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Understanding South Dakota Farmers' Intentions to and Adoption of Conservation Practices: An Examination of the Theory of Planned Behavior

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UNDERSTANDING SOUTH DAKOTA FARMERS' INTENTIONS TO AND ADOPTION OF CONSERVATION PRACTICES: AN EXAMINATION OF THE THEORY OF PLANNED BEHAVIOR.

BY

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THESIS ACCEPTANCE PAGE

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This thesis is approved as a creditable and independent investigation by a candidate for the master's degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ABBREVIATIONS

BMPs	Best Management Practices
SD	South Dakota
FAO	Food and Agricultural Organization
TPB	Theory of Planned Behavior
IRB	Institutional Review Board
TRA	Theory of Reasoned Action
ANOVA	Analysis of Variance
SDSU	South Dakota State University
NPKS	Nitrogen, Phosphorus, Potassium and Sulfur
GFI	Gross Financial Income
NRCS	Natural Resource Conservation Services
FSA	Farm Service Agency
SWCD	Soil and Water Conservation Districts
SDSHC	South Dakota Soil Health Coalition
USDA	United State Department of Agriculture

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ABSTRACT

UNDERSTANDING SOUTH DAKOTA FARMERS' INTENTIONS TO AND ADOPTION OF CONSERVATION PRACTICES: AN EXAMINATION OF THE THEORY OF PLANNED BEHAVIOR.

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Conservation agriculture practice is a sustainable farming method based on three principle: crop diversification, minimal soil disturbance or movement and permanent or semi-permanent of soil cover. Government and stakeholders within the agricultural sector in the United States are promoting conservation farming practices but limited voluntary adoption still exists among producers at the farm level. This research study investigated the factors that influence the adoption of conservation practices among producers in the eastern and central parts of South Dakota (SD). A modified theory of planned behavior (TPB) is used as a framework alongside socioeconomic and demographic indicators to understand farmers' current behavior and future intentions towards the adoption of conservation practices. Data were gathered from a sample of 3000 farming operations whose main crops are corn, soybeans, and wheat. Respondents were contacted three times using a modified tailored design approach by Don A. Dillman. The results from the Pearson correlation and the binary logistic regression confirms that TPB is a useful framework for understanding the behavior of farmers. Most of the three constructs of the TPB correlated

significantly to the adoption of cover crops, conservation tillage, and diversified crop rotation. The binary logistic regression model also suggests that attitude and perceived behavioral control predicted farmers' likelihood of adopting conservation tillage. This study also provided empirical evidence of the conservation practices producers currently use and those that they don’t use but intend to use in the future. This will help policymakers and conservation practitioners to develop policy measures that will help increase the voluntary adoption of conservation practices among farmers in SD.

CHAPTER ONE

This research seeks to understand the motivations and attitudes that are related to conservation agricultural practices among farmers in South Dakota (SD). A major economic activity in SD is farming (Beutler 2002; USDA, 2017). Conservation practices can be a win-win situation for both farmers and the environment because they can increase yield and protect the natural resource base. Hence this study explores the factors that influence the adoption of conservation practices by using a social-psychology framework. This study used a modified theory of planned behavior (TPB) and socioeconomic and demographic variables to explain farmers' intentions and usage of conservation practices. The research answered the following questions: 1) What are the factors that motivate and influence the adoption of conservation practices among farmers in SD? According to the TPB, human action is guided by three considerations: attitudes, subjective norms, and perceived behavioral control. Therefore, 2) this research seeks to examine whether these constructs explain farmers' behaviors towards the adoption of conservation practices. Also, 3) the research intends to study what type of conservation practices farmers in SD currently use and, if not using, intend to use in the next five years.

Data were collected through a survey of farmers in the eastern part of SD whose primary crops are corn, wheat, and soybean. The sample consist of 3000 farmers who were selected from six crop reporting districts (central, east-central, north-central, northeast, south-central and southeast). A stratified proportionate sampling method was used to select farmers from each crop district. Analysis of descriptive statistics of all variables was conducted and Pearson correlation coefficient is used to test the hypotheses

of this study. A binary logistic regression was also employed to analyze and determine the relationship between the dependent variable (actual behavior) and the independent variables (the three constructs of TPB and socio-demographic variables). This paper is structured as follows: an introduction, problem statement and background, literature review on conservation agriculture adoption in general, literature review on the theory of planned behavior, methods, data analysis, discussion and conclusion, limitations of study, references and appendix.

PROBLEM STATEMENTS AND BACKGROUND/HISTORY

Conventional agriculture is a farming system that involves intensive tillage, heavy irrigation, use of synthetic chemical fertilizer, pesticides, and genetically modified seeds (Beus and Dunlap 1990). Throughout the world, there is a growing concern about the soil productivity and larger environmental consequences of conventional agricultural practices (Knowler and Bradshaw 2007; Montgomery 2007; Farooq et al. 2011; Beus and Dunlap 1990). Conventional farming practices especially conventional tillage and burning of residue can cause the deterioration of the soil nutrient base which poses a threat to agriculture (Farooq et al. 2011). Tillage is defined as the mechanical preparation or manipulation of the soil for agricultural purposes (Farooq and Siddique 2015). Tillage of the land began in Mesopotamia around 3000 BC when man moved from hunting to more domesticated and conventional agriculture (Hillel 1998). The historical aim of tilling the land was to soften the soil to ensure good and uniform germination of seeds, weed control, and to help release soil nutrient for crops growth (Hoobs et al. 2008). Tilling the land also helps to reshape the soils physical, chemical, and biological

properties which are meant to improve crop growth and lead to higher crop yield (Farroq et al. 2011).

Conventional tillage became a major component of agriculture management practice and after the industrial revolution in the nineteenth century, there was an introduction of agricultural machinery into the farming system in the U.S. which intensified tillage activities (Hobbs et al. 2008). Intensive tillage and the use of heavy machinery brought mixed blessings, increased productivity, but also soil erosion and environmental degradation (Lal 2007). Soil erosion by run-off creates a serious problem both on and off the farm in the short and long run (Wauters et al. 2009). Effects on farms can include economic damages to crops and seedlings which also leads to the decline of soil productivity as a result of the loss of the top layer of the soil (Wauters et al. 2009). Effects off the farm on the other hand, can include the pollution of river water as a result of materials carried by flood water from the farm. Soil erosion is one of the major causes of soil degradation, nutrient depletion, and water pollution. On average, soil erosion on U.S. cropland in a year is 15.7 megagram/hectare (Sullivan 2004).

Tillage as a method of farming continued in the U.S. due to its benefit of softening the soil, weed control, relief from compaction and the release of soil nutrients (Hobbs et al. 2008). There was no uncertainty regarding the benefit of tillage to the farmer, but it also created problems for the farmer and the environment. In the 1930s tillage was questioned for the first time by Edward H. Faulkner, an agronomist, in a manuscript called “Plowman’s Folly” (Faulkner 1943; Farooq and Siddique 2015; Hobbs et al. 2008). There was a dust storm in the Midwestern U.S. in the 1930s, which lead people to question the role of tillage and soil management in unsustainable agricultural

systems (Hoobs et al. 2008). During the period of the dust storm, 91 million hectares (Mha) of land was degraded by severe erosion (Utz et al. 1938). Since then, the farming community and stakeholders within the agriculture sector in the U.S. have been advocating for reduced tillage systems (Uri 1998). Reducing tillage is promoted as a way to protect the soil, and, keeping the soil covered (Uri 1998; Friedrich et al. 2012).

Due to the problems created by conventional agriculture practices (intensive tillage), conservation agriculture is being promoted by various government and stakeholders within the agriculture sector. Conservation agriculture is a term introduced by the Food and Agriculture Organization (FAO) to indicate a method that maintains a permanent or semi-permanent organic soil cover meant to protect the soil physically from the sun, erosion (rain and wind) and to feed soil organisms (Friedrich et al. 2012; Hoobs et al. 2007). The reason for promoting conservation agriculture is to make better use of farmland through the integrated management of available natural resources and reduce the use of fuel for tillage which is better for the environment (Holland 2004; Govaerts et al. 2009, Putte et al. 2010, Baker et al. 2002; FAO 2001; FAO 2016; Garcia- Torres et al. 2003, Colmenero et al. 2013). Conservation agriculture also reduces the use of the mineral nitrogen in farming and improves the biological activities in soils which leads to long term increases in yield for farmers (Kassam, Friedrich and Derpsch 2018). Today, conservation agriculture is widely promoted by different countries because of its benefits in increasing yield and protecting the environment (Kassam, Friedrich and Derpsch 2018; Friedrich et al. 2012; FAO 2001; FAO 2016; FAO 2011).

Conservation tillage is one mechanism of conservation agriculture practices. In addition to conservation tillage, conservation agricultural practices such as diversified

crop rotation, cover crops, grass buffer strips and taking part in conservation reserve programs have also been demonstrated to be successful measures to control soil erosion and protect the environment (Roesch-McNally et al. 2017; Liebman 2013; Arora et al. 2003; Lubowski and Roberts 2008; Wauter's et al. 2009). A cover crop is a plant that is grown primarily to reduce erosion and improve soil health. The main goal of growing cover crops is to ensure that the soil is not left uncovered after harvesting the main crop on the land. Leaving the soil uncovered will increase the tendency of soil erosion. Cover crops are usually planted in the fall and allow to grow over the winter or sometimes planted in early spring and allow to grow through spring and summer. Example of cover crops are oats, alfalfa hay and mostly legumes crops (Roesch-McNally et al. 2017). These legumes crops increase the nitrogen content in the soil which help reduce the use of nitrogen fertilizer (Roesch-McNally et al. 2017). Diversified crop rotation is a practice of planting different kinds of crops on the same field alternatively (Liebman 2013; Kasu et al. 2019). Crop rotation helps to improve soil structure, fertility and reduce the spread of pest and diseases (Liebman 2013; Kasu et al. 2019). Growing legumes crops in rotation helps to increase water infiltration (Roesch-McNally et al. 2017). Planting of buffers along streams helps reduce the effect of soil erosion by improving water quality (Arora et al. 2003). Buffer strips help to trap sediments that accompany flood water into streams and rivers.

Government conservation reserve programs (CRP) encourage landowners to restore wetlands and environmentally sensitive land (Lubowski and Roberts 2008). For instance, land near waterways can be set aside for wildlife habitat (Lubowski and Roberts 2008). The U.S. federal government spends billions of dollars each year on encouraging

and subsidizing such agricultural conservation practices (Claassen and Ribaudo 2006; USDA, 2017). Farmers are also encouraged to switch towards conservation farming practices through participation in government extension programs which provide financial, educational, and technical support for farmers (Reimer and Prokopy 2013). However, there is still limited voluntary adoption of these practices at the farm level (Prokopy et al. 2019, Prokopy et al. 2008). There have been many research studies on conservation agriculture practices and factors that influence their adoption all over the world and the U.S. specifically. Factors identified by researchers that consistently influence voluntary adoption of conservation practices among farmers include farm characteristics, farmer's attitudes, economic factors, and farmer's socioeconomic and demographic characteristics, such as gross sale income, off farm income, farm size, level of education and age.

CHAPTER TWO

LITERATURE REVIEW ON FACTORS THAT INFLUENCE THE ADOPTION OF CONSERVATION PRACTICES IN THE U.S.

Farm Characteristics and Adoption

Farm characteristics are one of the factors that influence the adoption of conservation practices in the U.S. (Prokopy et al. 2019). Farm characteristics such as farm size were found to be positively related to the adoption of conservation practices (Prokopy et al. 2019, Prokopy et al. 2008). Prokopy and Babin (2014) conducted a study to understand the adoption of conservation practices by farmers from a research and practice perspective. They found the larger the farms, the more likely farmers are to adopt conservation practices. These findings were confirmed from their own survey of farmers in a watershed in north western Indiana. Smaller farms between 5-50 acres were indeed less likely to adopt conservation practices than farmers with greater acres (Prokopy and Babin 2014). Lambert et al. (2007) argue that larger farms can more quickly redeem the cost involved in engaging in conservation practices. This is possible through input cost savings and soil productivity enhancement (Lambert et al. 2007). Farmers who own their land showed a slightly more positive attitude as compared to negative attitude towards the adoption in majority of the studies reviewed (Prokopy et al. 2019). Rented land was seen as a barrier to adoption as many producers rent land on short term contracts and are less motivated to engage in conservation practices (Ranjan et al. 2019; Reimer et al. 2012). When landowners do not cooperate in the use of conservation practice on their land, adoption becomes a problem but when they are supportive, farmers intend to adopt the practice (Ranjan et al. 2019; Reimer et al. 2012).

Environmentally vulnerable land and waterbodies were found to have a statistically positive relationship with adoption of conservation practices (Prokopy et al. 2019, Lambert et al. 2007). Highly erodible land was considered by farmers as compatible with conservation practices (Ranjan et al. 2019, Lambert et. 2005). Compatibility of the proposed practice with current farming systems is a key consideration of farmers when deciding to engage in any conservation practice (Prokopy and Babin 2014, Lambert et al. 2005; Reimer et al. 2012). Many studies from the synthesis of conservation motivations and barriers in the U.S. found compatibility of conservation practices with the current farming practice equipment or infrastructure) and land quality (land availability, field shape, and topography) as a motivation for adoption (Ranjan et al. 2019; Lambert et al. 2007; Reimer et al. 2012). On the other hand, farmers with flat land did not see a reason to practice some types of conservation (no-till) because they do not have soil or water issues on their farm (Ranjan et al. 2019; Reimer et al. 2012).

Farmers' Attitude and Adoption

Attitudes are one of the strongest predictors of the adoption conservation practices among farmers in the U.S. (Prokopy et al. 2019). Examples of attitudes include perceived financial gain, off-farm environmental benefits, and stewardship (Prokopy and Babin 2014; Prokopy et al. 2019; Reimer et al. 2012). The more positive farmers' environmental attitudes are, the more likely they will adopt conservation practices (Prokopy and Babin 2014 Prokopy et al. 2008; Reimer et al. 2012). Farmers' positive attitudes toward conservation practices frequently result from their environmental awareness and knowledge about the practice (Prokopy et al. 2019; Wang 2019).

Perceived benefits of conservation practices such as reduction in soil erosion, water quality, and habitat provisioning was a motivating factor in adoption of conservation practices as well (Ranjan et al. 2019; Reimer et al. 2012). Farmers who saw themselves as stewards and interested in protecting the environment were more likely to adopt conservation practices (Ranjan et al. 2019; Prokopy and Babin 2014; Wang et al. 2019).Those who identified themselves as innovators, ready to learn and willing to try and experiment with new practices and learn from their experience were also more involved in conservation practices (Ranjan et al. 2019).

Ranjan et al. (2019) found environmental knowledge both hindered and motivated adoption. Farmers who were more concerned about the environment saw it as a motivation to adopt conservation practices. Farmers who were already engaging in a conservation practice and have engaged in it in the past were likely to adopt (Prokopy et al. 2019, Prokopy et al. 2008, Ranjan et al. 2019).Farmer's current or past experiences were also found to hinder the adoption of conservation practices. For example, farmers who had a negative experience were not willing to engage in the practice (Ranjan et al. 2019; Reimer et al. 2012). On the other hand, attitude variables such as government regulation, risk aversion, and self-interest identity were also found to have a negative relationship with adoption (Prokopy et al. 2019). Ranjan et al. (2019) also found the cumbersome process of engaging in government conservation programs as hindering adoption. Examples include excessive paperwork and lengthy application processes. The risk of uncertainty of the outcome of engaging in a particular conservation practice was a barrier to adoption of best management practices (BMPs) (Ranjan et al. 2019; Reimer et al. 2012). For example, farmers were uncertain about the usefulness of conservation

tillage on their farm (Ranjan et al. 2019; Reimer et al. 2012). Baumgart-Getz et al. (2012) found that the perceived risk of engaging in BMPs reduces with time and diminishes. These findings are indication that overtime, BMPs are perceived as less risky by farmers as more farmers widely engage in it (Baumgart-Getz et al. 2012). Farmer's understanding of how agriculture can impact environmental quality and understanding the consequences of a degraded system was insignificant on the adoption of BMP (Baumgart-Getz et al. 2012).

Economic Factors and Adoption

Economic benefits have been one of the major reason famers engage in conservation practices (Pannell et al. 2006; Reimer et al. 2012; Kasu et al. 2019). Farmers interviewed in a watershed in central Indiana named financial gain as one of the drivers for engaging in conservation practices (Prokopy and Babin 2014). Economic factors such as income, and yield were all found to have a positive relationship with adoption (Prokopy and Babin 2014, Prokopy et al. 2019, Baumgart-Getz et al. 2012, Ranjan et al. 2019; Reimer et al. 2012; Kasu et al. 2019). Prokopy et al. (2019) is of the view that personal financial condition may reduce or eliminate economic constraints on adoption of conservation or other management practices. However, farmers' behavior is not only driven by profit maximization (Willock et al. 1999). For some farmers, making money may not be their ultimate goal but rather how to secure the family lifestyle by keeping the farm property in the family for the future generation.

A major finding from Ranjan et al. (2019) was the cost involved in implementing conservation practices. The costs involved in planting cover crops as well as terminating it, changing to no-till from conventional tillage farming, adoption of grassed waterways,

nutrient management, adoption of hedgerows and biodiversity enhancing vegetated features were barriers to adoption due to the cost involved (Ranjan et al. 2019; Reimer et al. 2012). Incentives were necessary to encourage farmers to adopt these type of conservation practices (Ranjan et al. 2019). Programs on environmental awareness and knowledge was a positive significant predictor of adoption (Baumgart-Getz et al. 2012). Government programs that pay farmers incentives to engage in various types of conservation practices were motivating factors that encourage the adoption of conservation practices (Ranjan et al. 2019; Reimer et al. 2012). An initial reduction in yield after implementing certain types of conservation practices (no-till) was also an important economic factor that hinders adoption (Ranjan et al. 2019; Reimer et al. 2012).

Formal Education, Skills and Knowledge and Adoption

In some studies farmers' formal education has proven to be positively related to the adoption of conservation practices (Prokopy et al. 2019, Prokopy et al. 2008, Lambert et al. 2007). Adoption of conservation practices is a learning process (Ghadim and Pannell 1999). First, farmers need to collect information regarding the new technology and also assess and evaluate that information (Pannell et al. 2006). Then, farmers make a decision about whether to adopt the new technology or not because at the initial process, farmers may be uncertain about the new practices (Pannell et al. 2006). Hence farmers may feel reluctant in making a decision to adopt the new practice (Pannell et al. 2006). The second aspect of the learning process is the enhancement in farmers' knowledge and skills in applying the innovation to their situation (Ghadim and Pannell 1999).

Usually, most new farming innovations require a certain level of skills and knowledge to be able to effectively engage in the practice. By practically engaging in it,

reading, listening and watching, farmers can enhance the skills necessary for the innovation (Pannell et al. 2006). Lambert et al. (2007) is of the view that expert advice may help to convince the adoption of specialized conservation practices among farmers. Baumgart-Getz et al. (2012), on the other hand found that farmers former level of education was insignificant, but extension training had a positive influence on the adoption of BMPs. Singh et al. (2018) also found a significant moderate relationship between producer's attendance at demonstration sites and field days of four conservation practices (cover crops, nutrient management, filter strips and two- stage ditches). Agricultural producers indicated during interviews that cover crop demonstration sites and field days gave them the opportunity to learn from people who were outside their regular professional networks (Singh et al. 2018).

Age and Adoption

Prokopy and Babin (2014) also found that older farmers who were closer to retirement were less likely to change their behavior and adopt new practices. This is because of the cost involved in purchasing new equipment and learning a new technology or management skills (Prokopy and Babin 2014). Baumgart-Getz et al. (2012) also found age to have a significant and negative impact on BMPs. Older farmers have a shorter time to plan than the younger farmers which make them less likely to adopt new technology (Baumgart-Getz et al. 2012). Wang et al. (2019) also found that factors that reduce the time horizon to cultivate on the same farm such as age and the possibility of moving significantly reduce the adoption of diversified crop rotation. On the other hand, Lambert et al. (2007) is of the view that younger farmers may be willing to make such investment because of their longer farming horizons. Age was also found to be negatively significant

with adoption more often than positive in the significance vote count of a meta-analysis on the adoption of conservation practices (Prokopy et al. 2019).

Social Factors and Adoption

Farmers' social networks, such as family, colleague farmers, chemical dealers, seed dealers, and crop consultants also play a significant role in the adoption of conservation practices (Prokopy and Babin 2014, Getz et al. 2012 Ranjan et al. 2019). When farmers act as leaders in the community (for example as conservation leaders or champions, and watershed coordinators) encouraging conservation adoption was found be a major factor motivating adoption (Ranjan et al. 2019). Prokopy and Babin (2014) found that well respected, successful, and innovative farmers who engage in the practice and share their knowledge and experience was helpful in increasing adoption. When a well-respected farmer engages in a practice and become successful, then there is a rapid diffusion within the community (Prokopy and Babin 2014; Reimer et al. 2012). They found this occurrence happening in Indiana with cover crops (Prokopy and Babin 2014).

Distrust or trust in information sources from farmers, watershed groups, conservation agencies, and university extension were relevant themes that motivated or hindered the adoption of conservation practices (Ranjan et al. 2019). Farmers and watershed groups identified as a trusted sources of information motivated adoption of conservation practices (Ranjan et al. 2019). Perception of neighbors' success also resulted in motivation for adoption of BMPs (Ranjan et al. 2019). Neighbor's challenges resulted in hindering the adoption. Farmers who try something new each year and never stick to it are poor promoters of new innovations (Prokopy and Babin 2014). Prokopy et al. (2019), on the other hand, found that conservation agencies and university extension

as a source of information generated mixed results. Seven studies identified conservation agencies as trusted sources of information motivating adoption while three studies saw them as distrusted information sources hindering adoption (Prokopy et al. 2019). This is an indication that not all organizations are seen as trusted sources regarding information on conservation practices. Baumgart-Getz et al. (2012) is of the view that adoption efforts should combine complementary social factors (e.g., farmers' attitude, environmental awareness, extension training and networking) to increase their overall impact. For example, using networks to implement extension efforts and sharing information represents a rational way to combine and extend the reach of factors found to have a significant effect on BMP adoption (Baumgart-Getz et al. 2012).

THE THEORY OF PLANNED BEHAVIOR

Based on the scholarship reviewed above, the current study took an integrative approach to understand how social psychological, socioeconomic, and demographic factors influence farmers' current behavior and future intentions towards conservation practices. Research studies based on the theory of planned behavior (TPB) provide more insight into farmers' behavior than socio- demographic variables alone which makes the theory a useful framework for understanding both intention and behavior (Hansson et al. 2012; Greaves et al. 2013; Borges et al. 2014). Several studies on adoption of conservation practices suggest that the TPB offers a suitable framework for investigating conservation measures (Wauters et al. 2010, Beedell 2000, Borges et al. 2014, Werner et al. 2017, Deng et al. 2016).

The Theory of Reasoned Action (TRA), was the first model developed by Fishbein and Ajzen to predict human behavioral intention and actual behavior in 1975.

According to the TRA, human behavior originates from a person's behavioral intention (Fishbein and Ajzen 1991). These behavioral intentions are determined by two components - attitude towards the behavior and subjective norms. Attitude towards a behavior is the extent that the performance of a behavior is evaluated positively or negatively. Subjective norms are the social pressures a person feels from others, such as their social networks, family, and friends.

The TRA was criticized for inadequately predicting intention and actual behavior by other scholars (Trafmow 2009, Ogden 2003). Attitudes and subjective norms alone were not sufficient for predicting human behavioral intention and actual behavior. The theory failed to predict behaviors that require access to certain opportunities such as skills, knowledge, and resources. In response to the limitation of the theory in predicting human behavioral intention and behavior, perceived behavioral control was added to the theory. Perceived behavioral control measures how a person perceives their ability to control any given behavior, thus how easy or hard it is to display a certain behavior. It explains the presence of factors that may facilitate or prevent the performance of the behavior (whether or not the person has the skills, knowledge, and resources to engage in that behavior). With the addition of perceived behavioral control, TPB includes a measure for behaviors beyond the complete control of people (Ajzen 1991).

TPB is a social psychological theory designed by Icek Ajzen (1991) to understand and predict specific behavior. According to the theory, human behavior emanates from the intention to perform the behavior which is determined by three psychological constructs. These psychological constructs are attitude, subjective norms, and perceived behavioral control, which work together to lead to a positive or negative behavioral

intention. According to the theory, the more favorable these three constructs are, the more likely the behavior intention leading to actual behavior.

Conceptualizing the Constructs of TPB

Attitude is one of the key components of the TPB, which measures the way people feel towards a particular behavior. Attitude is constituted by two factors, behavioral beliefs, and evaluation of the potential outcome of performing the behavior in question. Behavioral beliefs are the motivation people feel to perform a behavior as a result of likely consequences of the behavior. It focuses on what the individual thinks will occur as a result of performing the behavior. Outcome evaluation, on the other hand, refers to the way an individual views and evaluates the prospective outcome of a performed behavior. For example, a farmer may believe that conservation farming practices will improve soil health, protect the environment, and increase crop yield (positive belief). He may also believe that conservation farming practices lead to low yield and high expenses (negative belief). From this example, the behavioral belief of engaging in conservation farming practices corresponds to improving soil health and an increase in crop yield. At the same time, it can also correspond to the belief of low yield and expensive to implement. For outcome evaluation, a farmer may evaluate the outcome of a conservation practice as positive if it has actually improved his soil health and increased crop yield. On the other hand, a farmer may evaluate the outcome of a conservation practice as negative if it resulted in low yield and increased cost. Therefore, a positive behavioral belief and a positive outcome evaluation would result in a positive attitude which leads to behavioral intention and behavior. On the other hand, a negative

behavioral belief and negative outcome evaluation will lead to lack of intention and behavior of farmers' to engage in conservation practices.

Subjective norms are perceived social pressure to perform or not to perform a particular behavior (Ajzen 1991). It focuses on a person's social networks, group beliefs, family, friends, and colleagues. There are two components of subjective norms, normative beliefs, and motivation to comply. Normative beliefs are the normative expectations of others. When a reference group approves of a behavior, people are more likely to perform the behavior. There is a direct correlation between normative beliefs and behavioral intention. Motivation to comply refers to the willingness of the individual to comply or not comply with the social norms of the reference group. For example in the case of farmer intention and behavior towards conservation practices, if a farmer has a colleague, a friend or someone he respects or looks up to who thinks conservation farming practices are good and want him or her to engage in conservation practices (normative belief), and the farmer feels it is important to consider his friend's opinion (motivation to comply), a positive subjective norm is produced, which will eventually lead to intention and behavior. Both normative beliefs and motivation to comply need to be observed to lead to a positive subjective norm.

The third component of TPB, perceived behavioral control refers to the degree that a person believes that they can control any given behavior. It explains how easy or difficult it is to display a certain behavior. Two components that explain the perceived behavioral control constructs are control beliefs and control frequency. Control beliefs are the perception of control someone has in performing a certain behavior. Control frequency is the degree of ease or difficulty in carrying out that behavior. Perceived

behavioral control affects both intention and behavior. For example, if a farmer thinks engaging in conservation farming practices is not a difficult practice (control beliefs) and he has the skills and knowledge to engage in it (control frequency), he will have a positive behavioral control leading to intention and eventually behavior. The theory suggests that people are much more likely to intend to enact certain behaviors when they feel they can enact them successfully.

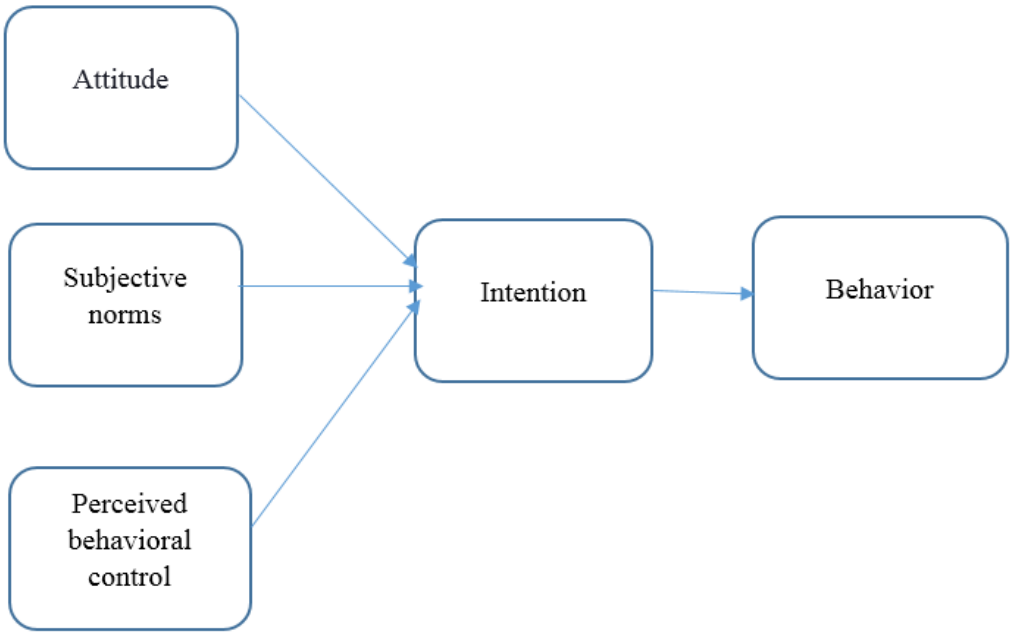


***Figure* 1.** Diagram of the theory of planned behavior.

The diagram above shows how the three independent constructs of the theory lead to intention and behavior. Attitudes, subjective norms, and perceived behavioral control must work together to lead to intention and behavior. A positive attitude, favorable social norms and high level of perceived behavioral control are the best predictors of forming a behavioral intention and in turn behavior (Ajzen 1991). The more favorable these three constructs are, the stronger the intention of an individual to perform the behavior.

The TPB has been used to understand farmers' intention, decision, and adoption behavior in diverse areas of agriculture (Borges et al. 2014). Examples of studies include conservation agriculture (Beedell and Rehman 2000) entrepreneurship (Bergevoet et al. 2004), soil conservation (Wauters et al. 2010), diversification of agricultural products (Hansson et al. 2012, Seger et al. 2017) water conservation practices (Yazdanpanah et al. 2014) and organic farming (Lapple and Kelly 2013). The TPB has also been used in several studies more specifically to explain farmers' environmental behavior regarding the reason for the adoption and non-adoption of conservation practices (Wauters et al. 2009; Beedell and Rehman 2000; Rehman et al. 2004; Yazdanpanah et al. 2014). While, the TPB is a good framework for studying farmers' behavior intention and actual behavior (Wauters et al. 2009; Beedell and Rehman 2000; Borges et al. 2014; Werner et al. 2017; Deng et al. 2016), findings suggest that the predictive power of the theory of planned behavior varies by population and geographic location and the specific behavior being studied.

Deng et al. (2016) analyzed the environmental conservation behavior of farmers using the TPB. They found that farmers' intention to conserve and achieve environmental sustainability from payment for ecosystem service programs in eco-environmentally fragile areas was positively influenced by attitudes, subjective norms, and perceived behavioral control. A similar result was also found about farmers' intention to adopt improved grassland practices (Borges et al. 2014). Farmers were influenced by evaluation of the use of improved grassland management, by their perception about social pressure to engage in the practice, and their own ability to engage in improved natural grassland (Borges et al. 2014). Beedell and Rehman (2000) studied two groups of farmers using the

TPB and found that farmers who belong to a conservation group (members of the farming and wildlife advisory group) had a positive attitude and felt more pressured by society, family and their colleagues to manage the environment positively than other farmers because they have greater environmental awareness. Results from the same studies also provide evidence that even though all the three constructs of the theory influence farmers' intention to engage in conservation practices, other components within the theory had a greater influence than others. For example, Deng et al. (2016) found that perceived behavioral control was the most important element explaining farmers' ecological conservation behavior followed by subjective norms and attitudes. Beedell and Rehman (2000) found very few differences in perceived behavioral control between the two groups because both felt largely in control of their specific behavior being studied.

In other studies, one or two components were found to be predictive of farmers' intention and actual behavior. Werner et al. (2017) found that farmers with a positive attitude toward cover crops have a higher probability to be strong intenders, while perceived difficulty was a barrier in adopting cover crops. Wauters et al. (2009), in their study of farmers' adoption of soil conservation practices, found attitude as the main explanatory variable of intention and behavior. Perceived behavioral control and subjective norms did not provide a significant contribution in the prediction of intention and behavior (Wauters et al. 2009). According to Greaves et al. (2013), the TPB offers a greater insight into predicting farmers' behavior when socio- economic and demographic variables are included in statistical analyses.

The study proposed here includes measures for the constructs of TPB, as well as socioeconomic and demographic variables. This study as indicated earlier employs a

modified form of TPB to understand farmer actual behavior and future intentions to engage in conservation practices. It was modified in the sense that instead of predicting intention, actual behavior is predicted. This type of study, to the researchers' knowledge has not been applied to understand the conservation behavior of SD farmers. Wang et al. (2019) from their study of conservation practice adoption in the northern Great Plains recommended that future efforts to understand farmer's conservation behavior should focus more on farmers' attitudes and perceptions of conservation practice. Therefore, this study is a contribution to the literature regarding factors that influence farmers adoption of conservation practices related to how the TPB predict actual behavior instead of current intention which was the original design of the TPB.

CHAPTER THREE

METHODS

The target population for this research project are producers in SD whose primary crops are corn, wheat, and soybeans. Livestock producers are also included but not farmers who only focus on livestock farming. The sample size for this project is 3,000 farmers with their record of planted acres in 2017 purchased from Farm Market ID. Producers who made more than $150,000 in gross farm income were selected randomly from six crop reporting districts in the eastern and central part of SD (where most of the commodity crops are produced), namely central, east-central, north-central, northeast, south-central and southeast. The major commodity crops grown in these districts are corn, soybeans, and wheat while other minor crops include alfalfa, oats, and sunflower.

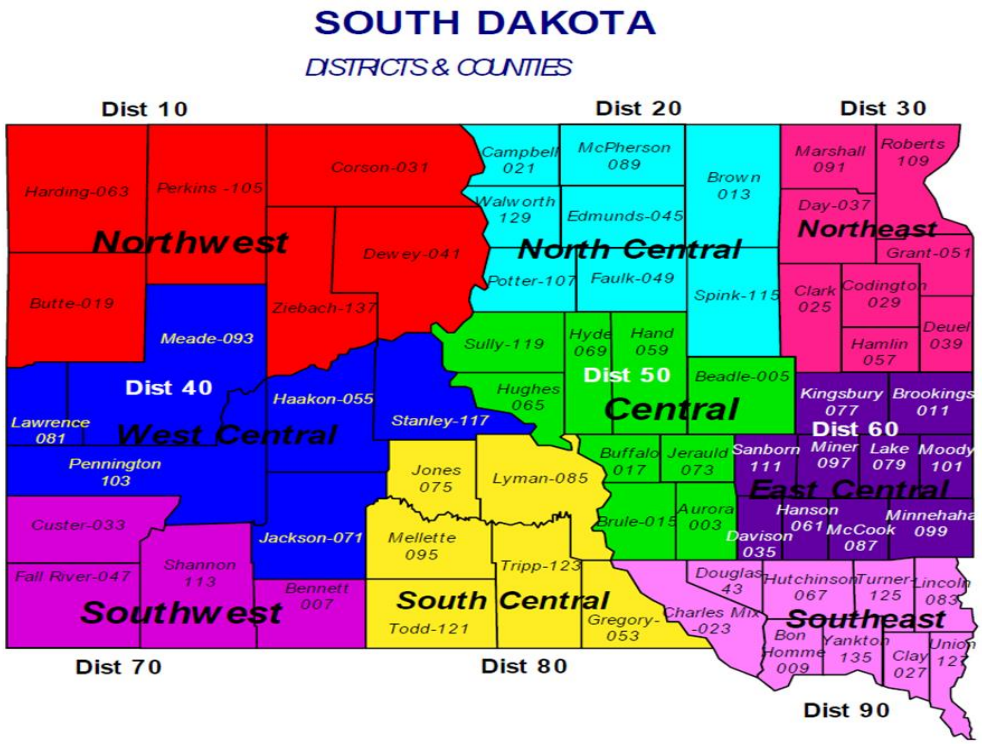


***Figure* 2.** Map of cropping districts in the eastern South Dakota**. *Source*:** (https://www.nass.usda.gov/Statistics_by_State/South_Dakota/index.php)

Stratified proportionate sampling was used to select farming operations randomly from each cropping district according to the number of operations in the district (See Figure 2). There were 560 (18.67%) farmers selected from the central district, 515 (17.16%) from east-central, 684 (22.80%) from north-central, 489 (16.30%) from the northeast, 252 (8.40%) from south-central and 500 (16.67%) from the southeast district. The purpose of using proportionate sampling is to ensure the data gathered is a true representation of farmers in SD. Respondents were contacted three times using a modified tailored design approach (Dillman et al. 2014). The first contact consisted of an advance letter with a $2-dollar bill incentive. The letter informed respondents about the purpose of the research and how the information gathered would benefit them by providing research and educational programs that will meet their needs, increase economic activities, and lead to environmental sustainability.

The advanced letter contained a link for the survey so that respondents who wanted to take the survey immediately online could do so. The second contact was a mail survey which include a stamped return envelope for those who did not respond to the first wave. The last contact was another mail survey with a stamped return envelope for those who did not respond to the first and second waves to give them another opportunity to take the survey. The process of multiple contacts and incentives to respondents has been proven to increase the response rate (Dillman et al. 2014). This process is represented in figure 3 below.

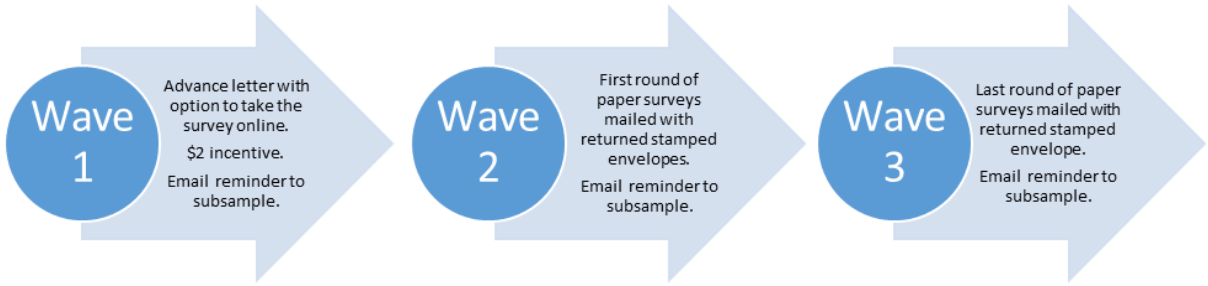


***Figure* 3.** Diagram of the modified tailored design approach by Don Dillman.

The response rate is very crucial for survey research because it helps the researcher to confidently generalize the sample results to the entire population being studied. The response rate for this research project was 17.7%. Response rates in general have gone down in recent decades (Dillman et al. 2014, Stedman et al. 2019). One of the challenges in survey research is achieving a high response rate to ensure the validity of the data and avoid non-response bias. Fowler (2002) is of the view that there is no minimum acceptable response rate; it depends instead on the research topic, target population, and sample size.

A non-response bias test was conducted to determine if farmers who responded to the survey differ in key ways from those who did not (e.g, acres planted and GFI). From the result, it was found that planted acres of farmers who responded to the survey ranged from 5-17,681, with an average of 1,151 acres and median of 681. Planted acres for non-respondents on the other hand ranged from 12-65,478 with an average of 1,365 acres and a median of 792 acres. From a two-sample t test, it was found that non-respondents had a significantly higher average acreage planted than respondents. The GFI for respondents ranged from $150,076 to $6,956,941 with an average of $593,270 and a median of $381,060. The GFI for non-respondents on the other hand ranged from $150,249 to $20,496,506 with an average of $702,600 and a median of $436,552. Again, non-respondents had a significantly higher GFI than respondents from the figures indicated.

These non-respondent bias tests show that the results are somewhat biased towards smaller operations, both in terms of acres operated and annual income generated. There were a few large operations that serve as outliers contributing to the skewing the mean values, but the median values were much closer for both indicators than the means.

From our experience conducting this survey project, the relatively low response rate of 17.7% could be attributed to the time in which the surveys were sent which was in June and July of 2019. Farmers prefer to complete surveys in December, January, and February (Pennings et al. 1999), but this timing was not an option for the project. Apart from unideal timing, during the period of June and July 2019, SD experienced severe flooding which created a devastating situation for farmers. Many farmers could not get their seed planted and those that did also lost much of their seed due the flooding. The survey instrument was also long, and included very technical questions, and complicated questions which could have required farmers to refer to their records or their consultants in order to answer some of them. Farmers say that questions that require them to consult their records are difficult to answer (Pennings et al. 1999). Stedman et al. (2019) found a similar evidence from their longitudinal study of mail surveys from 1971 to 2017 that the percent of complex questions led to lower response rates.

Instrument Construction

The survey questions measuring the actual behavior and the intention of farmers to engage in conservation practices were part of a larger survey project. The larger project was aimed at studying the current nutrient management practices of producers in SD. The survey asked producers detailed questions regarding the management of nitrogen, phosphorus, potassium, and sulfur (NPKS) and micronutrients of major crops in

the eastern and central (SD). The goal of the project was to help guide future soil fertility research and educational programming in the state. The researcher was allowed to design and add questions which were constructed based on the goal of the research which seeks to understand SD farmers' intention and behavior towards adopting conservation practices. The TPB was used to construct questions that measure attitude, subjective norms, and behavioral control in the intended and actual adoption of agricultural BMPs. A thorough literature review was conducted to understand the various types of conservation practices that are commonly practiced in SD and being encouraged. From the literature, three main conservation practices were identified namely cover crops, conservation tillage, diversified or extended crop rotation (Wang 2019). The planting of buffers along streams or field edges and enrolling in the conservation or wetland reserve program were other conservation practices in SD that were asked about on the survey. To ensure all conservation practices were captured by the instrument, an 'other' category for conservation practices was added for farmers to select and write in other practices they use.

One of the concerns about survey research and instruments that measure attitude and behavioral questions is the validity of the instrument. There are several ways to ensure the validity of instrument, one of which is content validity. With content validity, researchers ensure that the measure(s) covers the full range of the concept's meaning (Schutt 2019). Much literature was reviewed to understand how other researchers use the TPB and the kind of measures used to capture the various constructs within the theory. Through the literature review, different dimensions within the theory were identified. Readily accessible behavioral beliefs, normative beliefs and control beliefs of farmers

were also identified. Questions were designed to capture the entire meaning of the theory in relation to conservation practices among farmers. The survey questions were also face valid because the questions define the TPB more than any other concept. By just looking at the questions, "on its face" one should be able to determine which question measures what component within the TPB. Hence the survey instrument can be said to be valid and measures the TPB in explaining farmers' intention and behavior. All the survey materials were approved by the South Dakota State University Institutional Review Board (IRB) for use on human subjects.

Measures

The three conceptual independent constructs of the TPB are attitude, subjective norms, and perceived behavioral control. Attitude is derived from behavioral beliefs (Bi and Ei) where Bi is the belief about outcome of a particular behavior and Ei is the evaluation of the outcome of the behavior (Wauters et al. 2010). Subjective norms on the other hand are derived from normative beliefs (Nj and Mj), where Nj is the belief about the normative expectation of important referents and Mj is the motivation to comply with what the important referent thinks. Perceived behavioral control is derived from control beliefs (Ck and Pk) where Ck is the belief about factors that may facilitate or hinder the performance of the behavior and Pk is the perceived power to facilitate or prevent the behavior (Wauters et al. 2010). Based on this explanation, the questions were designed to encompass each of the elements of each component of the TPB. A five-point Likert scale is used to measure the responses to each statement. Respondents were asked to state their level of agreement and disagreement with each statement, which ranged from strongly

agree at five points (positive responses) to strongly disagreeing at 1 point (negative responses).

Attitude is measured by whether respondents agree or disagree that conservation practices improve soil health, protect the environment, and increase yield. Subjective norms are measured by whether respondents agree or disagree that their colleague farmers are increasingly using conservation practices and whether it has an influence on them deciding to adopt the practice or not. Perceived behavioral control is measured by whether respondents agree or disagree they have all the necessary skills and knowledge to engage in conservation practice. All the statements measuring the TPB captures the multiple dimensions of attitude (behavioral beliefs and outcome evaluation), subjective norms (normative beliefs and motivation to comply) and perceived behavioral control (control beliefs and control frequency). The statements are captured in **Table 1 below**. Other independent variables include gender, age, gross operational income, educational level, off-farm income, farm size (total acres), years primary farm decision-maker, and whether producers consider the location and soil characteristics to minimize leaching or run off fertilizers. Table 1 below represents measures for all the variables in this study.

***Table* 1**. Variable Measures.

Variable	Measure
Actual behavior (cover crops, conservation tillage, diversified/extended crop rotation)	(1) Currently use (2) Does not use, intends to use (3) Does not use, does not intend to use (4) Does not use, does not apply
Intended Behavior, Next 5 Years (cover crops, conservation tillage, diversified/extended crop rotation)	(1) Currently use (2) Does not use, intends to use (3) Does not use, does not intend to use (4) Does not use, does not apply
Attitude 1. Conservation farming practices improve soil health (Behavioral beliefs) 2. Conservation farming practices increase crop yields (Outcome evaluation) 3. Conservation practices protect natural resources for future generations (Behavioral beliefs)	(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Strongly Agree
Subjective norms 1. Farmers around me are increasingly using conservation practices (Normative beliefs) 2. Conservation practices protect natural resources for future generations (Motivation to comply) 3. I feel encouraged by other farmers to use conservation practices (Motivation to comply).	(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree 4) Agree (5) Strongly Agree
Perceived behavioral control 1. The way land is managed has an impact on water quality (Control beliefs). 2. I have the skills I need to be able to use most conservation practices (Control beliefs). 3. Whether I engage in conservation farming practices or not depends entirely on me (Control beliefs). 4. Conservation farming practices are not difficult to implement (e.g., in time, money, labor, knowledge or obtaining permit(s). (Control frequency)	(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree 4) Agree (5) Strongly Agree
Gender	(1) Male (2) Female
Age	Measured as a continuous variable in years
Gross operational income	(1) Less than $ 150,000 (2) 150,000 to $ 349,999 (3) 350,000 to $ 999,999 (4) $1 million or more
Educational level	(1) Less than high school (2) High school diploma/GED (3) Some college/technical school (4) College degree (5) Post – graduate degree
Off farm income	(1) Yes (2) No
Farm size (Total acres)	Measured as continous variable in acres
Years primary farm decision maker	Measured as a continous variable
Considering location and soil characteristics to minimize leaching or run off fertilizers	(1) Never heard of it (2) Familiar but not currently using (3) Currently using (4) Not applicable

Hypotheses

As discussed earlier, the TPB hypothesizes that intention to practice behavior is the driving force leading to the actual performance of the behavior which is determined by three independent constructs (attitudes, subjective norms, and perceived behavioral control). But for this study, the researcher used a modified TPB which predicted actual behavior and future intention of farmers in SD regarding the adoption of conservation practices. To the researcher's knowledge, this type of modified TPB has not been used before hence contributing to the literature about the TPB in understanding farmers' behavior and future intentions. The testing of actual behavior gives the researcher a concrete evidence about how the three constructs directly influence farmers' behavior. This is represented in figure 4 below.

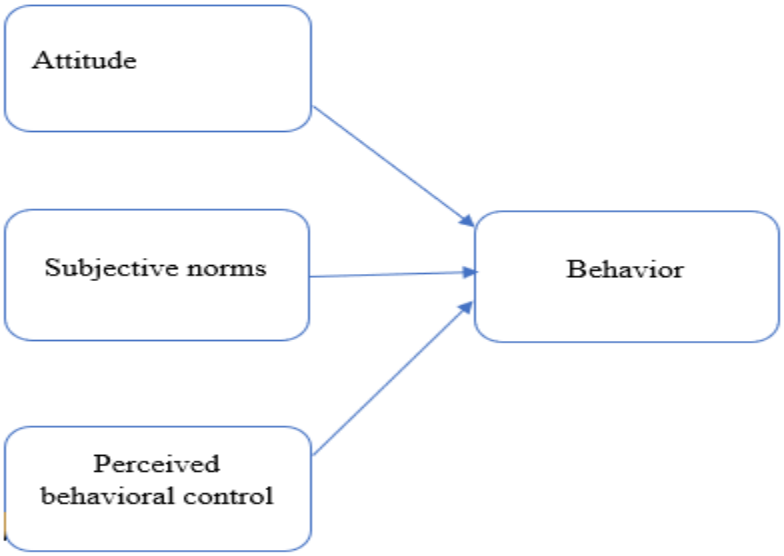


***Figure* 4.** Conceptual Diagram Explaining SD Farmers' Conservation Practices.

In this research, intention is defined as a farmer's intention to engage in different types of conservation practices in the next five years. Actual behavior is defined as

conservation practices farmers are currently using. Hence the following hypotheses were developed.

1. Farmer's attitudes, subjective norms, and perceived behavioral control effect actual conservation behavior.
2. Farmer's attitudes, subjective norms, and perceived behavioral control effect their future intention to engage in conservation practices.

CHAPTER FOUR

DATA ANALYSIS AND RESULT SECTION

Descriptive Statistics, Farm Characteristics, and Levels of Measurement of Socioeconomic and Demographic Variables

Conducting research on an entire population is very expensive considering the time and resources needed (Schutt 2019). Moreover, we do not need to get data from a whole population to understand it and studying the whole population can lead to research fatigue. Therefore, most research studies are done on a sample of the population which is summarized using descriptive statistics. The findings from the descriptive statistics can then be generalized to the larger population if probability sampling is used. Age and farm size are interval and ratio variables or simply continuous variables. These variables are best summarized using the mean and standard deviation because they have detailed information associated with them. The mean helps to determine the average of the variable while the standard deviation helps to determine how widespread or close the data points are from the mean. A high standard deviation is an indication that the data is widely spread out while a smaller standard deviation shows the data is not widely spread. There is no good or bad standard deviation, but rather they are indicators of how your data is spread out. Therefore, a good standard deviation depends on the researcher's expectation within the distribution and the specific variables being studied. Thus, whether you expect the data to be centered or spread out around the mean, but a smaller standard deviation is usually preferred among researchers.

***Table* 2.** Summary statistics for socioeconomic and demographic characteristics of the sample.

Variable	Mean	Standard Deviation	Minimum	Maximum
Age (N= **372**)	58.70	11.78	24	89
Farm Size (in acres) (N= **334**)	2042.02	2970.18	80	35000
Acres Owned (N= **314**)	1111.48	1418.73	8	10000
Acres Rented (N= **285**)	1153.11	2122.89	10	25000
Years Primary Farm Decision Maker (N= **358**)	30.70	14.16	3	69

Source: Author's Survey

The results in Table 2 above indicates that farm size, acres owned, and acres rented have a high standard deviation which is an indication that the data is widely spread out regarding those variables and there are outliers within the data accounting for the high variation. Age and years of farm decision-maker had a relatively low standard deviation indicating those variables are not widely spread out. The average age of farmers from the data was 58.70 which indicates that most of the farmers are old. The oldest among them was 89 years and the youngest was 24 years with a standard deviation of 11.78. The average age from the sample is slightly higher than the average age of 56.2 of all producers from the 2017 Agriculture Census in SD (USDA, 2017). It is not only in SD that the average age is high but the U.S. in general has an average age of farmers around 57.5 (SDDA, 2017).

The average farm size from the sample data is 2042.02. The highest total acres of land farmers cultivate in the data was 35,000 acres with the least being 80 acres. The standard deviation of the total acres is 2970.18. When the 35,000 acres response was deleted from the data, the average acres cultivated was 1943.37 with a standard deviation

of 2359.46 with a minimum value and maximum of 80 acres and 16,000 acres, respectively. Therefore, the high acre of 35,000 in the data accounted for the high standard deviation and variation within the sample data regarding average acres cultivated in SD. The total acres, or the size of farms cultivated by farmers, includes both acres they own and acres they rent. The average acres owned is 1111.48 with a maximum acreage of 10,000 and a minimum of 8 acres. The standard deviation of acres owned by farmers is 1418.73. The average acres rented is 1153.11 with a maximum acre's size of 25,000 and a minimum of 10 acres. The standard deviation of acres rent by farmers is 2122.89. These results are indications that most land cultivated by farmers in the sample is rented as compared to land they own and operate. The average farm size of 2036.32 from the sample data was higher than the average farm size of 1443 acres in the 2017 Agricultural Census in SD (USDA, 2017).

Regarding the number of years farmers have been the primary decision-makers on their farm, the average number of years was 30.70 with a standard deviation of 14.16. The minimum years' farmers indicated was 3 while the maximum was 69. Considering the mean regarding the years' farmers have been a decision-maker, the result shows that most farmers in the sample have been farming for quite some time, therefore, continue to make decisions regarding the farming operation. The result is not surprising considering the average age distribution in the data and SD in general which has an aging farming population.

Table 3 below displays the results of other demographic and socio-economic variables. Income, level of education, gender, and off-farm income are nominal and ordinal variables. For nominal variables, values are usually grouped into categories and

have no meaningful order while ordinal variables have a meaningful order. Both nominal and ordinal variables are best summarized and described using frequencies and percentages because these statistics show differences in distribution among the various groups being studied. Therefore, it is justified to use frequencies and percentages to measure the outcomes of the variables in Table 2 below.

***Table* 3.** Percentage and frequency distribution of other socioeconomic and demographic variables.

Gross Operational Income (N=353)	**Frequency**	**Percentage**
Less than $150,000	43	12.22%
From $150,000 up to $349,999	126	35.80%
From $350,000 up to $999,999	115	32.67%
$1 million or more	68	19.32%
Level of Education (N= 384)		
Less than high school	11	2.86%
High school diploma GED	99	25.78%
Some college/technical school	129	33.59%
College	133	34.64%
Graduate degree	12	3.13%
Gender (N=388)		
Male	382	98.71%
Female	5	1.29%
Off Farm Income (N=384)		
Yes	96	25.%
No	288	75%
Considering Location and Soil Characteristics to Minimize Leaching or Run Off Fertilizers (N= 417)		
Never heard of it	8	1.91%
Familiar but not currently using	91	21.77%
Currently using	288	68.90%
Not applicable	31	7.42%

Source: Author's Survey

For the gross operating income of farmers, the results show that the highest percentage (35.80%) of farmers earned from $150,000 to $349,999 gross operation sales in a typical year. 32.76% of farmers earn from $350,000 up to $999,999, the second-highest percentage. The remaining farmers earned more than $1 million and less than $150,000 representing 19.32% and 12.22% respectively. The majority of farmers in the sample data are in the category of the midsize family farm and moderate sales farms according to the USDA classification of farm size in relation to gross cash farm income (GCFI). The results in this study also correspond to the 2017 Agriculture Census Data as the majority of farmers earn $100,000 to 499,999 in farm value sales in SD (USDA, 2017). The results also show that few large operations earn $1 million and over and very few low sale farms are part of the data. The few low sale farms in the data were because the sample was restricted to farmers who earn more than $150,000 in GCFI.

For the level of education of farmers within the data, the majority of farmers indicated having a college degree representing 34.64% and 33.59% also reported they had some college/technical school education. The rest of the farmers within the data had a high school diploma (GED), post-graduate, and less than high school with 25.78%, 3.13%, and 2.86% respectively. This indicates that most farmers in this study have at least a formal education with many of them having college, some college/technical school, and high school diploma/GED. The results also indicate very few farmers have an educational level less than the high school. The fact that most farmers have some formal level of education in the data is an indication that the adoption of conservation practices in SD is promising as research shows that farmers with formal education are more likely to adopt new practices that enhance environmental quality (Prokopy et al. 2019, Prokopy

et al. 2008, Lambert et al. 2005). Also, those who are educated are more likely to respond to new technology.

For the results of the gender of farmers who responded to the survey, the majority of farmers in the data gathered were male (98.71%). Only 1.29% of the respondents were female. The gender distribution in the data also aligns with the 2017 Agricultural Census data as most producers constitute men (USDA, 2017). The percentage is a little high for men and lower for women in the sample data compared to the 2017 Agriculture Census Data where 69.61% are male and 30.38% are female. This result indicates that few women are engaged in farming in SD as many of them constitute men (USDA, 2017). This is likely attributed to the fact that the researchers asked the primary decision maker of the operation to take the survey which might result in more males taking the survey compared to females. Women landowners are also usually marginalized when it comes to the issue of conservation agriculture programs and education by federal agencies in the U.S. (Petrzelka, Sorensen and Filipiak 2018). Because of the difficulties and discrimination women landowners experience in finding information about government conservation programs, it can result in them being less likely to respond to surveys meant to understand their attitudes and behaviors regarding conservation agriculture practices. Concerning whether farmers worked off the farm for income in the previous year, 75% indicated not having income off the farm while 25% indicated having income off the farm. The results show that the majority of farmers engage in full-time farming while less engage in other economic ventures that generate income for them.

Farmers were asked about their level of experience with the practice of considering the location and soil characteristics to minimize leaching or runoff fertilizers.

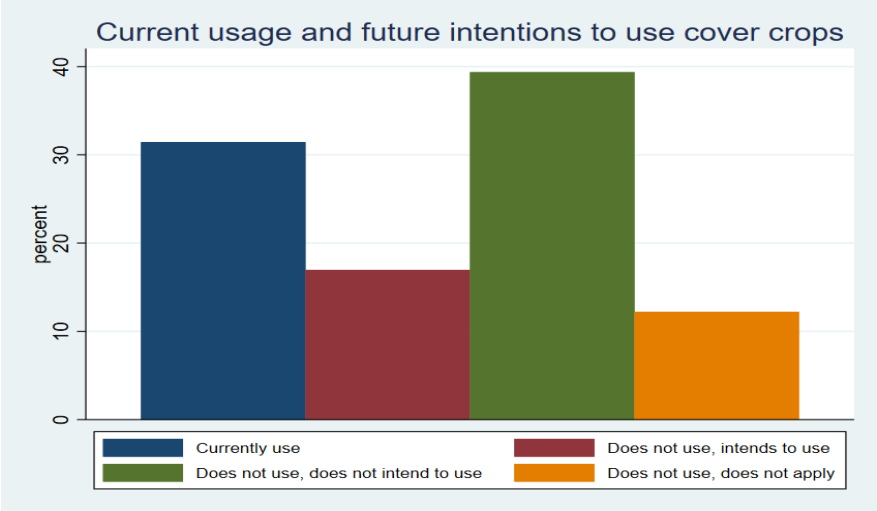
The results indicate 68.90%, representing the majority, currently engage in the practice. 21.77% said they were familiar with it but not currently using the practice. 7.42% indicated the questions did not apply to them while 1.91% said they have never heard it before. The results show that most farmers in SD are concerned about nutrient run-off through erosion hence take precautional measures to prevent it. The 21.77% who indicated they were familiar with the practice but not currently using also shows that most farmers are also aware that the location and soil characteristics affect the leaching of nutrients.

Dependent Variable

The initial idea for understanding farmer's intention and actual behavior towards the adoption of conservation practice using the TPB was to find out if farmers currently use a particular conservation practice and intend to use the same practice in the next five years. An option was also created for them to indicate if the question did not apply to them. The survey questions were designed in a way that farmers could select if they currently engage in a conservation practice and intend to use the same practice in the next five years. What this means is that they could select more than one response. But a closer look at the data indicated that most farmers interpreted the question in a different way thinking they were supposed to select only one answer choice which changed the initial plan for the data analysis. Therefore, since most of the farmers selected one option instead of selecting more than one, the 44 farmers who understood and answered the question correctly were deleted from the data and the remaining responses were recoded into four categories: 1) Farmers who currently use a particular conservation practice, 2) those who do not use currently but intend to use in the next five years, 3) those who do

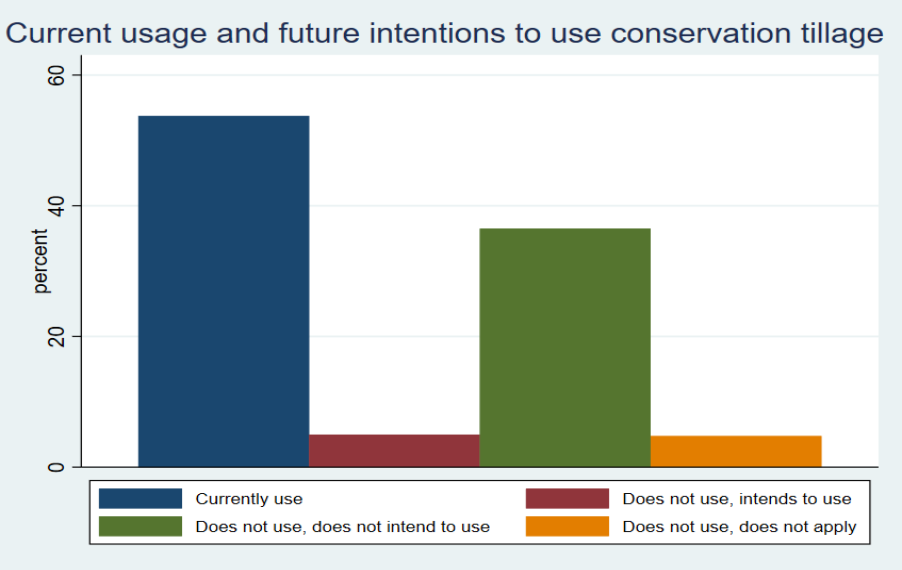
not use and do not intend to use in the next five years, and 4) those who do not use or the question does not apply to.

The five conservation practices farmers were asked about include cover crops, conservation tillage, diversified/extended crop rotation, planting of buffers along streams or field edges, and enrollment in conservation or wetland reserve programs. The three guidelines used to define conservation agriculture by the FAO include continuous minimum mechanical soil disturbance, permanent organic soil cover, and diversification of crop species grown in sequence or rotation (Derpsch and Friedrich 2010). Therefore, we focus on cover crops, conservation tillage, and diversified crop rotation as it reflects the FAO definition of conservation practices. These three practices are also more focused on protecting and improving the soil health. They are also the common conservation practices farmers are being encouraged to adopt in SD because of the role they play in increasing soil resilience towards extreme water conditions (Wang 2019). The results are displayed in Figures 5 and 6 below.



Source: Author's Survey

***Figure* 5.** Current usage and future intentions to use cover crops



Source: Author's Survey

***Figure* 6.** Current usage and future intentions to use conservation tillage

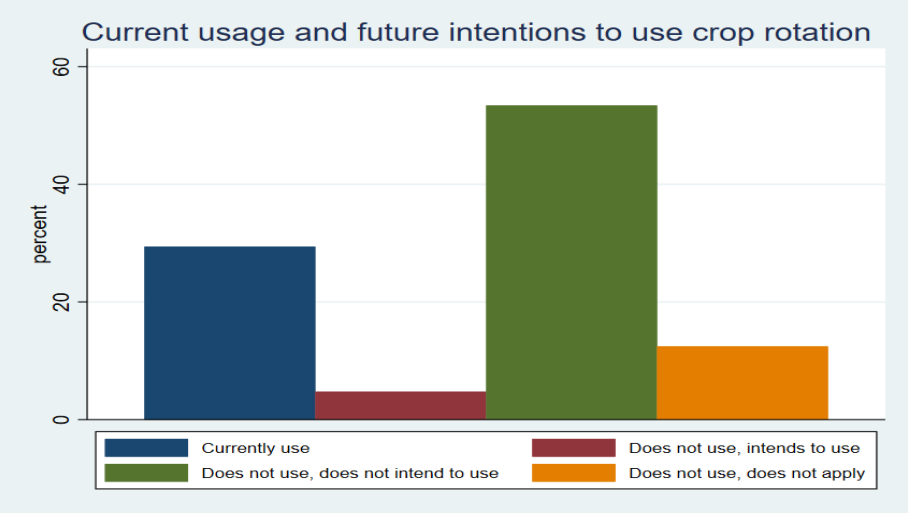


***Figure* 7.** Current usage and future intentions to use diversified crop rotation

***Table* 4.** Percentage and frequency of respondents indicating if they currently use or intend to use a conservation practice.

Types of conservation practices	**N**	**Currently use (1)**	**Does not use, intends to use (2)**	**Does not use, does not intend to use (3)**	**Does not use, does not apply (4)**
Cover crops	442	31.45% (139)	16.97% (75)	39.37% (174)	12.22% (54)
Conservation tillage (e.g., no-till, strip till, mulch till, ridge till or reduced till)	441	53.74% (237)	4.99% (22)	36.51% (161)	4.76% (21)
Diversified/extended crop rotation (e.g., 3 or more crops over a 3-5-year rotation)	442	29.41% (130)	4.75% (21)	53.39% (236)	12.44% (55)

Source: Author's Survey

Table 4 displays the descriptive results of the three major conservation practices farmers currently use, intend to use in the next five years, do not use and don't intend to use, and does not apply to them. Of the three practices, the highest percentage currently use conservation tillage. In the sample of 441, 237 representing 53.74% of farmers engage in the practice. Conservation tillage being the highest conservation practices farmers currently engage in SD is not surprising as it corresponds to the 2017 Agriculture census data regarding no-till adoption. From the 2017 Census data, 52.4% of the croplands in South Dakota are under no-till practice (USDA, 2017). Between the period of 2012 and 2017, the percentage of cropland under no-till increased by 7.1% across the state (Wang 2019). Wang (2019) found that the majority of the increase in no-till acres occurred in eastern counties. This is not surprising as the study area for this research was in the eastern part of SD where most of the commodity crops are produced.

Conservation tillage acres also increased by 24.4% between 2012 and 2017 in SD of which the majority occurred in the eastern and central parts of SD (Wang 2019).

The growing of cover crops was the second-highest conservation practice farmers are currently using. In the sample of 442, 139 farmers representing 31.45% are currently engaged in growing cover crops. Cover crops are a relatively new conservation practice being utilized in SD and as of 2012, cover crops in most county land were less than 1% but increased in 2017 by a percentage between 1% to 3% (Wang 2019). The lowest percentage reported using diversified/extended crop rotations. In the sample of 442, 130 farmers representing 29.41% engage in diversified or extended crop rotations. The result for diversified crop rotation being the least is not surprising as there has been a general reduction in crop diversity in SD. In recent decades, there has been an increase in acreage harvested of two major crops which are corn and soybeans (Wang 2019).

With regards to the conservation practices farmers don't use but intend to use in the future, cover crops were the highest among the three practices with 75 responses indicating 16.97%, followed by conservation tillage with 22 responses representing 4.99%, and diversified crop rotation with 21 responses representing 4.75%. In terms of conservation practices, farmers do not use currently and do not intend to use in the future, diversified crop rotation recorded the highest percentage at 53.39%. The growing of cover crop was the second highest with 39.37%, while conservation tillage was the least with 36.51% from the data gathered. Farmers who responded that the question does not apply to them were deleted from the data for the subsequent analysis. This is because the goal of the research is to focus on the farmers the questions apply to. Therefore, it is justifiable to remove those responses from the data to make sure the results accurately

reflect the behavior and future intention of farmers with regards to conservation practices in SD.

The Internal Consistency and Average Values of the Three Constructs of the TPB

The three constructs of the TPB are latent variables meaning a single statement cannot be used to measure attitude, subjective norms, and perceived behavioral control. Therefore, to accurately measure a latent variable, it is very important to ask more than one question to validly measure them. Cronbach's alpha is used to measure the internal consistency of multiple variables to justify combing the different statements to represent the variable (Cronbach 1951). Cronbach's alpha usually tells if the statements designed accurately measure the same variable of interest thus if there is consistency with the various statements regarding the construct. A Cronbach's alpha from 0.70 and above is usually recommended for social science research and it also justifies that the individual items are measuring the same construct or concept (Nunnally 1978). The statements measuring the TPB constructs were measured using a five-point Likert scale where 1 indicates a negative response and 5 indicating a positive response. These make the variable an interval or continuous variable hence best summarized with means and standard deviations.

***Table* 5.** Mean, standard deviation, minimum and maximum values of each statement used to measure the three constructs of the TPB.

Items	Mean	SD	Min	Max	Cronbach's alpha
Conservation farming practices improve soil health.	4.32	0.60	1	5	
Conservation farming practices increase crop yields.	4.13	0.68	1	5	
Conservation practices protect natural resources for future generations.	3.73	0.79	1	5	
Attitude	**4.01**	**0.57**	**1**	**5**	**0.75**
Farmers around me are increasingly using conservation practices	3.53	0.77	1	5	
Conservation practices protect natural resources for future generations.	3.34	0.89	1	5	
I feel encouraged by other farmers to use conservation practices.	3.38	0.82	1	5	
Subjective norms	**3.40**	**0.64**	**1**	**5**	**0.67**
The way land is managed has an impact on water quality.	3.33	0.90	1	5	
I have the skills I need to be able to use most conservation practices (Control beliefs).	4.15	0.64	1	5	
Whether I engage in conservation farming practices or not depends entirely on me	3.81	0.79	1	5	
Conservation farming practices are not difficult to implement (e.g., in time, money, labor, knowledge or obtaining permit(s)).	3.92	0.67	1	5	
Perceived behavioral control	**3.80**	**0.52**	**1**	**5**	**0.63**

Source: Author's Survey

The result in Table 5 indicates the individual mean value of each statement measuring the three constructs of the TPB and the average score of each component of the TPB. With the average score of the three constructs of the TPB, the attitude construct had the highest average score of **4.01** followed by perceived behavioral control with **3.80**. Subjective norms recorded the lowest average score of **3.40**. These results show that farmers in SD generally have a positive attitude towards conservation practices. They also have a relatively high perceived level of control to engage in conservation practices. The

results from subjective norms show that farmers are less influenced by colleagues, friends, and family to engage in conservation agriculture. Their impact on farmers' decisions to engage in conservation practices is low as compared to attitude and perceived behavioral control. The results from the attitude construct also align with past studies that found attitude to be the strongest predictor for the adoption of conservation practices among farmers in the U.S. (Prokopy et al. 2019). Considering the standard deviation for all the statements is less than 1 indicates that the data points are not widely dispersed.

The table also displays the internal consistency of the scales measuring the three constructs of the TPB. A Cronbach's alpha coefficient that is less than 0.70 is questionable. Therefore, there is acceptable reliability or internal consistency between the items measuring attitude because its Cronbach's alpha coefficient was above 0.70. The subjective norms items had a Cronbach's alpha coefficient of 0.67, and the perceived behavioral control items had a Cronbach's alpha coefficient of 0.63. The Cronbach's alpha if an item is deleted did not significantly improve the Cronbach's alpha coefficients which shows that the reliability is much better keeping all the items rather than deleting an item measuring subjective norms and perceived behavioral control. The moderate Cronbach's alpha coefficient of subjective norms and perceived behavioral control can be attributed to the heterogeneity and multidimensional nature of each construct. The statements were designed to capture subcomponents of each construct which might contribute to the moderate reliability coefficient. The small number of three items or statements measuring each construct could also be the reason for the lower Cronbach's alpha for subjective norms and perceived behavioral control. Peterson (1994) is of the view that a lower value of Cronbach's alpha is sufficient and justifiable when there is a small number of items in a

scale. Hinton et al. (2004) are also of the view that Cronbach's alpha from 0.50 to 0.70 is moderate reliability which is relatively good. Several studies have also supported a 0.60 Cronbach's alpha coefficient being acceptable which shows that a Cronbach's alpha of 0.60 and above is relatively good and can be used in this study (Moss et al. 1998; Hair et al. 2006 and Shrout 1998).

Constructs of the TPB Three Groups of Farmers

The reason for conducting this analysis is to determine how the average value of the TPB constructs varies among three groups of farmers. Considering the conceptual determinant of behavior according to the TPB, it would be expected that current adopters would have a higher value on the TPB constructs than future adopters and non-adopters. The same result would be expected for future adopters to have a higher significant average value than non-adopters. The findings from this analysis will help show the validity of the theory in explaining human behavior. The three groups of farmers being studied are adopters, future adopters, and non-adopters of the three conservation practices making it a categorical variable. To determine whether the average value of the three constructs of the TPB significantly varies among these three groups, a one-way analysis of variance (ANOVA) was employed to test the differences among the three groups. All the assumptions for the use of ANOVA tests were met which include independent groups, normal distribution of data, and equal variance between the groups. A one-way ANOVA was appropriate for this test as it determines whether there are any statistically significant differences between the means of three or more independent groups. In this case, the dependent variable is a continuous variable measured by Likert scales (attitude, subjective norms, and perceived behavioral control) and the independent variable is

categorical (adopters, future adopters and non-adopters of cover crops, conservation tillage, and diversified crop rotation).

***Table* 6.** Average values of the TPB variables for adopters, future intended adopters and non-adopters for cover crops, conservation tillage and diversified or extended crop rotation (N =243).

Cover crops			
TPB Constructs	**Adopters**	**Future adopters**	**Non adopters**
Attitude	4.15	4.02	3.91*
Subjective norms	3.40	3.51	3.32
Perceived behavioral control	3.89	3.82	3.69*
Conservation tillage			
TPB Constructs	**Adopters**	**Future adopters**	**Non adopters**
Attitude	4.16	3.86	3.73***
Subjective norms	3.49	3.25	3.16**
Perceived behavioral control	3.90	3.85	3.51***
Diversified crop rotation			
TPB Constructs	**Adopters**	**Future adopters**	**Non adopters**
Attitude	4.24	3.85	3.92***
Subjective norms	3.56	3.26	3.29**
Perceived behavioral control	3.99	3.82	3.68***

Source: Author's Survey

Average values on a scale where 1 is extremely negative and 5 is extremely positive

Significance of the coefficients is indicated as follows: * = $p<0.05$, ** = $p<0.01$ and *** = $p<0.001$.

Table 6 above displays the average values of the TPB scales calculated for the three separate groups of farmers. Adopters recorded a significantly higher score on the attitude component of the TPB for all the three conservation practices than future intenders and non-adopters. There was also a higher significant average score for perceived behavioral control for adopters than future intenders and non-adopters of the three conservation practices being studied. Subjective norms also recorded a higher significant average score for adopters than future intenders and non-adopters for

conservation tillage and diversified crop rotation. These results are indications that a higher value for the TPB variables are related to an increase in the adoption rate of the various conservation practices in SD. The higher the mean value of the TPB constructs, the more farmers currently adopt it and intend to adopt it in the future. Farmers who currently adopt the conservation practice have a more positive attitude and a higher perceived control to engage in the practices than future adopters and non-adopters. They are also in a way affected by their friends and colleague farmers that influence their decision to adopt the practices. A similar result was also found by (Wauters et al. 2009).

Correlation and Hypothesis Testing

For the hypothesis testing a correlation coefficient is used to determine whether the linear relationship in the sample data effectively models the relationship in the population. The Pearson correlation coefficient determines the strength and the direction of the linear relationship between the independent and dependent variables on a regression plot. When there is a positive relationship between two variables, it shows that both variables move in the same direction, and when it is negative, it shows that as one variable value increases, the other value decreases. The hypothesis test of the significance of the correlation coefficient shows whether the linear relationship in the sample data is strong enough to generalize to the population being studied. If a correlation test concludes that the correlation coefficient is significantly different from 0, it is an indication that there is a significant relationship between the independent and dependent variables. Therefore, the results can be used to effectively model the relationship in the population, or the results can be generalized to the entire population because there is a significant effect.

On the other hand, if the test results indicate that the correlation coefficient is not significantly different from 0, then we conclude that the correlation coefficient is not significant because there is insufficient evidence to conclude that there is a significant linear relationship between independent and dependent variables. Therefore, the regression line cannot be used to model a linear relationship between the independent and dependent variables in the population being studied. The Pearson correlation coefficient method has been used to test hypotheses regarding farmers' intention and behavior with the construct of the TPB (Senger et al. 2017; Wauters et al. 2010). One limitation of using this method in research is that it only uncovers a relationship, but it cannot provide a conclusive reason as to why there is a relationship. Also, a third unobserved variable might be causing the relationship between the two variables, indicating spuriousness.

Table 7. Spearman rank correlation results between behavior and three constructs of the theory of planned behavior**.**

Measures of the TPB	**Actual behavior**	**Correlation coefficient**	**Significance level**
Attitude	Cover crops	0.1572	0.0041
Subjective norms	Cover crops	0.0203	0.7131
Perceived behavioral control	Cover crops	0.1264	0.0212
Attitude	Conservation tillage	0.2600	0.0000
Subjective norms	Conservation tillage	0.1680	0.0022
Perceived behavioral control	Conservation tillage	0.2379	0.0000
Attitude	Diversified crop rotation	0.2286	0.0000
Subjective norms	Diversified crop rotation	0.1457	0.0079
Perceived behavioral control	Diversified crop rotation	0.2109	0.0001

Source: Author's Survey

The results of the spearman rank correlation coefficients represented in Table 7 show that nearly all three constructs of the TPB were significantly and positively correlated with actual behavior at a significance level of $p < 0.05$. The correlation between subjective norms and cover crops on the other hand was not statistically significant but was positive. The result of the correlation between subjective norms and cover crops shows that there is not enough evidence to conclude that farmers are influenced by their friends and colleagues to adopt cover crops. Overall, this result is an indication that attitudes, subjective norms, and perceived behavioral control influence farmers' decision to adopt the three conservation practices in SD. Considering the figures, the strength of the relationship or association is not very strong. All the correlation coefficients were closer to 0 than 1. Therefore, we reject the null hypothesis and conclude that farmer's attitudes, subjective norms, and perceived behavioral control significantly affect actual conservation behavior.

***Table* 8.** Spearman rank correlation results between future intention and three constructs of the theory of planned behavior.

Measures of the TPB	Future intention	Correlation coefficient	Significance level
Attitude	Cover crops	-0.0186	0.7363
Subjective norms	Cover crops	0.0771	0.1617
Perceived behavioral control	Cover crops	-0.0003	0.9955
Attitude	Conservation tillage	-0.0729	0.1853
Subjective norms	Conservation tillage	-0.0516	0.3494
Perceived behavioral control	Conservation tillage	-0.0448	0.4160
Attitude	Diversified crop rotation	-0.0596	0.2791
Subjective norms	Diversified crop rotation	-0.0453	0.4116
Perceived behavioral control	Diversified crop rotation	0.0012	0.9823

Table 8 above displays the result of the spearman rank correlation coefficients between the three constructs of the TPB and future intentions to use the three conservation practices practiced the most by farmers in SD. From the result, there is an insignificant negative relationship between the farmer's attitude and perceived behavioral control and future intentions to engage in growing of cover crops. Subjective norms had an insignificant positive relationship with future intention to grow cover crops, but the strength of the relationship is weak with a spearman's correlation coefficient of 0.0771. There was also an insignificant negative relationship between a farmer's future intention to engage in conservation tillage with attitude, subjective norms, and perceived behavioral control. The results also indicated an insignificant negative relationship between future intention to engage in diversified crop rotation with attitude and subjective norms. But perceived behavioral control had a positive insignificant relationship between a farmer's future intention to engage in diversified crop rotation, but the relationship is weak with a correlation coefficient of 0.0012. Therefore, we fail to reject the null hypotheses and conclude that farmer's attitude, subjective norms, and perceived behavioral control does not affect future intention to engage in conservation practices.

Modeling of Behavior

The dependent variables for the multivariate analysis for this research are farmers' actual behavior regarding conservation practices. The actual behavior of conservation practice was defined by the three types of conservation practices farmers are currently using and not currently using. A binary logistic regression model was employed to determine how the three constructs of the TPB, and other socioeconomic and

demographic variables influence farmers' current adoption of cover crops, conservation tillage, and diversified crop rotation. The logistic regression was applied because existing research indicates that farmers' adoption decisions can be estimated using binary logistic regression (Wauters et al. 2009, Ntshangase et al. 2017). Also, this current research is predicting adoption of conservation practices which makes the outcome variable binary or dichotomous hence best analyzed using a binary logistic regression. The behavior to engage in cover crops, conservation tillage, and diversified crop rotation are modeled as dichotomous variables where 1 is equal to when a practice is currently applied and 0 when it is not currently applied. Therefore, in these cases, the ordinary least squares estimation (OLS) cannot be applied (Wauters et al. 2009). Logistic regression is used to predict the probability of an event occurring or not or how likely an event will occur or not. The logistic regression model is typically used when the dependent variable can take two values and it is the case in this study. The independent variables can either be numerical or categorical (Ntshangase et al. 2017, Wauters et al. 2009).

The logistic regression model predicts the logit of the dependent variable (adoption of cover crops, conservation tillage, and diversified crop rotation) from the independent variable (Ntshangase et al. 2017, Wauters et al. 2009). The likelihood of the farmer in SD being adopters of the three conservation practices is predicted by odds (Y=1) that is the ratio of the probability that Y=1 and the probability that Y≠1. The Odds Y= P(Y=1)/1-P (Y ≠1). Therefore, the equation is given by In (P (Y =1)/1-P(Y≠1) = log-odds = Logit Y. It can also be expanded as Logit(Y) = $\alpha + \sum\beta 1X1 + \sum\beta 2X2 + ... + \sum\beta nXn + \varepsilon i$. Therefore P = the probability of adopting a practice and 1-P = probability that a

farmer does not adopt a practice, In = Natural log α = Intercept, B1, B2, etc. = coefficient of the independent variable and εi = the error term (Ntshangase et al. 2017).

Therefore, the linear function for adoption in the this study is given as logit (adoption) = In (P/1-P) = α + β1 attitude + β2 subjective norms, + β3 perceived behavioral control + β5 total acres + β6 years of being a decision-maker + β7 Education + β8 gross income + β9 off-farm income + considering location and soil characteristics to minimize runoff of fertilizers + εi (Ntshangase et al. 2017). For easy interpretation and understanding of the logistic regression output, the estimates b for B's will not be interpreted. Rather the exp(B) which is the odds ratio will be used to interpret the results because it is easier to interpret. It is easily interpreted as the change in odds that the dependent variable has a value of 1 when the respective independent or predictor variables increase with one unit (Ntshangase et al. 2017, Wauters et al. 2009). The odds ratio is defined as the relative odds of Y (i.e., adoption of soil conservation practices) when the value of X (e.g. attitude) increase by one unit.

***Table* 9.** Logistic Regression Model Predicting Cover Crops, Conservation tillage and Diversified Crop Rotation Adoption (Odds Ratio with Standard Errors).

Dependent variable			
Predictor	**Cover crops (1)**	**Conservation tillage (2)**	**Diversified crop rotation (3)**
Constant	0.03	**0.00** *	**0.01** *
Attitude (scale 1 – 5)	1.52 (0.58)	**3.47 (1.79)** *	1.75 (0.66)
Subjective Norms (scale 1 – 5)	0.84 (0.23)	0.79 (0.29)	1.05 (0.29)
Perceived Behavioral Control (scale 1 – 5)	1.29 (0.50)	**2.66 (1.30)** *	1.74 (0.72)
Age	**0.95 (0.02)** *	0.98 (0.01)	1.00 (0.01)
Farm Size (Total Acres)	1.00 (0.00)	**1.00 (0.00)** *	**1.00 (0.00)** *
Years Primary Farm Decision Maker	1.02 (0.02)	1.02 (0.26)	1.00 (0.01)
Education	1.23 (0.22)	1.56 (0.39)	1.23 (0.23)
Gross Income	0.95 (0.18)	0.82 (0.20)	1.07 (0.20)
Off Farm Income	1.40 (0.58)	1.80 (0.85)	0.95 (0.40)
Consider Location and Soil Characteristics to Minimize Leaching or Run Off of Fertilizers	**2.01 (0.74)** *	1.53 (0.66)	0.61 (0.22)
Fit Statistics			
Observations (N)	193	215	191
Log likelihood	-124.16275	-87.508062	-120.0555
Prob > chi2	0.0390	0.0000	0.0070
Pseudo R2	0.0714	0.2066	0.0917

Significance of the coefficients is indicated as follows: * = $p<0.05$, ** = $p<0.01$ and *** = $p<0.001$.

The Table 9 above shows the result from a binary logistic regression model of farmers' who currently adopt cover crops, conservation tillage, and diversified crop rotation and those who do not adopt them currently. The models indicate odds ratios and their standard errors. In general, the three models were statistically significant with a chi-square value of 0.03, 0.00 and 0.00, respectively. Therefore, compared to knowing nothing and just randomly guessing the effect of the three constructs of TPB, socio-economic, and demographic variables, the three models significantly improve the ability

to predict the likelihood of adopting cover crops, conservation tillage, and diversified crop rotation in SD.

From the first model which is predicting cover crop adoption, the age of farmers was significantly and negatively associated with cover crop adoption (b = 0.95, SE = 0.02, p = 0.03). Therefore, holding all other variable constants in the model, the age of farmers in SD was an important factor negatively influencing the adoption of cover crops. As farmers age increases by a year, the odds of adopting cover crops decreases by 5%. This is an indication that farmers who are older have a lower likelihood of being a cover crop adopter. Farmers who stated that they consider the location and soil characteristics to minimize leaching or runoff fertilizers are also more likely to adopt cover crops (b = 2.01, SE = 0.74, p = 0.01). The odds of adopting cover crops are 101% more than for those who are familiar but do not currently practice the rule of considering soil characteristics to minimize leaching or run of fertilizers.

For model two which is predicting conservation tillage adoption, the attitude of farmers which is measured by a Likert scale was significantly and positively associated with conservation tillage adoption (b = 3.47, SE = 1.79, p = 0.04). The result indicates that when the attitude increases by one unit, the odds of conservation tillage adoption increases by 247%. This shows that for farmers with a positive attitude towards conservation practices, the odds of adopting conservation tillage are more than twice as much. Perceived behavioral control which is also measured by a Likert scale significantly and positively influences the adoption of conservation tillage (b = 2.66, SE = 1.30, p = 0.01). When the perceived behavioral control increases by one unit, the odds of conservation tillage adoption increases by 166%. This shows that for farmers with a high

level of perceived behavioral control regarding conservation practices, the odds of adopting conservation tillage is 166% greater than farmers with relatively low perceived behavioral control. This result indicates farmers in SD in general have a positive attitude towards conservation agriculture practices. Also, it shows farmers have the skills and knowledge required to engage in conservation practices. For the effect of farm size (total acres cultivated) on the adoption of conservation tillage, there was a statistically significant result (b = 1.000575, SE = 0.00, p = 0.01). This result indicates that after successfully controlling for the effect of farm size, the relationship between the independent variables and the dependent variables (adoption and non-adoption of conservation tillage) is still statistically significant.

For model three which is predicting the adoption of diversified crop rotation, farm size (total acres cultivated by farmers) was statistically significant (b = 1.00022, SE = 0.00, p = 0.02). This result also shows that after controlling the effect of farm size, the relationship between the independent variables and the dependent variable is still statistically significant.

CHAPTER FIVE

DISCUSSION

This study adopts an integrative approach, examining how socioeconomic, demographic variables and psycho-social factors influence the adoption of conservation practices among farmers in SD. The purpose of the study was to examine the effectiveness of the modified TPB in explaining farmers' actual behavior towards the adoption of conservation practices. It was also to determine how other socio-economic and demographic variables affect farmers' decisions to engage in conservation practices. The original design of the TPB indicates that the intention to engage in a behavior is the driving force leading to the actual performance of that behavior which is determined by three independent psychological constructs. But intention does not lead to the actual performance of the behavior in all situations (Orbell and Sheeran 1998). Hence in this study the researcher used a modified TPB to validate how the three constructs of the TPB and other background variables predict actual conservation practices behavior. Studying and understanding farmers' actual conservation behavior in SD provided insights into how social psychological constructs are related to the adoption of soil conservation practices. The results showed that farmers' behavior towards soil conservation practices is influenced by both the three constructs of the TPB and other socioeconomic and demographic variables.

The correlations in Table 7 show that the three constructs of the TPB were positively and significantly correlated with the actual behavior of soil conservation practices. The correlation results show that psychological constructs have a significant impact relationship with farmers' decision to engage in soil conservation practices. The

implication here is that the more favorable farmers assess soil conservation practices, the influence of other farmers, and their perception and ability to engage in it successfully, the higher their interest to adopt it. The correlation results also indicate that farmers' attitudes, subjective norms, and perceived behavioral control does not influence future adoption of conservation practices, but we cannot generalize the result to the entire population because the results were not statistically significant.

The findings from the binary logistic regression especially for the adoption of conservation tillage in Table 9 show that the modified TPB predicts farmers' actual behavior regarding the adoption of conservation practices. Attitude and perceived behavioral control significantly and positively influence the adoption of conservation tillage in SD. Attitude also recorded the highest average value of 4.01 among the three constructs which is followed by perceived behavioral control with an average value of 3.80. These results are indication that most farmers in SD have a positive attitude towards conservation practices. Farmers also have the perception that their own ability can help them to engage in the practice successfully because they have the knowledge and necessary skills to engage in them. The positive attitude and the increased knowledge and skills of farmers concerning conservation practices can be attributed to the role of various organizations in SD promoting conservation practices. Examples include South Dakota State University (SDSU) Extension, Natural Resource Conservation Services (NRCS), Farm Service Agency (FSA), Soil and Water Conservation Districts (SWCD) and South Dakota Soil Health Coalition (SDSHC).

A study by Wang (2019) about farmers' knowledge of various conservation practices indicate that farmers who thought SDSU Extension was important in their

decision making were more knowledgeable about the various conservation practices than farmers who did not consider SDSU Extension as important in their decision making. Wang's study clearly shows that SDSU Extension promotes conservation agriculture practices in SD. The negative insignificant result from subjective norms on conservation tillage and cover crop adoption also show farmers are less likely to recognize social pressures as a driving force to engage in soil conservation practices. The result from subjective norms on cover crops and conservation tillage were insignificant hence we cannot say these findings reflect the entire population of SD. Considering the relatively low average value of subjective norms of 3.4 as compared to attitude and perceived behavioral control in Table 5, shows farmers in general in the sample data are less affected by social pressures to engage in soil conservation practices meaning their colleagues and contribute less regarding their decision to adopt soil conservation practices. Table 5 summarizes these findings.

For diversified crop rotation, the result shows that attitude, subjective norms, and perceived behavioral control positively influence adoption, but the result was not statistically significant. For cover crop adoption, attitude and perceived behavioral control positively influence its adoption but the results were also not statistically significant to make a prediction to the entire population of farmers in SD. Overall, the results in Table 9 shows the validity of the modified TPB in understanding farmers' actual behavior to some extent making the TPB an effective tool to understand farmers' environmental behavior. The age of farmers significantly and negatively influences cover crop adoption which is not surprising. Other studies have found similar result by explaining it in relation to the fact that older farmers have a shorter time horizon to farm

since they are nearing retirement (Prokopy and Babin 2014) Therefore, they are more reluctant to invest in conservation agriculture which returns on investment sometimes takes years before the farmer starts seeing the result in yield increase and reduction in input cost. On the other hand, younger farmers adopt new technology because they have more years ahead of them to farm hence invest in new technology (Lambert et al. 2005).

Farmers who currently practice the rule of considering the location and soil characteristics to avoid leaching were also more likely to adopt cover crops. This result is not surprising because cover crops are usually planted to prevent soil erosion on the land. Cover crops also increase the natural nitrogen content in the soil hence minimizing the use of nitrogen fertilizer. Wang et al. (2019) are of the view that the geographic location frequently affects the adoption decision of conservation practices. Therefore, farmers who are concerned about nutrient leaching through erosion are more likely to adopt this practice to protect the soil and nutrient runoff. Increase in acres cultivated or operated was also statistically significant on the adoption of conservation tillage and diversified crop rotation. But in general, findings from the literature regarding the adoption of conservation practices indicates farmers with larger acres are more likely to adopt conservation practices (Lambert et al. 2005; Prokopy and Babin 2014). The reason for farmers with larger acres being more likely to adopt various conservation practices is because the return on investment is higher as compared to smaller acres of farms (Lambert et al. 2005).

Farmers' level of education and the number of years they have been a decision-maker regarding the farming operation were also positively associated with the three soil conservation practices, but the results were not statistically significant. Farmers who earn

income off the farm were also more likely to adopt cover crop and conservation tillage, but the results were not statistically significant to generalize to the entire population of farmers in SD. Even though results were not statistically significant, it is a positive sign as we would expect those control variables to positively influence the adoption of conservation practices.

CONCLUSION

The result of this study provided an insight that can be very useful for policymakers and conservation practitioners. In general, farmers' attitude towards the adoption of conservation practices in SD was notable as compared to the other constructs considering their average value. More effort should be directed to educating farmers on the necessary skills and knowledge to adopt various conservation practices to reduce the difficulties and increase their level of knowledge regarding the practice. An increase knowledge and the level of skills of farmers regarding the various conservation practices will help farmers voluntary adopt these practices. The results also show that farmers' in SD are less influence by their social network to engage in conservation practices. In contrast, studies have shown that farmers are sometimes influence by their colleagues regarding the adoption of conservation practices (Prokopy and Babin 2014). Therefore in other to ensure social norms becomes a very useful and effective tool to increase adoption in SD, a deliberate effort should be made to organize training programs led by respected and successful farmers in the county or SD who are currently engaging in various conservation practices. Seeing other successful farmers practicing conservation practices and testifying about it will help encourage non-adopters to see the importance of such practices. SDSU Extension has been organizing many educational programs for farmers

in the state. Hence extension staff can modify their educational strategies by allowing other farmers to lead the discussion and practically demonstrate to other farmers regarding the adoption of conservation practices. This will be very helpful to increase conservation adoption practices as studies have also indicated farmers preferred learning through face to face interaction and field demonstration (Singh et al. 2018; Franz and Percy 2009; Trede 1998).

Wang et al. (2019) suggested that future efforts to understand conservation behavior in SD, North Dakota and Nebraska should focus more on farmers' attitudes and perceptions of conservation practices. Liu et al. (2018) also recommend that future research on BMPs in the U.S. should focus on social norms and risk perception in the decision-making process. Very little research of this kind has been undertaken in SD after examining the literature which justifies the importance of conducting a study of this nature. Therefore, this research study has filled in the gap in understanding farmers' adoption behavior related to social-psychological factors and socio economic and demographic variables in SD. The overall conclusion of this study shows that the modified TPB which predicted actual behavior is a very useful framework that can be used by researchers to understand farmers' behavior. Farmers in SD, in general, demonstrated a positive attitude, high level of control, and knowledge regarding the adoption of conservation practices but social norms were not an influencing factor when it comes to decisions to adopt soil conservation practices in SD.

LIMITATION OF THE STUDY

One of the limitations of this study was the fact that the questions meant to investigate and predict the behavior of conservation practices concerning the TPB was not an independent study. The survey questions were part of a larger survey that was designed to learn about the nutrient management practices of farmers in SD. The survey questions were often long and complex resulting in a somewhat low response rate of 17.7%. The time in which the surveys were sent to producers was also not favorable (June and July 2019) which was worsened by the unexpected flooding that occurred in SD. Experts who worked directly with producers reviewed the questions and it was sent to others to also review. A better approach would be to interview farmers who have first-hand knowledge about the topic before designing the questionnaires and then finally sending it for experts to review. Interviewing farmers will give the researcher a more in-depth understanding of farmers' beliefs about conservation practices. Also, during an interview, the researcher would be able to identify how farmers evaluate and perceive each practice, identify their important referent groups, and state their level of ease and difficulty with each practice from their point of view or perspective.

Another limitation of the study has to do with the fact that the TPB was not used the way it was designed. The modified TPB used in this study predicted actual behavior instead of predicting intention which finally leads to behavior. Even though this was a limitation in this study, Senger et al. (2017) who use the TPB to study the intention of farmers to diversify their agricultural production stated in their study that studying the intention of farmers was a limitation as compared to actual behavior. Therefore, the study of actual behavior in this study is an advantage in many regards. Most of the independent

variables in the binary logistic regression model were also insignificant even though positive. The reason for most independent variables having an insignificant result could be attributed to the low response rate. On the other hand, the sample data was similar in many ways to the SD farming population according to the 2017 Agriculture Census Data in SD. Therefore, it can also be deduced that the independent variables that were insignificant were actually not important predictors of usage of conservation practices. But in general, some of the key variables were significant and most were also in the direction that we would expert even though they were not significant. It therefore shows justification for further research regarding this topic. Also due to the complex nature of most questions on the survey, it resulted in a lot of the variables having missing values. Socioeconomic and demographic questions are usually asked at the end of most surveys and it was the same for this study. Most of the missing values can be attributed to the fact that most farmers got tired of answering all the questions as they got closer to the end of the survey resulting in a lot of item nonresponse. The results in this study can only be applied to the context of SD and the northern Great Plains and not the U.S. in general regarding social- psychological factors and socio-economic factors influencing the adoption of conservation practices.

For further research, researchers should conduct an independent study regarding this topic where a lot of items on the three constructs of the TPB can be measured. A qualitative study should also be conducted on the same topic to deeply understand farmers' attitudes, their social norms, and some difficulties they face regarding the adoption of conservation practices. Researchers should also be flexible when sending out

surveys as circumstances can change in farming. For example, just like in the case of SD in 2019 when planting was delayed due to the flooding that occurred which possible affected the response rate because the surveys were sent during the time farmers were still figuring out when to plant their seeds. Therefore, taking a survey at that might not be a priority for them.

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APPENDIX 1

The definition of the following conservation practices below are the various types of conservation practices the survey questions were designed to measure. These are common conservation practices found in the literature which farmers are encouraged to practice in South Dakota because they help improve soil health and the environment.

- Cover crops are crops often grown purposely for the benefit of the soil rather than crop yield. Farmers with livestock also grow cover crops to feed their animals. Cover crops have the potential to improve soil fertility, control soil erosion, help suppress weeds, improve water quality, and enhance crop diversity in the agricultural system (Roesch-McNally et al. 2017). They are mostly grown during late summer and expected to grow during fall and winter which is later plowed or tilled under in spring. Cover crop is one of the conservation practices promoted among farmers in the US (Roesch-McNally et al. 2017). Example of crops grown as cover crops include alfalfa, oats, wheat, legumes garden peas, etc.
- The United State Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) defines conservation tillage as a management practice that leaves enough crop residues from cover crops and cash crop on the surface of the soil after planting to provide at least 30% of soil cover (Balkcom et al. 2007). Conservation tillage is an agricultural management practice which encompasses different tillage practice such as no-till, strip-till, ridge-till or reduced till aim to minimize the mechanical disturbance of the soil which helps reduce soil erosion, water pollution. It helps reduce the use of fuel leading to low production cost and improvement in the general environmental quality.

Conservation tillage has several benefits which range from improvement in soil health and improved agricultural production.

- Diversified crop rotation is a farming practice of growing a different type of crops in rotation. Growing the same type of crop on the same plot of land depletes soils nutrients and decreases crop yield (Liebman 2013). Legumes crops grown in rotation fix atmospheric nitrogen in the soil through their symbiotic relationship with rhizobium bacteria hence reduce the use of nitrogen fertilizer (Liebman 2013). Crop rotation improves soil health and helps in pest management.
- Planting of buffers along streams is a conservation practice that involves the planting of buffer strips that minimize soil erosion by reducing runoff (Arora et al. 2003). Buffer strips help to trap sediment in runoff which includes chemical fertilizers, manure, and pesticides. Planting of buffers to trap elements from runoff is much better than allowing elements to flow directly into streams (Arora et al. 2003). This help to improve water quality. There are different types of buffer strips, some of which include filter strips, grassed waterways, contour grass strips or wind traps and riparian buffer zones. Buffer strips improve wildlife habitat and quality of air (Arora et al. 2003).
- Conservation wetlands reserve programs are voluntary programs landowners are encouraged to participate in order to protect and restore wetlands. The USDA through NRCS provides financial and technical support for landowners willing to enroll their land to help restore their wetlands (Lubowski and Roberts 2008). Landowners are offered payment for their land set aside for restoration since they will not be farming on those land for some time. It usually takes a period between

10 to 15 years. Land retirement programs are also programs aimed at restoring or not farming land. Environmentally sensitive cropland is taking out of production permanently or over an extended period usually under 10 to 15 years contracts. The purpose of this program is to ensure that those lands are restored and covered to help reduce soil erosion and improve water quality and also to reduce the lost of wildlife habitat. Farmers are offered incentive payments usually on an annual basis for participating in such programs (Lubowski and Roberts). These programs help to enhance wildlife habitat, soil conservation, increased recreation (agritourism) and other environmental benefits (Lubowski et al. 2006).

APPENDIX 2

Survey Questions Measuring Intention and Behavior of Farmers towards Conservation Practices

The following practices below represent the various types of conservation practices which are meant to understand farmers' intention and actual behavior. As discussed earlier, intention is determined by asking farmers their intention to engage in the practice in the next five years. Behavior is also determined by the type of conservation practices farmers are currently using.

1. Cover crops
2. Conservation tillage (e.g., no-till, strip till, mulch till ridge till or reduced till).
3. Diversified/extended crop rotation (e.g., 3 or more crops over a 3-5-year rotation)

Survey Questions Measuring the Theory of Planned Behavior

The theory of planned is measured by three independent psychological constructs: attitude, subjective norms, and perceived behavioral control. These three constructs are defined by components which include behavioral beliefs, outcome evaluation, normative beliefs, motivation to comply, control beliefs and control frequency. Attitude refers to the way people feels toward a particular behavior which is derived from behavioral beliefs and outcome evaluation. Behavioral beliefs have to do with the belief that a certain behavior would produce certain outcome. Outcome evaluation on the other hand refers to the way people think and evaluate possible outcomes of the behavior in question. These questions below measure the attitude variable.

1. Conservation farming practices improve soil health (Behavioral beliefs)
2. Conservation farming practices increase crop yields (Outcome evaluation)

3. Conservation practices protect natural resources for future generations (Behavioral beliefs)

Subjective norms refer to the social pressure people feel to perform a certain behavior which is derived from normative beliefs and motivation to comply. Normative beliefs explain whether important referent groups approve of the behavior or not. Motivation to comply explain whether the individual will comply or not with social norms of the referent group in relation to the behavior. These questions below measure the subjective norm variable.

1. Farmers around me are increasingly using conservation practices (Normative beliefs)
2. Conservation practices protect natural resources for future generations (Motivation to comply)
3. I feel encouraged by other farmers to use conservation practices (Motivation to comply).

Perceived behavioral control refers to how easy or difficult it is to perform a behavior and it is derived from control beliefs and control frequency. Control beliefs are the perception of control someone feels in performing a behavior, while control frequency is the degree of ease or difficulty in performing the behavior. These questions below measure the perceived behavioral control variable.

1. The way land is managed has an impact on water quality (Control beliefs).
2. I have the skills I need to be able to use most conservation practices (Control beliefs).
3. Whether I engage in conservation farming practices or not depends entirely on me (Control beliefs).

4. Conservation farming practices are not difficult to implement (e.g., in time, money, labor, knowledge or obtaining permit(s)). (Control frequency).

Control Variables

1. Ownership of acres operated is measured at a norminal level of with categories of Acres own and Acres rent.
2. Farm size is measured as a continous variable in total acres of land cultivated.
3. Off-farm income is measured at a norminal level with categories of Yes and No.
4. Gender is measured at a norminal level with categories of Male and Female.
5. Gross operational income is meaured at an ordinal level with categories of
    - Less than $ 150,000
    - From 150,000 up to $ 349,999
    - From 350,000 up to $ 999,999
    - $1 million or more
6. Level of education is measured at an ordinal level with categeries of
    - Less than high school
    - High school diploma/GED
    - Some college/technical school
    - College degree
    - Post – graduate degree
7. Age is measured as a continuous variable.
8. Considering location and soil characteristics to minimize leaching or run off fertilizers was measured at a nominal variable of
    - Never heard of it
    - Familiar but not currently using

- Currently using
- Not applicable