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Adoption of Sustainable Agriculture Practices among Kentucky Farmers

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Adoption of Sustainable Agriculture Practices among Kentucky Farmers[1]

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Abstract

Promoting the best management practices at an individual farm level is essential to ensure agricultural sustainability. This study analyzed whether and how various factors related to farm or farmers' characteristics influence the intensity of adoption of sustainable agriculture practices. We used a negative binomial regression model in data collected from a mail survey of farmers in Kentucky, USA. Our results showed that adoption intensity of sustainable agriculture practices varied significantly among agricultural districts in Kentucky. Farmers who grew row crops, had irrigation facilities, and were in favor of crop diversification were significantly more likely than their respective counterparts to adopt more sustainable agriculture practices. Similarly, college education and participation in the Tobacco Buyout Program also positively and significantly affected the intensity of adopting sustainable agriculture practices among Kentucky farmers. In contrast, a lack of adequate knowledge about sustainable farming and unfamiliarity with technology significantly and negatively related to less adoption of sustainable agriculture practices.

Keywords: Adoption Intensity, Best Management Practices, Small Farmers, Negative Binomial Regression, Kentucky.

1. Introduction

The U.S. Congress (1990) defined sustainable agriculture as the integrated system of animal and plant production practices that satisfy human food and fiber needs, enhance environmental quality by making the most efficient use of non-renewable resources, sustain the economic viability of farm operations, and enhance the quality of life. Sustainability in agriculture is a complex and dynamic concept, including a wide range of environmental, social, economic, and resource use issues that changes with the time, location, society, and priorities. It is intended to minimize the amount of external inputs added to maximize agriculture output/production and maintain farm resources achieving socioeconomic, environmental, economic welfare, and quality of life without harming the environment, public health, communities, and animal welfare (Kornegay et al. 2010; Pretty, 2008). Sustainable agriculture entails understanding the benefit of ecological and agronomic management, especially in regards to its manipulation and redesign to shift a farming system towards a natural system without reducing productivity (Pretty, 2008).

Ensuring sustainability in agriculture requires the integration of sustainable agriculture practices at the individual farm level. The growing awareness about the negative impact of traditional agriculture practices has raised questions about the challenge of sustainability in agriculture (Kornegay et al. 2010). Agriculture practices that help to ensure sustainable agriculture systems are often called sustainable agriculture practices (SAPs). SAPs are specific farming techniques or means to achieve the agriculture sustainability of individual farms. Sustainable agriculture adopts productive, competitive, and efficient practices while protecting and improving the environment and the global ecosystem, as well as the socio-economic conditions of local communities. Also, SAPs do not exclude external inputs but encourage incorporating them to complement local resources (Zaharia, 2010). While there are some widely applicable standards, SAPs are not "one-size-fits-all" prescriptions but uniquely designed for the best management practices to address the uniqueness of farming systems (Lashgarara, 2011).

The adoption of sustainable agriculture possesses several long and short-term benefits to farmers, society, and the nation as a whole. The adoption of sustainable agriculture emphasizes the benefits which is an output of making the best combination of the resources that a farmer possesses (Pretty, 2008). SAPs such as conservation tillage help to maintain the water table, increase carbon sequestration, improves soil fertility, and protects land from erosion reducing sediments load from agriculture lands (Knowler and Bradshaw, 2007). Designing, promotion, and adoption of location-specific sustainable agriculture practices are one of the important tools in protecting the environment, water quality, and agricultural land (Greiner et al. 2009). SAPs are also necessary means to reduce investments by billions per year in designing different conservation programs to reduce the pollution from agriculture lands (Mullendore et al. 2015). Adoption of SAPs also brings about other benefits such as an increase in net present value, reduction on-farm costs, labor and time saving, and increase in soil moisture and fertility which, in the long run, help to increase yield and stabilize the yield variation (Knowler and Bradshaw, 2007). SAPs adoption in European agriculture has proved that modern agriculture uses excessive inputs and causes water quality problems. These problems can be reduced by incorporating sustainable agriculture practices without reducing agricultural productivity. In the long run, adoption of SAPs can replace some or all external inputs in agriculture systems (Pretty, 2008).

Despite the widespread benefits and positive impacts of sustainable agriculture practices, the adoption of these practices is low in Kentucky due to various factors, including social and economic factors as well as policies that discourage fundamental changes in farming systems. The overall objective of this research was to investigate factors that affect adoption intensity of sustainable agriculture practices among Kentucky farmers. This was achieved by conducting a farmers' survey which provided the required data to develop a predictive model of SAP adoption.

The rest of the paper proceeds as follows. In section 2, we provide broad literature related to SAPs. We present the conceptual model in section 3. We explain data and model related details in section 4. In section 5, we describe the results and implications. We conclude the paper in section 6.

2. Literature Review

The adoption decision making process of SAPs is influenced by several factors such as farmers' knowledge and skills, existence of and connections to a market for the commodities they produce, agricultural policies and regulations, available resources, geographic features of the farm, and economic, social, and conservation motivations (Greiner et al. 2009; Kornegay et al. 2010; Lashgarara, 2011). Farmers with irrigation facilities are more likely to adopt soil conservation practices like cover crops (Bertgold et al., 2012; Snapp et al., 2005; Carlisle, 2016).

Socio-demographic factors such as age, land tenure, and cognitive factors such as knowledge and attitude towards a program are also believed to influence adoption of SAPs (Kabii and Horwitz, 2006). Age is found to have negative effect (Awan et al. 2015; Baumgart-Getz et al. 2012; Kabii and Horwitz, 2006) whereas the education is found to have a positive impact on the adoption of sustainable agriculture practices (Soule, 2001; Upadhyay et al. 2003). Factors such as income, education level, access to information, capital, positive environmental attitudes, environmental awareness, and farm size, generally have a positive impact on the adoption rate of SAPs (Carlisle, 2016; Prokopy et al., 2008). Hall et al. (2009) found that among floriculture farmers with a farm size of 1-5 acres, the relation is significant and positive with the adoption of SAPs, but not with other land sizes.

Access to quality information and extension training have a positive and significant impact on the adoption of best management practices (Baumgart-Getz et al. 2012). Farmers with better knowledge, education, and access to information have a positive impact on the adoption. In addition, knowledge, education, and access to information help to reduce other perceived barriers about practices (Carlisle, 2016). Also, networking and outreach activities among farmers motivate them to adopt and expand the adoption of SAPs. In Kentucky, the conservation agriculture was widely spread among farmers as a result of networking and the innovativeness of the system. The spreading of conservation practices gave a different direction to the agriculture and environment as well as the adoption of new practices in Kentucky (Coughenour, 2003).

Researchers have found that the relationship between farm size and the adoption of soil health-related practices are complicated. Farmers with sloping or highly erodible land are more likely to adopt soil conservation practices (Carlisle 2016; Soule et al. 2000). A study among Brazilian farmers found that the probability of adoption of environmentally friendly practices decreased with an increase in farm size, but increased with increased awareness about the negative effect of chemicals on health and the environment (Filho et al. 1999). However, the use of erosion control practices had a positive relationship with farm size among farmers in eastern Uganda (Barungi et al. 2013). Small farmers are more motivated to adopt soil health-related practices and relate their adoption behavior to environmental problems than large farmers. Also, small farmers identify the problem of soil erosion faster than larger farmers but are less likely to adopt technologies to reduce erosion. This may be due to higher investment in technologies per unit of land (Carlisle 2016).

Awareness, attitudes, available resources, and incentives influence the adoption of environmentally friendly practices among Michigan farmers. The study concluded that farmers' hesitation to adopt such practices were attributable to the misperception that SAPs are less profitable and SAPs require skilled and expensive labor (Swinton et al. 2015). However, farmers who have already adopted SAPs develop positive attitudes about practices and are motivated to adopt more in contrast to non-adopters, who are motivated by potential yield benefits. The protection of the environment, land conservation, belonging to the land, motivation to make changes and off-farm benefits are some of the motivations to adopt SAPs (Carlisle 2016).

Policies can have both positive and negative relationships with the adoption of SAPs. Policies like Farm Bill conservation programs have a positive impact on the adoption of SAPs. Farmers who have already participated in conservation programs are motivated to make long-term investments to adopt SAPs (Baradi 2009; Coughenour 2003; Carlisle 2016). A conservation reserve program was helpful to increase the adoption of SAPs to reduce erosion, but the pace of adoption is slow. However, Risk Management Agency policy prevents the adoption of cover crops as farmers may lose their insurance after adopting those cover crops (Carlisle 2016).

Adoption of SAPs has been well accepted as one of the tools for achieving environmental improvement in agriculture (Greiner et al. 2009). Kabii and Horwiz (2006) found that conservation easement is affected by socioeconomic, farm attributes, geography, behavior, attitude, and knowledge factors. Similarly, Knowler and Bradshaw (2007) summarized factors influencing the adoption of conservation tillage all around the world. Prokopy et al. (2008) summarized U.S. based research focusing on the adoption of sustainable agriculture practices during the last twenty-five years. Mullendore (2015) found that place attachment and place identity among farmers in Midwestern Agriculture have significant effects on conservation practices adoption. Similarly, among Michigan farmers, the adoption of new, environmentally friendly management practices was influenced by attitudes, available resources, and incentives (Swinton et al. 2015). In aggregate, the existing literature collectively indicates that the adoption of SAPs is affected by various socioeconomic, demographics, farm attributes, knowledge, behavior, and attitudes not only in the USA but throughout the world. Also, factors that affect the adoption of sustainable agriculture practices are not consistent throughout the world in the sense that one variable that appears to be statistically significant with a positive sign may not necessarily be statistically significant and possess the same direction in other locations (Baumgart-Getz 2012). However, research focus on determinant variables of SAPs adoption that are generally significant across different geographical areas can improve an overall adoption rate of SAPs (Prokopy et al. 2008).

3. Conceptual Framework

Farmers adopt SAPs for various reasons. Some farmers adopt SAPs because they believe these practices increase yield (and consequently net returns) associated with farming whereas others believe that SAPs are good for the environment. Whether farmers adopt the technology for a yield/profit reason or for an environmental quality reason, they believe that adopting SAPs give them higher utility than not adopting the technology. We believe that farmers adopt a higher number of SAPs because they perceive more number of SAPs adoption or more SAPs applied in more acres of land give them higher utility than otherwise. We can write this as: $U_{SAPs\ adoption=yes} > U_{SAPs\ adoption=no}.$ The probability of adopting SAPs can be shown as:

$$
\begin{aligned}
P_i &= \text{Prob}\left[U_{adopt} > U_{not\ adopt}\right] \\
&= \text{Prob}[X_i\alpha_1 + e_{1i} > X_i\alpha_0 + e_{0i}] \\
&= \text{Prob}[X_i(\alpha_1 - \alpha_0) > (e_{0i} - e_{1i})] \\
&= \text{Prob}[X_i b > \varepsilon_i] \\
&= \text{F}[X_i b]\,.
\end{aligned}
$$

Here, $X$is a matrix of explanatory variables, b (and α) is the parameter vector, ϵ (and e) is error term, F is the cumulative distribution function, i = 1 when SAPs are adopted, and i = 0 when no adoption occurs.

4. Research Method

4.1 Study Area

The study area of this research is the state of Kentucky, USA (Figure 1). Western Kentucky contributes significantly to the state's agricultural sector. This region is more mechanized than the other parts of the state. Central Kentucky is more urbanized compared to other regions. It has three big cities and several other small and growing urban centers. However, this area also has the highest number of farmers. This region is known for having large acres of farmland and a large number of farmers. Eastern Kentucky has fewer agriculture enterprises compared to the other regions of the state. This region is occupied by the Appalachian Mountain range and is also well-known for coal mining and reclaimed lands.

According to the Agriculture Census 2012, Kentucky has about 77,000 farmers and 13 million acres of land used for agriculture. The average size of a farm is 169 acres. The majority of farmers have less than 500 acres of farm. Most of the farm operators in Kentucky are small farmers with age above 45. Looking at the trend over some decades, the number of farmers is decreasing, the average size of each farm is increasing, and the average age of farmers is also increasing (NASS 2015).

4.2 Sampling Procedure Applied

A survey questionnaire was developed to ask respondents about their farm characteristics, current farming practices and knowledge and attitudes towards sustainable agriculture practices. The survey questionnaire was tested among small farmers all over the State of Kentucky in "Third Thursday Thing"—an outreach program on every third Thursday of each month—at the Kentucky State University Research Farm. Final survey questionnaire incorporated suggestions made by the participants. The annual gross sales value of farm outputs and agriculture districts were used for double-stratified sampling to select samples from all agriculture districts. The annual gross sales value and agricultural districts were taken as a reference while stratification for the proportional representation of farmers with different income levels throughout the state and farmers from different agriculture districts with different agricultural characteristics, respectively.

4.3 Data Collection Techniques Used

A mail survey, followed by phone calls, was conducted by The National Agriculture Statistics Service of the United States Department of Agriculture (NASS/USDA) from September 10, 2015 to January 13, 2016. One thousand surveys requesting information for the production year 2014 were mailed to farmers across Kentucky from the North Carolina Print Mail Center. Survey responses were returned and documented at Regional and Field Office (RFO) of USDA/NASS in Louisville, Kentucky. Surveys were randomly cross-verified by USDA/NASS staff and demographic and farm attributes summaries were cross-checked with the 2012 United States Census of Agriculture.

4.4 Definition of Variables

4.4.1 Dependent Variable

We found that majority of the farmers are non-adopters of the sustainable agriculture practices. Only 34.68% of farmers have adopted sustainable agriculture practices, and 65.32% of farmers have not adopted any types of agricultural practices that were identified as the most commonly adopted sustainable agriculture practices among Kentucky farmers by this research. Among adopters, the majority of farmers have adopted 1-7 different practices. About 22.37% of farmers have adopted 1-7 practices, 9.39% of farmers have adopted 8-14 practices, and only 0.65% of farmers have adopted more than 21 sustainable agriculture practices. At most, a single farmer has adopted up to 28 different types of most commonly adopted sustainable agriculture practices identified in this research.

<< Insert Table 1 >>

We found that farmers adopted thirty-one different types of sustainable agriculture practices throughout the state. “Manure distribution as fertilizer” was the most adopted practices by farmers followed by “reduced use of chemicals.” Agriculture practices such as precision agriculture, polyculture farming, reforestation, and mulching are adopted by only a few farmers. The results suggest that the easiness in the adoption process, technical skills requirements, investment, and income play important roles in farmers’ decisions of whether and which sustainable agriculture practices to adopt for their farm. Highly adopted practices among Kentucky farmers are less expensive as well as easy to adopt, and the least adopted practices are highly skill based and investment demanding. The most commonly adopted practices and their adoption intensity are shown in Figure 2.

<<Insert Figure 2 here>>

The description of variables and their descriptive statistics are given in Table 2. The dependent variable *(SAPs)* is the count variable (non-negative whole numbers) that shows the total number of sustainable agriculture practices adopted by Kentucky farmers who responded to the survey. The value of the dependent variable ranged from 0 to 28.

<<Insert Table 2 here>>

4.5.2 Independent Variables

Based on the literature review presented in section 2, the adoption of SAPs is affected by various socioeconomic factors, demographics, farm attributes, knowledge, education, behavior, and attitude. Fourteen explanatory variables related to these factors were used for the analysis: *Crops* (Row Crops growers), *Veggies* (vegetable growers), *Livestock* (livestock farmers), *Irrigation* (irrigation facilities in farm), *Diverse* (in favor of farm diversification), *Solo Proprietorship* (single owner of farm), *Off-Farm Work* (working off-farm for income), *Age* (year), *TBP* (participation in Tobacco Buyout Program), *College Degree* (education level of farmers), and *Land Operated* (Acres). Three barriers to adoption of sustainable agriculture practices—*Happy* (happy with current practices reflecting the attitude of farmers toward SAPs), *Implementation Difficulty* (perceived difficulty of implementation), and *Inadequate Knowledge*—were also used as independent variables in the model. These were the top three barriers marked by respondents in the survey. Six dummy variables are created based on crop growing regions of Kentucky to examine spatial impacts of on the adoption of sustainable agriculture practices. These crop growing areas are shown in Figure 1.

4.6 Econometric/Empirical Model

When the variable of interest is a count variable which is our case with the total number of SAPs adopted by farmers, a count data model is necessary. The number of SAPs adopted by farmers is a function of several independent variables identified in Table 2. The model can be written as:

$$E(SAPs_i|X_i) = \lambda_i = \exp(b_o + b_1X_1 + b_2X_2 + \ldots + b_nX_n)$$

where, $SAPs_i$ is the number of sustainable agricultural practices adopted by farmer i, b_o is the intercept of the regression model, b_1, b_2, …, b_n are coefficients of respective predictors $X_1, X_2, \ldots, X_n$ (Coxe et al. 2009). λ_i is the intensity of rate parameter. Given $SAPs_i$ is a count variable, we consider two linear exponential family distributions (Poisson and negative binomial) for analyzing the number of SAPs technologies adopted by farmers. In the Poisson distribution mean and variance are assumed equal, which generally is not the case. When this mean-variance equality assumption is violated, it is called an over dispersion problem. In such cases, the Poisson regression parameters will be inefficient. We can estimate a negative binomial model which produces coefficients that are robust to distributional misspecification as long as the dispersion parameter is known and the variance function is correctly specified.

4.7 Data Analysis Techniques Applied

Data were analyzed using SPSS 24.0. To address the disproportionate response rate among strata, the post-stratification weight was applied using the equation:

$W_{ih} = rP_h/r_h$

For each sample case in the post-stratum *h*, where r_h is the number of survey respondents in the post-stratum *h*, P_h is the population proportion from the U.S. Census 2012, and *r* is the respondent sample size (Little, 1993).

5. Results and Discussion

We compared the mean and variance of the number of SAPs practiced by farmers and find that those are not equal. Additionally, the likelihood ratio chi-square test is conducted to find if the dispersion parameter alpha is equal to zero. The test statistics indicate that SAPs are overdispersed and are not sufficiently described by the Poisson distribution. Therefore, we estimate an NBR model to understand the adoption intensity of sustainable agriculture practices by Kentucky farmers. The result of the NBR model shows that variables *Crops*, *Veggies, Irrigation*, *Diverse*, and *College Degree* were positive statistically significant at a 1% level. Also, variable *TBP* was positive and significant at a 5% level. Variables *Implementation Difficulty* and *Inadequate Knowledge* were statically significant at a 1% level, and *Age* was statistically significant at a 5% level, but all of these variables had negative signs in the model. Regional variables were statistically significant in the model at various significant levels. *AgDist_2* and *AgDist_4* were significant at a 1% level with positive signs, whereas *AgDist_3 and AgDist_5* were significant at a 5% level and both have negative signs.

<< Insert Table 3 here>>

We interpret the regression results as incident rate ratios by exponentiating the regression coefficients (the last column in Table 3). The variable *Crops* (farmers growing row crops) and *veggies* (farmers growing vegetables) were a significant predictor of adoption of sustainable agriculture practices in Kentucky. The results show that the incident rate for SAPs adoption for farmers growing row crops were 2.294 times the incident rate for the farmers without row crops. The incident rate for farmers growing vegetables was 1.511 times the incident rate for the farmers not growing vegetables. Several researchers have identified the role and importance of high value, short season, and cover crops to improve soil health, reduce pest infestation, weed control, and reduce the use of chemicals (Lichtenberg 2004; Singer et al. 2007; Snapp et al. 2005; Teasdale 2013). In addition, the adoption of sustainable agriculture is a common practice among vegetable farmers. The use of approaches that can enhance vegetable production safely has been increasing with increased interest of consumers in organic and healthy vegetables (Simmons 2008).

The *availability of irrigation facility* had a positive and significant effect on the adoption of sustainable agriculture practices among Kentucky farmers. The incident rate for farmers with irrigation facilities on the farm *(Irrigation)* was 1.876 times the incident rate for farmers without irrigation facilities. Awan et al. (2015) also found that availability of water had a positive impact on the adoption of sustainable agriculture practices among wheat-cotton farmers.

The incident rate for farmers in favor of farm diversification *(Diverse)* was 2.072 times compared to their counterparts. A significant predictor of the adoption of sustainable agriculture practices is whether farmers are in favor of diversifying their farms. Those farmers who were in favor of diversifying were also likely to adopt more sustainable agriculture practices compared to farmers who did not favor diversification. Farmers diversify their farms by adding high-value crops, short season crops and vegetables, and cover crops, which are helpful in weed control, reduce the use of chemicals, and improve soil health and fertility and ensure improved crop production (Lichtenberg 2004; Singer et al. 2007; Snapp et al. 2005; Teasdale 2013).

Also, the incident rate for farmers who participated in the tobacco buyout program *(TBP)* were 1.286 times compared to other farmers who did not participate in the TBP. The U.S. government has collectively spent billions of dollars in designing policies that shape agriculture and facilitate the conservation programs through different farm bills (Mullendore et al. 2015). These Farm Bill programs also transition farmers from tobacco to different crops that may have provided positive motivations for farmers who participated in the TBP program to adopt sustainable agriculture practices. Litchenberg (2004) found that the adoption of several soil and water conservation practices are responsive to the USDA/NRCS cost-sharing program. The increase in the cost of the practice reduces the adoption of conservation practices among Maryland farmers. Also, the interaction between different conservation practices may be less costly reducing the share of the cost. It may increase the adoption of conservation practices. Several other researchers also have found that the adoption of management practices related to soil health was enhanced by the Farm Bill Conservation Program (Carlisle 2016; Coughenour 2003; Soule 2001).

The incident rate for farmers with formal education level above college degree *(College Degree)* was 2.097 times compared to farmers without a college degree. This can be attributed to their awareness and better understanding of the benefit of adopting sustainable agriculture practices (Awan et al. 2015). Kabii and Horwitz (2006) also found that the attitude of farmers plays a role in the adoption of conservation agriculture. Lashgarara (2011) found that the education, knowledge, and attitude of farmers are significantly correlated with the adoption of sustainable agriculture adoption. Baumgart-Getz (2012) mentioned that attitude had a positive and significant influence on the adoption of agricultural best management practices. The chains of practices created following from the previous one (also called a “foot in the door” model) could lead to the complete transformation of farming systems (Wilson et al. 2014).

The percent change in the incident rate of SAPs’ adoption is a decrease of 1% for every single year the farmer’s age *(Age)* increases. Increasing farmer age had a negative impact on the adoption of sustainable agriculture practices among Kentucky farmers. This is consistent with several other studies. Awan *et al.* (2015) found that age had a negative relationship on the adoption of sustainable agriculture practices among Indian farmers. This could be because younger farmers have positive attitudes towards sustainable practices compared to older farmers, who are relatively hesitant to change farm practices from traditional to SAPs (Baumgart-Getz et al. 2012). The incident for farmers who perceive that the technology is difficult to adopt *(Implementation Difficulty)* were 4.892 times less compared to farmers who do not perceive implementation difficulty associated with SAPs. The incident rate for farmers with inadequate knowledge of technologies *(Inadequate Knowledge)* was 0.532 times less than farmers who do not perceive inadequate knowledge to adopt SAPs. These incident rates suggest the need for extension activities, training, and education to improve the adoption of SAPs. Swinton et al. (2015) reported that due to a perception of lower profitability farmers are unwilling to adopt technologies.

Hall et al. (2009) identified implementation concerns and perceived risk of failure as two major barriers to the adoption of sustainable agriculture and recognized the importance of education and training to overcome these barriers. These barriers can be overcome through education, extension, and outreach activities (Baumgart-Getz et al. 2012; Kornegay et al. 2010). These findings validate the importance of education to reduce knowledge barriers, as well as the perceived difficulty of implementation among farmers. Carlisle (2016) also suggested that education in combination with other activities such as research and policies are essential to mitigate the adoption barriers related to soil health equipment adoption.

The incident rate of adopting SAPs for farmers living in Agriculture District 2 *(AgDist_2)* and Agriculture District 4 *(AgDist_4)* were 2.352 times and 1.76 times more, respectively compared to the farmers living in Agriculture District 6 *(AgDist_6)*, the reference group. However, farmers residing in Agriculture Districts 3 *(AgDist_3)* and 5 *(AgDist_5)* possess behavior that is the opposite compared to the above two districts. The incident rate for these farmers in agriculture districts 3 and 5 were 0.676 and 0.669 times, respectively compared to the reference group *(AgDist_6)*. The result clearly shows that the issue of sustainability in agriculture is highly localized. Thus, the solution also should be location specific. A blanket approach to solving the problems of agriculture sustainability may not be equally valid and equally adaptive even in the same state or same country. Sustainable agriculture and sustainable agriculture practices are localized by nature and should be addressed locally. However, the solution should have a more significant impact on solving this global problem.

Districts 3 and 5 are known for having large acres of farmland and large number of farmers. Also, two major cities—Lexington and Louisville, and the capital city, Frankfort, and other several small and medium-size towns, can be found in this region. Due to the large market of agriculture commodities, farmers might be more focused on commercial farming and increased revenue rather than the sustainability of the farming system.

Research conducted among New Zealand dairy farmers to understand the adoption of the best management practices suggests that farmers close to each other make similar choices due to the potential for frequent interactions (Yang and Sharp, 2017). The results of the current research are partially supportive of the previous studies. Specifically, results from *agriculture districts 3* and *5* are consistent with the earlier findings since they are neighboring districts and have a similar result in the model. However, the results from agriculture districts *2* and *4* contradict previous findings. Agriculture district *2* is primarily farmland with some coal mining areas. This region is also well known for large size farm operations. A positive relationship with the adoption of sustainable agriculture practices in this region can be linked with the awareness among farmers about the negative impact of coal and coal mining sites on the environment and agricultural commodities. Also, since large enterprise and agriculture have occupied this region and has been one of the major parts of the economy for a long time, farmers in that region might have developed awareness about the importance and role of SAPs in the long-term sustainable agriculture enterprise.

Agriculture district 4 is in between two large cities: Louisville and Cincinnati, Ohio. The negative impact in the environment coming from two large cities, and also the awareness about the importance of sustainability and sustainable agriculture practices among small farmers in that region, might play an important role in shaping the adoption of sustainable agriculture practices among farmers in that region.

6. Conclusions

This study explored factors affecting the intensity of the adoption of sustainable agriculture practices among Kentucky farmers using negative binomial regression. Fourteen variables representing socioeconomic, demographics, farm attributes, attitudes, knowledge, and behavior were used in the analysis. Agriculture districts were included in the model to account for geographic or regional variations on adoption intensity.

We identified several important factors impacting the adoption of sustainable practices in Kentucky. Sustainability of agriculture and food systems has been a concern for scientists for a long time. However, the adoption of such practices varies by socioeconomics, demographics, and technology adoption, which are mostly localized and geographic characteristic-specific. Farmland use, crop selection (specifically, the choice to grow row crops), a positive attitude towards diversification, farmer perception about the level of difficulty in technology adoption, and the level of education attained by the farmer are all important factors that drive a farmer's decision to adopt sustainable practices. Difficulty in the implementation of such practices arises, entirely or partially, from inadequate knowledge. This indicates the need for more extension in outreach efforts among farmers. This study has some limitations that should be taken into consideration while interpreting the results. Also, the respondents were small-scale farmers, and thus the findings are more relevant to this group. In addition, the stratification by agricultural district reduced the sampling bias in the research; however, it is vital to take spatial variation in the analysis into account since farm operations, acreage devoted to agriculture, and sustainable practices vary among agricultural districts. For instance, eastern Kentucky has relatively less agricultural land compared to central and western Kentucky, which might have an impact on the decision making process in regards to the adoption of sustainable practices.

Making the decision to adopt—and deciding how many practices to adopt—is a complex process. Therefore, farmers make decisions in the broader context by considering several factors, such as economy, income, alternative opportunities, government policies, their attitude and behaviors, socioeconomic conditions, farm and farming conditions, location, and several other factors. This study should be helpful in developing extension and outreach efforts focusing on variations in demographics, farm size, education, and technology adoption attributes.

Compliance with Ethical Standards

Disclaimer: *Summaries were derived using data collected in the Kentucky State University Economics Survey by the National Agriculture Statistics Service, United States Department of Agriculture (NASS). Any interpretations and conclusion derived from the data do not necessarily represent the views of the NASS.*

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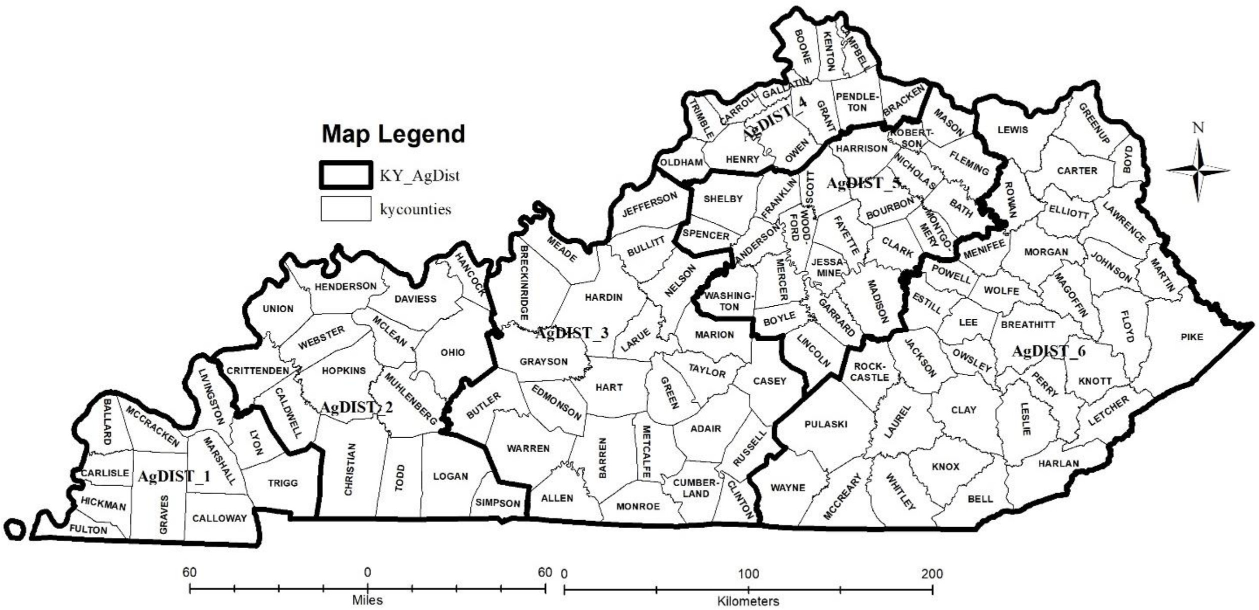

Figure 1. The State of Kentucky with the six crop growing regions and counties

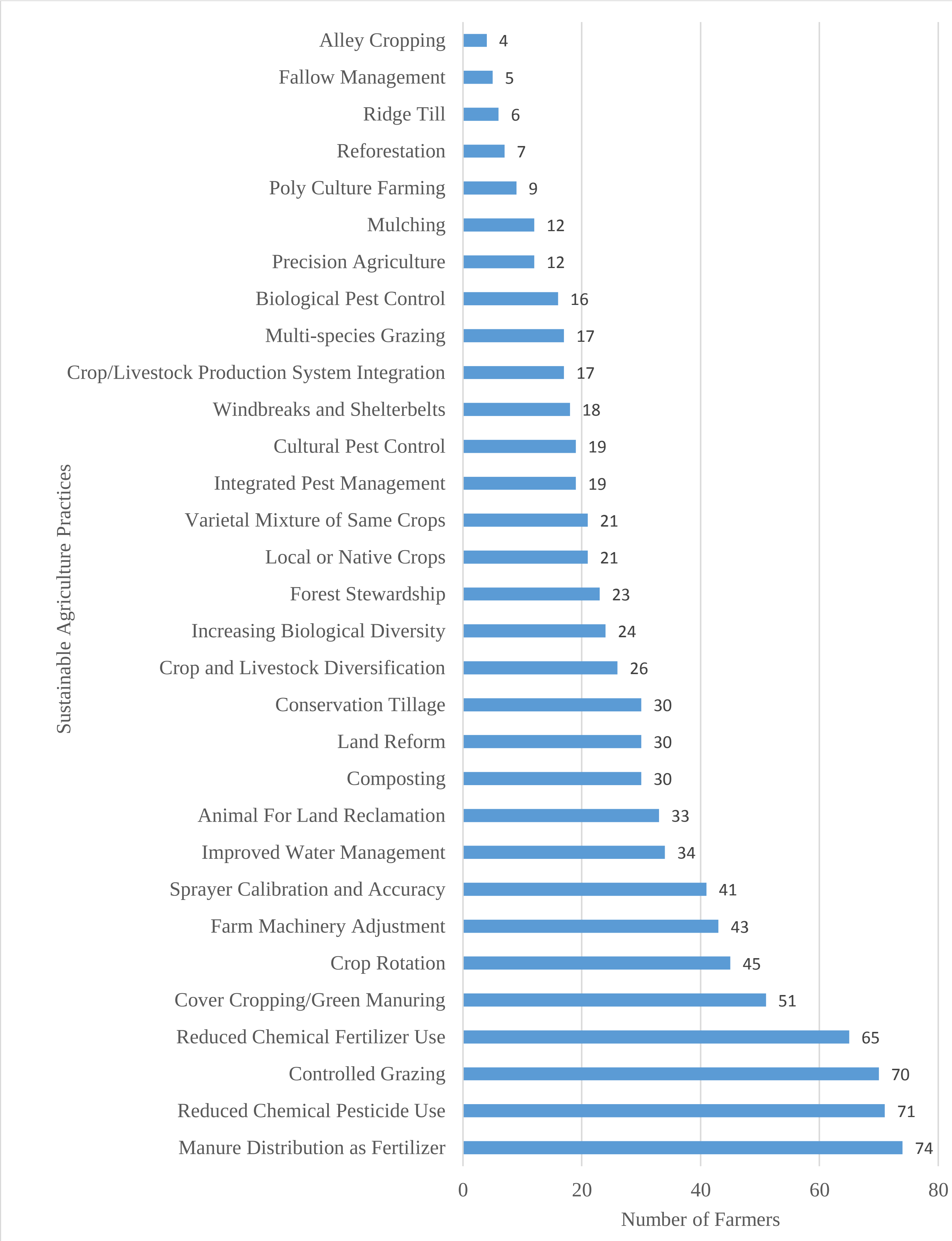

Figure 2. Most Commonly Adopted Sustainable Agriculture Practices among Kentucky Farmers

Table 1. Sustainable agriculture practices adopted by farmers (N = 230)

Number of Practices	Number of Farmers	Percent
0 (Not Adopted)	150	65.32
1 to 7	51	22.37
8 to 14	22	9.39
15 to 21	5	2.27
22 to 28	2	0.65

Table 2. List of Variables and their descriptive statistics

Variables	Variable Name	Mean	Variance
Dependent variable			
SAPs	Number of SAPs adopted by Farmers	2.52	21.16
Independent variables			
Crops	Row Crop Farmers; Yes = 1; Otherwise = 0	0.54	0.15
Veggies	Vegetable Growing Farmers; Yes = 1; Otherwise = 0	0.16	0.02
Livestock	Livestock Farmers; Yes = 1; Otherwise = 0	0.81	0.16
Irrigation	Irrigation Facility in Farm; Yes = 1; Otherwise = 0	0.04	0.04
Diverse	In Favor of Diversifying Farm; Yes = 1; Otherwise = 0	0.42	0.24
Sole Proprietorship	Farm with Sole Proprietorship; Yes = 1, Otherwise = 0	0.75	0.19
Off Farm	Working off Farm; Yes = 1; Otherwise = 0	0.49	0.25
Age	Age (Years)	62.85	149.81
TBP	Participated; Yes = 1; Otherwise = 0	0.42	0.38
College Degree	Formal Education: College Degree or above; Yes = 1; Otherwise= 0	0.20	0.16
Land	Total Land Operated (Acres)	169.60	300804.59
Happy	Happy attitude (A reason for not adopting SAPs); Yes = 1; Otherwise = 0	0.43	0.25
Implementation Difficulty	Perceived difficult of implementation of practices; Yes = 1; Otherwise = 0	0.05	0.05
Inadequate Knowledge	A reason for not adopting SAP; Yes = 1; Otherwise = 0	0.15	0.13

Table 3. Parameter Estimates Obtained from a Negative Binomial Regression Model of Factors Affecting Adoption of Sustainable Agriculture Practices Among Kentucky Farmers (N = 205)

Variables	Estimates (b)	SE	Exp (b)
Constant	0.024	0.423	1.024
Crops	0.830***	0.121	2.294
Veggies	0.413***	0.136	1.511
Livestock	0.228	0.143	1.257
Irrigation	0.629***	0.171	1.876
Diverse	0.728***	0.100	2.072
Sole Proprietorship	-0.084	0.116	0.920
Off Farm	0.063	0.120	1.065
Age (Years)	-0.010**	0.005	0.990
TBP	0.251**	0.105	1.286
College Degree	0.740***	0.136	2.097
Land	0.000	0.000	1.000
Happy	0.004	0.102	1.004
Implementation Difficulty	-1.588***	0.180	4.892
Inadequate Knowledge	-0.631***	0.158	0.532
AgDist_1	0.225	0.194	1.253
AgDist_2	0.855***	0.163	2.352
AgDist_3	-0.392**	0.161	0.676
AgDist_4	0.565***	0.159	1.760
AgDist_5	-0.402**	0.166	0.669

*** & ** = Statistically significant at 1% and 5% levels, respectively. SE is standard error.