num. Coefs):	
Municipality ID	67 - 0 = 67
Year	9 - 1 = 8

Note: Robust standard errors in parentheses at *** p<0.01, ** p<0.05, * p<0.

<u>*The 2022 Linear Model Results*</u>

The Ordinary Least Squares (OLS) model results for the EFP completion rate at the municipal level in 2022 are given in Table 4.10. We compare two models: one incorporating the 'extension events' variable with and without annual municipal environmental extension and tax funding, and

[40] Note that EFP is required if the producers want to sell their product to McCain Foods.

the other including the EFP technician coverage in the province with and without annual municipal environmental extension and tax funding. Similar to the previous model and following the previous studies, we employed heteroskedasticity-robust standard errors in these models as well.

We have similar findings for the 2022 models as the two-way fixed effects estimator model. Unlike the former, however, despite the positive coefficient, in both models with extension events and EFP technician coverage variables, the environmental extension funding was insignificant in explaining the EFP completion rate at the municipal level in 2022. In both models, a higher proportion of large farms generating annual gross farm receipts over $250,000 significantly enhanced the EFP completion rate in the municipality. This implies that producers with higher incomes are more likely to complete an EFP and adopt beneficial management practices.

Furthermore, in both models with annual municipal environmental extension and tax funding, the presence of a higher proportion of potato farms in the municipality positively affected their EFP completion rates at the 10% significance level. For instance, the M.D. of Taber and the County of Lethbridge, where nearly 55% of the potato producers in the province are located according to the 2021 Census of Agriculture, experienced a high number of EFP completions compared to previous years. As mentioned above, municipalities with a large proportion of potato farms could have been influenced by the EFP requirement by the Potato Growers of Alberta and decided to complete an EFP to be able to sell to McCain Foods and apply for the membership in different years. The presence of a significant portion of dairy farms in the municipalities significantly boosted their EFP completion rates in 2022. Indeed, Lacombe, Leduc, Lethbridge, Ponoka, and Red Deer municipalities, where a significant number of dairy farms were located in the province as of the 2021 Census of Agriculture, recorded high EFP completion numbers in 2022. This indicates that the Dairy Farmers of Canada's EFP mandate as part of the proAction program in September 2021 succeeded in encouraging dairy producers to consider committing to sustainable production practices.

Regarding the extension efforts variables, the coefficient for the extension events organized by the Agricultural Service Boards (ASBs) of the municipalities[41] was not statistically significant.

[41] Note that ASBs can hire the research associations to deliver extension activities on their behalf.

However, the magnitude of the variable was positive, as we expected. Similarly, the number of EFP technicians in the province did not significantly influence the EFP completion rates in 2022. This suggests that the ASBs might have used help from the research associations to deliver EFP-related extension activities. Additionally, as our conversation with the ARECA team revealed, EFP activity greatly varies among EFP technicians, which could have contributed to the insignificance of the EFP technician variable (Nadeau, L., ARECA, personal communication, May 17, 2024).

Table 4.11. Linear Regression Results for the Environmental Farm Plan Completion Rate at the municipal level in Alberta in 2022.

Independent Variables	*EFP Completion Rate (with extension & funding) (robust SE)*	*EFP Completion Rate (without funding, extension only) (robust SE)*	*EFP Completion Rate (with funding & Techs) (robust SE)*	*EFP Completion Rate (without funding, Techs only) (robust SE)*
Municipality Funding:				
Annual Municipal Environmental Extension funding per farm	0.072 (0.155)		0.117 (0.173)	
Annual Municipal Tax Revenue per farm	0.006 (0.014)		0.007 (0.015)	
Farm Income:				
%Gross Farm Revenue>$250K	0.030*** (0.008)	0.031*** (0.007)	0.029*** (0.008)	0.030*** (0.007)
Industry Standards:				
%Dairy Farms in 2022	0.122*** (0.019)	0.117*** (0.017)	0.129*** (0.017)	0.123*** (0.017)
%Potato Farms in 2015	0.017* (0.010)	0.015 (0.009)	0.016* (0.009)	0.013 (0.008)
Extension Efforts:				
Extension Events	0.024 (0.017)	0.026 (0.016)		
EFP Technician Coverage			-0.001	-0.001

			(0.001)	(0.001)
Constant	-0.001	-0.001	0.000	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	67	67	67	67
R-squared	0.45	0.44	0.44	0.43

Note: Robust standard errors in parentheses at *** p<0.01, ** p<0.05, * p<0.1

4.6. Conclusion

Most Canadian studies on the EFP focus on farm-level adoption (e.g., Yiridoe et al., 2010; Van Wyngaarden, 2021; Smith et al., 2020; Chapter 5 in this thesis). The literature on agricultural beneficial management practices and new technology adoption that discusses agri-environmental extension is studied within the context of farm level adoption, and there are limited studies which examine the provincial, municipal, or regional-level adoption rates. Hence, our study's main focus was to examine the effects of the agri-environmental extension variables, industry standards, and the proportion of large farms earning annual gross farm receipts exceeding $250,000 on the EFP completion rates at the municipal level in Alberta for the period of 2014-2022.

We collected municipal-level data for our analysis from various sources such as Government of Alberta, ARECA, Applied Research and Forage Associations, and Statistics Canada. We faced challenges in acquiring data at the municipal level. For example, environmental extension funding, which mainly comes from the municipality's Agricultural Service Boards Grant's Environmental Programs funding stream and municipal annual tax income, was not available at the municipal level for years prior to 2014. Also, data for EFP technician coverage at the municipal level existed only for certain years as some of the data was lost in the transition process to the online system in 2015 in Alberta EFP. Data on the focused extension events of the ASBs was also available for only 2021 and 2022. Thus, we selected our explanatory variables based on the limited number of farm-level EFP completion studies in Canada, literature on adoption worldwide, province-specific and industry-specific factors, and data availability. Given that the M.D. of Acadia and the Municipality of Crowsnest Pass were not represented in the Census of Agriculture, our study focuses on the factors affecting the EFP completion rate in 67 rural municipalities of Alberta.

As we had longitudinal data, we wanted to control for municipality and time-specific unobserved heterogeneity. Following the empirical literature on fractional response models (Angrist & Pischke 2009; Papke & Wooldridge 1996, 2008), we employed the two-way fixed effects estimation method developed by Correia (2016), which absorbed municipal-level and time fixed effects for the period from 2014 to 2022. Data on both extension events and EFP technician coverage was available only for 2022. Therefore, we examined Ordinary Least Squares (OLS) and fractional logit models. As the diagnostic tests indicated, the OLS model better explained our data. Thus, we reported results for these models only.

Our analyses revealed some important findings. First, environmental extension funding from the ASBs Grants' Environmental Program stream and the Canadian Agricultural Partnership's Environmental Stewardship and Climate Change programs showed a statistically significant positive impact on the EFP completion rate at the municipal level. For instance, Lethbridge, Mountain View, Red Deer, Rocky View, Warner, and Wheatland municipalities consistently had the highest level of environmental extension funding from 2014 to 2022. Consequently, these municipalities frequently appeared with the highest EFP completion rates during this period. This underscores the importance of the ASBs Grant's funding sources and policy incentive funding in enhancing EFP uptake in the province. While our findings cannot be directly compared to other studies, they do align with studies that mention the positive impact of agricultural extension on the adoption of new agricultural practices (Pannell et al., 2006; Van Wyngaarden, 2021; Reimer et al., 2012; Marsh et al., 2004). We also found that a higher proportion of farms in municipalities with annual gross receipts exceeding $250,000 positively affected municipal-level EFP completion rates only in 2022. Even though the coefficient of this variable was statistically insignificant in the 2014-2022 model, the magnitude of its effect was positive. These findings also suggest that most large farms in the province might already have completed an EFP.

Furthermore, the EFP mandate by the dairy industry in 2021 to encourage the sustainable sourcing in the supply chains significantly affected the EFP completion rates in both two-way fixed effects and the OLS models. Lacombe, Leduc, Lethbridge, Ponoka, and Red Deer municipalities experienced a surge in EFP completion numbers a year after the dairy EFP mandate was introduced. On the contrary, despite the Potato Growers of Alberta implementing an EFP requirement back in 2014 for membership in response to McCain Foods' sustainable sourcing criteria, our findings were statistically insignificant for the two-way fixed effects model and significant at 10% level for the 2022 model. Several factors could explain this. First, this could be because the number of potato farms in the province gradually decreased since the 2011 Census of Agriculture, and the majority of these farms are clustered only in the M.D. of Taber and the County of Lethbridge. Moreover, these municipalities experienced a high number of EFP completions in individual years only. Second, we could not access data on the number of the members of the Potato Growers of Alberta at the municipal level. Thus, capturing the effect of an EFP requirement in the potato industry in our models was difficult. Finally, the requirement to have an EFP only holds for sourcing to McCain Foods and is not a requirement for membership in the Potato Growers of Alberta.

It is important to note that some of our findings contradicted our initial hypotheses. For instance, the variable representing membership in the Applied Research and Forage Associations did not significantly influence EFP completion rates. This may arise from the availability of the EFP technicians among ASB staff in the municipalities who also partner with the research associations. The EFP technicians can deliver EFP-related extension activities, and thus the municipalities may not require assistance from the research associations. Additionally, not all research associations have been consistently involved in promoting the EFP program.

In conclusion, our study provides valuable insights into the factors driving EFP completion rates at the municipal level in Alberta, highlighting the significance of agri-environmental extension funding, industry standards, and the role of large farms. These findings not only contribute the existing limited body of research on EFP adoption, but also offer important implications for policymakers, EFP extension delivering agencies, and industry stakeholders aiming to enhance sustainable agricultural practices. Future research could explore modelling approaches for fractional response dependent variable and incorporating high-dimensional fixed effects to these models. However, these initiatives will require collecting a fuller set of data on extension efforts and investments at the sub-provincial levels. This would require data to be collected in a useable format by ARECA and the provincial government that collect and use data at the municipal government levels.

Chapter 5. Determinants of Environmental Farm Plan Adoption in Alberta at the Farm Level in 2014-2023

5.1. Introduction

The previous chapter provided an overview of the EFP completion at the municipal level. Thus, that analysis largely explored factors external to the individual farm. However, since the EFP is an essential component of the Canadian agri-environmental policy frameworks allowing producers to access cost-share programs, exploring determinants that promote or hinder EFP adoption decisions of producers at the individual farm level is important, particularly in the western provinces where EFP uptake has remained notably low over the years.[42] This chapter examines participation in the EFP program at the individual farm level and provides insights into the factors affecting producers' EFP adoption decision using data from the Environmentally Sustainable Agriculture Tracking Survey (ESAT) conducted biennially in Alberta.

5.2. A Brief Literature Review on the Environmental Farm Plan

The EFP program is acclaimed as an educational and planning tool that enhances environmental outcomes and builds public trust in agriculture (Wilton et al., 2022). The program connects producers to program managers and extension personnel, offering opportunities for stakeholders to communicate and learn from each other (Robinson, 2006a, b; Boxall, 2018). As producer participation in the program increased since its introduction into agri-environmental policy in 2003, several studies investigated the level of social acceptance of the program. Morrison and Fitzgibbon (2014) observed a broad acceptance and high uptake of the program across Canada. Even though earlier research confirmed these findings, they also reported that farmers had concerns about the confidentiality of the farm-level information generated by the program and the potential for regulation (Smithers & Furman, 2003; Yiridoe, 2000). Other studies commented on measuring the effectiveness of the program. Questions regarding the effectiveness of the EFP in enhancing environmental quality and the measurement of performance remain important for public policy formulation (Boxall, 2018; Robinson, 2006a, b).

[42] See Table 2.1 in Chapter 2.

Some researchers examined the barriers and motivations for participation in the EFP program. Yiridoe (2000) identified producers' concerns about public and governmental access to the environmental information associated with their farms as a key hindrance to program adoption. Farmers' hesitation to adopt was consistent with rational decision-making responses to avoid or minimize any potential adverse consequences regarding potential regulation. Similarly, Smithers and Furman (2003) found that producer apprehensions about confidentiality, stemming from past criticism of their farming and resource management practices, discouraged their participation. To avoid potential environmental information disclosure from the peer review stage of the EFP process, producers were willing to forego the possibility of financial assistance through the program. Subsequently, a study involving 56 farmers in Oxford County in Ontario, noted various technical and financial challenges as barriers to complete the EFP (Osch, 1997). Also, in another study, the lack of knowledge and information about the program were stated as significant obstacles to its promotion by agricultural organizations (Klupfel, 2000).

Motivations behind EFP participation have also been a research focus. Producers' desire to learn about environmental risks and self-assessment opportunities were cited as major incentives (Bidgood, 1994; Osch, 1997; Klupfel, 2000). Smith et al. (2020) highlighted that over 94% of Ontario farmers with an EFP out of 189 participated in the EFP workshops to access cost-share funding for the agri-environmental project they wanted to implement on their farms.

Other studies investigated the determinants affecting EFP adoption such as farm and producer characteristics and extension efforts. Atari et al. (2009) discovered that producers' age and formal education did not impact their program participation decisions in Nova Scotia, whereas farm income, years of experience, and type of agribusiness managed positively influenced EFP participation. Likewise, research in Nova Scotia stated that even though farmer's education could increase the quality of farm environmental stewardship performance, having formal education did not influence Nova Scotia's EFP program participation rate. In contrast, attending EFP-specific workshops, information sessions, and farm stewardship demonstrations were significant determinants of program uptake (Yiridoe, 2010). A study in Alberta highlighted that holding a degree, conservation training involvement, and higher gross farm revenue were significant factors affecting EFP adoption in Alberta (Van Wyngaarden, 2021).

As we have seen, most available studies on the EFP highlight the landscape, acceptance, monitoring, and assessment of the program (Wilton et al., 2022; Atari et al., 2009; Robinson, 2006a; Morrison & FitzGibbon, 2014). Some studies highlighting the barriers and motivations to EFP adoption (Van Osch, 1997; Klupfel, 2000) are outdated, as the program has evolved since the 2000s. There are a limited number of recent studies examining the factors affecting EFP adoption decisions of producers, especially those who do not have an EFP (Smith et al., 2020; Van Wyngaarden, 2021). Additionally, since the program was first introduced in the eastern provinces, the majority of research on the EFP concentrates on Ontario's EFP program (Summers et al., 2008; Robinson, 2006a, 2006b; Smithers & Furman, 2003). While foundational studies provide valuable insights into Canada's EFP program, a more comprehensive empirical investigation into the factors driving producer adoption decisions is needed, particularly in western Canada. This chapter aims to contribute to the existing limited empirical research in western Canada, particularly in Alberta, on agricultural producers' EFP adoption decisions, drawing on the broader literature of agri-environmental conservation practices (BMPs) adoption, using a unique dataset of information at the farm level based on the Environmentally Sustainable Agriculture Tracking Survey of Alberta.

5.3. Data and Sources

5.3.1. The Environmentally Sustainable Agriculture Tracking Survey

We utilized the Environmentally Sustainable Agriculture Tracking Survey (ESAT) for the period of 2014-2023 from the Government of Alberta to access data on Environmental Farm Plan (EFP) completion and producer and farm characteristics at the farm level. The Alberta Department of Agriculture and Irrigation sponsors the ESAT survey and uses the information to monitor the adoption of environmentally sustainable agricultural (ESA) practices, commonly known as the beneficial management practices (BMPs) in the province. Conducted almost biennially since 1997, the survey measures Alberta producers' awareness and adoption of ESA practices within specific agri-environmental risk areas to align with the government's agri-environmental policy goals (Government of Alberta, 2023). Survey results assist the government in tailoring policies, programs, and resources to current economic and environmental conditions (Government of Alberta, 2023).

Up until 2021, survey methodology employed a random and representative sample of 500 agricultural producers in Alberta who were interviewed over the telephone by market research companies such as Ipsos and Kynetec. From 2021 onwards, survey methodology transitioned to a combination of telephone and online surveys (Government of Alberta, 2023). The sample was drawn from the market research companies' database of over 30,000 unique agricultural producers in Alberta, and the sample database has remained consistent across all survey rounds. The survey's target population comprised producers with gross farm sales of at least $10,000 who are actively involved in decision-making about the ESA practices and operations used on their farms.

The research objectives of the survey evolved over time with notable revisions. In 2018, sustainability questions were introduced to assess producers' awareness and readiness for emerging sustainability schemes (AAF, 2018). In the 2021 round, the Ministry of Agriculture and Irrigation collaborated with researchers from the University of Alberta to update the survey's objectives, and along with other changes, the section on the EFP was specifically added to understand the factors influencing farmers' adoption decisions. However, in the 2023 round, the EFP section was removed, retaining only the question about farmers' use of the EFP tool and other environmentally sustainable agriculture tools. Also, the number of questions on ESA practices were considerably reduced (Government of Alberta, 2023).

5.3.2. Sampling method & Weights

The ESAT survey sampling frame was stratified by five regions: South, Central, Northeast, Northwest, and Peace to align with Alberta Census Agricultural Regions and Census Divisions. This alignment aimed to facilitate a meaningful comparison between the ESAT survey and Census of Agriculture data. The five regions were defined based on Census Divisions (CD), with specific CD allocation for each region:

- South – CDs 1, 2, and 3
- Central – CDs 4, 5, 6, 7, 8, 9, and 15
- Northeast – CDs 10 and 12
- Northwest – CDs 11, 13, and 14
- Peace – CDs 17, 18, and 19

In cases where the CD was unknown, regions were defined by municipalities by asking respondents where their farm was located. This sampling frame was utilized across all survey rounds, ensuring an equal representation of participants from each region (Government of Alberta, 2023; AAF, 2018; AARD, 2014).[43] However, in the 2021 survey, each region had at least 70 participants (Anders et al., 2021). Also, in the survey, producers were divided equally between production types such as livestock, crops, and mixed production across the survey rounds. Only the 2021 survey deviated from previous rounds, with an uneven distribution among production types: 61% of respondents had cropping only, 24% of respondents had livestock only, and 15% of respondents had mixed production types (Government of Alberta, 2023).

To maintain a representative sample, data in all survey rounds were weighted at the five regional levels. This weighting aimed to align the overall sample's regional and gross farm sales composition with the actual provincial distribution of farms in Alberta (AAF, 2018).[44] Weighting for the 2014 and 2016 survey rounds utilized the 2011 Census of Agriculture, while the 2018 and 2021 rounds used the 2016 Census, and the 2023 round used the 2021 Census.[45] With a sample of 500, results for all survey rounds are considered accurate within ± 4.4 percentage points, 19 times out of 20, relative to the entire population of Alberta farms. Error margins may vary within regions and other sub-groupings of the survey population (Government of Alberta, 2023; Anders et al., 2021; AAF, 2018; AARD, 2014).

5.3.3. Data on the Extension Variable

We used the same agri-environmental extension funding data described in the previous chapter. We gathered this information from the Grant Payments Disclosure Database of the Government of Alberta for the period of 2014-2022 to align with the ESAT survey data.

[43] See Figure 4.1A in Appendix 4 for Alberta Census Division map.
[44] The list of municipalities in the five regions is given in Table 4.1A in Appendix 4.
[45] For the weighting distribution by the Census of Agriculture years, refer to the Appendix A of the ESAT survey final reports.

5.4. Methods

5.4.1. An Econometric Model for the Environmental Farm Plan Adoption

The agricultural adoption literature is extensive and complex. Research in fields such as health promotion, marketing, agricultural extension, and anthropology has contributed to understanding producer behaviour related to agricultural technology adoption (Pannell et al., 2006; Prokopy et al., 2008). Key paradigms used to explain conservation practices adoption in the literature are the utility and income maximization frameworks and innovation-diffusion paradigms (Upadhyay et al., 2003). To date, no one model has fully captured the adoption process across many geographic areas and agricultural systems. Each adoption and diffusion model in the literature aims to address different questions by examining adoption in specific settings and at different scales. This variety leads to diverse assumptions and data usage, making direct comparisons across adoption models difficult (Montes de Oca Munguia et al., 2021). Consequently, studies in the adoption literature often employ a blend of different models and theories.

In this section, we focus on exploring the determinants of EFP adoption decisions of Albertan producers. To achieve this, we utilize the random utility model, a common approach in relevant literature, assuming that completing an EFP provides utility to a producer. We frame EFP completion as a binary decision: a producer either completes an EFP or does not. Previous studies have derived binary response models from the random utility model based on McFadden's (1974) random utility theory (Cooper, 1997, 2003; Jensen et al., 2015; Van Wyngaarden, 2021; Wu & Babcock, 1998). A fundamental underlying assumption of this theory is that producers are well aware of their preferences and make choices that maximize their utility. In our analysis, the producers' utility from the decision they make is represented as $U(X) = (E_Y, E_N)$ where U is the utility, E_Y is completing an EFP, and E_N is choosing not to complete an EFP. For a producer f, the adoption decision i is denoted by a binary variable A_{fi} which takes a value of 1 if a producer completes an EFP or 0 otherwise. Economic theory assumes that rational producers aim to maximize their utility by opting for choices they believe will make them better off. Thus, a producer will complete an EFP only if the expected utility from completing it exceeds that of not, represented as $E[U(E_Y)] > E[U(E_N)]$. The utility function of a producer cannot be directly observed by the researchers, however. Thus, the producer's utility function is composed of deterministic components V_{fi} observable to the researcher and a random component ε_{fi}:

$$(1)\ U_{fi} = V_{fi} + \varepsilon_{fi}.$$

Researchers can only predict probabilities related to the utility of a producer's choices by examining the observable factors included in the deterministic component V_{fi} of their utility functions. If a producer makes a choice i in particular, then U_{fi} is assumed to be the maximum among the available choices.

Typically, logit and probit econometric models are considered to estimate parameters associated with the binary choice scenarios. Due to the complexity of evaluating the multiple integrals of the normal distribution in the probit model, the logit model has become more popular in applications of random utility theory (Greene, 2012). Hence, we employ the logit model for our analysis. Assuming a linear-in-parameters functional form for V_{fi} a producer's utility function can be represented as:

$$(2)\ U_{fi} = X_{fi}'\beta + Y_{fi}'\gamma + \varepsilon_{fi}$$

where X_{fi} is a vector of observable producer and farm characteristics variables, and Y_{fi} is a vector of observable factors experienced by producer f related to extension efforts by the provincial and municipal governments affecting completion, and ε_{fi} is the random error term with a standardized Type 1 Extreme Value Distribution. β' and γ' are the vectors of coefficients associated with the observable producer and farm characteristics variables and extension efforts variables respectively.

In the logit model context, the probability of producer f completing an EFP (A_{fi} =1) is given by:

$$(3)\ P\{A_f = 1|X_f, Y_f\} = \frac{\exp\,(X_f{}'\beta + Y_f{}'\gamma)}{1+\exp\,(X_f{}'\beta + Y_f{}'\gamma)}$$

and conversely, the probability of producer f not completing an EFP (A_{fi} =0) is given by:

$$(4)\ 1 - P = \frac{1}{1+\exp\left({X_f}'\beta + {Y_f}'\gamma\right)}.$$

For simplicity, the utility of the reference option (E_N or A_{fi} =0) is often normalized to zero or a constant term (Greene, 2012; Hill et al., 2011). Considering E_N or A_{fi} =0, we will estimate the equation (3) using the logistic regression, which utilizes maximum likelihood method.

5.4.2. Key Variables Selection

As there is limited literature available specifically addressing the adoption of the EFP, we rely on the major studies in the beneficial management practices adoption literature to select potential variables for our EFP adoption model.

To this day, no single study has found a consistent set of variables affecting BMP adoption decisions of producers. However, several studies based on meta-analyses of existing research efforts, using the vote count method, have identified certain farm and operator characteristics as frequent statistically significant influencers in the adoption of agricultural conservation practices (Prokopy et al., 2008, 2019; Knowler & Bradshaw, 2007). Notably, the age of the farmer often negatively impacted the adoption of BMPs, with older farmers being less inclined to adopt these practices (Prokopy et al., 2008, 2019; Baumgart-Getz et al., 2012). However, other studies have found age to be an ineffective factor in explaining adoption (Knowler & Bradshaw, 2007; Liu et al., 2018). Education level is frequently considered to be another significant determinant, with more educated farmers showing willingness to adopt BMPs (Prokopy et al., 2008, 2019), particularly when it comes to more complex technologies (Pannell et al., 2006). Additionally, farmers' participation in conservation training positively impacts adoption by enhancing farmers' awareness and knowledge (Prokopy et al., 2008, 2019; Atari et al., 2009), although this has not been universally consistent across relevant studies (Prokopy et al., 2019). Moreover, income from farming, used as a measure of financial potential or commitment to farming, also shows a positive and significant correlation with BMPs adoption (Prokopy et al., 2008, 2019; Gillespie et al., 2007).

In our study, we also incorporate tenure, farm succession planning, and farm production type as farm characteristic variables. Tenure, defined as renting versus owning land, or having a more secure lease, has shown mixed effects in adoption research. Several studies have found landowners more likely to adopt conservation practices than renters (Soule et al., 2000; Kim et al., 2005), while others have not established a significant relationship between tenure and adoption (Baumgart-Getz et al., 2012; Knowler & Bradshaw, 2007; Liu et al., 2018). The type of farm production such as livestock or crop and farm succession plans also significantly influences producers' decisions regarding conservation practices adoption (Prokopy et al., 2019; Gillespie et al., 2007; Kim et al., 2005).

Furthermore, agricultural extension efforts can play a notable role in encouraging the adoption of voluntary conservation practices, as highlighted in the adoption literature (Rollins et al., 2018; Pannell et al., 2006). Often, a lack of sufficient information or awareness about a practice is a primary reason producers choose not to adopt conservation practices (Rogers, 2003). Extension officers serve as vital sources of information for producers and can have a positive impact on adoption (Rahm & Huffman, 1984). Marsh and Pannell (2000) have emphasized the importance of extension in the initial years following the introduction of new agricultural technology (practices). Thus, to capture the effects of extension efforts in EFP adoption, we developed estimates of agri-environmental extension funding as a proxy to assess extension efforts in our model.

Given that Alberta has 69 municipalities, each with unique agronomic conditions, information exchange methods, producer characteristics, and varying levels of agri-environmental and EFP extension services and funding, it is essential to consider the municipal-level unobserved heterogeneity in our analysis. These differences can significantly impact a producer's decision-making process, influencing their likelihood of completing an EFP compared to a producer in another municipality. However, incorporating 69 dummy variables into our logistic models is impractical, as it could lead to econometric issues such as the incidental parameters problem, as explained by Papke and Wooldridge (2008). Furthermore, our data is pooled cross-sectional, and not all municipalities are represented in each ESAT survey round. This limitation prevents us from controlling for both time and municipality fixed effects. Therefore, we will control the unobserved heterogeneity related to the five Alberta regions represented in the survey and agricultural policy frameworks, Growing Forward 2 (2013-2018) and CAP (2018-2023), in our models.

5.4.3. *Key Variables Construction and Empirical Model for Environmental Farm Plan Adoption*

In our study, we obtained the dependent and key variables on the farm and producer characteristics from the 2014-2021 ESAT survey rounds. The dependent variable 'EFP adoption' is dichotomous and coded as '0' when a producer reports not completing an EFP and '1' when a producer affirms completion. Likewise, all producer and farm characteristics variables are binary and denoted as '1' for an affirmative response and '0' for all other responses. We exclude some variables for referencing purposes to maintain clarity in our analysis. These excluded variables include a producer receiving the main part of their gross revenue from an equal mix of crops and livestock, a producer renting their land, and a producer reducing or selling their current farm operations.

Regarding extension variables, in the ESAT survey, there is a *training* variable which determines whether the producer participated in any agri-environmental training sessions in the past two years. It is unclear if this variable refers to attendance at EFP workshops as participation in these workshops is a part of the EFP process. However, our analysis of the variable indicates that this might not be the case. In the pooled 2014-2023 data, only 30% of the producers who held an EFP reported attending the training. Given this observation, we assume that this variable refers to conservational training only and include it in our analysis to examine its impact on the producer's EFP completion decision.

Moreover, we also incorporate an exogenous extension variable, the agri-environmental extension funding, to the ESAT survey dataset. We constructed this variable in several steps. First, we added the funding level municipalities receive from the environmental program part of the municipality's Agricultural Service Boards (ASB) Grant, Environmental Stewardship funding through the applied research and forage associations, and agricultural policy framework incentives through the Growing Forward 2 (GF2) for 2014-2018 and the Canadian Agricultural Partnership (CAP) for 2018-2023. Then, we divided the municipal-level funding data for the last two production years by the number of farms in each municipality using the data from the Census of Agriculture to get the extension funding per farm in each municipality.[46] We excluded the number of farms accumulating gross farm revenue of less than $10,000 per year in each census round. To illustrate an example, for the 2023 round, we used the sum of 2021 and 2022 extension funding data and divided it by the number of farms in each municipality, excluding the farms with the gross farm revenue of less than $10,000 in each municipality.[47] For the 2014 round only, we used the extension funding for 2014, as the data can only be traced back to 2014. We assume that the municipality's ASBs and applied research and forage associations spend the funding they receive from the provincial government under the environmental programs on agri-environmental extension efforts. We also assume that the policy incentive funding through GF2 had been paid out by 2018 and those through CAP by 2023.

For reference purposes, we exclude the CAP (2018-2023) policy period, and the Central region dummy variables. A detailed description of the variables used in our models is shown in Table 5.1.

Table 5.1. Description of the Key Variables used in the Econometric Analysis of the Environmental Farm Plan Adoption in Alberta.

Key Variables	Description
Dependent Variable:	
EFP adoption	If the producer completed an EFP
Producer Characteristics:	
Age 18-44	Producer's age ranging from 18 to 44
Age 45-64	Producer's age ranging from 45 to 64
Training	If the producer attended any agri-environmental training sessions in the past two years
Education	If the producer attended a degree or diploma program, specifically in an agriculture related area
GFR>250k	If the farm had gross farm revenue over $250,000 in the past year
Farm Characteristics:	
Livestock	If the main gross farm revenue source was from livestock
Equal mix	If the main gross farm revenue source was from the equal mix of crops and livestock
Own land	If the producer owns their farmland

[46] We used 2011 Census data for 2014-2016, 2016 Census data for 2018-2021, and 2021 Census data for 2023.
[47] ESATS survey data is based on each round's previous production year. For example, for the 2023 round, the data was gathered from the 2022 production year.

Maintain or expand operation	If the producer is planning to maintain or expand their current farm operations
Extension:	
Environmental Extension funding per farm	Agri-environmental extension funding per farm for the past two years (i.e., for ESATS 2023= (funding for 2021+funding for 2022)/ (number of farms based on Census 2021)); scaled by 10,000.
Dummy variables:	
GF2	Growing Forward 2 Agricultural Policy Framework period; between 2013-2018
South	If the municipality, where the producer is located, is in the South region
Northeast	If the municipality, where the producer is located, is in the Northeast region
Northwest	If the municipality, where the producer is located, is in the Northwest region
Peace	If the municipality, where the producer is located, is in the Peace region

Including the above-mentioned variables, we will estimate three logistic regression models using the statistical software STATA 14.0. For the first producer and farm characteristics model, we merged the ESAT survey from 2014 to 2023, and our dataset is pooled in a cross-sectional manner. To account for heterogeneity in the agricultural policy framework incentives, we included a policy dummy variable for the period of the Growing Forward 2 (2013-2018) program. We will also incorporate fixed regional dummy variables to control for unobserved heterogeneity across regions. Each regional dummy variable is assumed to capture unique unobserved effects associated with a producer f being located in that particular region and being exposed to biophysical influences such as weather, soil type etc., as well as local government effects such as municipality tax regimes and provincial government supports associated with municipal-level offices. Our first model is given by:

(i)

$$log\frac{P(A_{fi}=1)}{1-P(A_{fi}=1)} = \beta_0 + \beta_1 age_{18-44f} + \beta_2 age_{45-64f} + \beta_3 training_f + \beta_4 education_f + \beta_5 GFR > 250K_f + \beta_6 livestock_f + \beta_7 crops_f + \beta_8 livestock_f + \beta_9 ownland_f + \beta_{10} maintain\_expand_f + \partial_1 GF2_f + \partial_2 regions_f$$

Next, we will re-estimate the above model, adding the environmental extension funding variable:

(ii)

$$log\frac{P(A_{fi}=1)}{1-P(A_{fi}=1)} = \beta_0 + \beta_1 age_{18-44f} + \beta_2 age_{45-64f} + \beta_3 training_f + \beta_4 education_f$$
$$+ \beta_5 GFR > 250K_f + \beta_6 livestock_f + \beta_7 crops_f + \beta_8 livestock_f$$
$$+\beta_9 ownland_f + \beta_{10} maintain_{expand_f} + \gamma_1 extension_f$$
$$+\partial_1 GF2_f + \partial_2 regions_f$$

Lastly, we will evaluate yearly producer and farm characteristics models with the environmental extension funding variable for each ESAT survey round from 2014 to 2023. In this model, we exclude the policy dummy variable (GF2):

(iii)

$$log\frac{P(A_{fi}=1)}{1-P(A_{fi}=1)} = \beta_0 + \beta_1 age_{18-44f} + \beta_2 age_{45-64f} + \beta_3 training_f + \beta_4 education_f$$
$$+ \beta_5 GFR > 250K_f + \beta_6 livestock_f + \beta_7 crops_f + \beta_8 livestock_f$$
$$+\beta_9 ownland_f + \beta_{10} maintain_{expand_f} + \gamma_1 extension_f$$
$$+\partial_1 regions_f$$

Following the findings from previous studies, we expect the training, education, income, livestock production, tenure, and farm succession plan variables to have a positive effect on EFP adoption.

5.5. Results

5.5.1. Descriptive Statistics

Environmental Farm Plan Completion Across the Environmentally Sustainable Agriculture Survey Rounds

Figure 5.1 shows the EFP completion rates in Alberta for 2014-2023 based on the information in the ESAT survey. Notably, the EFP completion rate is higher over the years in the ESAT survey compared to completion rates in the Farm Management and Farm Environmental Management surveys conducted by Statistics Canada.[48] In the latter surveys, the number of farms holding an EFP has remained stable at about 25% since 2017. Figure 5.1 suggests that the EFP completion rate in Alberta varied between 37% and 47% in each ESAT survey round from 2014-2023. Despite the challenges of the COVID-19 pandemic, the EFP completion rate was at its peak in 2021, with approximately 47% producers holding an EFP. However, in the latest survey round, respondents reported a 6% decrease in the completion rate from the previous round. This higher EFP adoption rate in the ESAT survey suggests possible sample bias in the market research companies' agricultural database and/or the exclusion of the farms with gross farm revenue under $10,000 influencing the observed adoption rates.

In 2021, the survey included a dedicated section exploring why Alberta producers decided to adopt or not adopt the EFP. The findings revealed that over 70% of the producers who held an EFP viewed it as an effective tool for identifying environmental risks and promoting stewardship on their farms. Additionally, 60% completed the EFP to access the government cost-sharing programs. Conversely, 26% of the producers who did not hold an EFP did not see its relevance to their operations, and 21% perceived the EFP process as too time-consuming. Moreover, 22% stated they did not know what the EFP was. About 15% of the non-participating producers cited privacy concerns as one of the main reasons for not participating in the program; however, the EFP process is highly confidential (Anders et al., 2021).

[48] See Table 2.1 in Chapter 2.

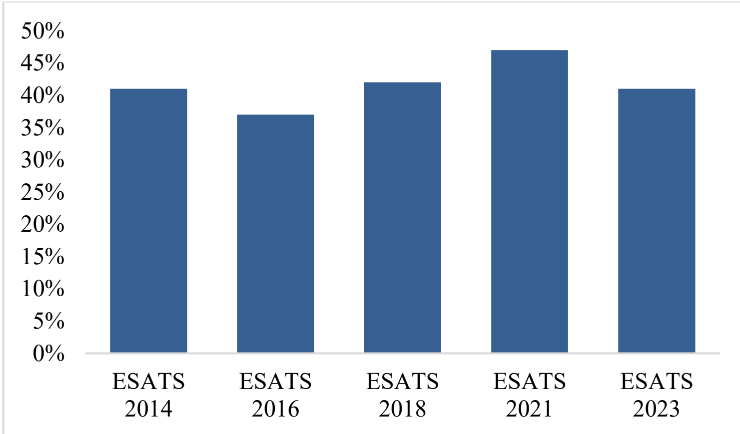

Figure 5.1. Percentage of Alberta Farms in the Environmentally Sustainable Agriculture Tracking Survey that held an Environmental Farm Plan across the 2014-2023 rounds.
Source: Government of Alberta (2014, 2016, 2023); AAF (2018); Anders et al. (2021).

There could be other factors affecting the EFP adoption decisions of the producers beyond those stated in the 2021 ESAT survey final report. To investigate further, we conducted a comparative analysis of the characteristics of Alberta producers who adopted an EFP and who did not. This involved merging data from the 2014-2023 ESAT survey rounds. During the merging process, certain municipalities, cities, and special areas that were absent in one or more survey rounds were excluded from the dataset.[49]

To highlight the characteristics of Alberta producers with and without an EFP between the 2014-2023 ESAT survey periods, it was found that the majority of producers deciding on EFP adoption in both groups fell within the 45-64 age range.[50] There was no significant difference between producers who completed an EFP and those who did not across different production types. A considerable percentage of the producers with an EFP attended conservation training (between 23-38%), held a diploma or degree (between 34-44%), and reported a gross farm revenue exceeding $250,000 across the survey rounds (43-60%) compared to the producers without one. Regarding the land tenure decisions, most EFP-holding producers both owned and rented their farms (between 60-69%), whereas nearly half of the producers without an EFP solely owned their lands

[49] See Table 4.2A in Appendix 4.

[50] See Table 4.3A in Appendix 4. Also, note that we included the excluded variables such as equal mix, rent land, both own and rent, reduce or sell variables for better comparison of the descriptive statistics.

(between 41-54%). In terms of farm operations, until 2021, between 68% and 77% of EFP-holding producers were either maintaining their current farm operations or planning expansions. However, interestingly, in the 2021 survey, nearly 70% of producers without an EFP indicated they were maintaining or planning to expand their current farm operations, compared to 66% of producers with an EFP. Additionally, the producers who did not have an EFP were more inclined to reduce or sell their farms than their counterparts with an EFP until 2021. Nevertheless, in the 2023 survey, a higher percentage of EFP-holding producers expressed a willingness to downsize or sell their farm operations compared to those without an EFP.

Extension Efforts in Alberta between 2014-2023 by Environmentally Sustainable Agriculture Tracking Survey Regions

In this section, we delve into the agri-environmental extension efforts by municipal governments across the five Alberta Agriculture and Irrigation regions as highlighted in the ESAT survey. We aligned the environmental extension funding data from municipalities within these regions, using it as an indicator of regional environmental extension efforts. We assume that producers who participated in the ESAT survey likely benefited from these environmental initiatives led by their municipal governments and other related agricultural organizations who received this funding.

Table 5.2 presents the average agri-environmental extension funding share of Alberta regions for the years 2014-2023. The data reveal a consistent increase in the average environmental extension funding amount allocated to the Agricultural Service Boards (ASBs) of the municipalities. Notably, the Central region received the highest average funding level in each period. This may be related to the fact that a significant portion of Alberta's agricultural producers and many of the larger farms — defined as those with annual gross farm sales exceeding $250,000 — are located in this region.[51]

[51] See Table 4.4A in Appendix 4 for more information.

Table 5.2. Average Annual and Average per-farm Agri-environmental Extension Funding Levels in Alberta Agricultural Regions.

Regions	2014		2016		2018		2021		2023	
	Average yearly	*Average per farm*	*Average yearly*	*Average per farm*	*Average yearly*	*Average per farm*	*Average yearly*	*Average per farm*	*Average yearly*	*Average per farm*
South	$ 296,272	$64	$ 592,545	$106	$ 587,545	$124	$ 549,689	$109	$ 730,298	$146
Central	$ 667,043	$62	$ 1,334,088	$126	$ 1,293,688	$113	$ 1,225,986	$127	$ 1,324,294	$115
Northeast	$ 240,000	$41	$ 480,000	$86	$ 485,000	$87	$ 526,016	$90	$ 556,631	$99
Northwest	$ 268,766	$36	$ 537,533	$76	$ 557,233	$78	$ 667,379	$100	$ 770,090	$125
Peace	$ 322,750	$123	$ 645,500	$191	$ 656,500	$164	$ 698,683	$213	$ 709,112	$207

Source: Government of Alberta (2023).

Until 2021, the Peace region received more funding than the Northwest and South regions, despite the latter having a greater number of farms. This suggests that there were more agricultural areas in the Peace region that required environmental improvements. Furthermore, analysis of the 2014-2023 pooled ESAT survey dataset reveals a correlation between higher environmental extension funding and the EFP completion rate (see Table 5.3). For instance, in the South and Central regions, nearly half of the farm areas are covered by the EFP program. Additionally, these regions also show a higher percentage of producers with a degree or diploma and those who attended a conservation training.

This initial descriptive analysis highlights the potential impact of targeted agri-environmental extension funding on EFP completion rates in the province. We expect this funding variable to have a positive effect on the EFP adoption decisions of Alberta producers.

Table 5.3. Regional Descriptive Statistics of Alberta producers for the 2014-2023 pooled cross-sectional model based on the 2014-2023 Environmentally Sustainable Agriculture Tracking survey and environmental extension funding.[52]

	Mean EFP	Average Age	Training	Education	GFR>250k	Livestock	Crops	Own land	Maintain or expand	Average Extension Funding per region	Average Extension Funding per farm	Obs (N)
South	51%	55-64	28%	42%	44%	25%	32%	53%	65%	$562,285	$ 111.31	466
Central	49%	55-64	20%	29%	37%	29%	30%	37%	66%	$1,202,914	$ 99.43	494
Northeast	36%	55-64	19%	25%	33%	22%	33%	41%	66%	$485,327	$ 81.35	453
Northwest	40%	55-64	20%	25%	27%	39%	39%	44%	64%	$577,013	$ 85.64	490
Peace	36%	55-64	19%	26%	34%	25%	27%	49%	61%	$627,458	$ 179.73	371

Source: Government of Alberta (2014, 2016, 2023); AAF (2018); Anders et al. (2021).

[52] Note that farms with annual gross farm revenue less than $10,000 were excluded from the analysis.

5.5.2. Results and Discussion

Results for Pooled Producer and Farm Characteristics Models with and without the Extension Funding Variable

We performed binary logistic regression analyses for the pooled 2014-2023 data with and without the environmental extension funding variable, which are (i) and (ii) equations as described in the methods section. We tested for multicollinearity employing the Variance Inflation Factor (VIF), and results showed values below 2.0 for all the models, indicating an absence of multicollinearity among the variables employed.

As Table 5.4 highlights, a producer's education, conservation training participation, and having gross farm revenue over $250,000 were significant predictors of their EFP completion decisions. The significance of the gross farm revenue over $250,000 variable may provide insights into the underlying cause of the stable EFP completion rate in Alberta, as suggested by Statistics Canada's Farm Management and Farm Environmental Management surveys across the census years.[53] As we discuss above, most of the producers who held an EFP in the ESAT survey had gross farm revenue over $250,000 in each survey round. This suggests that most of Alberta's agricultural land might be covered by an EFP as the producers operating larger farms have already adopted one. However, when we conducted a link test, which is a post-estimation diagnostic test used to identify whether the model may be suffering from omitted variable bias or misspecification, we discovered that our model (i) suffered from specification errors.[54]

To investigate the variable leading to specification errors, we conducted several additional regression analyses and found that the producer's education variable was the source of the issue. Consequently, we re-estimated model (i) excluding this variable, and it successfully passed the link test. As reported in Table 5.4, our new model (ii) reveals that a producer's participation in conservation training is a significant factor influencing their EFP completion decisions. Previous adoption research has identified that access to information plays a crucial role in enhancing the probability of farmers adopting conservation practices (Prokopy et al., 2008, 2019; Atari et al.,

[53] See Table 2.1 in Chapter 2.
[54] See Table 4.5A in Appendix 4.

2009). According to our marginal effects results, training participation increases the probability of EFP completion by 18.2 percentage points. Additionally, our farm income variable, defined as gross farm revenue exceeding $250,000, appears to be a significant predictor of the EFP completion. The marginal effects results reveal that higher income increased the probability of EFP completion by about 26 percentage points. As stated in past studies, higher farm income may ease the burden of investing in conservation practices for producers since BMPs adoption incentives involve cost sharing (Van Wyngaarden, 2021; Baumgart-Getz et al., 2012; Gillespie et al., 2007).

Including regional environmental extension funding levels in the adoption models revealed that the funding level was statistically insignificant in explaining EFP adoption (see model (iii) in Table 5.4). This result might be related to the pooling of the funding levels across regions. As we discussed in Chapter 4, environmental extension funding is accessed at the municipal level. Each municipality has different levels of agri-environmental extension funding depending on their unique agronomic conditions. As not all municipalities are represented in each ESAT survey round, we could not control for unobserved heterogeneity related to municipalities. Even though our results suggest that the environmental extension funding variable does not influence an individual producer's EFP completion decision, in the previous chapter we observed that it significantly affects EFP completion at the municipal level.

Regarding the regional variables, in all pooled models, the producers from the Northeast and Peace regions were less likely to complete an EFP compared to the producers in the Central region.

Table 5.4. Logistic Regression Coefficients and Marginal Effects for Pooled Farm and Producer Characteristics Models with and without Environmental Extension Funding.

	Model (i) (SE)	Model (i) Marginal Effects (SE)	Model (ii) (SE)	Model (ii) Marginal Effects (SE)	Model (iii) (SE)	Model (iii) Marginal Effects (SE)
Producer Characteristics:						
Age 18-44	-0.137	-0.029	-0.032	-0.007		
	(0.196)	(0.042)	(0.230)	(0.049)		
Age 45-64	0.0720	0.015	0.202	0.043		
	(0.133)	(0.028)	(0.152)	(0.0321)		
Training	0.813***	0.173***	0.856***	0.182***	0.905***	0.195***
	(0.140)	(0.028)	(0.150)	(0.030)	(0.138)	(0.028)
Education	0.502***	0.107				
	(0.128)	(0.027)				
GFR>$250k	1.087***	0.232***	1.226***	0.260***	1.139***	0.246***
	(0.125)	(0.024)	(0.139)	(0.026)	(0.123)	(0.023)
Farm Characteristics:						
Livestock	0.136	0.029	0.152	0.032	0.159	0.034
	(0.154)	(0.033)	(0.171)	(0.036)	(0.152)	(0.033)
Crops	0.00794	0.002	0.019	0.004	0.016	0.004
	(0.136)	(0.002)	(0.150)	(0.032)	(0.136)	(0.029)
Own land	-0.121	-0.026	-0.070	-0.015	-0.153	-0.033
	(0.126)	(0.027)	(0.140)	(0.030)	(0.125)	(0.027)
Maintain or expand operation	0.0283 (0.136)	0.006 (0.029)	0.169 (0.151)	0.036 (0.032)	0.048 (0.132)	0.011 (0.029)
Extension Variable:						
Environmental extension funding					-0.058 (0.533)	-0.013 (0.115)
Dummy Variables:						
GF2	-0.125	-0.027	-0.155	-0.033	-0.131	-0.028
	(0.124)	(0.027)	(0.170)	(0.037)	(0.124)	(0.027)
South	-0.0918	-0.020	-0.013	-0.003	-0.017	-0.004
	(0.176)	(0.038)	(0.194)	(0.042)	(0.172)	(0.038)
Northeast	-0.507***	-0.108***	-0.682***	-0.143***	-0.512***	-0.111***
	(0.166)	(0.035)	(0.195)	(0.040)	(0.165)	(0.035)
Northwest	-0.245	-0.053	-0.104	-0.023	-0.256	-0.056
	(0.164)	(0.036)	(0.181)	(0.039)	(0.164)	(0.036)
Peace	-0.507***	-0.1083***	-0.604***	-0.127***	-0.499***	-0.108***
	(0.184)	(0.039)	(0.192)	(0.040)	(0.187)	(0.040)
Constant	-0.719**		-0.794***		-0.594***	
	(0.201)		(0.218)		(0.203)	
Observations	2,274	2,274	1,776	1,776	2,274	2,274

*Note: Significance levels are ***p<0.01, **p<0.05, *p<0.1*

Results for Yearly Producer and Farm Characteristics Models with Extension Funding Variable

To account for the differences in the years, we also analyzed yearly regression models based on the ESAT survey rounds with the environmental extension funding variable (see Table 5.5). Unlike the pooled model analysis, we included the producer's education variable in the yearly models. To assess the validity of our models, several tests for logistic model specification were conducted.[55] The link test suggested that our explanatory variables were meaningful in explaining EFP adoption across all models. The Wald test confirmed the results from the link test, ruling out the hypothesis of no effect from predictor variables. We also tested our models for multicollinearity using the VIF, and results suggested no sign of multicollinearity in our models.

Yearly models consistently highlight significant impacts of conservation training participation and a gross farm revenue of over $250,000 on EFP completion across all the survey years. In the 2016, 2018, and 2023 models, a producer's education had a positive significant impact on EFP adoption. As Prokopy et al. (2008, 2019) emphasized, higher levels of education lead to an increased adoption of conservation practices. Notably, in the 2021 model, being primarily a livestock producer was statistically significant at 10% and increased the likelihood of EFP completion by 16 percentage points, aligning with the findings by Atari et al. (2009). Moreover, the 2023 model indicated that a producer owning land decreased the probability of EFP completion by nearly 11 percentage points at 10% statistical significance level. This might be due to the higher percentage of producers who both owned and rented their land than the producers who only owned their land in the 2023 survey. Interestingly, in the 2018 model, the environmental extension funding had a significant positive influence on EFP completion. According to the results of the marginal effects coefficients, increasing levels of environmental extension funding per farm by $10,000 in municipalities would correspond to an approximate 80 percentage points rise in the likelihood of EFP completion. This finding aligns with the previous BMP adoption research (Rollins et al., 2018; Pannell et al., 2006).

Regional differences were also observed in yearly models, with heterogeneity in EFP completion across regions in different years.

[55] See Table 4.5A. in Appendix 4.

Table 5.5. Yearly Producer and Farm Characteristics Model with Environmental Extension Funding.

	2014 Model		2016 Model		2018 Model		2021 Model		2023 Model	
	Coeff. (SE)	**ME (SE)**	**Coeff. (SE)**	**ME (SE)**	**Coeff. (SE)**	**ME (SE)**	**Coeff. (SE)**	**ME (SE)**	**Coeff. (SE)**	**ME (SE)**
Producer Characteristics:										
Age 18-44	-0.390	-0.078	0.539	0.117	-0.281	-0.054	-0.259	-0.054	-0.385	-0.078
	(0.577)	(0.116)	(0.275)	(0.089)	(0.459)	(0.087)	(0.421)	(0.087)	(0.450)	(0.091)
Age 45-64	0.011	0.002	0.336	0.073	0.120	0.023	0.310	0.064	-0.476	-0.097
	(0.331)	(0.066)	(0.412)	(0.059)	(0.276)	(0.053)	(0.315)	(0.064)	(0.315)	(0.063)
Training	0.792**	0.159**	0.638**	0.139**	0.793 **	0.151**	0.909**	0.187**	1.144***	0.232***
	(0.298)	(0.057)	(0.255)	(0.054)	(0.324)	(0.061)	(0.384)	(0.076)	(0.327)	(0.061)
Education	0.416	0.083	0.546**	0.119**	0.856 **	0.163**	0.342	0.070	0.547*	0.111*
	(0.307)	(0.061)	(0.247)	(0.052)	(0.292)	(0.053)	(0.305)	(0.062)	(0.303)	(0.060)
GFR>$250k	1.476***	0.296***	0.764**	0.166**	1.444***	0.276***	1.436***	0.296***	0.797**	0.162**
	(0.317)	(0.056)	(0.256)	(0.053)	(0.296)	(0.048)	(0.289)	(0.051)	(0.291)	(0.055)
Farm Characteristics:										
Livestock	-0.329	-0.066	0.004	0.001	-0.192	-0.037	0.781*	0.161*	0.065	0.013
	(0.432)	(0.086)	(0.260)	(0.057)	(0.299)	(0.057)	(0.426)	(0.086)	(0.362)	(0.074)
Crops	-0.525	-0.105	-0.205	-0.045	0.133	0.026	0.244	0.050	-0.157	-0.032
	(0.407)	(0.081)	(0.286)	(0.062)	(0.305)	(0.058)	(0.335)	(0.067)	(-0.157)	(0.066)
Own land	-0.052	-0.010	0.042	0.010	0.080	0.015	-0.136	-0.028	-0.515*	-0.105*
	(0.278)	(0.056)	(0.247)	(0.054)	(0.260)	(0.050)	(0.324)	(0.067)	(0.306)	(0.061)
Maintain or	0.360	0.072	0.206	0.045	0.340	0.065	-0.171	-0.035	-0.342	-0.069
expand	(0.309)	(0.062)	(0.271)	(0.059)	(0.278)	(0.053)	(0.347)	(0.071)	(0.326)	(0.065)
Extension Variable:										
Env.extension	-0.138	-0.028	-0.817	-0.178	4.226**	0.807**	-1.749	-0.360	0.054	0.011
funding	(1.249)	(0.250)	(0.898)	(0.195)	(1.650)	(0.308)	(1.660)	(0.341)	(1.591)	(0.323)
Dummy Variables:										
South	-0.446	-0.091	-0.645*	-0.138*	-0.426	-0.081	0.044	0.009	0.699*	0.154*
	(0.417)	(0.084)	(0.340)	(0.071)	(0.371)	(0.070)	(0.477)	(0.101)	(0.398)	(0.086)
Northeast	-1.175**	-0.222**	-0.141	-0.031	-0.534	-0.101	-0.331	-0.070	-0.539	-0.112
	(0.393)	(0.072)	(0.324)	(0.071)	(0.357)	(0.067)	(0.425)	(0.090)	(0.373)	(0.078)
Northwest	-0.098	-.0204	-0.221	-0.049	0.234	0.046	-0.545	-0.114	-0.521	-0.109
	(0.365)	(0.076)	(0.322)	(0.070)	(0.341)	(0.067)	(0.426)	(0.090)	(0.370)	(0.078)
Peace	-0.182	-0.038	-0.227	-0.050	-1.010**	-0.183**	-0.491	-0.103	-0.580	-0.120
	(0.443)	(0.092)	(0.332)	(0.073)	(0.392)	(0.067)	(0.451)	(0.095)	(0.468)	(0.094)
Constant	-0.575		-1.013**		-1.619***		-0.594		-.0179	
	(0.486)		(0.374)		(0.375)		(0.526)		(0.495)	
Observations	412	412	436	436	431	431	497	497	498	498

*Note: Significance levels are ***p<0.01, **p<0.05, *p<0.1*

5.6. Conclusion

In this chapter, we investigated some factors influencing the EFP completion decision of Albertan producers for the period 2014-2023 using the Alberta Environmentally Sustainable Agriculture Tracking Survey (ESAT). First, we evaluated our 2014-2023 pooled producer and farm characteristics binary logistic regression model and identified a specification error through post-estimation diagnostic tests. Further analysis pinpointed the producer's education variable as the source of the issue. We excluded this variable and re-estimated the model. The results underscored conservation training participation as a significant determinant of EFP completion decisions of the producers, aligning with previous research emphasizing the role of information access in fostering conservation practices adoption (Prokopy et al., 2008, 2019; Atari et al., 2009). Also, higher income levels increased the likelihood of EFP completion. This finding is consistent with previous adoption research (Van Wyngaarden, 2021; Baumgart-Gertz et al., 2012). We incorporated the environmental extension funding variable into our pooled cross-sectional analysis, and we did not find a significant impact of this variable on EFP completion.

After, we evaluated yearly models taking into account regional heterogeneity, and the 2018 model revealed a significant positive effect of the municipalities' environmental extension funding levels on EFP adoption, consistent with prior adoption studies (Rollins et al., 2018; Pannell et al., 2006). Also, the 2021 model identified production type, such as primarily livestock farming, as a significant factor, in line with Atari et al. (2009). Interestingly, the 2023 model showed that land ownership negatively influenced the EFP completion decisions of the producers. This finding contradicts most of the previous adoption studies; however, Soule et al. (2000) stated that the relationship between tenure and the adoption of conservation varies with the specific type of practice, and no farmer will adopt the practice if the short-term losses outweigh the long-term benefits. Furthermore, producer's education yielded an increased likelihood of EFP completion in the 2016, 2018, and 2023 models, reflecting the findings from the literature (Prokopy et al., 2008, 2019). The other findings remained consistent with the results of the pooled models.

In summary, our study found that the training and gross farm revenue over $250,000 variables consistently explain EFP adoption across all pooled and yearly models. These findings provide an important understanding of EFP completion at the farm level in Alberta. Particularly, the gross farm revenue variable could explain the stable EFP completion rates in the Farm Management Surveys by Statistics Canada, as most of the agricultural land in Alberta might be covered by an EFP. Additionally, our other findings regarding the importance of education, environmental extension funding, and regional variations offer valuable insights into the determinants of EFP completion among Albertan producers.

Chapter 6. The Role of Environmental Farm Plan and Agri-Environmental Extension in Beneficial Management Practices Adoption Decisions of Agricultural Producers in Alberta.

6.1. Introduction

In 2003, the Canadian government introduced their first national Agricultural Policy Framework (APF), a collaborative federal-provincial/territorial initiative with a substantial budget of $5.2 billion over five years. Of this amount, approximately $600 million was dedicated to the environmental chapter of the APF, aimed at enhancing environmental health through promoting the uptake of sustainable development practices (Office of the Auditor General of Canada, 2008). The APF marked the beginning of the government's reference to 'beneficial management practices' (BMPs) in agricultural policy documents (Hurlbert et al., 2023). These practices, when adopted by producers, serve as an approach to tackling environmental issues that may exist on farms (Rollins & Boxall, 2018).

The definition of BMPs varies across provinces. For example, Alberta defines a BMP as 'any management practice that reduces or eliminates an environmental risk' (Government of Alberta, 2023). BMPs are implemented utilizing a cost-share program that forms part of agri-environmental stewardship programs at the provincial level under each agricultural policy framework. Farms that implement one of the voluntary BMPs from the environmental stewardship programs are eligible to apply for government funding, which covers a fixed percentage of the adoption cost up to a pre-defined limit. To be eligible for government-sourced BMP funding, farms are required to have an EFP (Boxall, 2018; Rollins & Boxall, 2018).

Given the voluntary nature of adoption of BMPs, understanding the factors influencing farmers' management decisions is essential for designing policies and programs aimed at promoting environmental stewardship (Pannell et al., 2006; Pannell, 2003; Ghazalian et al., 2009; Prokopy et al., 2008; Gillespie et al., 2007). Several studies in Canada have explored the barriers, motivations, and determinants of BMPs and new technologies within environmental risk areas such as soil conservation, biodiversity, water quality, grazing management, and manure management, through both qualitative and empirical analyses (Dring et al., 2016; Rollins et al., 2018; Ghazalian et al., 2009; Tamini, 2011; Davey & Furtan, 2008; Filson et al., 2009). For example, one of the early studies by McNairn and Mitchell (1992) explored the factors affecting southwestern Ontario farmers' attitudes towards adopting soil conservation measures. Their research revealed that while most farmers were inherently inclined to implement these practices, the perception of economic risk significantly hindered producers' willingness to adopt. This aligns with the findings of Smit and Smithers (1992), who studied farm-level conservation efforts and barriers in adopting soil conservation practices in the same region and identified that economic constraints, along with the complexity and compatibility of the practices, and farmers' perception about the actual need for the practices, as the main barriers to adoption. Moreover, another study, utilizing a sample of 102 surveys and 20 interviews in a region of Eastern Ontario, discovered that benefits such as enhanced soil water retention, higher crop yields, and gratification from environmental improvement were key motivations for farmers to adopt tile drainage. Conversely, factors such as the capital cost, higher labour costs, and perceived lack of extension services acted as deterrents to adoption (Dring et al., 2016).

Furthermore, highlighting socio-economic factors, farm and farmer characteristics, Duff et al. (1991) analyzed the impact of farm and farmer characteristics on the BMPs adopted in Southern Ontario watersheds using a sample of 164 farmers. Their analysis showed that farm size, farm sales, level of farmer's education, and younger age affected BMP adoption. Similarly, Ghazalian et al. (2009) identified that these factors also impacted the adoption rates of various BMPs like solid and liquid manure control, crop rotation, riparian buffer strips, and herbicide control among the livestock producers in Quebec's Chaudière region. Furthermore, Filson et al. (2009) observed that farm size was the only factor that had a statistically significant correlation with BMP uptake across five watersheds in southern Ontario. Also, studies by Lamba et al. (2009) and Dupont (2010) underscored the importance of financial incentives in BMP adoption in the same region. Specifically, Dupont (2010) found a positive relationship between a farmer's decision to participate in BMP programs and the level of cost-sharing incentives offered to them. They mentioned that BMPs with the highest grant amount were significantly correlated with adoption.

More recent research in Alberta investigated the determinants of BMP adoption across several environmental risk areas, employing linear probability models within a random utility framework. This study revealed that age, participation in conservation training, higher gross farm revenue, producer's educational degree, and completion of an EFP substantially increased the probability of adopting BMPs (Van Wyngaarden, 2021).

Additionally, a few studies addressed the role of extension agencies in BMP adoption along with other factors. For instance, Tamini (2011) underlined the influence of advisory clubs on the probability of adopting most of the BMPs except establishing and maintaining a riparian buffer zone and immediate incorporation of manure in Quebec. Davey and Furtan (2008), through a probit model analysis of conservation tillage adoption, identified that along with other factors such as farm size, soil type, and climatic conditions, proximity to research stations had a significant impact on the adoption of conservation tillage in the Prairie provinces. Furthermore, Rollins et al. (2018) evaluated the efficacy of an agricultural extension program aimed at increasing the adoption of on-farm biodiversity in Alberta and examined the factors affecting adoption, estimating a probit model within a random utility theory. They noted that along with tenure and farm size, membership in watershed or environmental groups increased the likelihood of a recommended BMP adoption. Another study in the province by Van Wyngaarden (2021) found that even though the regional extension expenditure per farm was statistically insignificant in explaining BMP adoption decisions in their Alberta sample of producers, it was highly significant in the sample of producers who did not have an EFP.

As observed, the majority of the research on the determinants of BMP adoption in Canada focuses on the eastern provinces. Therefore, following our previous chapters, our study will shed light on the factors affecting the BMP adoption decisions of producers in Alberta. This chapter builds on Van Wyngaarden's (2021) suggestion that the EFP could be endogenous within the BMP adoption process at the farm level. Van Wyngaarden (2021) was unsuccessful in identifying instruments to explain EFP adoption within the BMP adoption econometric equation. Thus, this endogeneity hypothesis was not supported by their data. This chapter aims to address this endogeneity question using additional data. We will examine regional variables like agri-environmental extension funding, agricultural research association memberships, EFP technician availability, and extension activities by the Agricultural Service Boards of the municipalities outlined in Chapter 4, alongside farm and producer characteristics identified in Chapter 5 as potential instruments for explaining EFP uptake within the BMP adoption equation. The analysis will draw upon data from the 2014 to 2023 rounds of Alberta's Environmentally Sustainable Agriculture Tracking Survey and municipal-level data used in Chapter 4, utilizing an Instrumental Variables (IV) and two-step control function econometric approaches.

6.2. Data

6.2.1. The Environmentally Sustainable Agriculture Tracking Survey

The Alberta Department of Agriculture and Irrigation (AAI) actively offers technical support and targeted programs to help agricultural producers mitigate the environmental risks on their farms through adoption of environmentally sustainable BMPs. These practices are key indicators of producers' responses to environmentally sustainable agriculture and responsible resource management, providing multiple environmental and economic benefits for producers as well as society. For example, certain practices can reduce water contamination from manure and fertilizer runoff, thereby improving water quality for downstream communities and in some cases, water used by the producer's household. Another example is implementing the 4R nutrient management strategy to optimize fertilizer use, which can reduce input costs and boost farm profitability (Government of Alberta, 2023).

To monitor the BMP adoption rates to tailor policy, programs, and resources to fit current economic and environmental conditions, AAI sponsors the Environmentally Sustainable Agriculture Tracking Survey (ESAT), which has been conducted almost biennially since 1997 by marketing and research provider companies such as Ipsos Reid and Kynetec. The target population for the survey is agricultural producers with gross farm sales of at least $10,000 and who are actively engaged in making decisions related to the practices and operations used on their farms. The survey sample of 500 producers is consistent across years and drawn from the research providers' provincially representative database of 30,000 unique Albertan agricultural producers (AAF, 2018; Anders et al., 2021; Government of Alberta, 2023). The results of the survey are weighted at the five Alberta regions to maintain a representative sample.[56]

Until 2018, the ESAT survey tracked Alberta producers' awareness, attitudes toward, and adoption of 40 BMPs across eight environmental risk areas:

1. Soil Conservation – 3 practices,
2. Water Quality and Quantity – 12 practices,
3. Manure Management – 11 practices,
4. Wildlife Habitat Conservation – practices,
5. Grazing Management – 2 practices,
6. Agricultural Waste Management – 1 practice,
7. Energy and Climate Change – 3 practices and
8. General Practices – 5 practices.

In 2021, the number of BMPs in the survey was reduced to 20 and BMPs were measured across the following environmental risk areas:

1. Water Quality – 7 practices,
2. Soil Health – 5 practices,
3. Air Quality – 3 practices, and
4. Biodiversity – 5 practices.

Furthermore, in the 2023 round of the survey, one practice was added to the 'Air Quality' risk area (Government of Alberta, 2014, 2016, 2023; AAF, 2018; Anders et al., 2021).[57]

[56] See Chapter 5 for more information about survey methodology and for the weighting distribution by the Census of Agriculture years and the Appendix A of the ESAT survey final reports.
[57] See Tables 6.1 and 6.2 for the list of BMPs across the environmental risk areas.

The survey rounds from 2014 to 2018 can be merged and directly compared as the environmental risk areas and the practices measured remained the same. However, the data from the 2021 and 2023 rounds could not be merged due to a significant decline in the number of survey questions and practices. Moreover, in the 2023 round, the eligibility requirements for some practices and the wording of some questions were altered, making direct comparisons of the results across the various survey rounds somewhat difficult. Therefore, for our analysis, we have three ESAT survey datasets: 2014-2018, 2021, and 2023.

6.2.2. Municipal level data

We used the municipal level data described in Chapters 4 and 5 in our search for instruments for our assumed endogenous variable — adoption of an EFP. For the 2021 and 2023 models, we also utilized information on the availability of the Alternative Land Use Services (ALUS) program in the municipalities. ALUS is a national, non-profit charitable organization that partners with local organizations and community leaders to deliver ALUS programs (ALUS, 2024). Their programs offer farmers and landowners annual per-acre payments for adopting various BMP projects such as riparian management, grazing management, water retention, and wildlife habitat conservation that maintain and enhance the ecosystem services (ALUS, 2024; France & Campbell, 2015). It is noteworthy that an EFP is not required to access ALUS funding for the implementation of these various BMPs.[58]

6.3. Methodology

6.3.1. Dependent Variable Development

We relied on the ESAT survey methodology and Van Wyngaarden (2021)'s study to formulate our dependent variable. The adoption of each BMP within environmental risk areas is treated as a binary decision: '1' indicates adoption, and '0' indicates non-adoption. As we have several BMPs under each environmental risk area, and each practice has adoption and eligibility criteria, our dependent variable is defined as:

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[58] See Figure 2.1 in Chapter 2 for an explanation of the role of EFP in the Canadian Agri-Environmental incentive policy/programs.

$$ESA\ Score_{ik} = \frac{Number\ of\ Practices\ Adopted_{ik}}{Number\ of\ Practices\ Eligible\ _{ik}}$$

where the environmentally sustainable agriculture (ESA) score represents a BMP score for the risk area k for an agricultural producer i. It is calculated by dividing the number of practices adopted by a producer i in the environmental risk area k by the number of practices for which producer i is eligible in the same risk area. The eligibility and adoption criteria for each practice are defined in the ESAT survey reports.

Figure 6.1 illustrates the calculation of an ESA score for the '*Air Quality'* environmental risk area in the 2023 ESAT survey round. It includes four BMPs such as the application of chemical fertilizer at the recommended rate, production of grid-connected electricity, solid and compost manure incorporation, and planting of trees on the farmland for agricultural purposes. If we wish to determine the eligibility and adoption for the 'planting of trees on the farmland for agricultural purposes', all respondents of the survey are eligible to adopt the practice except those producers who have answered 'do not know' or 'not applicable to my operation', and a planting of trees is counted towards adoption. Likewise, there are eligibility and adoption criteria for each practice. If the producer i is eligible for all four practices under 'Air Quality', but has adopted only two of the practices, then their adoption score is 50%.

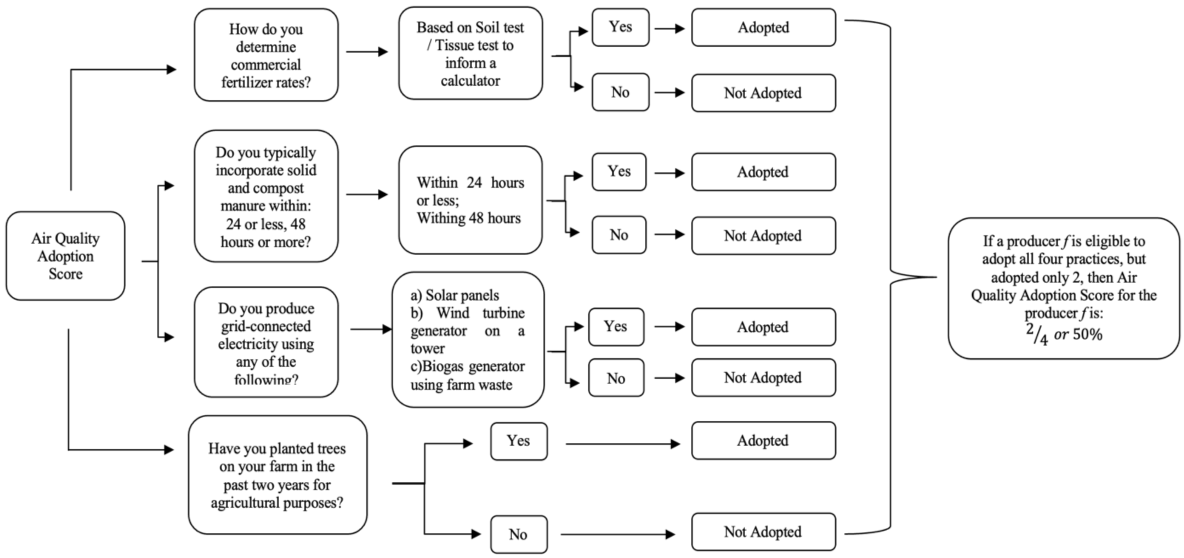

Figure 6.1. An Example of Environmentally Sustainable Agriculture (ESA) score calculation for the "Air Quality" environmental risk area.

The criteria for eligibility and adoption for each practice within each risk area are given in Tables 6.1 and 6.2. Notably, the 2023 survey round introduced modifications to the eligibility and adoption requirements for certain practices. For instance, in the 'Biodiversity' risk area in 2021, the practice of 'avoiding draining or filling in natural wetlands and/or sloughs' was revised to 'maintaining, enhancing, or restoring wetlands on the farm' in 2023. Also, in 2021, only producers who had any natural rivers, streams, wetlands, or sloughs were eligible for the practice; but in 2023, all producers were eligible. All the revisions of the 2023 ESAT survey can be found in Table 6.2.

Table 6.1. A Summary of Eligibility and Adoption Criteria for all Beneficial Management Practices (BMPs) under all Risk Areas in the 2014-2018 Environmentally Sustainable Agriculture Tracking Surveys.

Risk Areas	BMPs	Eligibility Criteria	Adoption Criteria
Soil Conservation:			
	Use Reduced Tillage	Producers whose farmland included acres in crop production	The seeding operation into the stubble of the previous crop was the only tillage pass completed.
	Use legumes in rotation	Producers whose farmland included acres in crop production	Used pulsed crops in cropping rotation
	Use winter cereals in rotation	Producers whose farmland included acres in crop production	Used winter cereals in cropping rotation
Water Quality and Quantity:			
	Maintain buffer areas along edge of natural water bodies	The farmland had any natural rivers, streams, wetlands or sloughs	Maintained buffer areas of grass and/or trees along the edge of rivers, streams, sloughs, wetlands or ditches
	Avoid draining or filling in natural wetlands/sloughs	The farmland had any natural rivers, streams, wetlands or sloughs	Did not drain or fill in natural wetlands or sloughs
	Apply chemical fertilizer at recommended rate	Applied commercial fertilizers on their farmland	Applied commercial fertilizer based on the results of a soil or tissue test
	Control runoff from manure storage	Producers who had livestock	Controlled runoff from all or some of their manure storage
	Control runoff from livestock pens	Producers who had livestock	Controlled runoff from all or some of their livestock pens
	Control runoff from feeding areas	Producers who have livestock	Controlled runoff from all or some of their overwintering in-field feeding areas
	Plug or seal abandoned wells	Producers who had active wells on their farmland	Total number of inactive, abandoned or unused wells that were properly sealed or plugged (>0)
	Properly seal and maintain active wells	Producers who had abandoned, inactive or unused wells on their farmland	Total number of inactive, abandoned or unused active wells that were properly maintained (>0)
	Maintain a 10m buffer area from water bodies when applying pesticides	Applied crop protection products and had natural water bodies on their farmland	Maintained at least a 10m buffer area from water bodies when applying crop protection products

	Maintain a 10m buffer area from water wells when applying pesticides	Applied crop protection products and had active and/or inactive water wells on their farmland	Maintained at least a 10m buffer area from water wells when applying crop protection products
	Manage livestock access to water bodies that are used as a water source	Grazed livestock and had natural water bodies on their farmland	Managed or control livestock access to water bodies that are used as a water source
	Choose wintering site to avoid manure contamination	Grazed livestock and had natural water bodies on their farmland	Located all or some of their winter feeding and bedding sites to prevent runoff from manure entering natural water bodies
Wildlife Habitat Conservation:			
	Retain bush or native grassland	All Respondents	Retained woodlands, bush or native grassland
	Manage grazing for wildlife habitat	Producers who grazed livestock on their farmland	Managed their livestock grazing to provide habitat for wildlife
	Manage grazing to encourage natural rejuvenation of understory in woodlands	Producers who grazed livestock on their farmland	Managed grazing to encourage natural growth of understory in woodlands (understory may include small trees, shrubs, forbes and grasses)
Grazing Management:			
	Protect riparian areas from grazing to prevent overuse	Producers who grazed livestock on their farmland	Avoided or minimized grazing in riparian and/or bush areas in the late summer or autumn
	Time grazing to avoid vulnerable times of the year for riparian areas	Producers who grazed livestock on their farmland	Timed the grazing of riparian areas to avoid grazing during spring and early summer
Manure Management:			
	Avoid applying manure or compost on frozen or snow-covered ground	Applied liquid or solid manure/compost to land	Typically applies manure/compost on frozen or snow-covered ground
	Avoid storing manure near water wells	Stored manure and have active/abandoned water wells	Did not store manure within 100m of active/abandoned water wells
	Frequency of application	Applied manure to land	Applied manure once every two years, three years or less
	Incorporate manure after applying	Applied solid manure	Incorporated solid manure within 24 or 48 hours

	Applying liquid manure	Applied liquid manure	Broadcasted with incorporation within 24 or 48 hours after application
	Avoid applying close to waterways to minimize increased nutrient runoff	Applied manure to land	Considers any of the following: Distance between manure applications and waterways – that is low lying paths where surface water collects and flows, slope of land, application method
	Sampling and analyzing the manure for nutrient content	Applied liquid or solid manure or compost to land	Applied manure – either solid or liquid, based on a soil or tissue test or manure nutrient test or book values
	Manure application based on P or N&P	Applied liquid or solid manure to land	Manure application rates are typically based on crop nitrogen or phosphorus requirements
	Keeping manure records	Typically manages more than 500 tons of manure per year	Kept records detailing the amount and field location of where the manure was spread for all or some of their fields
Agricultural Waste Management:			
	Recycle Plastics	Have livestock & used baler twine, feed bags, silage wraps and/or bale wraps	"Yes" to any of the following: Recycled plastics such as baler twine, feed bags, silage wraps and/or bale wraps
Energy and Climate Change:			
	Energy saving practices	All Respondents	If a producer had any sub-meters other than the main utility meter that shows the total electricity usage for their entire property
	Renewable Power	Produced grid – connected electricity	"Yes" to any of the following: Produced grid-connected electricity using solar panels, not counting for water pumping or electric fencing; wind turbine generator on a tower; biogas generator using farm waste
	Participate in carbon credit trading	All Respondents	Participated in the Alberta Carbon offset market
General Practices:			
	Precision Farming VRT	Applied crop production	Utilized variable rate technology in the application of commercial fertilizer/crop

		products/commercial fertilizer.	protection products such as herbicides, insecticides, and fungicides
	Soil sampling fields at least once every three years	Typically soil samples all, some of none of their fields	Soil samples yearly or at least once every three years
	Trees for agricultural purposes	All Respondents	Planted trees on their farm in the past 2 years for agriculture purposes (shelterbelts/windbreaks, wildlife habitat, soil conservation, odor control, etc.)

Source: Alberta Agriculture and Forestry (2018).

Table 6.2. A Summary of Eligibility and Adoption Criteria for all Beneficial Management Practices (BMPs) under all Risk Areas in the 2021-2023 Environmentally Sustainable Agriculture Tracking Surveys.

Risk Areas	BMPs	Eligibility Criteria	Adoption Criteria
Soil Health:			
	Used reduced tillage	Farmland included acres in crop production	The seeding operation into the stubble of the previous crop was the only tillage pass completed.
	Use pulse crops in rotation	Farmland included acres in crop production	Used pulse crops in cropping rotation
	Frequency of Manure application	Applied solid/liquid/compost manure to farmland	Applied manure once every two years, three years or less. *(Note: In 2023 survey, once every three years and less than once every three years counted towards adoption)*
	Sampling and analyzing the manure for nutrient content	Applied liquid or solid manure or compost to land	Applied solid/liquid manure based on a soil or tissue or manure nutrient test or book values
	Manure application based on P or N&P	Applied liquid or solid manure to land	Manure application rates were based on crop nitrogen or phosphorus requirements *(Note: In 2023, if a producer's manure application rates were based on both crop nitrogen and phosphorus requirements, then the practice is counted as 'adoption')*

Water Quality:			
	Control runoff from manure storage	Producers who had livestock	Controlled runoff from all or some of their manure storage
	Control runoff from livestock pens	Producers who had livestock	Controlled runoff from all or some of their livestock pens
	Choose wintering site to avoid manure contamination	Grazed livestock and had natural water bodies on their farmland	Located all or some of their winter feeding and bedding sites to prevent runoff from manure entering natural water bodies
	Avoid applying manure or compost on frozen or snow-covered ground	Applied liquid or solid manure/compost to land	Did not apply manure/compost on frozen or snow-covered ground
	Avoid storing manure near active water wells	Stored manure and had active/abandoned water wells	Did not store manure within 100 meters of active water wells
	Avoid applying close to waterways to minimize increased nutrient runoff	Applied manure to land	Considers any of the following factors when applying solid/liquid manure: distance between manure applications and waterways; slope of land; application method. *(Note, in 2023, the wording of this question was changed, slope of land and application method was given as one option)*
Biodiversity:			
	Protect riparian areas from grazing to prevent overuse	Producers who grazed livestock on their farmland	Avoided or minimized grazing in riparian and/or bush areas in the late summer or autumn *(Note: In 2023, changed to "in the spring and early summer")*
	Time grazing to avoid vulnerable times of the year for riparian areas	Producers who grazed livestock on their farmland	Timed the grazing of riparian areas to avoid grazing during spring and early summer (*Note: In 2023, changed to "Time the grazing of riparian areas to avoid wet soils that are susceptible to compaction and hummocking")*
	Retain bush or native grassland *(Note: in 2023, changed to "manage")*	All Respondents	Retains (manages) woodlands, bush or native grassland

	Avoid draining or filling in natural wetlands/sloughs *(Note: in 2023, changed to "Maintaining, Enhancing, or Restoring Wetlands on the Farm")*	The farmland had any natural rivers, streams, wetlands or sloughs *(Note: In 2023, all respondents were eligible)*	Did not drain or fill in natural wetlands or sloughs *(Note: In 2023, "Maintained, Enhanced, or Restored Wetlands on the Farm"; adoption is calculated taking out the respondents who answered "Not Applicable")*
	Manage grazing for wildlife habitat	Producers who grazed livestock on their farmland	Actively managed their livestock grazing land to create wildlife habitat
Air Quality:			
	Apply chemical fertilizer at recommended rate	Applied commercial fertilizers on their farmland	Applied commercial fertilizer based on the results of a soil or plant tissue test *(Note: In 2023, "Soil test / Tissue test to inform a calculator")*
	Renewable Power *(Note: In 2023, wording of the question asked changed)*	Produced grid – connected electricity	"Yes" to any of the following: Produced grid-connected electricity using solar panels, not counting for water pumping or electric fencing; wind turbine generator on a tower; biogas generator using farm waste
	Incorporate solid manure after applying	Applied solid manure *(Note: In 2023, those using solid/compost manure on fields not direct seeded)*	Incorporated solid manure within 24 or 48 hours *(Note: In 2023, "Incorporated solid or compost manure together")*
	Trees for agricultural purposes	All Respondents	Planted trees on their farmland in the last two years for agricultural purposes

Source: Anders et al. (2021); Government of Alberta (2023).

6.3.2. A Theoretical Model for Beneficial Management Practices Adoption

As highlighted in the previous chapter, the decision-making process regarding the adoption of agricultural practices by farmers is inherently complex, integrating insights from diverse disciplines (Pannell et al., 2006; Prokopy et al., 2008; Upadhyay et al., 2003). Due to the complex nature of adoption decisions, and that producer knowledge and beliefs can greatly vary, it is challenging to achieve a universal understanding of what drives adoption in agriculture (Pannell & Claassen, 2020).

A study by Upadhyay et al. (2003) categorized the adoption literature into three paradigms: income, utility, and innovation. The income paradigm is aligned with neoclassical economic theory and assumes that farmers, as rational actors, prioritize maximizing profits. Thus, producers will adopt technologies and practices that increase farm net returns (Cary & Wilkinson, 1997). Nonetheless, this paradigm is criticized for its inability to account for possible heterogeneity in farmers' preferences, overlooking that not all decisions are purely economically driven (Nowak, 1987). Conversely, the utility paradigm accounts for a wider range of motivating factors. It suggests that producers base their adoption decisions on maximizing their utility, not just profit (Rahm & Huffman, 1984). The existing social science literature seems to favour this paradigm. Several studies have tried to explain the observable socio-economic factors that affect the adoption decisions of farmers based on a random utility framework (Rollins et al., 2018; Van Wyngaarden, 2021; Langpap, 2004; Ghazalian et al., 2009; Bell et al., 1994; Jensen et al., 2015). Finally, many rural sociologists prefer the innovation diffusion adoption paradigm introduced by Rogers (1962; 2003), which underscores the importance of information, risk factors, and social status of farmers (Tey & Brindal, 2012; Liu et al., 2018). However, this theory fails to recognize various dimensions of the individual characteristics of the decision maker (Prager & Posthumus, 2010).

Given the limited data available in the ESAT survey on observable socio-economic factors, and challenges to understand the spatial and temporal level of extension efforts by the provincial government and municipalities, our analysis begins by positing a random utility framework informed by previous studies. The utility associated with BMP adoption j in a risk area k by an agricultural producer i is defined as:

$$U_{fjk} = V_{ijk} + \varepsilon_{ijk}$$

where V_{ijk} represents the deterministic part of the utility which can be observed by a researcher, and ε_{ijk} is the random error term capturing unobserved factors affecting the utility of the agricultural producer. The deterministic part of the utility is given by:

$$V_{ijk} = X'_{ijk}\beta + Y_{ijk}'\gamma$$

where X'_{ijk} is a vector of farm and producer characteristics variables, Y_{ijk} is the vector of extension variables, and β and γ are the vectors of parameters to be estimated. If the adoption decision of an agricultural producer i by adopting practice j in a risk area k is given by A_{ijk}, then our utility function becomes:

$$U_{ijk} = X_{ijk}'\beta + Y_{ijk}'\gamma + \varepsilon_{ijk}$$

A_{ijk}=1 if U_{ijk}> 0, A_{ijk}=0 otherwise.

Adoption occurs when A_{ijk}= 1 and does not when A_{ijk}= 0. It is important to highlight that we have several BMPs across multiple environmental risk areas, and a producer's adoption decision for each practice is binary: "Yes" for adoption, and "No" for non-adoption. Based on the eligibility and adoption criteria for each practice, we calculated the BMP adoption scores across multiple risk areas. As we plan to develop econometric models for each risk area using these fractional scores, interpreting the models in terms of the random utility framework will not be straightforward.

6.3.3. An Econometric Model Identification

Given that the eligibility and adoption criteria for the BMPs across multiple risk areas are the same, we merged the ESAT 2014, 2016, and 2018 survey rounds. We could not merge the 2021 and 2023 survey data as the number of BMPs was reduced and the wording of some questions was altered making the comparison of the results somewhat difficult. Consequently, our analyses will be based on three datasets: a pooled cross-sectional dataset from the 2014-2018 rounds, and separate datasets for the 2021 and 2023 rounds. Focusing on our goal of examining the factors affecting the BMP decisions of the agricultural producers in rural municipalities of Alberta, we excluded data from farms in cities such as Edmonton, Calgary, and Fort McMurray. We merged these ESAT survey farm level datasets with various corresponding annual municipal information using the regional location of the farm reported in each ESAT survey round. This allows examination of the exposure of each farm in the ESAT survey data to municipal extension and tax funding information, membership of the municipality in various agricultural research associations, extension technician coverage, and availability of ALUS funding. We note that some of the rural municipalities were omitted from the analysis.[59]

As in Chapter 4, the choice of our econometric modeling approach is guided by the nature of our dependent variable and the characteristics of our data. Our dependent variable $ESA\ Score_{ik}$ lies within the [0,1] interval as a producer could theoretically reach a 100% completion rate under each risk area or adopt none of the recommended BMPs. For simplicity, we incorporated the BMPs under the 'Agricultural Waste Management' environmental risk area to the 'General Practices'. In our data, within each risk area we have some extreme values of 0s and 1s (see Tables 6.3 and 6.4).

Table 6.3. Number of Extreme Values Associated with BMP Adoption Scores Across Agri-Environmental Risk Areas based on the 2014-2018 Environmentally Sustainable Agriculture Tracking Surveys.

Risk Areas	Number of "0" s	Number of "1" s	Sample Size
Soil Conservation	432 (41%)	30 (3%)	1047
Water Quality and Quantity	22 (2%)	445 (35%)	1,279
Wildlife Habitat Conservation	219 (17%)	748 (58%)	1,282
Grazing Management	152 (20%)	437 (57%)	773
Manure Management	24 (3%)	165 (23%)	729
Energy and Climate Change	843 (65%)	14 (1%)	1,293

[59] See Table 4.2A of Chapter 5 in Appendix 4.

General Practices	269 (21%)	27 (2%)	1,293
Overall ESA	4 (0.3%)	1 (0.1%)	1,283

Table 6.4. Number of Extreme Values Associated with BMP Adoption Scores Across Agri-Environmental Risk Areas based on the 2021-2023 Environmentally Sustainable Agriculture Tracking Surveys.

Risk Areas	Number of "0" s		Number of "1" s		Sample Size	
	2021	2023	2021	2023	2021	2023
Soil Health	69 (14%)	71 (15%)	111 (23%)	96 (20%)	485	473
Water Quality	7 (2.2%)	22 (7%)	112 (36%)	179 (57%)	314	316
Biodiversity	7 (1.4%)	110 (24%)	206 (42%)	109 (24%)	497	463
Air Quality	159 (32%)	123 (12%)	71 (14%)	9 (2%)	497	499
Overall	0	9 (2%)	10 (2%)	0	497	499

We discussed various modeling approaches for the fractional response variable employed in Chapter 4 as well as the need to consider multiple fixed effects. Similar considerations are involved with this farm-level response data. However, when an econometric model does not have many fixed effects, using the fractional logit model described by Papke and Wooldridge (1996) is one of the best approaches. When the true model is unknown and the goal is only to understand the causal impact of independent variables on a response variable rather than accurate prediction of the response, then adhering to a linear regression function is advised over arbitrarily choosing a non-linear alternative (Angrist & Pischke, 2009).

Regarding our study, in the ESAT survey dataset, we cannot really control for the municipal-level fixed effects as the municipalities are imbalanced in our pooled cross-sectional dataset, meaning that some municipalities are not represented in the earlier rounds of the survey data.[60] Thus, we will only account for the year fixed effects in our 2014-2018 model. In the previous chapters, we

[60] The producer data within an ESAT survey round does not come from each Alberta municipality, thus not all municipalities are represented in each ESAT survey dataset we used.

discussed the importance of the EFP in educating agricultural producers about environmental risks on their farms and accessing the BMP cost-shared funding offered by the agricultural policy framework in Alberta.[61] Therefore, we will account for the EFP adoption within our BMP adoption models. We assume that all explanatory variables in our BMP models are exogenous, except the EFP adoption variable. Hence, we hypothesize that the EFP adoption variable is endogenous within the BMP equation.

The endogeneity of one of the explanatory variables typically stems from issues such as simultaneous causality, omitted variables, measurement error, and reverse causality. Commonly, the problem arises from omitted variable bias, which occurs when a relevant explanatory variable correlated with the included regressors is left out from the model, or if there are unobservable omitted factors that influence both the outcome and the regressor of interest. Not addressing the issue leads to biased and inconsistent estimates as well as poor predictive power of the model (Verbeek, 2017). In our case, in Chapters 4 and 5, we identified some of the factors affecting the EFP adoption at both municipal and farm levels in Alberta. We assume that some of these factors might also be influencing the producer's decision to adopt BMPs. To deal with the presumed endogeneity, we will test the variables as instruments to explain the EFP adoption within the BMP equation from the previous chapters. Given that we have a fractional response model with a binary endogenous explanatory variable (EEV), we will consider both linear and non-linear methods of testing for and addressing the endogeneity.

To deal with the endogeneity in the presence of a discrete EEV, we can still use the instrumental variables (IV) approach with the linear model estimated by two-stage least squares (2SLS) to instrument the endogenous binary regressor (Angrist, 2001; Angrist & Imbens, 1995; Terza et al., 2008). This approach requires the instruments z to meet two conditions: 1) relevance $Cov(z, y_2) \neq 0$ where the instruments in the vector z are correlated with the endogenous variable y_2, 2) exogeneity $Cov(z, \varepsilon_1) = 0$ where a vector of instruments z must not be correlated with the error term of the main equation (Verbeek, 2017). Angrist & Pischke (2009) suggest that the exogeneity requirement of an instrumental variable is more complicated as it requires two things. First, the instrument must be randomly assigned and not influenced by the dependent variable y_1

[61] Refer to the Figure 2.1. in Chapter 2.

(conditional upon regressors). Second is the condition of ‘exclusion restriction’, where the instrument predicts the dependent variable y_1 only through the instrumented variable y_2, conditional upon other regressors, not directly or through a third unobserved variable, and it requires the instrument itself to be excluded from the main equation. The endogeneity in the linear models can be established using several diagnostic tests. For instance, the Durbin-Wu-Hausman test suggests that we should compare the OLS estimator with the IV estimator with a null hypothesis of no systematic difference between the two estimates, implying that the EEV y_2 is exogenous (Davidson & MacKinon, 2021).

However, while the 2SLS IV method can be used as an alternative, tackling the problem of endogeneity in limited dependent variable models is complicated due to their nonlinear nature (Wooldridge, 2010). In our case, as our structural equation, which is the equation of interest, and the reduced form equation, which estimates the EEV, are both nonlinear, we will consider the two-step control function method. According to Wooldridge (2010), the control function approach uses additional regressors to break the correlation between endogenous explanatory variables and unobserved factors affecting the response variable. This approach was first suggested by Terza et al. (2008) as the two-stage residual inclusion (2SRI) IV method to solve the endogeneity problem for a binary EEV y_2, which involves adding residuals from the probit model for EEV y_2 to the main equation. Nevertheless, Wooldridge (2014) recommended the incorporation of the generalized residuals from the probit model in the first stage instead, as the inclusion of residuals cannot be justified. Therefore, we will also explore the two-step control function model recommended by Wooldridge (2014) for the structural equation with a fractional response variable and a binary endogenous explanatory variable.

To implement this approach, first we will regress the other explanatory variables along with the regressors using the probit model with the underlying normality assumption. Next, we will extract the generalized residuals from the probit model and plug them into the fractional probit model along with the EEV y_2. We can also interact the generalized residuals with the EEV y_2. It is important to note that this approach posits that the error term ε_1 in the main equation y_1 depends on (z, y_2) only through the generalized residuals r_2 from the first stage y_2. This method focuses on the average partial effects rather than parameter estimates. After the estimation, the coefficient of the residual r_2 and the interaction term $y_2 r_2$ can be tested using the Wald test with the null hypothesis of exogeneity.

As seen, in the presence of the binary EEV within the fractional response equation, handling the endogeneity is complex. Employing the nonlinear modeling approach offers an approximate solution to the endogeneity problem and uses strong assumptions about the parameters of the model, as noted by Wooldridge (2014, 2015). On the other hand, using the Linear Probability Model for the binary EEV and linear model for the main equation may not yield consistent results either as the estimated probabilities might fall outside the [0,1] interval and the linear functional form may not effectively capture the potential nonlinear relationship between explanatory and response variables (Papke & Wooldridge, 1996, 2008; Horrace & Oaxaca, 2006). Therefore, we will explore both linear and non-linear models, selecting the most suitable model based on the outcomes of diagnostic tests. We will also outline the mathematical representation of both the 2SLS IV and the two-step control function approaches in the discussion below.

Two-Step Control Function Approach

In the first step of the two-step control function approach suggested by Wooldridge (2014), the probit model is chosen due to the underlying normality assumption. The model is given by:

$$y_2 = 1[z\delta_2 + \varepsilon_2 \geq 0] \text{ with } \varepsilon_2 | z \sim Normal\ (0,1)$$

where y_2 is the binary EEV, z includes all exogenous variables (i.e., instruments) that influence y_2, δ_2 is the vector of coefficients, and ε_2 is the error term, assumed to be normally distributed and capturing unobserved factors included in z. In this stage, we estimate this probit model and calculate the inverse Mills ratio, which is the ratio of the probability density function ϕ to the cumulative distribution function Φ:

$$\hat{P} = P(y_2 = 1|z) = \Phi(z\delta_2)$$

$$\lambda = \frac{\phi(z\delta)}{1-\Phi(z\delta)} \text{ (for non-selection, i.e., } y_2 = 0)$$

$$\lambda = \frac{\phi(z\delta)}{\Phi(z\delta)} \text{ (for selection, i.e., } y_2 = 1)$$

The inverse Mills ratio is also referred to as the generalized residuals and corrects for the non-randomness of the of the sample in the main equation (Vella, 1998; Wooldridge, 2015). We assume that λ captures all the endogeneity that arises from the omitted variable bias, in the main model.

In the second stage, we will incorporate the Mills ratio and its interaction with the EEV, along with the EEV to the main fractional response probit model y_1:

$$y_1 = \Phi(x_1\beta_1 + \gamma\, y_2 + \theta\lambda + \delta(y_2\lambda) + \varepsilon_1)$$

where y_1 is the dependent variable of the structural equation, Φ denotes cumulative distribution function of the standard normal distribution, x_1 is the vector of other exogenous predictors on y_1, y_2 is the EEV, λ is the generalized residuals from the first stage, and $y_2\lambda$ is the interaction between the EEV and the generalized residuals, and ε_1 is the error term accounting for other unobserved heterogeneity in the model. The β_1, γ, θ, and δ are the parameters to be estimated. The conditions on the model are:

$$E(y_1|y_2, z, \lambda) = \mathrm{E}(y_1|y_{2,}\lambda)$$

$$E(y_1|y_2, z, \lambda) = \mathrm{E}(y_1|x_1\lambda)$$

where the first condition indicates that the generalized residuals λ fully encapsulate the endogeneity of the EEV y_2. Once we control for λ, the additional presence of the instruments z in the main equation does not provide any further information about our response variable y_1. Further, to understand the magnitude of the effect of the EEV y_2 on the dependent variable y_1, the average partial effects can be obtained using statistical software such as Stata. In the last step, the estimated coefficients θ and δ from the generalized residual and its interaction with the EEV y_2 can be tested using the Wald test. The null hypothesis tested here examines whether the coefficients associated with these residuals are zero, indicating no endogeneity issues.

The Two-Stage Least Squares Instrumental Variables Approach (2SLS IV)

We will employ the 2SLS IV approach from the econometric textbooks by Verbeek (2017) and Greene (2012). The first stage of the model is given by:

$$X = Z\Pi + U$$

where X represents the matrix of endogenous variables that are potentially correlated with the error terms in the main equation, Z is the matrix of instrumental variables and other exogenous variables, and Π is the coefficients to be estimated, and U is the error term for the first stage regression. We estimate the coefficients Π in the first stage and obtain the predicted values of X:

$$\widehat{\Pi} = (Z'Z)^{-1}Z'X$$

$$\hat{X} = Z\widehat{\Pi}$$

where $\widehat{\Pi}$ and $\hat{X}$ are the estimates obtained from the first stage. In the second stage, predicted values $\hat{X}$ are used as regressors in the second stage:

$$Y = \hat{X}\beta + \varepsilon$$

where Y is the dependent variable, β is the coefficient measuring the impact of X on Y, and ε is the error term. The estimation of β is given by:

$$\hat{\beta}_{IV} = (\hat{X}'\hat{X})^{-1}\hat{X}'Y$$

where $\hat{\beta}_{IV}$ is the IV estimator of β obtained by regressing Y on the predicted values $\hat{X}$ from the first stage. The 2SLS IV approach has the following conditions on the instruments:

1. Relevance – $Cov(Z, X) \neq 0$, the instruments Z must be correlated with the endogenous regressors X;

2. Exogeneity – $Cov(Z, \varepsilon) \neq 0$, the instruments must be uncorrelated with the error term ε of the main equation;
3. Exclusion – the instruments Z should affect the dependent variable Y only through the endogenous variables X.

After the estimation, there are several diagnostic tests that examine the validity and the strength of the instruments. For example, Verbeek (2017) recommends checking if the F-test after the first stage exceeds 10. A high F-statistic in the first-stage regression means that the instruments are sufficiently correlated with the endogenous variables they are supposed to predict, reducing the likelihood of the bias associated with weak instruments. We will utilize the 'ivreghdfe' Stata command by Correia (2016), controlling for time fixed effects. This command will produce weak identification tests such as the Kleibergen-Paap rk Wald F statistic and Stock-Yogo, Craig-Donald Wald F-statistic, under-identification test such as the Kleibergen-Paap rk LM statistic, and overidentification test such as the Hansen J statistic. The under-identification test, the Kleibergen-Paap rk LM statistic, examines whether the instruments in the IV regression model are strong enough to reject the null hypothesis of under-identification. If the equation is under-identified, it implies that the instruments fail to provide enough information to estimate the parameters of the endogenous variables uniquely (Kleibergen & Paap, 2006). Similarly, the weak identification tests also assess whether the instruments are strong enough to provide reliable estimates, as weak instruments can lead to biased and inefficient estimates. Generally, for the instruments to pass the tests, the values of the Kleibergen-Paap rk Wald F statistic and Craig-Donald Wald F-statistic should be higher than the certain threshold of the Stock-Yogo critical values (Cragg & Donald, 1993; Stock & Yogo, 2005; Kleibergen & Paap, 2006). The Stock-Yogo test focuses on the potential bias in the IV estimator relative to an OLS estimator. The threshold values help to ensure that the bias does not exceed certain percentages like 5%, 10%, 20%, or 30% of the OLS estimator's bias. Choosing the acceptable bias threshold is up to the researcher's objectives (Andrews, et al., 2019). Regarding the overidentification test, the Hansen J statistic examines whether the residuals from the 2SLS regression are orthogonal to the instruments used. If the test statistic is significantly different from zero, it suggests that the overidentifying restrictions are invalid, and the instruments are correlated with the error terms (Hansen, 1982).

6.3.4. Key Variables Selection and Empirical Models

The meta-analyses of several adoption studies by Prokopy et al. (2008) and Knowler and Bradshaw (2007) determined that there are no factors consistently influencing BMP adoption as the effect of the variables might differ across farmers and farm locations. Nonetheless, several studies found that farm and farmer characteristics, extension efforts, and socio-economic factors are critical in BMPs adoption decisions of the farmers (Wu & Babcock 1998; Prokopy et al., 2019; Knowler & Bradshaw, 2007). For instance, older age is often correlated with a low adoption rate as older farmers tend to be less inclined to adopt conservation practices (Prokopy et al., 2008, 2019; Baumgart-Getz et al., 2012; Feder & Umali, 1992). This might be due to older farmers having shorter planning horizons than younger farmers (Baumgart-Getz et al., 2012). Also, younger farmers might be more aware of the benefits of the BMPs (Gould et al., 1989; Carlisle, 2016).

The education level of the farmer has been shown to positively influence adoption rates across numerous studies (Knowler & Bradshaw, 2007; Prokopy et al., 2008). Specifically, higher levels of education favored adoption (Prokopy et al., 2019; Knowler & Bradshaw, 2007; Ghazalian et al., 2009), particularly the adoption of more complex technologies (Pannell et al., 2006). Additionally, farmers' participation in conservation training has been observed to positively influence adoption (Baumgart-Getz et al., 2012; Van Wyngaarden, 2021).

Land tenure decisions can also play a significant role in the adoption of BMPs. Studies by Soule et al. (2000) and Kim et al. (2005) suggest that renters are less inclined to adopt BMPs that offer long-term benefits compared to the owners. However, other studies have not established a significant relationship between tenure and adoption (Baumgart-Getz et al., 2012; Knowler & Bradshaw, 2007; Liu et al., 2018).

In addition, farm production types, such as livestock or crops can impact BMP adoption. Prokopy et al. (2008) discovered that livestock farmers were considerably less inclined to implement conservation practices compared to crop farmers.

Finally, farm succession planning is expected to increase the BMP adoption rate (Gillespie et al. 2007; Prokopy et al. 2019). In our study, we define 'maintaining or expanding the farm operation' variables as indicative of farm succession planning and hypothesize that these variables positively affect BMP adoption.

Apart from the above-mentioned factors, extension efforts and participation by producers in conservation programs, catchment groups, and land care groups have also been positively associated with adoption (Upadhyay et al., 2003; Gillespie, et al., 2007; Kington & Pannell, 2003; Marsh & Pannell, 2000; Prokopy et al., 2015). Therefore, we attempted to assess the exposure of farms to extension using municipal-level information. Since extension is largely the responsibility of the Agricultural Services Boards (ASBs) of the municipalities, we used various measures of funding as a proxy for extension efforts. As discussed in Chapter 4, the ASBs of the municipalities fund their programs through property taxes, user fees, grants and other funding sources (ASBs, 2023). One of these measures, available in Alberta Government records, was the annual tax revenue from each municipality. We divided this by the number of farms in that municipality to derive a level of influence of the farm sector in the regional economy.

We also generated a dummy variable for the presence of ALUS in a municipality. Each municipality that maintained an ALUS program had the dummy variable equal to '1', while those that did not have a value of 0. We expected the presence of an ALUS program to have a positive impact on BMP adoption. As ALUS programs offer the producers and landowners cost-share funding to establish BMPs as well as annual per-acre payments for their management and maintenance, and that they do not require an EFP for participation (ALUS, 2023; Rocky View County, 2023), we expected the ALUS dummy to have a positive effect on BMP adoption.

As the EFP is an extension tool that educates producers on the environmental risks on their farms and is a requirement for government-provided BMP cost-shared funding, we will include it in the BMPs equations. However, we assume EFP adoption to be endogenous within this equation and we will search for instruments to explain EFP within the BMP framework. Generally, the valid instruments may follow the economic theory, or have been studied in previous research (Verbeek, 2017). In our case, only Van Wyngaarden (2021) tried to address the endogeneity of the EFP but failed to find valid instruments. Thus, we will choose our instruments based on the significant determinants of EFP adoption at the municipal and farm levels explored in Chapters 4 and 5 of this thesis.

Based on the existing literature, and using the variables in Table 6.5, we will estimate the following empirical models:

1) *Two-Stage Control Function Approach:*

$$(i)\ \Pr(EFP_i = 1|z_i) = \Phi(\Upsilon_0 + \Upsilon_1(z_{instruments,i}) + \Upsilon_2(x_{exogenous,i}) + \ u_i)$$

$$(ii)\ \Pr(ESA\ Score_{ik} = y_{ik}|x_i, \hat{r_i}) = \Phi(\beta_0 + \beta_1 EFP_i + \beta_2 \hat{r_i} + \beta_3(EFP_i * \hat{r_i}) + \beta_4 Age1844_i + \beta_5 Age4564_i + \beta_6 Training_i + \beta_7 Education_i + \beta_8 Livestock_i + \beta_9 Crops_i + \beta_{10} Own\_land_i + \beta_{11} Maintain/Expand_i + \beta_{12} Annual\ Municipal\ Tax\ Revenue_i + \beta_{13} Year_{ik} + \varepsilon_{ik}$$

where y_i represents the ESA score for the producer *i* in a risk area *k*, which is in the interval [0,1], and $\hat{r_i}$ is the generalized residuals from the first stage. Note that, the first stage is estimated using the probit, and the second stage employing the fractional probit models.

2) *Two-Stage Least Square Instrumental Variables Approach (2SLS IV):*

$$(i)\ EFP_i = \alpha_0 + \alpha_1(z_{instruments,i}) + \alpha_2(x_{exogenous,i}) + \epsilon_i$$

$$(ii)\ ESA\ Score_{ik} = \beta_0 + \beta_1 \widehat{EFP_i} + \beta_2 Age1844_i + \beta_3 Age4564_i + \beta_4 Training_i + \beta_5 Education_i + \beta_6 Livestock_i + \beta_7 Crops_i + \beta_8 Own\_land_i + \beta_9 Maintain/Extend_i + \beta_{10} Annual\ Municipal\ Tax\ Revenue_i + \beta_{11} Year_{ik} + \varepsilon_{ik}$$

where $\widehat{EFP_i}$ are the predicted values of the EFP adoption EFP_i from the first stage.

Also, for the ESAT survey round for which we cannot find valid instruments, we will estimate the following linear and fractional logit models for the sample with and without an EFP:

a) *Linear OLS Model:*

$$ESA\ Score_{ik} = \beta_0 + \beta_1 Age1844_i + \beta_2 Age4564_i + \beta_3 Training_i + \beta_4 Education_i + \beta_5 Livestock_i + \beta_6 Crops_i + \beta_7 Own\_land_i + \beta_8 Maintain/Extend_i + \beta_9 Annual\ Municipal\ Tax\ Revenue_i + \varepsilon_{ik} \quad \sim EFP = 0$$

$$ESA\ Score_{ik} = \beta_0 + \beta_1 Age1844_i + \beta_2 Age4564_i + \beta_3 Training_i + \beta_4 Education_i + \beta_5 Livestock_i + \beta_6 Crops_i + \beta_7 Own\_land_i + \beta_8 Maintain/Extend_i + \beta_9 Annual\ Municipal\ Tax\ Revenue_i + \varepsilon_{ik} \quad \sim EFP = 1$$

b) *Fractional Logit Model:*

$$ESA\ Score_{ik} = \frac{\exp(x'\beta)}{1 + \exp(x'\beta)} \qquad \sim EFP = 0$$

$$ESA\ Score_{ik} = \frac{\exp(x'\beta)}{1 + \exp(x'\beta)} \qquad \sim EFP = 1$$

where x is the vector of our independent variables.

Table 6.5. Description of the Key Variables Used in the Econometric Analysis of the Farm-level Beneficial Management Practices Adoption in Alberta.

Key Variables	Description
Dependent Variable:	
$ESA\ Score_{ik}$	Proportion of the number of practices adopted by a producer *i* in the environmental risk area *k* relative to the number of practices for which producer *i* is eligible in the same risk area.
Independent Variables:	
Age 18-44	Producers' age ranging from 18 to 44.
Age 45-64	Producers' age ranging from 45 to 64.
Training	If the producer attended any agri-environmental training sessions in the past two years.
Education	If the producer attended a degree or diploma program, specifically in an agriculture related area.

EFP	If the producer holds an Environmental Farm Plan (EFP).
Livestock	If the main gross farm revenue source was from livestock.
Crops	If the main gross farm revenue source was from crops.
Own land	If the producer owns their farmland.
Maintain or expand operation	If the producer is planning to maintain or expand their current farm operations.
Extension Efforts Variables:	
Annual Municipal Tax Revenue per farm	Economic and Agricultural Development Revenue in a municipality divided by the number of farms in a municipality; as a proxy to municipality's tax funding; scaled by 10,000.
ALUS	If the municipality that a producer is in has an ALUS office (i.e., if the municipality is an ALUS member).
Instruments explored for the EFP adoption:	
GFR>250k	If the farm had gross farm revenue over $250 000 in the past year.
If the municipality is a part of RA (dummy)	If the municipality a producer is located is a part of one of the Applied Research and Forage Associations ('1' if 'Yes', and '0' if 'No').
Annual Municipal Environmental Extension funding per farm	Sum of ASB grants Environmental Program Funding Stream, Canadian Agricultural Partnership Funding through Environmental Stewardship and Climate Change programs, and Applied Research and Forage Associations funding through Environmental programs in a municipality divided by the number of farms in a municipality; scaled by 10,000.

6.4. Results

6.4.1. Descriptive Statistics

Environmentally Sustainable Agriculture Tracking Survey 2014-2018 rounds.

Table 6.6 presents the average number of eligible practices, adoption, and the mean value of the environmentally sustainable agriculture (ESA) practices score (also known as the BMPs adoption score) across seven environmental risk areas based on pooled 2014-2018 data from the ESAT survey.[62] The survey data pertains to the preceding production year. For example, the ESAT 2014 survey round corresponds to the 2013 production year, while the 2018 round corresponds to the 2017 production year. As the EFP is an important tool to educate the producers about their on-farm environmental risks, we have analyzed the mean values for the sample of all producers and producers with and without an EFP. Our analyses reveal that the BMPs under the 'Water Quality and Quantity (78%)', 'Manure Management (68%)', 'Wildlife Habitat Conservation (72%)', and 'Grazing Management (69%)' were frequently adopted by Albertan producers during the production year of 2013-2017. During this period, the Growing Forward-2 (GF2) agricultural policy framework was actively in operation and offered cost-shared funding ranging from 30-70% of adoption costs under the 'On-Farm Stewardship' and 'Confined Feeding Operation Stewardship' programs (Government of Alberta, 2015, 2016). These programs provided cost-shared funding for BMPs under several environmental risk categories, which align with the BMPs in the ESAT survey environmental risk categories mentioned above. The purpose of these programs was to improve water quality and promote sustainable management of inorganic agricultural wastes (Government of Alberta, 2015). Despite the government-sourced cost-shared funding availability for 'Agricultural Waste Management' BMPs such as 'used oil storage' and 'agricultural plastic waste management', the weighted mean adoption score was only 33% based on the pooled 2014-2018 ESAT survey rounds. Similarly, BMPs under 'Energy and Climate Change' were the least adopted based on the pooled survey results, with a weighted mean ESA score of 14%. In every environmental risk area, the adoption rate was higher among producers who held an EFP in comparison to those who did not have one. Moreover, producers who had an EFP were eligible for funding for more BMPs in all risk categories compared to the producers who did not hold one.

We also explored characteristics of producers who were eligible to adopt at least one of the BMPs across various agri-environmental risk areas in the ESAT survey.[63] Approximately 54-58% of these producers were between the age of 45 and 64 years. Additionally, 27-30% had degrees in agriculture-related fields, and 41-48% held an EFP. The highest attendance at conservation

[62] For simplicity, we incorporated the practices under the 'Agricultural Waste Management' into 'General Practices'.
[63] See Table 5.1A in Appendix 5.

training sessions, at 49%, was noted in 'Wildlife Habitat Conservation'. Around 39-42% of the producers owned their land, and over 55% both owned and rented their lands. In terms of farm succession planning, more than 60% of the producers were maintaining or planning to expand their farm operations. Also, overall, there were slightly more crop producers in the sample than livestock producers.

The Environmentally Sustainable Agriculture Tracking Survey 2021-2023 rounds.

Due to changes in eligibility criteria, the wording of the questions, and the number of questions in the 2021 and 2023 survey rounds (which correspond to the 2020 and 2022 production years), we were unable to merge these data with the 2014-2018 pooled dataset. Instead, we separately analyzed the mean eligibility and adoption of practices, as well as the weighted mean ESA adoption scores of the 2021 and 2023 survey rounds across four agri-environmental risk areas: 'Soil Health', 'Water Quality', 'Biodiversity', and 'Air Quality' (see Table 6.7). According to our results, on average, the producers were eligible to adopt 12 practices in 2021 and 13 practices in 2023 survey rounds. Out of these practices, in both survey rounds, the producers on average adopted 7 practices. The producers who held an EFP adopted more BMPs compared to the producers who did not hold one. Regarding the ESA scores, the overall adoption score was 6% greater in 2021 compared to the 2023 survey period.[64] Moreover, the overall adoption score was notably higher among the producers who completed an EFP compared to producers who had not in both survey rounds. According the 2021 ESAT survey data, 62% of producers mentioned that they completed an EFP to access the government cost-share funding. However, only 11% reported having accessed the government funding. Also, 72% of producers stated they adopted an EFP to identify and address environmental risks on their farms. This may suggest that producers adopted an EFP for both financial and educational reasons.

Across the four agri-environmental risk areas, the ESA scores for 'Water Quality' remained high, namely, 75% in 2021 and 76% in the 2023 survey rounds. Conversely, the ESA scores for 'Air Quality' were the lowest during the 2021 and 2023 survey periods, at 36% and 31% respectively.

[64] Our results may slightly vary than the results in the ESAT survey final reports as we dropped the cities from our analysis.

In all agri-environmental risk areas, producers with an EFP had a greater score than those without one. This could be due to the eligibility of the producers with an EFP to the cost-shared funding offered through the Canadian Agricultural Partnership's (CAP 2018-2023) Environmental Stewardship and Climate Change programs (Government of Alberta, 2019). The producers without an EFP still adopted BMPs across all environmental risk areas, suggesting that they might have reached out to other organizations for funding assistance such as the ALUS as their programs do not require an EFP completion.

As outlined in Figure 2.1 in Chapter 2, an EFP not only serves as an educational tool for producers to learn about the environmental risks on their farms, but it also enables them to access BMP cost-shared funding through agri-environmental policy programs. Therefore, we hypothesize that the EFP is important in explaining BMP adoption and is possibly endogenous. In Chapters 4 and 5, we observed the provincial, farm, and producer-level factors significantly affecting EFP adoption. Using these statistically significant variables, we searched for instruments for our endogenous EFP variable.

Since we could not find instruments that explain EFP adoption within the BMP equation, we examined the characteristics of producers both with and without an EFP, who were eligible to adopt at least one of the BMPs across four agri-environmental risk areas in the 2021 and 2023 ESAT surveys.[65] This analysis will be useful in interpreting regression results for these survey periods in the next section. Our findings show that, in both 2021 and 2023, the average age range for producers who had an EFP and were eligible for at least one of the BMPs was 55-64 years. Conversely, producers without an EFP tended to be older, falling within the 65-74 years age range. In both periods, more producers with an EFP had a degree in an agriculture-related field and had attended conservation training sessions compared to the producers without an EFP. Furthermore, in both survey rounds, a higher percentage of the BMP eligible producers with an EFP across all environmental risk areas, generated gross farm revenue exceeding $250,000 in the last production year. Also, the share of the BMP eligible producers with an EFP who were planning to reduce or sell their farm operations was higher than the sample without an EFP in the 2023 survey period. On the contrary, in 2021, more BMP eligible producers without an EFP across all environmental

[65] See Tables 5.2A and 5.3A in Appendix 5.

risk areas were planning to reduce or sell their farm operations. Moreover, in 2021, a higher percentage of BMP eligible producers with an EFP owned their land compared to those without an EFP. However, in 2023, this trend had reversed, with a greater proportion of eligible producers without an EFP owning their land.

Table 6.6. Mean Value of BMPs Eligibility and Adoption for Alberta producers across Seven Agri-Environmental Risk Areas based on the pooled 2014-2018 Environmentally Sustainable Agriculture Tracking Survey Dataset.

	Soil Conservation (3 practices)	Water Quality & Quantity (12 practices)	Wildlife Habitat Conservation (3 practices)	Grazing Management (2 practices)	Manure Management (11 practices)	Energy & CC (3 practices)	General Practices (6 practices)	Overall Practices (40 practices)
Mean number of eligible practices								
All Producers	2.4	6.6	0.94	1.1	3.2	2.8	4.3	22.5
Producers with an EFP	2.6	6.7	2	1.4	3.3	2.9	4.7	23.25
Producers without an EFP	2.2	6.6	2.13	1.2	3.2	2.8	4	21.85
Mean number of adopted practices								
All Producers	0.8	5.3	1.5	1.3	3.8	0.4	1.5	12.3
Producers with an EFP	1	5.6	1.5	1.4	4.3	0.5	1.7	13.4
Producers without an EFP	0.7	5	1.5	1.2	3.5	0.3	1.3	11.4
Mean weighted ESA score in %								
All Producers	26%	78%	72%	69%	68%	14%	33%	53%
Producers with an EFP	32%	83%	73%	76%	72%	17%	37%	57%
Producers without an EFP	21%	74%	71%	64%	66%	11%	30%	50%

Table 6.7. Mean Value of BMPs Eligibility and Adoption for Alberta producers across Four Agri-Environmental Risk Areas based on the 2021-2023 Environmentally Sustainable Agriculture Tracking Survey.

	Soil Health (5 practices)		Water Quality (7 practices)		Biodiversity (5 practices)		Air Quality (3 practices)		Overall Practices (20 practices)	
	2021	*2023*	*2021*	*2023*	*2021*	*2023*	*2021*	*2023*	*2021*	*2023*
Mean number of eligible practices										
All Producers	3.2	3.2	2.7	2.8	3.4	3.2	2.1	3	11	12
Producers with an EFP	3.3	3.4	2.8	3	3.4	3.2	2.1	3.2	12	13
Producers without an EFP	3.1	3	2.5	2.5	3.3	3.2	2.1	3	11	12
Mean number of adopted practices										
All Producers	2	2	3.3	3.8	2.1	1.8	1	1	7	7
Producers with an EFP	2	2	3.5	4	2.2	1.9	1	1	8	8
Producers without an EFP	1.6	2	3	3.4	1.9	1.8	1	1	4	6
Mean weighted ESA score in %										
All Producers	45%	49%	75%	76%	67%	53%	36%	31%	56%	50%
Producers with an EFP	53%	56%	79%	86%	71%	53%	45%	42%	63%	58%
Producers without an EFP	38%	43%	71%	73%	65%	53%	29%	25%	51%	45%

Alberta Land Use Services (ALUS) Partnership 2020-2022

The first ALUS program in Canada was launched in 2006 in the Rural Municipality of Blanshard in Manitoba in collaboration with Keystone Agricultural Producers and Delta Waterfowl Foundation. The program arrived in Alberta in 2010, with the first ALUS project initiated in the County of Vermilion River. Later, in 2012, Parkland County joined the ALUS Community (ALUS, 2023). Currently, there are 21 ALUS partnerships in Alberta offering cost-shared programs across several agri-environmental risk areas. The common BMP projects ALUS is interested in funding are:

- Riparian Management
- Adaptive Multi-paddock Grazing
- Cropland Conversion
- Eco-buffers
- Delayed Grazing/Haying
- Bioengineering
- Water Retention
- Salinity
- Habitat Connectivity
- Pollinator Strips
- Afforestation

However, the list is not exhaustive and ALUS may fund any project that increases ecosystem services and improves the environment (Campbell, C., ALUS, personal communication, April 15, 2024).

Table 6.8 shows the ALUS partner municipalities and their EFP completion rates in Alberta for 2020 and 2022. Since we have data on ALUS partnerships for these years, we will merge them with the ESAT 2021 and 2023 surveys as the survey rounds correspond to the previous production year. In 2020, ALUS had partnerships with 15 municipalities.[66] Later in 2022, six more municipalities joined the ALUS partnership.[67] As discussed in Chapter 4, among the ALUS partner municipalities, only Red Deer, Wheatland, Mountain View, and Vermilion River are associated with frequently high EFP completion numbers, while Northern Sunrise and Brazeau

[66] We counted as 15, but Wetaskiwin-Leduc is considered as one ALUS Partnership.
[67] Barrhead-Westlock-Athabasca is considered as one ALUS Partnership.

municipalities frequently had low EFP completion numbers. Also, our analyses indicate that almost half of the member municipalities in 2020 and 2022 had low EFP completion numbers. This may suggest that the agricultural producers in these municipalities might prefer accessing ALUS cost-shared funding rather than government funding as the former does not have an EFP completion requirement.

Table 6.8. ALUS partner municipalities in Alberta by EFP completion rates and numbers in 2020 and 2022 calendar years.

2020		2022	
Partners	***EFP completion numbers***	***Partners***	***EFP completion numbers***
Vermilion River, County of	23	Red Deer, County of	23
Red Deer, County of	19	Lacombe, County of	20
Mountain View, County of	18	Vermilion River, County of	20
Flagstaff, County of	14	Mountain View, County of	18
Lacombe, County of	13	Leduc, County of	17
Wetaskiwin, County of	13	Wheatland, M.D. of	15
Wheatland, M.D. of	12	Westlock, County of	15
Two Hills, County of	7	Rocky View, County of	14
Rocky View, County of	6	Wetaskiwin, County of	14
Big Lakes, County of	4	Barrhead, County of	13
Northern Sunrise, County of	4	Athabasca, County of	10
Leduc, County of	4	Flagstaff, County of	7
Parkland, County of	2	Parkland, County of	6
Brazeau, County of	1	Vulcan, County of	4
Lac Ste. Anne, County of	0	Two Hills, County of	4
		Lac Ste. Anne, County of	4
		Pincher Creek, M.D. of	4
		Sturgeon, County of	2
		Big Lakes, County of	2
		Northern Sunrise, County of	1
		Brazeau, County of	0

Source: ALUS (2023, 2024); ARECA (2023)

6.5. Regression Results

Due to changes in the quantity and wording of the ESAT survey questions after 2018, we were not able to merge the recent datasets. Thus, we estimated three models for three datasets: the pooled 2014-2018, 2021, and 2023 ESAT survey models. The main goal of our study was to fill the research gap hypothesized in a study by Van Wyngaarden (2021) about the endogeneity of the Environmental Farm Plan (EFP) within BMPs adoption equations. We succeeded in finding potential instruments for the pooled 2014-2018 model based on the results of several hypothesis tests utilizing the influential variables uncovered in Chapters 4 and 5, which focused on the municipal and farm-level EFP adoption determinants. Some of these determinants such as 'research associations membership of the municipalities', 'annual municipal tax revenue', 'EFP technician coverage', 'annual municipal environmental extension grants', and the extension efforts by the Agricultural Service Boards (ASBs) of the municipalities, represent agri-environmental extension variables that are intended to promote EFP adoption. For the 2021 and 2023 models, none of the potential instruments from our previous chapters were valid. Thus, for these survey periods, we divided our sample into the producers with and without an EFP to correct for assumed endogeneity following Van Wyngaarden (2021). Since we have data on the ALUS partnership of certain municipalities, we examined if the presence of ALUS in those municipalities affected BMP adoption at the farm level. It is crucial to note that along with the cost-shared funding without an EFP requirement, ALUS also provides technical assistance to the producers with their BMP projects' implementation. Below, we will discuss our findings for all our models based on ESAT survey rounds from 2018 to 2023.

6.5.1. Results from the IV 2SLS and Two-Step Control Function Methods based on the 2014-2018 ESAT Surveys

To address the presumed endogeneity of the EFP adoption variable in the BMP equations, we estimated our 2014-2018 model employing both the Instrumented Variables Two Stage Least Squares (IV 2SLS) and the two-step Control Function (CF) approaches by Wooldridge (2014). The time fixed effects for the IV 2SLS models have been absorbed using the 'ivreghdfe' Stata command, while in the control function models, we incorporated time fixed effects associated with survey rounds.[68] We tested several variables that explained the EFP adoption at the farm and rural municipal levels in the previous chapters as instruments for the endogenous EFP within BMP equations. Only the combination of 'research associations membership of the municipalities', 'gross farm revenue over $250,000 at the farm level', and 'annual municipal environmental extension funding per farm' variables passed the diagnostic tests for the instruments. We could not perform the Durbin-Wu-Hausman test for endogeneity as our dataset used weights and the test is sensitive to weights and heteroskedasticity-robust standard errors. Given that our main response variable is fractional, the previous research suggested the use of heteroskedasticity-robust standard errors in both linear and nonlinear estimations (Lewis & Linzer, 2005; Wooldridge, 2014, 2015). As the two-step control function approach for fractional response variables with a binary endogenous variable produces larger standard errors, Wooldridge (2014) recommended bootstrapping the standard errors to improve the accuracy of the estimates. However, we were unable to do so, again, because of the weights applied to our data. The results from both models should be used with caution due to these estimation setbacks we encountered. Prior to analyses, we conducted a Variance Inflation Factor (VIF) test on our independent variables to detect multicollinearity, following Verbeek (2017), who recommended a VIF threshold of 10. The VIF values for our models were below 2, indicating no significant multicollinearity issues.

Table 6.9 presents both linear and nonlinear regression results for the overall ESA adoption rate (i.e., BMP adoption score) and two environmental risk areas 'Water Quality and Quantity' and 'Energy and Climate Change' based on the ESAT survey for 2014-2018. Our analyses address the potential endogeneity issues associated with the binary EFP adoption variable, which is '1' for adoption, and '0' for non-adoption, in the BMPs adoption framework. In all our models, we instrumented the EFP variable using 'research associations membership of the municipalities', 'gross farm revenue over $250,000 at the farm level', and 'annual municipal environmental extension funding per farm' variables from the preceding chapters. The results from the IV 2SLS estimation for the 'Overall' ESA adoption score reveal that having an EFP led to a 0.17 percentage point increase in the overall adoption score.

[68] Also, note that we excluded variables such as equal mix, rent land, both own and rent, reduce or sell variables as a reference category.

In the two-step control function model, the generalized residuals ($\hat{r}_i$) from the first stage probit regression were statistically significant, indicating that the CF approach worked and that the EFP variable is likely to be endogenous. The Wald test results on the EFP variable in Table 6.10 and its interaction with the generalized residuals ($EFP * \hat{r}_i$) from the first stage indicate strong evidence against the null hypothesis of exogeneity, suggesting that the EFP is endogenous in our model and validating the importance of the generalized residuals in the second stage fractional probit model. It is important to note that we assume the generalized residuals correct for endogeneity. The average partial effects on the EFP ($\widehat{APE}_{EFP}$) have the same positive magnitude as in the IV 2SLS model for the overall BMP adoption. Also, both linear and nonlinear models indicate that overall, crop producers were less likely to adopt BMPs compared to producers accumulating earnings from the equal mix of crop and livestock production. In the CF model, producers having a degree related to an agricultural field substantially enhanced overall BMP adoption.

In the 'Energy and Climate Change' ESA adoption score model, the endogeneity of the EFP and the use of the instruments was reasonable according to the diagnostic test results (see Table 6.10). In the CF approach, the Wald test only checks for endogeneity and validates the implementation of the control function, which involves the generalized residuals. Thus, we examined the strength and validity of our instruments based on diagnostic tests in the IV 2SLS estimation. The results reveal that all the instruments were strong and valid in the linear model. Regarding the factors affecting the BMP adoption score in this agri-environmental risk area, both estimation approaches demonstrate similar results. The producers who held an EFP tended to have higher adoption scores under 'Energy and Climate Change'. Being older and being a livestock producer were negatively associated with the adoption of those BMPs.

Further, in the 'Water Quality and Quantity' BMP adoption score model, the CF approach did not work as the included generalized residual ($\hat{r}_i$) from the first-stage probit model accounting for endogeneity of the EFP was statistically insignificant in the second-stage fractional probit model. Additionally, we failed to reject the null hypothesis of exogeneity in the Wald test on the EFP and its interaction with the generalized residual. Nevertheless, the IV 2SLS estimation diagnostic test results demonstrate that the instruments used to explain the impact of the EFP were valid and strong. Therefore, we only rely on the results of the linear estimation method for the adoption model under this agri-environmental risk area. The findings from the IV 2SLS reveal that younger producers with an EFP and a diploma were more likely to adopt BMPs under 'Water Quality and Quantity'.

In all our models, the annual municipal tax revenue per farm, which we assumed to be related to expenditures spent on agri-environmental extension in the municipal Agricultural Services Boards, was statistically insignificant.

Table 6.9. The ESA (BMPs) Adoption Regression Results for the pooled ESAT 2014-2018 Survey Rounds using the IV 2SLS and Control Function Approaches to Handle Endogeneity in EFP.

	Overall (SE)		*Water Quality and Quantity (SE)*		*Energy and Climate Change (SE)*	
Dependent Variables	IV 2SLS	Control Function	IV 2SLS	Control Function	IV 2SLS	Control Function
Age 18-44	0.021	0.054	0.059**	0.208*	-0.058	-0.325
	(0.021)	(0.053)	(0.027)	(0.097)	(0.036)	(0.155)
Age 45-64	-0.010	-0.024	0.017	0.058	-0.074**	-0.361***
	(0.013)	(0.030)	(0.019)	(0.060)	(0.022)	(0.090)
Education	0.022	0.066**	0.047**	0.177**	-0.027	-0.059
	(0.014)	(0.031)	(0.019)	(0.062)	(0.027)	(-0.059)
Training	0.0148	0.048	0.028	0.117*	-0.029	-0.094
	(0.014)	(0.032)	(0.020)	(0.067)	(0.031)	(0.103)
EFP	0.170***	0.391***	0.138**	0.409*	0.383***	1.717***
	(0.046)	(0.099)	(0.068)	(0.214)	(0.095)	(0.317)
Own land	-0.020	-0.045	-0.009	-0.023	0.035*	0.219**
	(0.012)	(0.029)	(0.018)	(0.057)	(0.021)	(0.084)
Maintain or expand operation	-0.004 (0.014)	0.008 (0.030)	0.005 (0.021)	0.034 (0.060)	-0.019 (0.024)	0.009 (0.090)
Crops	-0.054**	-0.137***	-0.013	-0.045	0.023	0.093
	(0.017)	(0.039)	(0.025)	(0.077)	(0.031)	(0.102)
Livestock	-0.009	-0.021	0.018	0.056	-0.081**	-0.451***
	(0.017)	(0.038)	(0.025)	(0.078)	(0.029)	(0.108)
Annual Municipal Tax Revenue per farm	0.041 (0.059)	0.063 (0.150)	0.015 (0.113)	0.009 (0.366)	0.014 (0.119)	-0.130 (0.549)
Year 2016		-0.001		-0.010		0.056
		(0.032)		(0.063)		(0.094)
Year 2018		-0.068*		-0.087		-0.045
		(0.034)		(0.064)		(0.090)
$\hat{r}_i$		-0.180**		-0.103		-1.027***
		(0.077)		(0.152)		(0.234)
$\mathbf{EFP}_i * \hat{r}_i$		0.010		-0.076		0.234
		(0.090)		(0.187)		(0.262)
Constant		0.034		0.459***		-1.646***
		(0.064)		(0.124)		(0.201)
$\widehat{APE}_{EFP}$		0.152***		0.118 **		0.365***
		(0.037)		(0.058)		(0.073)
No. of Obs.	999	999	996	996	1004	1004
AIC	-930.59	1381.24	-184.87	1091.28	196.13	736.54
BIC	-881.52	1454.84	-135.83	1164.84	245.25	810.21

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Note: Instruments for EFP: RA membership, Annual Environmental Extension Funding, GFR>250k

Table 6.10. The Results from the Diagnostic Tests for the pooled 2014-2018 ESAT Survey IV 2SLS and Control Function Models.

	Overall		*Water Quality and Quantity*		*Energy and Climate Change*	
	IV 2SLS	CF	IV 2SLS	CF	IV 2SLS	CF
Wald Test on EFP & $EFP_i * \widehat{r_i}$ (Chi-squared; Note: H0: Exogeneity)		14.99***		3.65		29.54***
Under-identification:						
Kleibergen-Paap rk LM statistic (Chi-squared)	37.99***		37.99***		39.18***	
Weak Identification:						
Cragg-Donald Wald F statistic	17.68		17.62		18.34	
Kleibergen-Paap rk Wald F statistic	14.18		14.17		14.76	
Stock-Yogo weak ID test critical values:						
5% maximal IV relative bias	13.91		13.91		13.91	
10% maximal IV relative bias	9.08		9.08		9.08	
Overidentification:						
Hansen J statistic (Chi-squared)	3.22		1.71		3.07	

6.5.2. Results for the 2021 and 2023 ESAT Surveys

To address the potential endogeneity of the EFP, we estimated our models with a split sample of producers: those who reported having an EFP and those who did not have one in 2020 and 2022 production years based on the ESAT survey 2021 and 2023 rounds. We applied both the linear and the fractional logit models for both survey rounds as outlined in Section 6.2.4. We could not account for incorporating the municipality related fixed effects in our models due to a small sample size and statistical issues such as incidental parameters associated with including many fixed effects in the fractional logit models discussed in Chapter 4. In linear models, controlling for municipal-level heterogeneity means adding over 60 municipality dummy variables which is too many given our limited sample size of producers. Therefore, instead of focusing on prediction, we decided to focus on the magnitude of the effects of the independent variables. For model selection, we relied on the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) values, as the F-test and LR tests are only appropriate in comparing nested models within the same family and the R-squared from linear models cannot directly be compared with pseudo-R-squared values from the fractional logit models (Wooldridge, 2018). Textbooks suggest selecting a model with lower AIC and BIC values (Verbeek, 2017). Thus, we will discuss the results from the linear models for both survey rounds due to their lower AIC and BIC values.[69]

Tables 6.11 and 6.12 display the outcomes from the linear regression analyses on the ESA score adoption rates across four agri-environmental risk areas based on the ESAT survey rounds of 2021 and 2023, respectively corresponding to the production years of 2020 and 2022. The results from the overall adoption score model show that younger age and gross farm revenue exceeding $250,000 positively and significantly affected the adoption score rate in both 2020 and 2022 production years in the sample of the producers without an EFP. In 2020, the producers owning land and being in the ALUS partner municipality were less likely to adopt BMPs. Being a crop and livestock producer compared to mixed production significantly improved the adoption score. Conversely, in 2022, being a crop producer decreased the overall adoption score by almost 0.18 percentage points. In the sample of the producers with an EFP, in 2020, being a livestock

[69] See Tables 5.4A, 5.5A and 5.6A in Appendix 5 for the fractional logit regression results.

producer positively affected the adoption. ALUS membership of the municipality was negatively associated with adoption. In 2022, only the younger age and attendance in conservation training improved the adoption score.

In the ‘Soil Health’ risk area, in 2020, younger producers with an EFP had higher adoption scores. However, in the sample of producers without an EFP, older producers had a higher soil health adoption score. Also, in the sample of producers who had an EFP, a producer’s education increased the adoption score. Being a livestock producer negatively affected BMP adoption, resulting in a 0.18 percentage point decrease in the adoption score. In both samples, larger farms (i.e., those with gross farm revenue over $250,000) were adopting the BMPs related to this risk category. Similarly, in 2022, the gross farm revenue over $250,000 had a similar impact on adoption in both samples. The ALUS partnership of the municipalities had a significant negative influence on the adoption scores of both samples.

The determinants ‘Water Quality’ ESA adoption score for 2020 and 2022 had heterogeneous results across the two samples. In 2020, among EFP-holding producers, the conservation training and crop production positively influenced the adoption score in this category. Contrarily, in the other group, crop producers were less inclined to adopt water quality BMPs. In 2022, EFP holders with higher education level and land ownership were associated with increased adoption rates, while being a crop producer was linked to reduced adoption score. In the sample of producers who did not have an EFP, younger producers with higher farm revenues were more likely to adopt water quality BMPs.

Further, in the ‘Air Quality’ adoption model, in 2020, agriculture-related education increased the adoption score by 0.21 percentage points among producers without an EFP. Younger age was associated with higher ‘Air Quality’ BMPs adoption score in both samples. Additionally, attending conservation training and owning land positively impacted the ‘Air Quality’ BMPs adoption score for EFP-holders. In both groups, land ownership was negatively linked to adoption, while crop production led to a higher adoption score.

Lastly, as the Agricultural Research and Extension Council of Alberta (ARECA) added the Habitat & Biodiversity Assessment Tool (HBAT) to their 'Habitat Management' chapter in 2021, we were interested in observing the determinants that affected the producers' adoption decisions of 'Biodiversity' related BMPs after 2021. Thus, the findings for the 2022 production year are presented separately in Table 6.13. The results reveal that none of the variables were significant and associated with the biodiversity BMPs adoption in the sample of producers with an EFP in both 2020 and 2022 production years. However, in 2020, younger producers without an EFP and with a diploma in an agricultural field were highly likely to adopt BMPs in this risk category. In 2022, having access to ALUS in their municipality negatively influenced the biodiversity adoption score.

Table 6.11. Linear Regression Results for the BMPs Adoption (ESA Score) Across Environmental Risk Areas in Alberta in 2020 based on the Environmentally Sustainable Agriculture Tracking Survey 2021.

Independent Variables	*Overall (SE)*		*Soil Health (SE)*		*Water Quality (SE)*		*Biodiversity (SE)*		*Air Quality (SE)*	
	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP
Age 18-44	0.076**	0.102**	0.116*	0.115	0.066	0.003	0.001	0.017	0.131*	0.292***
	(0.035)	(0.044)	(0.069)	(0.085)	(0.072)	(0.077)	(0.087)	(0.094)	(0.072)	(0.111)
Age 45-64	0.042	0.045	0.015	0.137**	0.077	-0.105*	0.064	-0.065	-0.001	0.121*
	(0.032)	(0.048)	(0.058)	(0.061)	(0.063)	(0.060)	(0.056)	(0.059)	(0.056)	(0.073)
Education	0.025	0.067**	0.100**	0.079	-0.047	0.085	0.001	0.003	0.063	0.211***
	(0.029)	(0.028)	(0.049)	(0.051)	(0.057)	(0.066)	(0.051)	(0.059)	(0.051)	(0.076)
Training	0.060**	0.066	0.032	0.070	0.118***	0.046	-0.015	0.128*	0.191***	0.137
	(0.030)	(0.045)	(0.064)	(0.073)	(0.041)	(0.085)	(0.051)	(0.070)	(0.058)	(0.094)
GFR>250k	0.016	0.073**	0.136**	0.181***	-0.014	0.074	0.037	-0.025	-0.028	0.076
	(0.031)	(0.031)	(0.059)	(0.049)	(0.047)	(0.058)	(0.059)	(0.048)	(0.058)	(0.059)
Own land	0.029	0.042	0.054	-0.018	0.025	0.019	0.005	0.017	0.096*	0.016
	(0.029)	(0.047)	(0.056)	(0.060)	(0.051)	(0.057)	(0.053)	(0.057)	(0.055)	(0.075)
Maintain or expand operation	-0.012	0.005	-0.060	-0.077	-0.002	-0.063	-0.025	0.091	0.022	-0.070
	(0.038)	(0.049)	(0.067)	(0.066)	(0.069)	(0.057)	(0.061)	(0.066)	(0.064)	(0.074)
Livestock	-0.004	-0.018	-0.183**	-0.052	-0.003	-0.047	-0.046	-0.246***	-0.007	0.083
	(0.038)	(0.051)	(0.071)	(0.090)	(0.066)	(0.057)	(0.066)	(0.061)	(0.067)	(0.086)
Crops	-0.019	-0.098**	-0.043	-0.054	0.095*	-0.148**	-0.222***	-0.293***	0.026	-0.028
	(0.031)	(0.043)	(0.057)	(0.055)	(0.056)	(0.073)	(0.052)	(0.074)	(0.059)	(0.077)
ALUS	-0.016	0.019	0.096	-0.005	0.102	0.019	-0.192	-0.079	0.007	-0.061
	(0.050)	(0.045)	(0.081)	(0.099)	(0.078)	(0.065)	(0.142)	(0.071)	(0.073)	(0.101)
Constant	0.575***	0.448***	0.473***	0.330***	0.688***	0.797***	0.752***	0.717***	0.341***	0.169**
	(0.046)	(0.054)	(0.075)	(0.081)	(0.079)	(0.081)	(0.075)	(0.076)	(0.075)	(0.077)
Observations	301	195	295	189	192	121	301	195	301	195
R-squared	0.16	0.17	0.18	0.18	0.12	0.18	0.13	0.27	0.12	0.22
AIC	-226.97	-124.84	153.19	57.40	-10.67	-12.52	100.73	52.83	174.99	107.23
BIC	-186.19	-88.84	193.75	93.06	25.16	18.23	141.51	88.84	215.78	143.23

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 6.12. Linear Regression Results for the BMPs Adoption (ESA Score) Across Environmental Risk Areas in Alberta in 2022 based on the Environmentally Sustainable Agriculture Tracking Survey 2023.

Independent Variables	*Overall (SE)*		*Soil Health (SE)*		*Water Quality (SE)*		*Air Quality (SE)*	
	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP
Age 18-44	-0.020	0.142**	0.010	0.137	0.058	0.190*	-0.030	0.013
	(0.056)	(0.059)	(0.076)	(0.101)	(0.109)	(0.115)	(0.099)	(0.094)
Age 45-64	0.027	-0.017	0.044	-0.084	0.042	0.034	0.063	-0.042
	(0.049)	(0.046)	(0.072)	(0.071)	(0.051)	(0.085)	(0.075)	(0.043)
Education	0.036	0.062	0.053	0.068	0.129**	0.001	0.148***	0.045
	(0.041)	(0.047)	(0.078)	(0.062)	(0.062)	(0.079)	(0.049)	(0.051)
Training	0.077	0.069*	-0.027	0.100	0.030	0.126	0.055	0.028
	(0.047)	(0.035)	(0.083)	(0.072)	(0.044)	(0.087)	(0.064)	(0.058)
GFR>250k	-0.011	0.079**	0.131*	0.122**	0.113	0.216***	-0.106	0.062
	(0.045)	(0.038)	(0.069)	(0.058)	(0.071)	(0.072)	(0.055)	(0.044)
Own land	-0.045	-0.090**	-0.083	-0.078	0.141***	0.008	-0.118**	-0.111***
	(0.050)	(0.037)	(0.083)	(0.060)	(0.052)	(0.079)	(0.056)	(0.041)
Maintain or expand operation	0.057 (0.060)	-0.040 (0.045)	0.002 (0.092)	0.003 (0.084)	-0.068 (0.067)	-0.081 (0.090)	0.083 (0.075)	0.054 (0.042)
Livestock	0.105*	0.141***	-0.025	0.008	0.044	0.066	0.032	-0.023
	(0.059)	(0.046)	(0.092)	(0.070)	(0.044)	(0.082)	(0.069)	(0.046)
Crops	0.043	0.136***	0.104	-0.055	-0.176*	-0.072	0.110**	0.132**
	(0.050)	(0.050)	(0.091)	(0.075)	(0.101)	(0.096)	(0.047)	(0.058)
ALUS	-0.083**	-0.064*	-0.184***	-0.098*	-0.028	0.102	-0.059	-0.058
	(0.039)	(0.036)	(0.059)	(0.055)	(0.061)	(0.076)	(0.056)	(0.038)
Constant	0.489***	0.434***	0.531***	0.435***	0.892***	0.653***	0.300***	0.242***
	(0.052)	(0.051)	(0.079)	(0.084)	(0.058)	(0.114)	(0.056)	(0.053)
Observations	206	192	201	175	133	120	206	192
R-squared	0.18	0.28	0.16	0.17	0.31	0.14	0.23	0.21
AIC	-110.05	-93.15	81.61	44.44	-21.15	65.69	13.25	-50.16
BIC	-73.44	-57.32	117.95	79.25	10.65	96.35	49.86	-14.33

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 6.13. Linear Regression Results for the BMPs Adoption (ESA Score) Biodiversity Risk Area in Alberta in 2022 based on the Environmentally Sustainable Agriculture Tracking Survey 2023.

Independent Variables	*With EFP (SE)*	*No EFP (SE)*
Age 18-44	-0.023	0.118
	(0.178)	(0.096)
Age 45-64	-0.061	-0.035
	(0.109)	(0.093)
Education	-0.026	0.120
	(0.091)	(0.086)
Training	0.124	-0.024
	(0.108)	(0.097)
GFR>250k	-0.043	-0.077
	(0.102)	(0.076)
Own land	-0.031	-0.074
	(0.116)	(0.077)
Maintain or expand operation	0.205	-0.122
	(0.140)	(0.081)
Livestock	0.163	0.044
	(0.125)	(0.085)
Crops	-0.036	0.106
	(0.099)	(0.085)
ALUS	-0.127	-0.132*
	(0.112)	(0.069)
Constant	0.432***	0.672***
	(0.137)	(0.107)
Observations	192	175
R-squared	0.13	0.11
AIC	193.67	140.98
BIC	229.51	175.80

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

6.6. Discussion and Conclusions

The main goal of this chapter was to understand the impact of the EFP on the adoption of environmentally sustainable agriculture (ESA) practices, also known as BMPs. Econometric models of adoption were developed across several agri-environmental risk areas and examined the impact of farm and producer characteristics, extension, and alternative cost-shared programs partnership variables using the ESAT survey 2014-2023 rounds and municipal level data from Chapter 4.

Holding an EFP has a significant positive influence on BMP adoption. This makes sense given that the main government funding mechanism to help producers adopt is having an EFP. As we explained in Chapter 2, a producer does not need to access this funding source as they can adopt the BMPs on their own or use ALUS or other funding sources. Because of the main funding source requirement and impact of similar variables such as gross farm revenue exceeding $250,000, the EFP is probably endogenous in the BMP adoption process. However, other researchers have not studied the role of the EFP in BMP adoption, or those that have, were unsuccessful in finding valid instruments to explain the endogeneity. We were able to address this issue with some of our data in several agri-environmental risk areas, and likely, where we could not, it was a data limitation issue as we did not have sufficient observations.

We tested several determinants of EFP adoption at both farm and municipal levels as instruments. Only the combination of ‘research associations membership of the municipalities’, ‘gross farm revenue over $250,000 at the farm level’, and ‘annual municipal environmental extension funding per farm’ variables passed the diagnostic tests as the valid and strong instruments for having an EFP within ‘Overall’, ‘Energy and Climate Change’, and ‘Water Quality and Quantity’ BMP adoption score equations. This finding involved the use of the pooled cross-sectional 2014-2018 ESAT survey rounds, which correspond to the 2013-2017 production year periods, and exemplifies a large data set within our study. It is important to highlight that we also could not deal with the large standard errors in the CF models as the bootstrapping did not work with the weights. Due to the fractional nature of the main dependent variable, we applied heteroskedasticity-robust standard errors as suggested by Wooldridge (2014).

For the 2021 and 2023 survey rounds, to correct for the endogeneity, we divided the sample into the producers with and without an EFP and estimated both fractional logit and linear models for each subsample following Van Wyngaarden (2021). As the AIC and BIC values for the linear models were smaller, we selected them over fractional logit models for discussion.

6.6.1. The outcomes of the pooled 2014-2018 ESAT survey models

As discussed in the previous chapters, the EFP's role as a primary educational and informational resource for producers has been noted in several EFP related studies (MacKay & Hewitt, 2010; Boxall et al., 2013). In addition, the EFP is required to access cost-shared government BMP funding offered via the agricultural policy frameworks. Our findings from both linear and nonlinear estimations of the 2014-2023 pooled ESAT survey rounds once again highlight the importance of the EFP in the BMPs adoption decisions of producers when controlled for endogeneity. In the 'Overall', 'Energy and Climate Change', and 'Water Quality and Quantity' ESA score linear adoption models, having an EFP increased the adoption scores significantly. It is noteworthy that during this period, the main goal of the Alberta cost-shared programs offered through the Growing Forward 2 (2013-2018) was to improve the water quality (Boxall, 2018). Subsequently, the adoption score in the 'Water Quality and Quantity' risk area was the highest among the producers with EFPs suggesting that they accessed the government cost-shared funding. The outcomes of the CF estimation method showed the same results, except for the 'Water Quality and Quantity', as the endogeneity of the EFP could not be established using the nonlinear approach. It is important to highlight that the Applied Research and Forage Associations, farms accumulating gross farm revenue over $250,000 annually, and the municipal level agri-environmental extension funding efforts affected BMPs adoption in the above-mentioned agri-environmental risk areas through the EFP. This may suggest that the larger farms had already completed an EFP and during the process assessed the environmental risks on their farms, and thus, voluntarily accessed cost-shared funding to adopt BMPs in 2013-2017, and the environmental extension efforts by the research associations and municipalities, had successfully targeted the EFP adoption, which in turn increased the BMPs adoption.

Regarding producer and farm characteristics variables, the age of the producer significantly increased the ESA adoption scores for 'Water Quality and Quantity' and 'Energy and Climate

Change' models. In the first model, younger age was associated with the higher score, while in the latter model, older age was negatively affecting the adoption score. These results are consistent with prior research indicating that older farmers typically have a shorter planning horizon compared to their younger counterparts (Prokopy et al., 2008, 2009; Baumgart-Getz et al., 2012; Feder & Umali, 1992). Moreover, a producer's education in the agriculture-related field positively influenced the adoption scores of the 'Overall' and 'Water Quality and Quantity' BMPs. It has been noted in the literature that higher educational levels tend to enhance the adoption of BMPs, particularly of more complex technologies (Knowler & Bradshaw, 2007; Ghazalian et al., 2009; Prokopy et al., 2019; Pannell et al., 2006). Land tenure also significantly affected decisions to adopt 'Energy and Climate Change' BMPs, in line with previous studies (Soule et al., 2000; Kim et al., 2005). Furthermore, crop producers were less likely to adopt overall BMPs, whereas livestock producers were less inclined to adopt 'Energy and Climate Change' BMPs compared to those with mixed production. In the literature, crop producers were generally more likely to adopt BMPs than livestock producers, according to Prokopy et al. (2008). Nonetheless, in our case, the producers with mixed production types were likely to have higher BMPs adoption scores.

6.6.2. The outcomes of the 2021 and 2023 ESAT survey models

Moving on to the findings of our 2021 and 2023 ESAT survey models, which correspond to the production years 2020 and 2022, the producer and farm characteristics were heterogeneous across the agri-environmental risk areas and between the samples with and without an EFP. For example, younger age was highly significant for both samples in the 'Overall' and 'Air Quality' models, and only for the producers with an EFP in 'Soil Health' model in 2020. Conversely, in 2022, younger producers in the sample without an EFP had higher 'Overall' and 'Water Quality' ESA adoption scores. These findings suggest that younger producers are more likely to be environmentally oriented and are more receptive to new information, and have longer planning horizons, which may enhance their recognition of the benefits of BMPs (Carlisle, 2016). The older age showed up significant only in 2020 in the sample of producers who did not have an EFP. The older producers without an EFP were more likely to adopt 'Soil Health', and 'Air Quality' BMPs, while they were less inclined to adopt 'Water Quality' BMPs. This finding is slightly contradictory since we observed that in the 2021 ESAT survey, the average age for the producers adopting 'Water Quality' was 55-64 years, and the adoption rate was above 70% for both samples. The magnitude of effect of older age is consistent with the previous literature (Prokopy et al., 2008; 2009; Baumgart-Getz et al., 2012).

The education, which we define as a producer having a diploma in agriculture-related field, had a positive effect on 'Overall' and 'Air Quality' adoption scores of the producers without an EFP in 2020. However, in the same year, the impact of education was favourable for EFP-holders adopting 'Soil Health' BMPs. In 2022, the education increased the adoption scores in only 'Water Quality' and 'Air Quality' models for the EFP-holders. The positive magnitude of the impact of education in several models is cohesive with the previous findings in Canadian BMPs literature (Van Wyngaarden, 2021; Ghazalian, 2009; Duff et al., 1991).

Next, conservation training attendance was a significant determinant boosting the 'Soil Health', 'Water Quality', and 'Air Quality' adoption scores of the EFP-holders in 2020. This could be because in the 2021 ESAT survey results, the percentage of producers who had attended conservation training was higher for the EFP-holders across all risk areas. In the sample of producers without an EFP, the positive impact of conservation training was observed in 'Biodiversity' and 'Overall' ESA adoption score models in 2020 and 2022 production years respectively. In general, the positive influence of conservation training found in our several models is in line with the previous studies (Baumgart-Getz et al., 2012; Van Wyngaarden, 2021).

Further, producers in both samples accumulating higher income (i.e., annual gross farm revenue over $250,000) were more inclined to adopt 'Soil Health' in both 2020 and 2022 production years. The effect of higher income was notably significant on BMPs adoption scores for EFP-holders in the 'Air Quality' category in 2022. For producers without an EFP, higher income encouraged the adoption of 'Overall' BMPs in both years, as well as 'Water Quality' BMPs in 2022. The importance of the higher income in improving the adoption scores in our models resonates with the earlier research (Baumgart-Getz et al. 2012; Prokopy et al. 2008).

Land tenure, which we defined as land ownership, in our models, was significant mostly in our 2021 survey models corresponding to the 2020 production year. In 2020, the land ownership increased the adoption scores compared to the 'both renting and owning' and only 'renting' tenure under 'Air Quality', while in 2022, the variable enhanced the adoption scores under 'Water Quality' agri-environmental risk areas for the sample of producers with an EFP. This may suggest that the landowners are more inclined to adopt BMPs that offer long-term benefits compared to the renters (Soule et al., 2000; Kim et al., 2005). The negative impact of the land tenure was also observed in the 'Overall' ESA adoption model in the sample of producers without an EFP, and in the 'Air Quality' model in both samples in 2022. In the corresponding survey round, the higher percentage of producers without an EFP, who were at least eligible to adopt one of the 'Air Quality' BMPs, had a mixed type of tenure compared to the category only owning land. However, the percentage of land ownership was higher among the producers who were eligible to at least one of the BMPs overall and did not have an EFP. The mixed effects were found in a study by Deaton et al. (2018), which suggested that the impact of tenure might vary with different types of BMPs.

The influence of farm production types varied widely across the models and samples. In 2022, livestock producers boosted the overall adoption score in both samples. Conversely, in 2020, producers with an EFP were less likely to adopt 'Soil Health' BMPs, while those without an EFP were more hesitant to adopt BMPs under the 'Biodiversity' environmental risk area compared to mixed type producers. Crop producers with an EFP in 2020 had higher 'Water Quality' BMPs adoption scores, whereas this effect was negative for producers without an EFP in the same category. Furthermore, this group of producers showed a lower likelihood of adopting BMPs in the 'Overall' and 'Biodiversity' models. In 2022, being a crop producer led to increased adoption scores for 'Air Quality' in both samples and improved 'Overall' adoption scores in the sample without an EFP. While previous studies tend to show crop farmers as less inclined to adopt conservation practices compared to livestock farmers (Prokopy et al., 2008), our findings are mixed, with some models related to agri-environmental risk areas showing a preference for mixed production types.

Lastly, the variable indicating the municipalities' partnership with ALUS was statistically insignificant across all models in 2020. However, the magnitude of the impact was positive towards the 'Overall', 'Water Quality' ESA scores for the producers without an EFP, suggesting that this group of producers might have reached out to ALUS cost-shared funding which does not require an EFP to implement their BMPs projects. In contrast, in 2022, the impact of the ALUS variable was significant and negative in the 'Overall' and 'Soil Health' adoption score models. These findings do not imply that the ALUS partnership hinders BMP adoption. Our analyses revealed several crucial factors influencing EFP completion rates at both municipal and farm levels, offering valuable insights for policymakers, program managers, extension agents, and industry stakeholders aiming to enhance sustainable agricultural production practices in the province. Given the fact that ALUS is interested in funding any project that enhances the environment, the negative impact could suggest that some partner municipalities might have shown less interest in assisting producers with agri-environmental BMPs during 2020 and 2022.

Conclusions and Policy Implications

This thesis presents three papers that provide a comprehensive examination of the Alberta Environmental Farm Plan (EFP) program, explaining its evolution, processes, key components, uptake, and its role in the adoption of BMPs across several agri-environmental risk areas. We employed several econometric methods to examine the role of the EFP completion in the adoption of BMPs using data from government databases, the Environmentally Sustainable Agriculture Tracking (ESAT) survey, and direct communications with stakeholders and managers to examine the determinants of program adoption at both municipal and farm levels. Our analyses revealed several crucial factors influencing EFP completion rates at both municipal and farm levels, offering valuable insights for policymakers, program managers, extension agents, and industry stakeholders aiming to enhance sustainable agricultural production practises in the province.

Chapter 4 revealed that agri-environmental extension funding from the Agricultural Service Boards grant and federal agricultural policy frameworks positively influenced EFP completion rates at the municipal level. This suggests that agri-environmental extension plays an important role in increasing EFP uptake. Thus, policymakers should prioritize increasing and optimizing agri-environmental extension funding to support EFP extension efforts by municipalities. Additionally, the EFP requirement from main buyers in the potato and industry mandates in dairy sectors significantly influenced EFP completion rates at the municipal level. This implies that the producers are positively reacting to sustainable sourcing standards in the supply chains by adopting EFPs and learning about the environmental risks in their production activities.

A high proportion of large farms with annual gross farm receipts exceeding $250,000, as discussed in Chapter 4, and higher income levels (i.e., annual gross farm revenue over $250,000), as discussed in Chapter 5, positively influenced EFP adoption at both the municipal and farm levels. This suggests that a significant portion of Alberta's agricultural lands could already be covered by farms with an EFP. Since most successful farms in western Canada are larger than in eastern Canada, this could explain the low and stable EFP completion rates reported for the western provinces in the Farm Management Surveys by Statistics Canada. Moreover, the farm-level analysis in Chapter 5 uncovered that attendance by producers in conservation training positively influenced EFP adoption in all ESAT survey rounds. The EFP program managers, municipalities, and research associations should continue to prioritize and expand conservation training initiatives, ensuring that more producers have access to these educational resources to promote awareness and implementation of sustainable agricultural practices.

Since adoption of an EFP is a requirement for accessing government cost-share funding through the agricultural policy frameworks, we assumed that the EFP is endogenous in the BMP adoption process. In the last paper, Chapter 6, we established the endogeneity of the EFP within the adoption of BMPs for the ‘Overall’, ‘Water Quality and Quantity’, and ‘Energy and Climate Change’ in the 2014-2018 pooled ESAT survey rounds. We addressed the endogeneity issue using variables such as the municipality where a producer was located, the use of applied research and forage associations in the extension process, farms generating over $250,000 in annual gross farm revenue, and municipal-level agri-environmental extension efforts as instruments in the EFP equation. Our findings indicate that the EFP has a significant positive effect on BMP adoption across the above-mentioned environmental risk areas. This suggests that producers utilize their action plans developed during the EFP completion process to apply for cost-share funding. However, we do not know if they accessed other funding sources during that period as there was no data available in the 2014-2018 ESAT survey rounds.

To account for the endogenous EFP variable within the BMP adoption equation in the later 2021-2023 survey rounds, we divided the producers into samples with and without an EFP. We incorporated the ALUS partnership of the municipality where the producer was located as an indicator of an alternative means to access cost-share funding. We assumed that some producers without an EFP would seek funding through the ALUS program, as this program does not require an EFP for participation. However, in some agri-environmental risk models, the ALUS program had either a significantly negative impact or no impact on BMPs adoption. Utilizing the exploratory analysis in Chapter 4, we observed that most ALUS member municipalities had low EFP adoption rates during that period. This could suggest that some partner municipalities might have shown less interest in assisting producers with agri-environmental BMPs during the 2020 and 2022 production years.

In summary, this thesis highlights the critical role of the EFP program in fostering sustainable agricultural practices in Alberta. The findings identify the importance of targeted extension funding, industry collaboration, and continuous training initiatives to further enhance EFP uptake. Stakeholders should prioritize enhancing agri-environmental extension services by increasing funding and the level of support by EFP technicians in the municipalities, especially with low adoption rates. Policymakers should also focus on providing more accessible and streamlined EFP completion processes, addressing producers' concerns about the time and complexity of the EFP. Additionally, they should promote the program through targeted outreach campaigns and conservation training. The EFP program not only educates farmers and provides access to government cost-shared funding, but also promotes the environmental and economic sustainability of agriculture in Alberta.

Limitations and Guidelines for Future Research

The primary challenge encountered in our analyses was the limitation of available data. In our municipal-level analysis in Chapter 4, we faced significant data gaps. The most important gap was our inability to determine the total annual budget for the Agricultural Service Boards (ASBs) of each municipality. Although we accessed data on ASBs' grant transactions, we lacked information on the portion of taxes allocated to agri-environmental programs and extension. In essence, we could not determine the ASB total budget, or the specific portion of the budget allocated to agri-environmental program components. Specific data on actual funding spent on agri-environmental extension delivery in the municipalities was also unavailable, forcing us to assume that all funds received through the Resource Management stream of the ASB's grant were allocated to extension programs. We also could not incorporate the number of EFP technicians and workshops into our models due to the absence of municipal data for most years, partly due to data loss during the program's transition to an online system in 2015 and subsequent changes in program management in 2017. Furthermore, we lacked data on the extension efforts of the ASBs before 2020 and on the annual number of members for industry organizations such as Alberta Milk and the Potato Growers of Alberta at the municipal level. These limitations hindered our ability to evaluate the actual impact of EFP extension personnel, efforts, and industry standards on municipal-level EFP adoption.

In the farm-level analyses conducted in Chapters 5 and 6, we encountered several challenges related to the Environmentally Sustainable Agriculture Tracking (ESAT) survey. While the survey might be representative at the regional level, it is likely not representative at the municipal level. Consequently, this limitation prevented us from thoroughly examining the impact of agri-environmental extension efforts at both municipal and farm levels. Also, questions related to EFP adoption, such as the reasons for completion, were only included in the 2021 survey round. Incorporating an EFP assessment in future surveys would allow researchers to gain a deeper understanding of the barriers and motivations influencing individual producers' participation in the program. Moreover, it is crucial to continue including questions related to government cost-share or other funding programs in future survey rounds, as these were only present in the 2021 and 2023 rounds. It is important to note that we could not perform spatial analysis to explore the impact of neighboring municipalities on farm-level adoption as well as proximity to research associations or extension agents, and municipal geographic factors such as differences in environmental conditions or local policies. Due to inconsistent representation of all municipalities, especially in the earlier ESAT survey rounds, we were unable to account for municipality-related unobserved heterogeneity or utilize clustered standard errors in our analysis. Also, due to data limitations in Chapter 6, we relied on several hypothesis tests to select instruments for the EFP within the BMP adoption process. Future researchers may wish to explore more robust theoretical frameworks and identify better instruments for EFP adoption.

We recommend that program managers interested in evaluating Alberta's agri-environmental program impacts implement standardized data collection processes and robust tracking and reporting mechanisms at the municipal level. Achieving this will require collaborative efforts from the provincial government, ARECA, municipalities, research associations, and other organizations dedicated to promoting sustainable agriculture in the province. Establishing data-sharing agreements among these entities can help create a more comprehensive dataset for evaluating Alberta's agri-environmental policy programs. Additionally, we advise the provincial government to employ stratified sampling techniques in the ESAT surveys to ensure proportional representation of municipalities. Increasing the survey sample size, consistently incorporating questions related to the EFP and funding sources for BMPs adoption, and ensuring consistent representation of municipalities will enhance the richness of the dataset. This will also enable researchers to account for municipal-level unobserved heterogeneity and perform basic spatial analyses, providing deeper insights into the factors influencing sustainable agricultural practice adoption decisions of the agricultural producers in Alberta. Of course, these recommendations likely require enhanced funding levels leading to increases in staff and resources. This is only possible if program evaluation is considered critically important in ensuring existing expenditures and resources are being used effectively.

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Appendix 1 (Chapter 1)

Table 1.1A. Environmental Farm Plan Program Delivery and Oversight in Canada.

Province	Year EFP was first introduced	EFP Program Delivery & Oversight
British Columbia	2005	Investment Agriculture Foundation; Government of British Columbia
Alberta	2003	Agricultural Research and Extension Council of Alberta; Alberta Agriculture and Forestry
Saskatchewan	2005	Saskatchewan Ministry of Agriculture
Manitoba	2005	Keystone Agricultural Producers; Manitoba Department of Agriculture and Resource Development
Ontario	1993	Ontario Soil and Crop Improvement Association; Ontario Ministry of Agriculture, Food and Rural Affairs
Quebec	1996	Ministry of Agriculture, Fisheries, and Food of Quebec
New Brunswick	1996	The Agriculture Alliance of New Brunswick; New Brunswick Agriculture, Aquaculture, and Fisheries
Nova Scotia	1995	Nova Scotia Federation of Agriculture; Nova Scotia Department of Agriculture
Prince Edward Island	1996	Prince Edward Island Federation of Agriculture; Prince Edward Island Department of Agriculture
Newfoundland/Labrador	1995	New Foundland Labrador Department of Fisheries, Forestry, and Agriculture

Sources: Provincial governments websites; Wilton et al. (2022); AAFC (2011).

Appendix 2 (Chapter 3)

Table 2.1A. Agricultural Research and Forage Associations in Alberta and their member municipalities.

Agricultural Research and Forage Associations	Member municipalities
Battle River Research Group (BRRG)	Paintearth, Stettler, Camrose, Beaver, Flagstaff
Chinook Applied Research Association (CARA)	Provost MD, Special Area 2, Special Area 3, Special Area 4, Acadia MD, Starland
Gateway Research Organization (GRO)	Thorhild, Westlock, Barrhead, Woodlands, Lac Ste. Anne, Parkland
Grey Wooded Forage Association (GWFA)	Red Deer, Ponoka, Mountain View, Wetaskiwin, Clearwater, Lacombe
Foothills Forage and Grazing Association (FFGA)	Cardston, Pincher Creek MD, Willow Creek MD, Ranchland MD, Vulcan, Newell, Foothills, Wheatland, Rocky View, Kneehill, Starland
Farming Forward (Previously West Central Forage Association)	Brazeau County, Woodlands Country, Leduc County, Parkland County, Lac St. Anne County and Yellowhead County
Farming Smarter (FS)	Wheatland, Newell, Vulcan, Foothills MD, Willow Creek MD, Lethbridge, Taber MD, Cypress, Forty Mile, Warner, Cardston
Lakeland Applied Research Association (LARA)	Bonnyville MD, St. Paul, Smoky Lake, Lac La Biche
Mackenzie Applied Research Association (MARA)	Mackenzie
North Peace Applied Research Association (NPARA)	Northern Lights, Peace MD
Peace County Beef and Forage Association (PCBFA)	Big Lakes, Clear Hills, Fairview MD, Saddle Hills MD, Spirit River MD, Birch Hills, Peace MD, Smoky River MD, Grande Prairie, Greenview MD, Northern Sunrise
Smoky Applied Research and Demonstration Association (SARDA)	Grande Prairie, Greenview MD, Smoky River MD, Big Lakes, Northern Sunrise

Source: ARECA (2019).

Appendix 3 (Chapter 4)

Table 3.1A. List of rural municipalities, specialized municipalities, and Special Areas Board in Alberta.

District 1 (located in southern Alberta)	Rocky View County	Greenview, M.D. of
Cardston County	Special Areas Board	Mackenzie County
Cypress County	Starland County	Northern Lights, County of
Foothills County	Stettler County	Northern Sunrise County
Forty Mile, County of	Wheatland County	Opportunity M.D. of
Lethbridge County	District 3 (located generally in west of Edmonton)	Peace, M.D. of
Newell, County of	Athabasca County	Saddle Hills County
Pincher Creek, M.D. of	Barrhead, County of	Smoky River, M.D. of
Ranchland, M.D. of	Brazeau County	Spirit River, M.D. of
Taber, M.D. of	Leduc County	District 5 (generally located in the east of Edmonton)
Vulcan County	Lesser Slave River, M.D. of	Beaver County
Warner, County of	Thorhild County	Camrose County
Willow Creek, M.D. of	Lac Ste. Anne County	Bonnyville, M.D. of
Crowsnest Pass, Municipality of	Parkland County	Flagstaff County
	Sturgeon County	Lac La Biche County
District 2 (located in north of Calgary and south of Wetaskiwin)	Westlock County	Lamont County
Acadia, M.D. of	Wetaskiwin, County of	Minburn, County of
Bighorn, M.D. of	Woodlands County	Smoky Lake County
Clearwater County	Yellowhead County	St. Paul, County of
Kneehill County	District 4 (generally located in the northwest region)	Provost, M.D. of
Lacombe County	Big Lakes County	Strathcona County
Mountain View County	Birch Hills County	Two Hills, County of
Paintearth, County of	Clear Hills County	Vermilion River, County of
Ponoka County	Fairview, M.D. of	Wainwright, M.D. of
Red Deer County	Grande Prairie, County of	Wood Buffalo, Rural Municipality of

Source: RMA (2023).

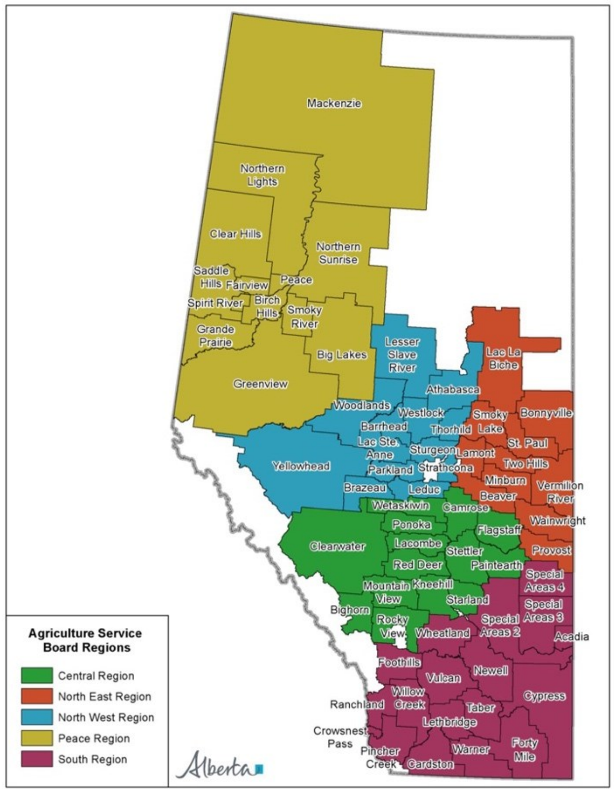

Figure 3.1A. Agricultural Service Boards coverage in Alberta.
Source: AAF (2021).

Table 3.2A. Characteristics of municipalities with most frequent low EFP completion numbers in 2014-2021.

Municipalities	*No. of Farms*		*Agricultural Land Acreage (in acres)*		*Gross Farm Receipts over $250,000*	
	Census 2011	*Census 2021*	*Census 2011*	*Census 2021*	*Census 2011*	*Census 2021*
Big Lakes, County of	375	320	432,827	350,598	36	46
Brazeau, County of	487	429	289,674	231,444	11	22
Fairview, M.D. of	225	178	304,190	248,109	62	66
Smoky River, M.D. of	310	300	587,336	672,504	156	168
Spirit River, M.D. of	69	125	82,212	193,868	16	43

Source: ARECA (2023); AARD (2014); Statistics Canada (2021).

Table 3.3A. Characteristics of municipalities with most frequent high EFP completion numbers in 2014-2021.

Municipalities	*No. of Farms*		*Agricultural Land Acreage (in acres)*		*Gross Farm Receipts over $250,000*	
	Census 2011	*Census 2021*	*Census 2011*	*Census 2021*	*Census 2011*	*Census 2021*
Red Deer, County of	1531	1510	973,968	999,738	277	346
Mountain View, County of	1636	1576	933,882	1,021,950	253	312
Lethbridge, County of	933	1014	701,095	1,150,044	350	432
Vermilion River, County of	1029	1125	1,363,540	1,510,970	304	410
Willow Creek, M.D. of	772	833	1,126,368	1,262,951	184	249
Wheatland, County of	782	825	1,121,462	1,315,866	278	339

Source: ARECA (2023); AARD (2014); Statistics Canada (2021).

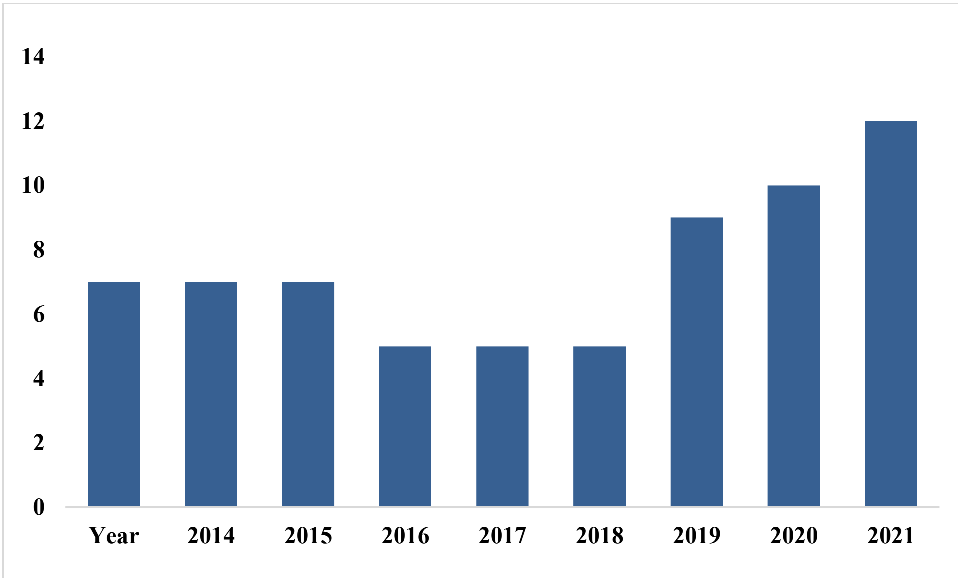

Figure 3.2A. Number of municipalities without ASB Grant Environmental Programs Funding in 2014-2022.
Source: Government of Alberta (2023).

Table 3.4A. Number of Potato and Dairy farms across Agricultural Census 2011, 2016, and 2021.

Municipalities	*Potato Farms*			*Dairy Farms*		
	Census 2011	*Census 2016*	*Census 2021*	*Census 2011*	*Census 2016*	*Census 2021*
Athabasca County	0	1	0	3	3	3
Barrhead County	1	0	1	22	17	20
Beaver County	0	0	2	4	4	1
Big Horn M.D.	0	0	0	0	0	0
Big Lakes County	1	1	0	0	0	0
Birch Hills County	0	0	0	1	0	0
Bonnyville M.D.	1	0	0	2	1	1
Brazeau County	1	0	0	3	1	1
Calgary	1	0	0	0	0	0
Camrose County	0	3	0	13	7	11
Cardston County	1	0	0	3	3	4
Clear Hills County	0	0	1	1	2	0
Clearwater County	0	0	0	14	9	9
Cypress County	2	1	1	1	1	2
Edmonton	0	3	1	0	1	0
Fairview M.D.	1	0	0	0	0	0

Flagstaff County	0	0	0	3	4	3
Foothills M.D.	2	1	2	2	2	2
Forty Mile County	11	10	7	2	2	2
Grande Prairie County	0	1	0	0	0	0
Greenview M.D.	0	0	0	1	1	2
Kneehill County	0	1	0	3	2	3
Lac La Biche County	0	0	0	1	0	1
Lac Ste. Anne County	0	0	0	5	2	4
Lacombe County	10	5	5	54	49	44
Lamont County	0	0	0	2	1	0
Leduc County	4	2	2	57	38	35
Lesser Slave River M.D.	0	0	0	1	0	0
Lethbridge County	4	5	15	55	60	54
Mackenzie County	3	1	0	2	1	5
Minburn County	2	0	0	4	1	1
Mountain View County	3	1	0	28	22	23
Newell County	5	3	8	3	4	4
Northern Lights County	0	1	0	0	0	2
Northern Sunrise County	1	0	0	2	2	3
Paintearth County	0	0	0	0	0	1
Parkland County	9	8	7	10	9	4
Peace M.D.	1	0	0	0	0	0
Pincher Creek M.D.	1	0	0	2	1	1
Ponoka County	3	0	0	61	48	44
Provost M.D.	0	1	0	0	0	1
Ranchland M.D.	0	0	0	0	0	0
Red Deer County	2	0	1	37	36	33
Rocky View County	4	2	2	5	2	0
Saddle Hills M.D.	1	0	1	0	0	0
Smoky Lake County	2	1	0	0	1	0
Smoky River M.D.	0	0	0	0	0	0
Special Area 2	0	0	0	0	0	1
Special Area 3	0	0	0	1	0	1
Special Area 4	0	1	2	0	0	2
Spirit River M.D.	1	0	0	0	0	0
St. Paul County	0	0	0	3	2	2
Starland County	1	0	0	1	2	1
Stettler County	0	0	0	7	4	3
Strathcona County	1	2	3	5	5	4
Sturgeon County	5	3	3	7	5	4
Taber M.D.	53	56	51	6	6	6

Thorhild County	1	0	1	0	1	0
Two Hills County	0	0	0	1	0	3
Vermilion River County	0	0	1	1	0	2
Vulcan County	1	0	2	2	2	1
Wainwright M.D.	0	1	0	1	0	2
Warner County	0	0	0	0	0	0
Westlock County	1	1	0	10	8	8
Wetaskiwin County	6	3	3	19	23	17
Wheatland County	1	2	0	1	1	1
Willow Creek M.D.	0	0	0	5	9	8
Woodlands County	0	1	0	2	1	0
Yellowhead County	1	1	1	6	5	3
Total	**149**	**125**	**123**	**485**	**411**	**393**

Source: AARD (2014); AAF (2020); Statistics Canada (2021).

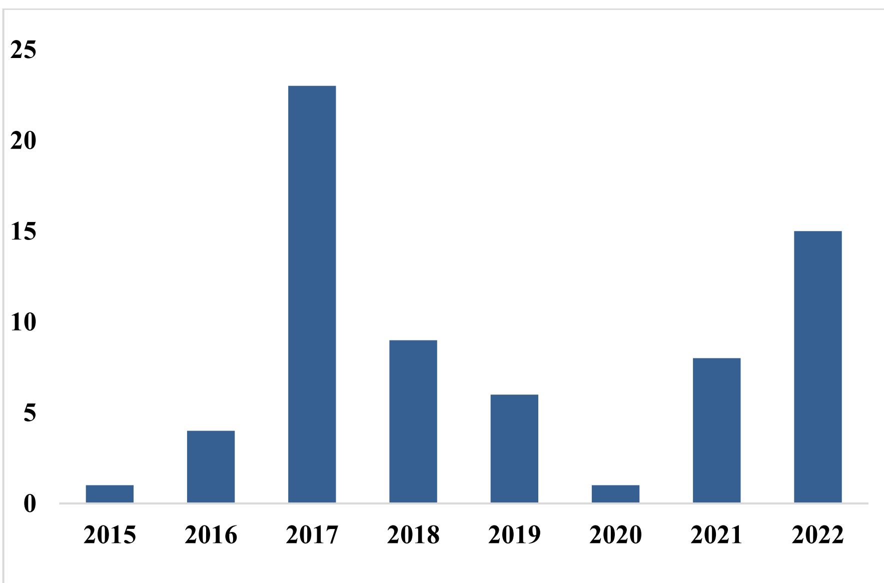

Figure 3.3A. The EFP Completion numbers in the M.D. of Taber in 2015-2022.
Source: ARECA (2022).

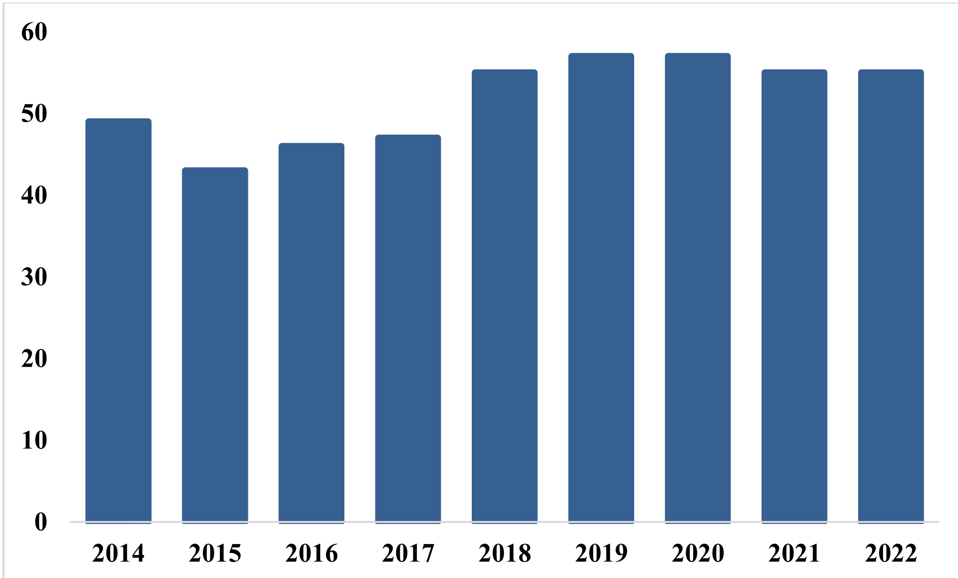

Figure 3.4A. Number of Applied Research and Forage Associations' Partner Municipalities in Alberta in 2014-2022.
Source: Annual Reports of Applied Research and Forage Associations from 2014-2023; ARECA (2022).

Table 3.5A. Fractional Logit Regression Coefficient Results for the Environmental Farm Plan (EFP) Completion Rate at the municipal level in Alberta in 2022.

Independent Variables	*EFP Completion Rate (with extension & funding) (robust SE)*	*EFP Completion Rate (without funding, extension only) (robust SE)*	*EFP Completion Rate (Techs & funding) (robust SE)*	*EFP Completion Rate (Techs only, without funding) (robust SE)*
Municipality Funding:				
Annual Municipal Environmental Extension funding per farm	2.398 (15.517)		7.152 (16.141)	
Annual Municipal Tax Revenue per farm	0.528 (1.248)		0.597 (1.305)	
Farm Income:				
%Gross Farm Revenue>$250K	2.932*** (0.715)	2.975*** (0.694)	2.863*** (0.745)	2.953*** (0.712)

Industry Standards:				
%Dairy Farms in 2022	7.957***	7.658***	8.576***	8.299***
	(1.848)	(1.764)	(1.545)	(1.382)
%Potato Farms in 2015	0.466	0.371	0.423	0.230
	(0.912)	(0.865)	(0.809)	(0.747)
Extension Efforts:				
Extension Events	1.498	1.692		
	(1.579)	(1.570)		
EFP Technician Coverage			-0.082	-0.075
			(0.124)	(0.117)
Constant	-5.681***	-5.644***	-5.578***	-5.517***
	(0.259)	(0.246)	(0.293)	(0.280)
Observations	67	67	67	67
Pseudo R-squared	0.02	0.02	0.02	0.02

Note: Robust standard errors in parentheses at *** p<0.01, ** p<0.05, * p<0.1

Table 3.6A. An Environmental Farm Plan (EFP) Completion Rate 2022 Model Comparison.

Models for 2022	*AIC*	*BIC*
Linear Model with Extension Events & Funding	-475.124	-459.691
Fractional Logit Model with Extension Events & Funding	21.724	37.157
Linear Model with Extension Events Only	-478.390	-467.366
Fractional Logit Model with Extension Events Only	17.725	28.749
Linear Model with EFP Technician Coverage & Funding	-473.734	-458.301
Fractional Logit Model with Technician Coverage & Funding	21.725	37.158
Linear Model with EFP Technician Coverage Only	476.416	-465.392
Fractional Logit Model with Technician Coverage Only	17.728	28.752

Appendix 4 (Chapter 5)

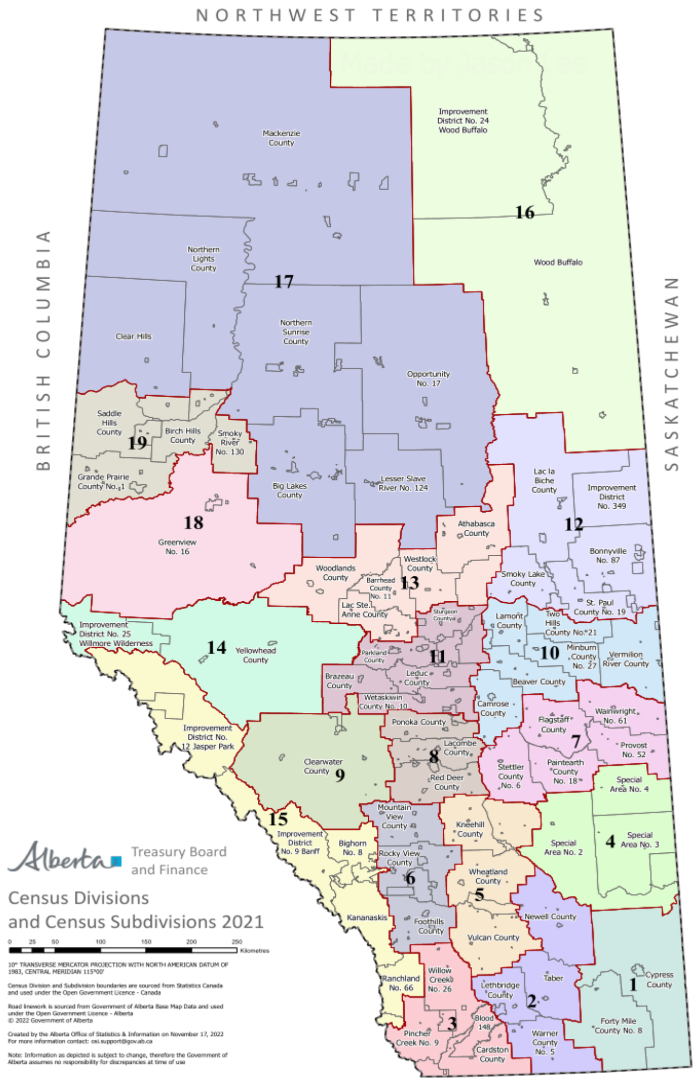

Figure 4.1A. Alberta Census Divisions and Census Subdivisions 2021.
Source: Government of Alberta (2023).

Table 4.1A. Regions Classified by Municipality.

South	Central	Northeast
Cardston County	Acadia No.34, M.D., of	Beaver County
Cypress County	Bighorn No.8, M.D. of	Bonnyville No.87, M.D. of
Forty Mile No.8, County of	Calgary	Camrose County
Lethbridge, County of	Clearwater County	Lac La Biche County
Medicine Hat	Consort	Lamont County
Newell, County of	Flagstaff County	Minburn No.27, County of
Pincher Creek No.9, M.D. of	Foothills No.31, M.D., of	Smoky Lake County
Taber, M.D. of	Hanna	St. Paul No.19, County of
Warner No.5, County of	Kneehill County	Two Hills No.21, County of
Willow Creek No.26, M.D. of	Lacombe County	Vermilion River, County of
Northwest	Mountain View County	**Peace**
Athabasca County	Paintearth No.18, County of	Big Lakes, M.D. of
Barrhead No.11, County of	Ponoka County	Birch Hills County
Brazeau County	Provost No.52, M.D. of	Clear Hills County
Edmonton	Ranchland No. 66, M.D of	Fairview No.136, M.D. of
Lac Ste. Anne County	Red Deer County	Grande Prairie No.1, County of
Leduc County	Rocky View County	Greenview No.16, M.D. of
Parkland County	Starland County	Lesser Slave River No.124, M.D. of
Strathcona County	Stettler No.6, County of	MacKenzie, M.D. of
Sturgeon County	Vulcan County	Northern Lights, County of
Thorhild No., County of	Wainwright No.61, M.D. of	Northern Sunrise, County of
Westlock County	Wheatland County	Opportunity No.17, M.D. of
Wetaskiwin No.10, County of		Peace No.135, M.D. of
Woodlands County		Saddle Hills County
Yellowhead County		Smoky River No.130, M.D. of
		Spirit River No.133, M.D. of

Source: Government of Alberta (2014, 2016, 2023); AAF (2018); Anders et al. (2021).

Table 4.2A. List of municipalities, cities, and areas not included in the analysis

South	*Central*	*Northwest*	*Peace*	*Others*
Medicine Hat	Acadia No.34, M.D.	Edmonton	Opportunity No.17, M.D.	Fort McMurray
	Bighorn No.8, M.D.			Wood Buffalo, Regional Municipality of
	Calgary			Special Area 2
	Consort			Special Area 3
	Hanna			Special Area 4
	Ranchland No.66, M.D. of			Municipality of Crowsnest Pass

Table 4.3A. Characteristics of Alberta agricultural producers who hold and does not hold an EFP across the 2014-2023 ESATS rounds.

	Holds an EFP					*Does not hold an EFP*				
	2014	*2016*	*2018*	*2021*	*2023*	*2014*	*2016*	*2018*	*2021*	*2023*
Farmer Characteristics:										
Age 18-44	5%	12%	10%	9%	10%	8%	7%	9%	8%	8%
Age 45-64	57%	65%	53%	55%	38%	50%	55%	45%	41%	40%
Training	38%	37%	27%	23%	30%	18%	19%	11%	10%	12%
Education	34%	44%	39%	37%	40%	21%	25%	17%	22%	23%
GFR>250k	43%	60%	55%	50%	44%	14%	36%	18%	20%	25%
Farm Characteristics:										
Livestock	34%	31%	30%	24%	23%	37%	32%	34%	19%	26%
Crops	45%	23%	29%	25%	26%	46%	23%	21%	22%	24%
Equal mix	20%	15%	10%	14%	20%	14%	18%	14%	16%	13%
Own land	39%	31%	37%	36%	40%	50%	41%	49%	45%	54%
Rent land	2%	0%	0%	1%	0%	0%	1%	1%	1%	1%
Both own and rent	60%	69%	63%	63%	60%	50%	56%	49%	53%	45%
Maintain or expand	68%	77%	77%	71%	66%	52%	63%	51%	64%	70%
Reduce or sell	30%	22%	25%	29%	34%	42%	33%	45%	34%	28%
Obs. (N)	184	191	204	302	256	228	245	227	195	242

Source: Government of Alberta (2014, 2016, 2023); AAF (2018); Anders et al. (2021).

Table 4.4A. Number of farms in Alberta Regions by Gross Farm Sales.

Regions	*No. of 2011 Census Farms with $10K+ in Gross Farm Sales*	*No. of 2016 Census Farms with $10K+ in Gross Farm Sales*	*No. of 2021 Census Farms with $10K+ in Gross Farm Sales*
South $10K to < $100K	2289	1866	1936
South $100K to <$250K	1121	1084	1003
South $250K to <$500K	775	736	734
South $500K +	1008	1481	1522
Total South	**5193**	**5167**	**5195**
Central $10K to < $100K	6844	5946	6006
Central $100K to <$250K	2709	2644	2471
Central $250K to <$500K	1655	1754	1635
Central $500K +	1739	2554	2743
Total Central	**12947**	**12898**	**12855**
Northeast $10K to < $100K	3220	2722	2649
Northeast $100K to <$250K	1145	1141	1117
Northeast $250K to <$500K	700	787	734
Northeast $500K +	636	991	1075
Total Northeast	**5701**	**5641**	**5575**
Northwest $10K to < $100K	4800	4060	3750
Northwest $100K to <$250K	1166	1354	1158
Northwest $250K to <$500K	623	688	634
Northwest $500K +	612	874	914
Total Northwest	**7201**	**6976**	**6456**
Peace $10K to < $100K	2694	2091	2026
Peace $100K to <$250K	874	841	892
Peace $250K to <$500K	458	538	475
Peace $500K +	459	701	757
Total Peace	**4972**	4171	**4150**
TOTAL FARMS	**39,640**	**34,853**	**34,232**

Source: AARD (2014); AAF (2020); Statistics Canada (2021); Government of Alberta (2014, 2016, 2023); AAF (2018); Anders et al. (2021).

Table 4.5A. Post Estimation tests for pooled 2014-2023 and yearly EFP adoption models.

	Link Test	*Log pseudolikelihood*	*Wald Test*	*Obs (N)*
Pooled models with and without Environmental Extension Funding variable for 2014-2023:				
Pooled Model 1	failed	-1374.6199	significant	2274
Pooled Model 2	passed	-1064.2359	significant	1,776
Pooled Model with extension variable	passed	-1387.041	significant	2,274
Yearly Farm and Farm Characteristics Models:				
Year 2014	passed	-234.46339	significant	412
Year 2016	passed	-278.84029	significant	436
Year 2018	passed	-243.28472	significant	431
Year 2021	passed	-276.60887	significant	497
Year 2023	passed	-293.27784	significant	498
Yearly Farm and Farm Characteristics Models with Environmental Extension Funding variable:				
Year 2014	passed		significant	
Year 2016	passed		significant	
Year 2018	passed		significant	
Year 2020	passed		significant	
Year 2023	passed		significant	

Appendix 5 (Chapter 6)

Table 5.1A. Descriptive Statistics of Alberta Producers Who Were Eligible to at least one Beneficial Management Practice Across Agri-Environmental Risk Areas based on the 2014-2018 ESAT Survey.

	Soil Conservation	*Water Quality & Quantity*	*Wildlife Habitat Conservation*	*Grazing Management*	*Manure Management*	*Energy & Climate Change*	*General Practices*	*Overall*
Age 18-44	9%	9%	9%	8%	9%	9%	9%	9%
Age 45-64	58%	54%	54%	54%	56%	54%	54%	54%
Degree	30%	29%	29%	27%	29%	29%	29%	29%
Conservation Training	26%	24%	49%	23%	24%	24%	24%	24%
EFP	48%	44%	43%	41%	43%	43%	43%	43%
Own Land	39%	42%	42%	42%	43%	42%	42%	42%
Rent Land	1%	1%	1%	1%	1%	1%	1%	1%
Both Own and Rent	60%	57%	57%	57%	56%	57%	57%	57%
Reduce or sell	29%	34%	34%	32%	31%	34%	34%	34%
Maintain or Expand	68%	63%	63%	64%	65%	63%	63%	63%
GFR from crop	48%	39%	39%	26%	25%	39%	49%	39%
GFR from Livestock	31%	42%	42%	50%	52%	42%	42%	42%
Equal Mix of Both	21%	20%	20%	24%	24%	20%	20%	20%
No. of Observations	1047	1289	1282	773	729	1293	1293	1293

Table 5.2A. Descriptive Statistics of Alberta Producers with and without an Environmental Farm Plan Who Were Eligible to at least one Beneficial Management Practice Across Agri-Environmental Risk Areas based on the 2021 ESAT Survey.

	Soil Health		*Water Quality*		*Biodiversity*		*Air Quality*		*Overall Adoption*	
	With EFP	Without EFP	With EFP	Without EFP	With EFP	Without EFP	With EFP	Without EFP	With EFP	Without EFP
Age	55-64 years	55-64 years	55-64 years	55-64 years	55-64 years	65-74 years	55-64 years	65-74 years	55-64 years	65-74 years
Degree	36%	23%	33%	25%	35%	21%	35%	21%	35%	21%
Conservation Training	11%	11%	22%	11%	21%	10%	21%	10%	21%	10%
GFR>250K	53%	22%	43%	36%	52%	21%	52%	21%	52%	21%
Own Land	34%	40%	36%	45%	50%	45%	35%	45%	35%	45%
Rent Land	1%	1%	1%	2%	1%	2%	1%	2%	1%	2%
Both Own and Rent	65%	58%	63%	53%	64%	54%	64%	54%	64%	54%
Reduce or Sell	27%	33%	32%	36%	28%	35%	28%	35%	28%	35%
Maintain or Expand	73%	66%	68%	62%	72%	64%	72%	64%	72%	64%
GFR from crop	26%	22%	37%	28%	26%	22%	26%	22%	26%	22%
GFR from livestock	26%	19%	36%	28%	25%	19%	26%	19%	25%	19%
Equal Mix of Both	11%	17%	17%	24%	12%	16%	12%	16%	12%	16%
No. of Observations	298	189	194	121	304	195	304	195	304	195

Table 5.3A. Descriptive Statistics of Alberta Producers with and without an Environmental Farm Plan Who Were Eligible to at least one Beneficial Management Practice Across Agri-Environmental Risk Areas based on the 2023 ESAT Survey.

	Soil Health		*Water Quality*		*Biodiversity*		*Air Quality*		*Overall Adoption*	
	With EFP	Without EFP	With EFP	Without EFP	With EFP	Without EFP	With EFP	Without EFP	With EFP	Without EFP
Age	55-64 years	65-74 years	55-64 years	65-74 years	55-64 years	65-74 years	55-64 years	65-74 years	55-64 years	65-74 years
Degree	44%	24%	48%	25%	43%	24%	42%	22%	42%	22%
Conservation Training	33%	15%	42%	12%	34%	11%	35%	12%	35%	12%
GFR>250K	35%	22%	29%	16%	33%	18%	34%	18%	34%	18%
Own Land	37%	50%	36%	54%	40%	55%	38%	56%	38%	56%
Rent Land	1%	1%	0%	1%	0%	2%	1%	2%	1%	2%
Both Own and Rent	63%	48%	64%	44%	60%	43%	62%	43%	62%	43%
Reduce or Sell	35%	28%	40%	29%	38%	28%	37%	27%	37%	27%
Maintain or Expand	64%	71%	60%	70%	61%	70%	63%	71%	63%	71%
GFR from crop	26%	23%	29%	29%	26%	21%	25%	20%	25%	20%
GFR from livestock	23%	30%	29%	43%	23%	33%	22%	30%	22%	30%
Equal Mix of Both	20%	14%	29%	17%	21%	13%	20%	12%	20%	12%
No. of Observations	249	224	166	150	239	224	256	243	256	243

Table 5.4A. Fractional Logit Regression Results for the BMP Adoption (ESA Score) Across Environmental Risk Areas in Alberta based on Environmentally Sustainable Agriculture Tracking Survey 2021.

Independent Variables	*Overall (SE)*		*Soil Health (SE)*		*Water Quality (SE)*		*Biodiversity (SE)*		*Air Quality (SE)*	
	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP
Age18-44	0.311**	0.434**	0.464	0.512	0.384	0.047	-0.033	0.033	0.571*	1.485***
	(0.154)	(0.181)	(0.305)	(0.373)	(0.408)	(0.390)	(0.403)	(0.428)	(0.315)	(0.536)
Age 45-64	0.171	0.176	0.004	0.619**	0.448	-0.582*	0.351	-0.389	-0.008	0.683*
	(0.137)	(0.183)	(0.243)	(0.272)	(0.326)	(0.319)	(0.291)	(0.281)	(0.231)	(0.369)
Education	0.123	0.279**	0.432**	0.344	-0.239	0.446	0.047	0.026	0.269	0.982***
	(0.127)	(0.115)	(0.208)	(0.216)	(0.314)	(0.339)	(0.275)	(0.290)	(0.211)	(0.337)
Training	0.263**	0.276	0.119	0.316	0.834***	0.227	-0.065	0.646	0.790***	0.644
	(0.133)	(0.187)	(0.275)	(0.315)	(0.281)	(0.486)	(0.248)	(0.432)	(0.243)	(0.438)
GFR>250K	0.088	0.300**	0.566**	0.761***	-0.118	0.431	0.303	-0.065	-0.126	0.418
	(0.131)	(0.124)	(0.238)	(0.205)	(0.295)	(0.276)	(0.309)	(0.234)	(0.241)	(0.299)
Own land	0.122	0.164	0.254	-0.082	0.200	0.067	-0.020	0.082	0.406*	0.124
	(0.125)	(0.184)	(0.241)	(0.258)	(0.304)	(0.271)	(0.283)	(0.302)	(0.226)	(0.414)
Maintain or expand operation	-0.036	0.023	-0.151	-0.348	0.134	-0.292	-0.218	0.414	0.102	-0.430
	(0.160)	(0.190)	(0.281)	(0.290)	(0.335)	(0.269)	(0.341)	(0.330)	(0.266)	(0.422)
Livestock	-0.016	-0.056	-0.820***	-0.264	-0.064	-0.188	-0.173	-1.092***	-0.036	0.400
	(0.161)	(0.196)	(0.316)	(0.403)	(0.365)	(0.284)	(0.367)	(0.296)	(0.275)	(0.427)
Crops	-0.078	-0.402**	-0.253	-0.233	0.553	-0.732**	-0.939***	-1.357***	0.101	-0.143
	(0.130)	(0.172)	(0.233)	(0.244)	(0.339)	(0.339)	(0.280)	(0.317)	(0.241)	(0.400)
ALUS	-0.145	-0.006	-0.214	0.081	-0.297	-0.194	-0.335	-0.515	-0.023	-0.077
	(0.109)	(0.190)	(0.215)	(0.303)	(0.329)	(0.288)	(0.331)	(0.320)	(0.209)	(0.360)
Constant	0.307	-0.209	-0.038	-0.749**	0.774*	1.435***	1.076***	1.118***	-0.656**	-1.604***
	(0.191)	(0.208)	(0.303)	(0.357)	(0.411)	(0.466)	(0.397)	(0.379)	(0.312)	(0.439)
No. of Obs.	301	195	295	189	192	121	301	195	301	195
AIC	297.70	356.97	286.30	308.92	166.60	209.68	268.89	309.97	300.83	286.17
BIC	338.48	392.97	326.85	344.58	202.43	240.43	309.67	345.97	341.60	322.18

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 5.5A. Fractional Logit Regression Results for the BMP Adoption (ESA Score) Across Environmental Risk Areas in Alberta based on Environmentally Sustainable Agriculture Tracking Survey 2023.

Independent Variables	*Overall (SE)*		*Soil Health (SE)*		*Water Quality (SE)*		*Air Quality (SE)*	
	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP	With EFP	No EFP
Age 18-44	-0.085	0.596**	0.030	0.555	0.753	1.159	-0.152	0.044
	(0.228)	(0.247)	(0.324)	(0.430)	(0.613)	(0.756)	(0.431)	(0.482)
Age 45-64	0.121	-0.074	0.188	-0.385	0.158	0.186	0.272	-0.291
	(0.198)	(0.191)	(0.299)	(0.322)	(0.493)	(0.428)	(0.321)	(0.281)
Education	0.154	0.262	0.224	0.296	-1.437***	-0.030	0.644***	0.272
	(0.166)	(0.191)	(0.324)	(0.261)	(0.488)	(0.425)	(0.212)	(0.280)
Training	0.328*	0.298**	-0.114	0.449	0.581	0.747	0.232	0.162
	(0.188)	(0.146)	(0.345)	(0.310)	(0.448)	(0.572)	(0.278)	(0.338)
GFR>250K	-0.051	0.335**	0.567**	0.528**	1.150**	1.358***	-0.463**	0.295
	(0.183)	(0.152)	(0.278)	(0.244)	(0.570)	(0.468)	(0.231)	(0.240)
Own land	-0.192	-0.384**	-0.357	-0.358	1.969***	0.072	-0.522**	-0.682***
	(0.203)	(0.153)	(0.342)	(0.265)	(0.703)	(0.404)	(0.254)	(0.251)
Maintain or	0.235	-0.178	0.009	0.022	-0.871	-0.429	0.377	0.372
expand operation	(0.237)	(0.184)	(0.372)	(0.375)	(0.645)	(0.462)	(0.337)	(0.284)
Livestock	0.453*	0.601***	-0.099	0.039	0.720	0.342	0.136	-0.197
	(0.247)	(0.189)	(0.373)	(0.304)	(0.612)	(0.438)	(0.309)	(0.320)
Crops	0.184	0.582***	0.455	-0.248	-1.370**	-0.355	0.493**	0.684**
	(0.199)	(0.206)	(0.388)	(0.338)	(0.608)	(0.471)	(0.207)	(0.288)
ALUS	-0.347**	-0.271*	-0.786***	-0.439*	-0.142	0.553	-0.256	-0.376
	(0.157)	(0.148)	(0.246)	(0.240)	(0.424)	(0.396)	(0.239)	(0.237)
Constant	-0.053	-0.271	0.132	-0.257	2.492***	0.616	-0.870***	-1.173***
	(0.206)	(0.210)	(0.323)	(0.350)	(0.731)	(0.548)	(0.259)	(0.322)
No. of Obs.	206	192	201	175	133	120	206	192
AIC	224.48	364.13	212.92	287.83	88.79	216.06	212.64	279.20
BIC	261.09	399.96	249.25	322.65	120.59	246.72	249.24	315.03

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 5.6A. Fractional Logit Regression Results for the BMP Adoption (ESA Score) Biodiversity Risk Area in Alberta based on Environmentally Sustainable Agriculture Tracking Survey 2023.

Independent Variables	*With EFP (SE)*	*No EFP (SE)*
Age 18-44	-0.108 (0.756)	0.495 (0.409)
Age 45-64	-0.256 (0.471)	-0.148 (0.385)
Education	-0.104 (0.386)	0.508 (0.368)
Training	0.542 (0.444)	-0.098 (0.395)
GFR>250k	-0.194 (0.444)	-0.323 (0.318)
Own land	-0.132 (0.490)	-0.315 (0.321)
Maintain or expand operation	0.893 (0.609)	-0.515 (0.341)
Livestock	0.729 (0.532)	0.181 (0.353)
Crops	-0.154 (0.413)	0.440 (0.350)
ALUS	-0.553 (0.466)	-0.549* (0.286)
Constant	-0.305 (0.567)	0.723 (0.456)
No. of Obs.	192	175
AIC	206.39	340.78
BIC	242.23	375.59

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1