Agricultural Sustainability Definitions and Metrics by Wheat Farmers in Kansas

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DAS 582

Final Report

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Introduction

The definition of agricultural sustainability has been a long-standing debate in science and society. This is partially because it lacks an analytical or optimal definition, as it varies with time, landscape and demographic cohorts (Rittel and Webber, 1973). The fact that the word "sustainability" has different meanings to different groups of people has been a nail in the collective coffin of the scientists, policymakers, and stakeholders working towards sustainability. Most research in the field of sustainability recently has adopted a set of parameters known as the "Triple Bottom Line" approach, splitting the singular definition of sustainability into three dimensions: economic, social, and environmental. This paper aims to explain those three definitions of sustainability as well as walk through the research we conducted to create a definition for sustainability across wheat farmers in Kansas.

As stated above, sustainability in agriculture is often framed within the three pillars of economic, social, and environment, yet applying them consistently in a regional context like Kansas remains a major challenge. Different sectors often emphasize different pillars; producers often prioritize economic sustainability, and environmental groups tend to focus on resource conservation, making it difficult to align goals and definitions across stakeholders. This conflict persists even though sustainability rests on the principle that agricultural practices must meet present food needs without compromising the ability of future generations to meet their own. The U.S government formally reinforcing this concept by legally defining sustainability in Title 7, Section 3103 as an integrated system of plant and animal production practices that will, over the long-term satisfy human food and fiber needs; enhance environmental quality; make the most efficient use of nonrenewable resources; sustain economic liability of farm operations; and enhance quality of life for framers and society as a whole.

However, despite a formal definition, there is no agreement on how sustainability should be defined or used in Kansas agriculture. This lack of consensus is especially problematic given the state's drastic regional diversity. The U.S. Great Plains is the world's largest contiguous winter wheat-producing region (Fischer et al., 2014). During the last decade, an annual average

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USDA-NASS. United States Department of Agriculture - National Agricultural Statistics Service. (2024).

Mottaleb, K. A., Kruseman, G. & Snapp, S. Potential impacts of Ukraine-Russia armed conflict on global wheat food security: A quantitative exploration. *Global Food Security* **35**, 100659 (2022) of 13M ha were sown to wheat in the Great Plains (USDA-NASS, 2024), totaling an average of 32 Mt or 62% of U.S. wheat production (USDA-NASS, 2024). During the last 10 years, 8% of wheat traded internationally was sourced from the U.S. Great Plains, primarily imported into developing countries (Mottaleb et al., 2022). Western farms deal with water scarcity and unsustainable groundwater extraction from the Ogallala Aquifer, creating the need for water-saving and irrigation management technologies (Grey, 2013). On the other hand, eastern and central farms face challenges of soil erosion and degradation (Herendeen, 2002). These differing environmental challenges shape different sustainability priorities across regions, highlighting the need for a Kansas-specific definition that can honor the three pillars of economic, environmental, and social factors, but is still flexible enough to reflect regional constraints and local production challenges.

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During the last century, multiple agricultural technologies improved on-farm sustainability such as the introduction of semi-dwarf wheat cultivars (Miralles and Slafer, 1995) and enhanced use of nitrogen fertilizer (Spiertz J.H.J, 2009) during the Green Revolution. These practices contributed positively to profitability and food security at the expense of the environment (e.g., soil nitrogen mining, and reactive nitrogen release to water bodies and to the atmosphere; Lassaletta, et. Al, 2014). Other common management practices in the world of agricultural sustainability include, “mulching and recycling of organic residues, improving soil structure and quality by amendment of organic material, water conservation and water use efficiency, agro-forestry and mixed farming, diversified cropping systems including the use of indigenous foods, no-till agriculture, the use of micronutrient rich fertilizers, inoculating soils for improved biological N fixation, and microbial processes to increase P uptake,” (Halberg 983). This quote shows just a few of the many management practices to promote sustainability. Having an idea of what needs to be done to be considered “sustainable” is not the question, though. The question is how does society implement said practices in most, if not all, farms? In the end, sustainability for the world cannot be obtained individually, it must be a widespread effort.

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The adoption of sustainable practices in Kansas for wheat farming is constrained by a complex connection of economic, social, and environmental challenges that vary considerably by farm size and regional contexts. In other studies farm size has emerged as a critical determinant of sustainable practice adoption, as larger farms have advantages in accessing capital, labor, and technology needed to implement new practices. Research across multiple regions in Nepal and Pakistan has found that larger farms tend to have higher levels of education, greater labor availability, and more investment capacity for inputs such as fertilizers and equipment, as well as higher overall expenditures than smaller operations (Ali, 1996). This disparity in farm size translates directly into differences in adoption rates, larger farms can afford long-term investments in advanced irrigation systems, precision agriculture technologies, and conservation equipment, while smaller farms are often forced into short-term. Even though only one farmer in our project listed farm size as a factor that limits sustainable practice adoption, lack of financial and labor resources was still listed as a major factors limiting practice adoption

Goals

This study shows the outcomes of a qualitative survey of Kansas wheat farmers that aim to: (i) define an operational definition of sustainability for wheat production; (ii) identify farming practices that improve overall on-farm sustainability; and (iii) list major challenges that prevent adoption of such practices by Kansas wheat growers. We discuss the implications of our findings aiming to improve overall on-farm sustainability in Kansas and beyond.

Methods

We used a qualitative survey to collect data needed to achieve objectives. As the project needed to be contained within one semester and we were unable to plan travel time, an online form was deemed the most efficient method. We chose qualitative over quantitative to better capture themes and ideas related to sustainability and allow farmers to convey their thoughts with minimal constraints.

To prepare to write the survey, our team looked to previous studies using similar methods. This meant we had to find research focused on sustainability or conservation that used surveys in a quantitative manner. We looked to the United States Department of Agriculture and their design of a survey about farmer perceptions about conservation methods to gain an understanding of design and precise wording (USDA/NASS 2024). McKinsey & Company's 2024 survey on global sustainability issues also served as a great reference, as it covered as it aligned with our own questions and provided great examples on survey flow and different examples of how sustainability and farming methods intersect.

We used the Qualtrics Survey System to conduct our research, creating a survey consisting of 16 questions with the majority being long-answer questions. To reach a greater amount of our target demographic of Kansas wheat farmers in one move, we used the Kansas Wheat Commission listserv. Responses were collected from September to October, with a goal of receiving 30 quality responses. However, we were only able to obtain a total of 15 survey responses, 5 of which were incomplete. This left a total of 10 quality responses where at least 75% of the survey was completed. Survey questions are shown below.

Table 1

Demographic
What year were you born? How do you describe yourself? (Gender) What is the highest level of education you have completed?
Background Information
Do you include wheat in your crop rotation? How many acres of wheat do you typically plant each year? Leave blank if you prefer not to disclose. Which counties in Kansas do you farm in?
Objective 1 - Defining Sustainability
What does agricultural sustainability mean to you? Based on your definition of sustainability, how would you measure the economic sustainability of your operation? Based on your definition of sustainability, how would you measure the environmental sustainability of your operation?
Objective 2 - Identifying Sustainable Practices
What, if any, farming practices/technologies contribute positively to environmental sustainability of your operation? From the practices you listed on the previous question, in what amount of time would you expect them to have a positive environmental impact on your operation, if at all?

Objective 3 - Major Challenges that Prevent Adopting Practices
How often do you attend extension meetings and/or agricultural research updates?
Are there any factors that limit your ability to adopt new or existing farming practices that are known to have positive economic and environmental outcomes? Please describe those factors and give reasons why you do not adopt new practices, if any.

Note: The table above lists the questions asked in the survey, and what objectives (if any) the questions related to.

Once we received all likely responses, we separated the questions using Excel, assigning each respondent a number based on the order they responded. From there, we conducted a triple-blind coding process to extract concepts from written survey answers. The method consists of extracting concepts from each long-form question to create a matrix, counting occurrences and frequencies of the concepts. We used libraries *tidyverse* and *readxl* available in R for data wrangling. Following these, we utilized *ggplot2* package available in R to visualize the number of times a concept within a written answer. Supplementary section includes the code for reproducible analysis.

Results

The objective of our survey was to amass data from wheat farmers in Kansas regarding their individual definitions of economic and environmental sustainability. We did not receive as many respondents as we had expected or hoped to, but regardless, some interesting data trends arose. Our respondents ranged in age from 29 to 76, from wheat farm sizes of 50 acres to 3500 acres, and in counties from Seward to Clay. Demographic data is shown in Table 2.

Table 2

Birth Year	**Gender**	**Education Level**
1949	**Female**	**Bachelor's degree**
1958	**Male**	**Associates or technical degree**
1962	**Male**	**Graduate or professional degree**
1966	**Male**	**Bachelor's degree**

1997	**Male**	**Bachelor's degree**
1984	**Male**	**Bachelor's degree**
1960	**Male**	**Associates or technical degree**
1983	**Male**	**Graduate or professional degree**
1953	**Male**	**Bachelor's degree**

From the data we obtained from our respondents, we extracted concepts that indicate agricultural sustainability on their wheat farms and plotted them in order of occurrence in the respondents' answers, shown in Figure 1.

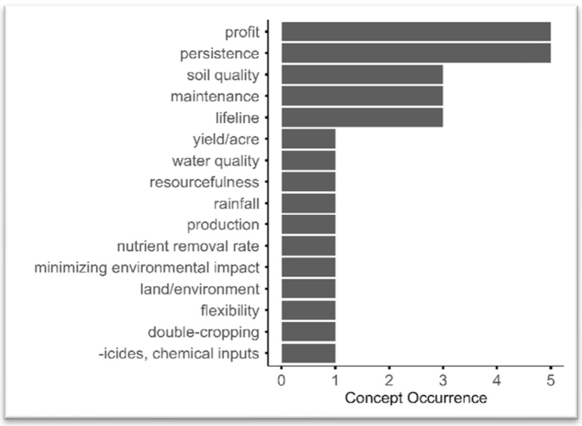

Figure 1: Ranking the concepts in definitions of agricultural sustainability based on number of occurrences of each concept across respondents' definitions.

Profit and persistence are the most commonly occurring indicators for sustainability among the respondents, showing that many respondents understand the concept of economic sustainability best. Maintenance and soil quality pertain more towards the concept of environmental sustainability, and lifeline towards social sustainability. It seems that, in general, farmers are most interested in long term economic viability for their families instead of the ecological benefits of being sustainable environmentally. This fact is highlighted in a response from the last question, which asks whether there were any more comments they wanted to make, when one farmer states, "Farmers have the land and environment in their best interest, it's what feeds their families, in some cases the land has been in families for generations, they don't need an overreach of government and big ag companies pushing policies or ideas that don't make sense on the farm." For farmers such as this one, economic persistence is key for sustainability.

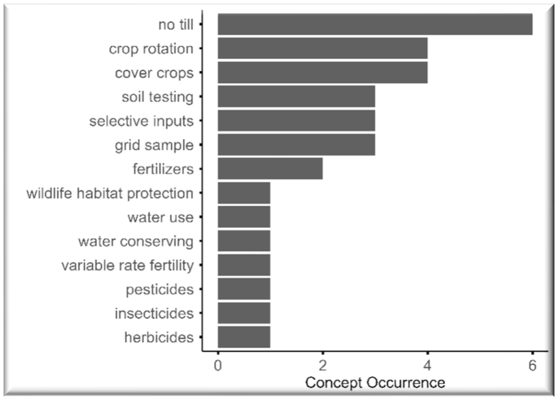

Figure 2: Ranking the management practices used by respondents based on number of occurrences of each practice across responses.

We also asked respondents about the practices they have adopted that contribute positively to sustainable development on their wheat farms, with data showing that no-till farming, or farming in which the upper layer of soil is not disturbed to plant seed, is the most common practice adopted amongst our respondents, shown in Figure 2.

The top answers from our respondents about their agricultural sustainability practices include no-till, crop rotation, cover crops, soil testing, selective inputs, grid sampling, and fertilizers, in decreasing order of occurrence. Each of these concepts were given in responses more than once and should therefore be aptly considered when creating a static definition for agricultural sustainability.

When gathering this data, we came up with a hypothesis that the size of the wheat farm would be directly proportional to the amount of sustainability practices used, in the sense that larger farms would have more sustainability practices in place. However, when we analyzed the data, we found no correlation between size and practices at all. In fact, we found that the smallest wheat farm utilized the most practices, whereas the largest wheat farm was one of the lowest in terms of sustainability practices. Apart from the concepts shown on the graph, there were some outlying answers that should not be overlooked in the data. The farmer with the smallest farm size also mentioned under the last question that in his tillage efforts, he is, "also reducing the nutrient stratification on my field which makes P [phosphorous] runoff worse." In the same response, he mentioned, "another conservation practice on my field is the use of terraces and waterways." Although this data did not fit within the constraints of our analysis parameters, it is still important information to include.

A supplementary file of the code we used to analyze our data is included below:

Supplementary Materials 1

Discussion

Kansas wheat farmers in this study defined sustainability primarily through economics, focusing on profit and persistence on their farm, while maintaining or improving yields. Profit and persistence were the most frequently mentioned concepts mentioned in open-ended survey questions, while terms such as livelihood, flexibility, and land/environment showed less frequently. Management practices that farmers linked sustainability were mostly no-till, crop rotation, cover crops, and soil testing. These results show that for the farms who responded to the survey, sustainable wheat production meant staying economically viable well implementing several soil management practices, rather than adopting highly technical and advanced practicers.

This study had several limitations that affected how the findings can be generalized when defining sustainability. The survey only had ten complete responses, far below our original goal of thirty responses, and responses were concentrated around Riley and Clay counties, with only a few Reponses in southwest Kansas, limiting regional representation in the study. The short time frame of one semester meant the survey could only run for a few months, limiting opportunities for responses and more in-depth interviews that could have strengthened insights. In comparison similar studies in Europe sampled 1,500 farms across seven years (Zahm, 2008). This study also shows that much larger sample sizes are feasible and can be used to address farmer perceptions of sustainability and management strategies.

Even with these limitations, the results provide insight into the main objective of the project. The First of which being defining what sustainability means for Kansas wheat farmers, the findings show that definitions are rooted in economic sustainability and farm survival, with a few environmental concepts of soil and water health added in. For the second objective, identify farming practices that improve overall on-farm sustainability, the survey responses suggested that Kansas wheat growers are implementing sustainable practices that can be low cost and improve soil health such as no-till, cover crops, and selective input use. For the final objective, list major challenges that precent adoption of sustainable practice by Kansas wheat growers the report's background literature review highlighted that smaller farms typically lack access to capital, labor, and technology, pushing them toward short-term profit making it difficult to invest in practices like precision agriculture or advanced irrigation systems. Even though there was only one farm in our study explicitly stated farm size as a challenge to sustainable practice adoption, five other growers in the study stated lack of financial resources as a barrier to practice adoptions

These findings have several implications for agronomy and policy in Kansas. Due to the emphasis on no-till, crop rotation, and cover crops, future research and outreach can build on the existing familiarity with these practices while also helping farmers integrate more water management, nutrient efficiency, and chemical input reduction into their sustainability frameworks. For policy, the results highlight the importance of incentives and cost-share programs that lower up-front costs of implementing sustainable practices, especially in smaller farms. The findings also demonstrate the need for clear definition of sustainable agriculture in Kansas that acknowledges the regional differences across the state while still including the three pillars. Future research should focus on expanding the sample to other Kansas regions, combine the survey questions with interviews and link connect the reported sustainability practice to economic and environmental data so that sustainability efforts can be evaluated.

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