Co-Developing Climate-Smart Strategies: Enhancing Resiliency Among Alabama Row Crop Producers and Agricultural Stakeholders

by

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Abstract

This thesis is embedded in a large USDA-NRCS project titled the *Future of Farming: Increasing Adoption of Conservation Practices among Alabama Row Crop Farmers* (FFP). The FFP is designed to demonstrate the benefits of several climate-smart technologies --cover crops, variable rate irrigation, soil moisture sensors--as well as nutrient management practices, to bolster soil health and improve water and nutrient use efficiency. Specifically, this research uses a collaborative, systems approach, to develop a shared understanding of the practices and technologies that may foster innovative conservation approaches to agricultural production through engaged learning opportunities, incentive payments for cover crop adoption, and on-farm demonstrations. This thesis is split into two papers as my contribution was two-fold. The first examines the co-development of a knowledgebase about climate-smart technologies, which required the use of innovative, collaborative, extension methods and meeting structures. Using a qualitative approach, the challenges of co-developing knowledge and conducting transdisciplinary science were identified using word frequency queries. The second identifies barriers to adoption of climate-smart technologies to inform the FFP research and extension team about the most effective ways to tailor discussion and meeting content. The statistical significance of actors that used climate related words was determined and supplemented by word frequency queries. Findings from both papers indicate a lack of regional-specific knowledge and engaged learning methods that impedes the teaching about and implementation of conservation-based farming methods. Results suggest Cooperative Extension ought to develop research relevant to the specific climate-based concerns of stakeholders in the Southeast and incorporate co-produced knowledge into the development of conservation strategies.

Acknowledgements

This thesis is dedicated to my sister Carrie Stewart. Thank you so much for encouraging me to be the best student and researcher I can be. I look to you as inspiration to pursue my dreams and work hard toward my career goals. My time in graduate school would not have been as productive without your support and advice. I would like to thank my parents John and Patricia Stewart for the words of encouragement and love throughout my transition from undergraduate to graduate school. The continuous guidance from you both pushed me to get to where I am today.

Thank you so much to the Future of Farming team and my research partner McKayla Robinette. I have learned so much during the past 2 years about Extension and the importance of transdisciplinary work. Specifically, thank you Dr. Michelle Worosz, my advisor, for guiding me through this thesis and training me to be a skilled qualitative researcher. Thank you, Dr. Ryan Thomson, for mixed-methods suggestions and help with the graduate school transition. I would like to give a special thank you to Dr. Brenda Ortiz for the encouragement to present my research at the AIAEE conference in Thessaloniki, Greece. I am grateful for the experience.

Special acknowledgement to the National Science Foundation (NSF) for supporting my research through the Climate Resiliency National Research Traineeship. I have learned so much from the PIs on the project especially Dr. Karen McNeal, and Dr. Nedret Billor. Without this funding I would be unable to achieve this degree and pursue my interests in science communication. The NRT program truly reconceptualized what it means to be a dedicated researcher and successful student. I have learned so much from this opportunity and am confident it will open doors for me in the future.

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List of Abbreviations

ACES	Alabama Cooperative Extension System
CC	Crop Consultant or Agronomist
EA	Extension Agent
ER	Professor and Extension Specialist
F	Farmer
FFP	Future of Farming Project Core Team
FFP(TD)	Future of Farming Core Team and Project Participants
G	Government Employee
NRCS	Natural Resources Conservation Service
OR	Other Researcher
SWCC	Soil and Water Conservation Committee
SI	Sustainable Intensification
TD	Transdisciplinarity
USDA	United States Department of Agriculture

CHAPTER 1: PROLOGUE

My Master of Science was funded by a National Science Foundation Traineeship (NRT) for Climate Resilience (NSF Grant #1922687) and this research was funded by a Conservation and Innovation Grant through the Natural Resources Conservation Service (CIG Grant #NR203A750013G01). This grant trains climate scientists and leaders focused on building resilient communities in the Southeastern US to prepare disaster responses and recovery (Auburn NRT Climate Resilience 2021). NRT trainees include students from earth systems science, engineering, geosciences, forestry and wildlife sciences, climate science, data science, agriculture, and social science disciplines. Any opinions, findings, and conclusions or recommendations expressed in this thesis are those of myself and do not necessarily reflect the views of the National Science Foundation (NSF).

1.1. THE FUTURE OF FARMING: INCREASING ADOPTION OF CONSERVATION PRACTICES AMONG ALABAMA ROW CROP FARMERS

My research is a part of a larger transdisciplinary study at Auburn University funded by a United States Department of Agriculture (USDA) Natural Resources Conservation Services (NRCS) grant focusing on conservation and innovation (CIG) (Prasad et al. 2020). The Future of Farming: Increasing Adoption of Conservation Practices among Alabama Row Crop Farmers (FFP) is a six-year study which includes five primary investigators: three Professor and Extension Specialists, one Rural Sociology Professor, and one external agricultural economist who is an external consultant. Auburn University graduate students and post-doctoral researchers assist this core team. Specifically, the rural sociology group within the Future of Farming team includes Dr. Michelle Worosz a sociologist of food and agriculture, McKayla Robinette a M.S.

rural sociology graduate student, and me a M.S. rural sociology graduate student and NRT Fellow. For the purposes of this thesis, Alabama professor and extension specialists and other researchers will be referred to as the FFP research team while the transdisciplinary team including project participants will be referred to as FFP(TD).

The larger objective of the FFP is to demonstrate the benefits of climate-smart technology including the implementation of cover crops, variable rate irrigation, soil sensors, and nutrient management practices to bolster soil health and improve water and nutrient use efficiency (Figure 1). The demonstration of these climate-smart technologies includes comparison of "business as usual" practices and "aspirational" conservation techniques on three cooperator farms in North, Central, and South Alabama which serve as tech-in sites. The design uses a collaborative, systems approach, to develop to a shared understanding of the practices and technologies, foster innovative conservation approaches to agricultural production through engaged learning opportunities, incentive payments for cover crop adoption, and on-farm demonstrations. One-on-one meetings, field days, and interactive workshops have been used to increase knowledge exchange and identify barriers to climate-smart technology adoption. Participants within the FFP included Alabama Cooperative Extension agents (ACES), government employees from the Alabama Soil and Water Conservation Committee and United States Department of Agriculture Natural Resources Conservation Services, Alabama row crop producers, and crop consultants from private companies. The Future of Farming team is monitored by Alabama Soil and Water Conservation Committee (SWCC) and the Alabama office of USDA-NRCS (Natural Resources Conservation Services).

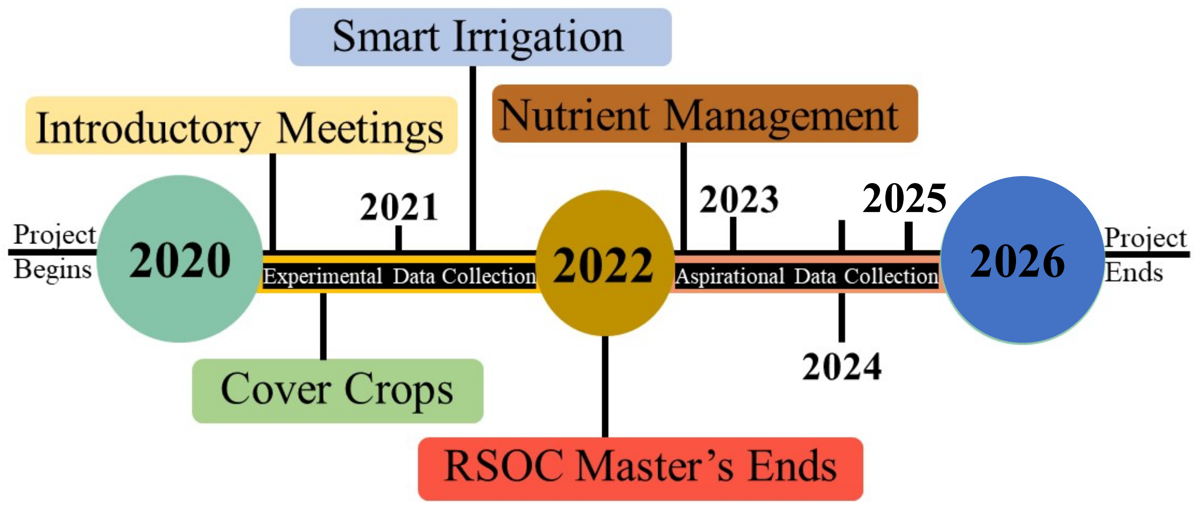

Figure 1: The FFP timeline 2020-2026. Introductory meetings and cover crop workshops took place in 2020-2021. Smart irrigation demonstrations occurred in the summer of 2021. Nutrient management sessions began in the winter of 2022. Spring and summer cover cropping workshops began in 2022 but they are not included in this introductory analysis.

My contribution to the Future of Farming team was two-fold. The first involved co-developing a knowledge base about climate-smart technologies. This co-production required designing innovative, collaborative extension methods, meeting structures, interactive content. The second contribution included analyzing the barriers to adoption of climate-smart technologies and practices to help inform the FFP team on the most effective ways to tailor discussion and meeting content. These barriers represent biases or fractures in understanding and impede teaching about and implementation of sustainable farming methods. Rifts in comprehension of the growing severity of climate change greatly impacts agricultural productivity and vitality.

I use an integrated, transdisciplinary, approach to better understand and communicate the resilience of natural, social, and built environmental systems. This framework greatly influenced the trajectory of my thesis work and contributed toward my ability to understand the impacts of climate change on agriculture and suggest novel solutions to increase resilience.

The objectives of this thesis are to (Figure 2)

1) Document and Analyze Perceptions of Climate Change

    Investigate the language used by Future of Farming Project participants to articulate climate change impacts on Alabama farms and the Southeast United States to determine the salience of environmental stewardship in the presence of conventional agricultural practices.

1) Identify Barriers to Adoption of Climate-smart Technologies

    Identify barriers and limitations that may inhibit Alabama row crop farmers from implementing climate-smart technologies and practices.

2) Explore the Challenges of the Co-Development of Knowledge

    Document and share lessons from the Future of Farming engagement events to illustrate the effectiveness of team discussions and field day events.

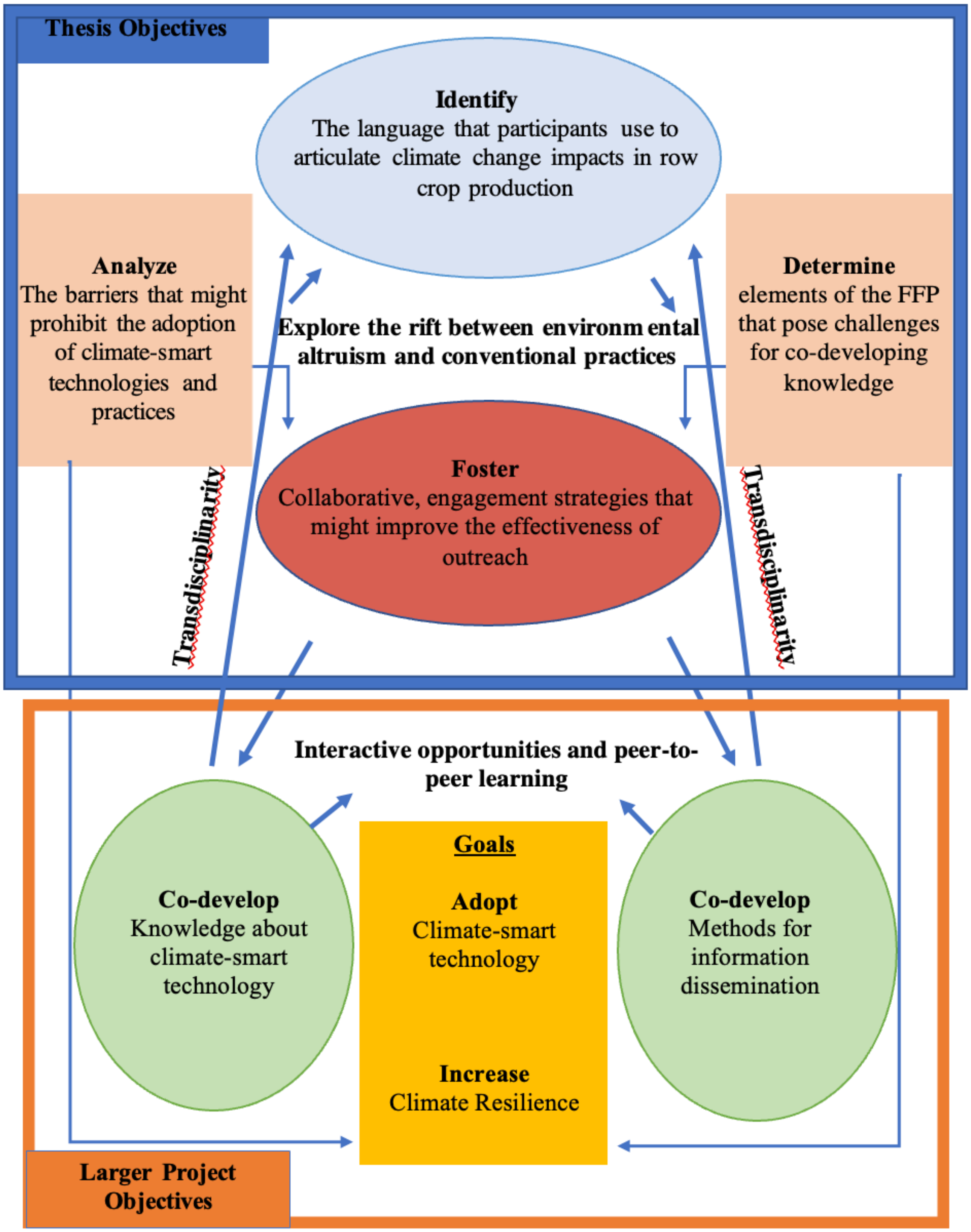

Figure 2: Master's Thesis Objectives. Diagram which illustrates the master's thesis objectives and its interrelation to achievable outcomes of the FFP. This thesis has two parts: one to identify how the Alabama row crop community perceiving climate stress and to analyze ways to disseminate climate-based information to FFP participants.

1.2 ORGANIZATION

This thesis is split into three chapters. Chapters two and three include papers designed for submission to *Sustainability* and the *Journal of Extension.* Both papers explore the academic and extension component of the research underscoring the challenges of the adoption of climate-smart agricultural practices and practical sustainable application. Chapter two will detail the findings of objectives 1 and 2, the perceptions, limitations, and barriers that inhibit sustainable farming implementation. This paper will be designed for publication in the journal *Sustainability,* an open access, cross-disciplinary platform. The goal of this paper, "The Challenges of Identifying, Accepting, and Adapting to Climate Repercussions Among Alabama Row Producers," is to investigate the cognitive dissonance between environmental altruism and conventional practices as a utilitarian tool. The first paper analyzes participants' perceptions of climate in the Southeast and how they impact resiliency. The third chapter "Co-developing Strategies, Practices, and Technologies for Agro-Climate Resiliency among the Alabama Row" *Producers,* discusses methods to develop educational collaborations with producers, government, and industry to achieve sustainability goals. The paper targets objective three and it is designed to discuss implementation strategies for outreach and sustainable participation methods for the *Journal of Extension*. The second paper will explore the facilitation of interactive learning opportunities and peer-to-peer learning in the co-development of knowledge about climate change as well as the methods for information dissemination. The findings for each article are organized according to the respective author instructions of the outlet. The final chapter, Epilogue, details conclusions from the research project, as well as limitations, triangulation, and reflexivity.

CHAPTER 2: THE CHALLENGES OF IDENTIFYING, ACCEPTING, AND ADAPTING TO CLIMATE REPERCUSSIONS AMONG THE ALABAMA ROW PRODUCERS

Stewart, Hannah, Michelle R. Worosz, McKayla Robinette, Ryan Thomson, Karen McNeal, Brenda Ortiz, Audrey Gamble, Leah Duzy, and Rishi Prasad.

2.1 ABSTRACT

Climate repercussions are acknowledged by the agriscience community, but individual producers are slower to recognize, accept, and adapt. The Future of Farming Project (FFP) engages with producers and stakeholders through the co-exploration of climate-based conservation challenges and strategies. Sustainable intensification is an alternative growth imperative to the treadmill of production which might combat climate-based challenges by targeting social development, inequality, and community development. Videorecorded data were collected from FFP field days, follow-up interviews, and FFP research and extension team meetings. These data were transcribed, thematically coded, and visualized in NVivo 11 to identify and quantify the actors and concepts associated with climate change and the challenge implementing sustainable technologies and practices for resilience. The results illustrate no statistical significance between different actors mention of climate change and barriers of adaptation including individualized information application, individualistic information application, and cost and financial restrictions. Thematic coding and visualization for agriscience projects has potential to communicate a range of issues associated with the effects of climate on row crop agriculture.

2.2 INTRODUCTION

2.2.1 CLIMATE CHANGE AND AGRICULTURE

Anthropogenic climate change accelerates natural hazard occurrences and severity (IPCC 2018; IPCC 2021; Pathak et al. 2018), directly influencing nutrient availability, soil biodiversity, crop productivity and variability, water and air quality, and public health (IPCC 2018; IPCC 2021; McMichael et al. 2006; Ray et al. 2015). The Natural Resources Conservation Services (NRCS) identified soil health as a priority conservation area as it is extremely vulnerable to the effects of climate change (USDA NRCS 2014). Despite existing soil degradation, nutrient loss, and erosion in the Southeast region, farmers are generally known to have political, social, and financial aversions to adopting sustainable practices designed to reduce climate hazards (Bartels et al. 2013; Crane et al. 2011).

2.2.2 ALABAMA SOILS AND WATER

Alabama is particularly at risk of flooding and drought which is intensified by climate change due to the state's diverse land cover and history of intense soil degradation (Davenport 2007; US EPA 2016). Due to historical deforestation and intense agricultural practices, especially from cotton production, Alabama topsoil has been lost from coastal flooding and wind and water erosion (Davenport 2007; US EPA 2016; Yahn 2019). Subsequent nutrient run off and dissipating soil biodiversity diminishes the profitability of the landscape. In addition, temperatures are rising, and droughts are increasing. It is projected in the next sixty years Alabama will have 15-45 more days a year above 95°F (US EPA 2016). Increased periods of drought are likely to cause crop failures. Soil conservation strategies such as no-till, crop rotation, and soil and plant tissue testing will help to identify and reduce the effects of climate change by improving soil structure, preventing erosion, reduce fertilizer leaching, and improve crop nutrition (Davenport 2007; Yahn 2019).

The lack of state water policy coupled with growing demand from an increasing population puts Alabama's water supply and quality at risk due to unclear expectations for water access and use (USDA 2014; USDA NRCS 2022). Warming temperatures intensifies evaporation and increases water demands, especially for the agricultural industry (IPCC 2018; US EPA 2016; USDA NRCS 2014). Higher temperatures allow more moisture into the atmosphere and these higher temperatures, and associated vapor pressure deficits, increase evaporation and promote drought. National climate models predict Alabama will have higher evapotranspiration incidences from increased temperature and higher amounts of runoff due to the building intensity of rainfall rates which result in lower groundwater recharge rates (US EPA 2016). The intensification of runoff due to increased intensity precipitation from changes to climate increases nitrogen and pesticide runoff into water sources and greatly decreases water oxygen content and quality. Alabama is ill equipped to mitigate these changes as adaption, ideally, should be embedded in planning, learning, and adjusting to climate change and reducing vulnerability (Crane et al. 2011). However, Alabama farmers are often left out of the system analyses used to create both climate projection models and adaption policy to increase climate resilience (Crane et al. 2011; IPCC 2018).

2.2.3 THE FUTURE OF FARMING PROJECT

The Future of Farming Project (FFP[TD]) is a 6-year transdisciplinary study that aims to increase the adoption of climate-smart technologies including cover cropping, variable rate irrigation, and soil moisture monitors to reduce nutrient loss. Transdisciplinary, peer-to-peer, and person-centered learning styles deviate from top-down knowledge dissemination and are suggested to improve material retention and information about technology adoption (Hod and Ben-Zvi 2018). FFP(TD) stakeholders include crop consultants, Alabama Cooperative Extension (ACES) agents, government employees (i.e., United States Department of Agriculture [USDA], Natural Resource Conservation Service [NRCS], Soil and Water Conservation Committee [SWCC]), and other actors associated with the project. The project spans three regions of Alabama row crop production, North, South, and Central. The project is directed by a multidisciplinary team of three Professor and Extension Specialists, one external consultant, and one research professor, as well as a team of undergraduate, graduate, and post-doctoral students. Specifically, this research uses a collaborative, systems, approach to develop a shared understanding of the practices and technologies that may foster innovative conservation approaches to agricultural production. This shared understanding is established through engaged learning opportunities, incentive payments for cover crop adoption, and on-farm demonstrations. The project aims to increase resiliency to climate change and build a network of motivated stakeholders to advocate for conservation and sustainable practices. Facilitating the development of a knowledgebase about climate-smart technologies and analyzing the barriers that prohibit the adoption of climate-smart technologies and practices helps inform the core research and extension team on the most effective ways to tailor stakeholder discussions and meeting content. Barriers to adoption represent fractures in knowledge and experience, as well as potential biases, that inhibits teaching and receiving information about sustainable farming methods.

Using a mixed methods approach, this project is intended to determine [how Alabama row crop producers and associated stakeholders perceive climate-change], as well as [the barriers and limitations that might prohibit the adoption of climate-smart technologies and practices]. Language used by FFP(TD) participants to articulate how climate change affects agriculture in the Southeast illustrates perceptions of environmental stewardship that may create barriers to the adoption of climate-smart technologies and practices.

2.3 LITERATURE REVIEW

2.3.1 INTENSIFICATION

The Future of Farming Project and stakeholder's perceptions of climate change, environmental stewardship, and the adoption of climate-smart technology are situated within the context of the treadmill of production, or agricultural technology treadmill, and sustainable intensification, which detail the dependence on conventional, capital intensive, farming practices.

2.3.2 THE TREADMILL OF PRODUCTION: TECHNOLOGY TREADMILL

The treadmill of production (TOP), introduced by Alan Schnaiberg, explains the increased demand for natural resource extraction and decreased emphasis on environmental preservation that occurred following World War II (Gould et al. 2004). Schnaiberg suggests that the treadmill accelerates the adoption of harmful, conventional, decisions and practices propelled by the capitalistic motivation of shareholders (i.e., investors, managers). Thus, the perpetual pursuit for maximizing economic growth is increasingly accompanied by harsh environmental degradation and stakeholder exploitation (i.e., workers, community members) (Gould et al. 2004; Hannigan 2014). Much like a treadmill, stakeholders 'run in place' as shareholders increase the pace of capital-intensive production, resource depletion, and environmental pollution. The Kennedy Administration's Chief Agricultural Economist, Willard Cochrane, referred to agroindustrialization, the rapid technological development and increased financial input, as the "technology treadmill" or "agricultural treadmill" (Gould et al. 2004; Suppan 2020; Weinberg 2000).

Beginning in the 1950's the agricultural sector transitioned toward technologically intensive management and production to promote capital accumulation (Pielke & Linnér 2019). An aggressive and rapid push to implement expensive machinery and agrichemicals resulted in low economic benefit for farmers and a dependency on subsidies and other financial incentives (Suppan 2020). The rapid adoption of capital-intensive agricultural technology contributed to the eventual farm crisis of the 1980's where record production forced prices down while land and equipment prices increased due to inflation (Suppan 2020). Agricultural intensification was accomplished through increased cropping intensity, high market price crops, external inputs (i.e., chemical fertilizers, disease controls, expansive land usage, selective breeding), and increased per capita commodity production (Pretty & Bharucha 2014). Many of these external inputs led to growing environmental damage, agroecosystem vulnerabilities, and disruption of social systems (Pretty 1997; Pretty & Bharucha 2014).

The agricultural treadmill predicts that the exploitation of natural resources such as soil, water, and nutrient quality and availability (Yahn 2019) is valued over mitigation and proactive sustainability (Hannigan, 2014) as farmers adopt "the next best" conventional practice or technology (Suppan 2020). The rapid pursuit of economic growth directly influences degradation and dissociates producers from their environment (Curran 2017; Hannigan 2014). Capitalist compulsion explains the tendency of producers to use and crop consultants, and government employees to suggest, highly technical practices that encourage the need for conservation applications and management. In the 'race to the top' (Figure 3) the biophysical environment becomes an opportunity for material exhaustion and manipulation to produce financial capital. Cyclic production and adoption practices propel consumption of new agrotechnology and overpowers innate altruistic behavior to conserve scarce resources. Weinberg et al. (2000)

suggests community emphasis on critical thinking and mindfulness about agro-environmental stewardship and establishing the market values of biological and social needs, may encourage the implementation of climate-smart technologies.

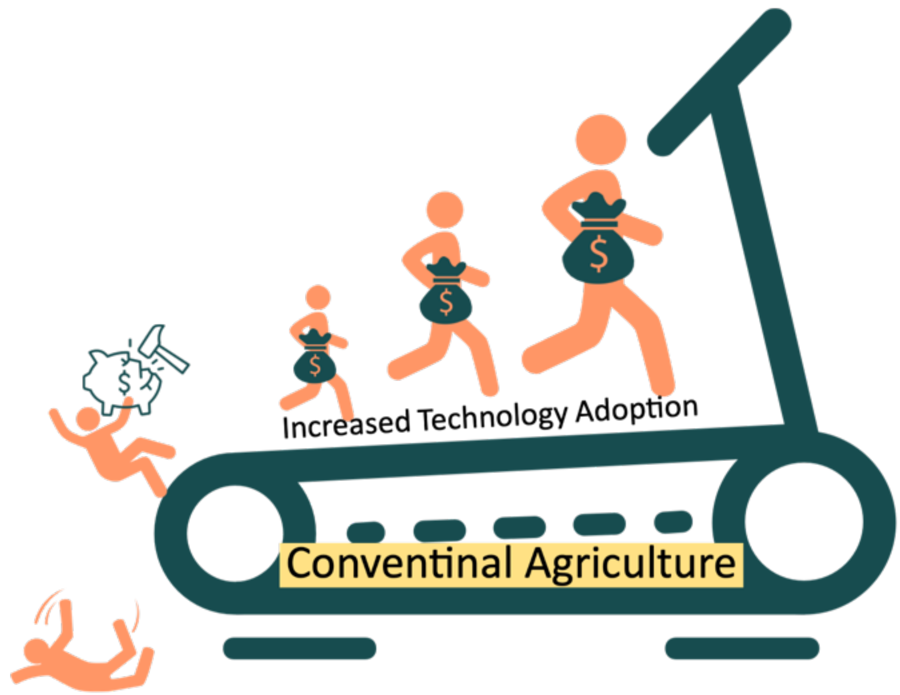

Figure 3: Agricultural Treadmill. Producers are compelled to adapt into expensive technologies to maximize production.

2.3.3 SUSTAINABLE INTENSIFICATION

A complimentary theory to the growth imperative of the Treadmill of production is "sustainable intensification" (SI). SI is the notion that there can be transition away from the most damaging conventional practices and toward local governance initiatives, socially sustainable markets, and policy change that promotes resiliency (Garnett et al. 2013; Mouratiadou et al. 2021). The objective of sustainable intensification is to increase the social and environmental productivity of agricultural lands (Donovan 2020). However, there is a lack of specifically defined objectives and technologies which diversify agricultural operations from capitalist, conventional practices, while also benefiting local economies and increasing farmer support. The International Maize and Wheat Improvement Center (2020) suggests two approaches that might promote sustainable intensification: ecological intensification, a systems approach that includes social and cultural perspectives such as farmer support and assistance; and climate-smart agriculture, an approach that focuses on adaption and resilience to climate stress using conservation practices (Figure 4). It is suggested that SI be summarized into four concepts beginning with building a knowledge base through establishing farmer support, gender and racial equality, rural development, and economic vitality. Enhancing agroecological goals using soil, water, and nutrient management practices. Encouraging through climate-smart agricultural practices such as cover cropping, nutrient management, and variable rate irrigation. Which will enhance climate resilience including preventing severe climate shocks and pest infestation to enhance sustainable infestation.

Sustainable intensification is a form ecological modernization which compliments the growth imperative of the treadmill of production. The goal of SI is to optimize production by avoiding unnecessary external inputs. SI conservation practices seek to increase production without subjecting the environment to intense degradation or converting nontraditional land to agricultural production, unlike the traditional treadmill which encourages conventional agriculture (Donovan 2020). The integration of climate-smart agricultural technologies designed to mitigate climate change impacts requires a localized shift in production practices and behaviors. Pretty (1997) and Pretty and Bharucha (2014) indicate that developing ingenuity and incorporating diversity into agri-systems requires the development of human and social capital (i.e., learning networks, communication skills, technical competence). This integration will advance societal goals for sustainable agriculture and community by productively enhancing farmers capacity for innovation, leadership, ingenuity, and management. Thus, SI encourages technological and agroecological advancement that enhances conservation by addressing those social and knowledge gaps that the agricultural treadmill does not address.

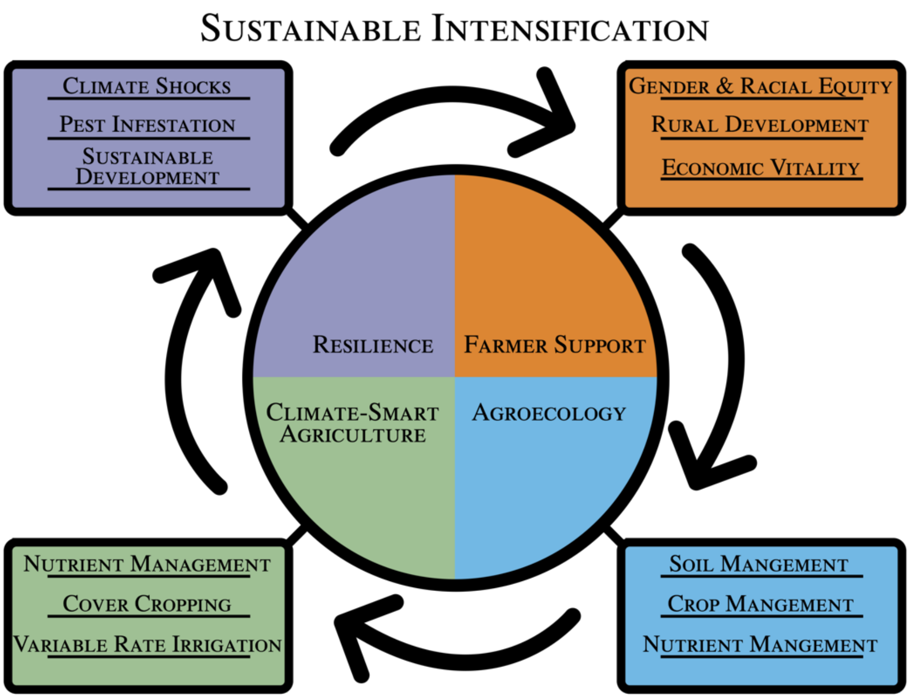

Figure 4: Sustainable Intensification. The four major examples which illustrate sustainable intensification and its components.

2.4 METHODS

To answer how Alabama row crop producers and associated stakeholders perceive climate-change, as well as the barriers and limitations that might prohibit the adoption of climate-smart technologies and practices a mixed methods approach was used. A Fisher's exact test and word frequency query were utilized to determine the significance of FFP(TD) actors' identification of climate change, conservation, and barriers to climate-smart technology adoption. Data collection and analysis took place from May 2020 to February 2022 during FFP(TD) planning meetings, on-farm demonstrations, farmer focus groups (i.e., field days), and an incentive payment program meetings to enhance the adoption of cover cropping.

2.4.1 SUBJECT BASE

The FFP research and extension team recruited three producer cooperators, one each from the North, Central and Southern regions of the state, to serve as regional collaborators. These cooperators host and run project trials and workshops. They were selected using previously established connections and contacts from the Alabama Cooperative Extension System (ACES). Additional participants, also from the three regions, were selected to be members of a learning community and provided insight into the specific environmental, social, and political barriers to adoption of cover cropping, variable rate irrigation, and nutrient management across the state. Participants were contacted via email, phone, and text message. The recruitment method was a nonprobability sampling of subjects and their acquaintances using a snowball technique, traditionally referred to as a "community reference system" (Falk and Harrison 1998). The snowball recruitment method usually results in a homogenous sample of participants (Strunk and Mwavita 2020). The FFP(TD) project aimed to represent the row crop industry in Alabama, which tends to be homogenous, which is subsequently compatible with the recruitment method. The participant base expanded over the course the project.

2.4.2 REGIONAL AND TEAM MEETINGS

2.4.2.1 FFP RESEARCH AND EXTENSION TEAM

Several investigator meetings (n=15) took place to reflect on the project's goals and producer meeting structure, as well as participant collaboration. During these meetings the research extension team prepared material for climate-smart education, participant engagement, and travel. Meeting observations were handwritten, video recorded with the Apple MOTIV App, and transcribed immediately after meetings.

Initial background visits, regional meetings, and observations of participants and cooperator farmers during the first year of the project, 2020, were conducted through socially distant meetings and zoom interviews to respect the health recommendations of Auburn University for COVID-19. All members of the Future of Farming team were vaccinated and followed national and University COVID-19 guidelines.

2.4.2.2 FFP(TD)

All FFP(TD) participants were asked to sign a video and photo release statement which was approved by the Auburn University Office of Human Research, IRB# 20-207 EX 2004. Regional meetings included a mixture of engagement strategies to collect data on the perceptions of climate-smart technology and barriers to their adaption, and to encourage peer-to-peer engagement among project participants and primary investigators (Table 1).

Four rounds of regional Future of Farming field day meetings (n=11) took place for introductory purposes (fall and winter of 2020), cover crop demonstrations (fall of 2020 and spring of 2021), irrigation demonstrations (summer of 2021), and nutrient management (winter 2021) (Table 2). A nutrient management meeting was not held in the North due to scheduling conflicts with potential meeting participants. Immersive observations of subject behavior and participation were performed at the regional meetings. Meeting observations were handwritten, video recorded with the Apple MOTIV App, and immediately transcribed.

Table 1: Engagement Activities and Activity Descriptions for Regional Meetings.

Engagement Activity	Description
FFP Email updates and Facebook group	Created by the FFP research and extension team for the FFP(TD) to update participants on project progress and upcoming meetings.
FFP(TD) Peer-to-peer discussions	Non-prompted conversations with FFP(TD) surrounding meeting content information.
FFP research and extension discussions	Directed by the core members of the FFP research and extension team for participants.
FFP(TD) On-farm visits and trials	Production information supplied by the host producer for the FFP(TD).
Field day guest speakers and presentations	Invited by the FFP research and extension team to share research or product information with FFP(TD).
FFP debriefing sessions and surveys	Post field-day feedback for content, engagement, and participation among the FFP research and extension team.

Table 2: Description of FFP(TD) Meetings Including Content, Attendance, and Length.

Date	Participants*	Attendance	Content	Length
07/20/20	FFPRET	NA	Introduction & Project Prep	1:00:00
08/28/20	FFP(TD)	n=05	External Advisor Introductions	1:45:42
09/09/20	FFP(TD)	n=35	Key Extension Informational	0:58:23
09/24/20	FFP(TD)	n=21	South Stakeholder Informational	2:05:49
12/07/20	FFP(TD)	n=21	North Stakeholder Informational	1:41:00
12/09/20	FFP(TD)	n=17	Central Stakeholder Informational	4:00:00
12/11/20	FFPRET	n=09	Introductory Debrief	2:38:00
01/25/21	FFPRET	n=09	Cover Crop Field Day Prep	1:28:13
02/05/21	FFPRET	n=04	Collaborative Methods	1:08:52
02/08/21	FFPRET	n=11	Cover Crop Field Day Prep	2:53:00
02/17/21	FFP(TD)	n=25	Central Cover Crop Field Day	4:00:00
03/03/21	FFP(TD)	n=23	South Cover Crop Field Day	4:00:00
03/08/21	FFP(TD)	n=20	North Cover Crop Field Day	4:00:00
03/17/21	FFPRET	n=10	Cover Crop Field Day Debrief	1:44:00
04/09/21	FFPRET	n=07	Cover Crop Field Day Debrief	3:00:00

Date	Participants*	Attendance	Content	Length
04/24/21	FFPRET	NA	Year End Debrief & Potluck	2:12:49
05/10/21	FFPRET	n=05	PI Collaborative Methods	0:52:26
05/13/21	FFPRET	n=14	Incentive Payments	0:59:34
05/21/21	FFPRET	n=10	Irrigation Field Day Prep	1:45:00
06/03/21	FFP(TD)	n=25	Central Irrigation Field Day	4:15:00
06/15/21	FFP(TD)	n=22	South Irrigation Field Day	3:30:00
07/15/21	FFP(TD)	n=27	North Irrigation Field Day	3:30:00
10/08/21	FFPRET	NA	Irrigation Debrief	2:00:00
11/02/21	FFPRET	n=05	PI Collaborative Methods	1:30:00
11/16/21	FFPRET	n=09	Indicators	4:00:00
11/29/21	FFPRET	n=08	Nutrient Mgt Field Day Prep	1:25:00
12/02/21	FFP(TD)	n=31	Central Nutrient Mgt Field Day	4:00:00
12/07/21	FFPRET	n=45	Nutrient Mgt Field Day Prep	1:30:00
12/09/21	FFP(TD)	n=38	South Nutrient Mgt Field Day	1:00:00

* The Future of Farming Project research and extension team and Future of Farming Project (Transdisciplinary)

2.4.3 PARTICIPANTS

Participants of the FFP(TD) were required to sign-in prior to meetings and field days disclosing their sociodemographic information. Future of Farming producer participants are generally homogenous as most farmers self-identified as male and white (Table 3). Overall, the FFP(TD) demographics relate closely to the characteristics of principal producers in the state (National Agricultural Statistics Service 2017).

Table 3: Socio-Demographics of Farmers at Regional Meetings and Follow-Up Interviews as Compared with Alabama Primary Producer Demographics.

	FFP(TD) Workshops	FFP(TD) Follow-Up Interviews	Alabama Principal Producers
Race			
White	98.48% (n=65)	94.12% (n=16)	90.98% (n=48,279)
Black/African American	0.00% (n=0)	0.00% (n=0)	6.67% (n=3,537)
Asian	0.00% (n=0)	0.00% (n=0)	0.21% (n=109)
Native Hawaiian Pacific Islander	0.00% (n=0)	0.00% (n=0)	0.03% (n=16)
Native American	0.02% (n=1)	5.88% (n=1)	1.15% (n=608)
More Than One Race	0.00% (n=0)	0.00% (n=0)	0.97% (n=514)
Total	(n=66)	(n=17)	(n=53,063)
Hispanic			
Yes	0.00% (n=0)	0.00% (n=0)	0.85% (n = 453)
No	100.00% (n=66)	100.00% (n=17)	99.15% (n=52610)
Identified Gender			
Female	1.52% (n=1)	0.00% (n=0)	10.20% (n=4,393)
Male	98.48% (n=65)	100.00% (n=17)	89.80% (n=38,670)

National Agricultural Statistics Service 2017: Female Producers - Selected Producer Characteristics: 2017; Male Producers - Selected Producer Characteristics: 2017; Selected Farm Characteristics by Race: 2017; Hispanic, Latino, or Spanish Origin Producers - Selected Producer Characteristics: 2017.

Each participant was assigned a pseudonym by their occupation or role in the project. This followed a Code Number system (Table 4). Further, all participants are referred to using they/them pronouns to protect their identifying features.

Table 4: Pseudonym Key for the Code Number System.

Code	Description
CC	Crop Consultant
EA	Extension Agent
ER	Professor and Extension Specialist
F	Farmer
G	Government Employee
OR	Other Researcher

2.4.4 FOLLOW-UP INTERVIEWS

The core faculty of the project were interviewed annually using similar questions from the year prior (Appendix A). Year one targeted the teams' previous experience and their perception of soil conservation and the project goals. Interviews in year two focused on water conservation, team strengths and weaknesses, and goal adaptations. These internal interviews served to realign the objectives of the project and focus FFP research and extension attention toward underrepresented areas or aspects of the project. All interviews were zoom or video recorded and transcribed. FFP members were also requested to complete a debriefing Qualtrics survey after each set of field days to establish feedback on meeting content and structure.

In addition to the core research and extension team, an interview protocol was developed for each FFP(TD) stakeholder type (Appendix A). Participants were asked about their current and past operations, climate-based perceptions, and sustainability goals. These protocols include prompts about soil and water conservation, climate-smart technologies, information access and design, meeting content, and suggestions for the FFP. The interview questions provided insight into the existing perceptions surrounding the effects of climate change and the limitations which may inhibit climate-smart technology adoption. When farmers were interviewed, their current conservation management practices and programs were documented via video and photographs.

Follow-up interviews took place with 32 participants in the North region (n=9), Central region (n=13), and South region (n=10). Interviews were completed with county extension agents (n=7); farmers (n=17), including all FFP(TD) cooperators; crop consultants (n=5); government employees (n=3); professor and extension specialists (n=3); and other associated researchers (n=11) (Table 5).

Table 5: List of Interviews Recorded, Transcribed, And Coded by Region.

	Farmer (F)	**ACES (EA)**	**Government (G)**	**Crop Consultant (CC)**	**Professor and Extension Specialist (ER)**	**Other Researcher (OR)**	**Total**
North	6	3	-	-	NA	NA	9
South	7	3	-	-	NA	NA	10
Central	4	1	3	5	3	11	27
Total	17	7	3	5	3	11	46

2.5 ANALYSIS

2.5.1 THEME GENERATION

All data were uploaded to NVivo 11 for coding. Transcripts of participants' interviews and meetings were categorized to establish thematic ideas or codes. These codes were driven by my research questions, as well as 1) the project objectives at large, 2) themes from the literature, and 3) issues that emerged from the data itself. Codes included insights based on FFP(TD) and FFP research and extension team relationship to the project, sustainability needs and opportunities, and previously attempted conservation trials (Appendix C). Participants were interviewed during the theme generation process to confer larger concepts that govern decision-making and perception.

An iterative version of open coding using Wolcott's approach (Creswell & Poth 2017) was completed. Wolcott's data analysis includes highlighting information in the description, identifying regularities, contextualizing data with suggestions from the literature, and comparing cases. First, immersive coding was conducted by a three-person rural sociology sub-team (Creswell & Poth 2017). Second, axial coding was used to determine Central themes. Selective coding was used to develop theme relationships and a further evolve the developing codebook (Appendix C). Axial coding was more specific and required less cross communication as the codes evolved and solidified. During this process we cross referenced thematic ideas and code selection with the FFP research and extension team during interviews and planning meetings. Tertiary, the final round of coding, was completed to finalize codes used for analysis; tertiary codes are the most specific to the project objectives and directly target thematic evidence of the project objectives. Coding comparisons were made at each phase and consensus was reached. Several meetings of the coding team took place in between each round of coding to establish thematic accuracy and collaborative coding efficiency.

Finally, all FFP(TD) *actors* or personnel types in each region were converted to cases. Cases are 'units of analysis' that represent information attributed to each actor type in the FFP(TD) project (NVivo 2022). For instance, each case was assigned an attribute variable that indicated either person (actor) or region. Case classifications help organize the types of data in the project and streamlined the content of the analysis.

2.5.2 INTER-CODER RELIABILITY

Using a coding comparison query, the inter-rater agreement between coders was calculated using the Cohen's kappa coefficient and percentage agreement (Fleiss et al. 200; NVivo 2022). The Cohen's kappa coefficient uses the agreement between coders, which is adjusted by expected agreement by chance, and it is represented by a probability between 0.00 and 1.00 (Fleiss et al. 200; NVivo 2022).

$$\varkappa = P_0 - P_e / 1 - P_e$$

P_0: the amount of agreement between two coders

[equivalent to the 'percentage agreement' calculated by NVivo]

P_e: is the probability of chance agreement

A coefficient ≤ 0 indicates no coding agreement whereas 1 indicates complete or perfect coding agreement. Fleiss et al. (2003) recommends a score of 0.75 to 1.00 to be considered high agreement, whereas moderate agreement is between 0.41 and 0.75 and poor agreement is < 0.40. The kappa coefficient is comparable to percentage agreement, which reports the percentage of the number of contingent codes divided by the total number of units within a transcript.

$$(x + y^*)/z = \%$$

z= total characters in transcript

x= characters not coded by either coder

y= characters coded by both coder

**Does not incorporate codes by one coder only*

An interview transcript from an extension agent (F8: 11/16/20) and the introductory meeting in North Alabama (C2: 02/17/21) were randomly chosen to assess inter-coder reliability. The coding comparison query found the average kappa value for all codes attributed to F8 was 0.89 and the percentage agreement was 97.60%, which suggests high coder agreement (Fleiss et al. 2003). The coding comparison query suggests the average kappa value for all codes attributed to C2 was 0.67 and the percentage agreement was 99.78%. This is indicative of a medium to high coder agreement (Fleiss et al 2003). The percentage agreement was recorded in the higher threshold while the kappa efficient was lower but more moderately comparable. Much of the high agreement was attributed to continuous discussion among the two coders, regular discussion among the three-person sub-team, and recoding divergent codes once a consensus was reached.

2.5.3 TEXT SEARCH QUERY

Text search queries are a function of NVivo (2022) which allow specific searches for targeted words or phrases. The query is used to explore the contextual reference to each phrase, as well as its prevalence in the data. A text search query was run to identify keywords mentioned by personnel coded as actors. The query included all workshop, meeting, interview, email, and survey data from the FFP(TD). The results of the text search query were organized by the actor who referenced each word or phrase rather than the total number of mentions per actor. The following phrases were used: climate change, regenerative ag or agriculture, carbon credits, climate-smart, sequestration, ecosystem services, conservation, carbon markets, carbon footprint, and global warming.

2.5.4 STATISTICAL TESTS OF INDEPENDENCE

A statistical test of independence was used to assess whether observations consisting of measures on two categorical variables, expressed in a contingency table, were independent of each other. This test was conducted in R Studio. The purpose of the test was to determine if there were non-random associations between two categorical variables: (1) six "actor" type categories (i.e., crop consultant [CC], extension agents [ACES], farmers [F], government employees [G], other researchers [OR], professor and extension specialist [ER]) and (2) "related mentions by actor type" with two categories representing sustainable intensification (i.e., "climate change" and "conversation"). These two phrases were chosen as they were mentioned more frequently than other words and relate to climate resiliency and sustainable agriculture. We assessed the associations between these two categorical variables to identify the perceptions of sustainability among FFP(TD) participants by testing the following hypotheses:

H_o: There is no association between actor type and mentions of "climate change" and "conservation."

H_a: There is an association between actor type and mentions of "climate change" and "conservation."

There are two commonly used statistical tests of independence: Chi-squared and Fisher's exact tests for testing such hypotheses. This study had a simple random sample, the observations were independent of each other, and the sample size was large, but adequate expected cell count assumption was violated. Since the data were imbalanced, that is, more than 50% of cells, had expected values less than 5, the Chi-squared test was not used. These data are reported in the findings (Table 6). When a Chi-square test is used in violation of this assumption, the result may not be reliable because this test depends on an approximation. Instead, the Fisher's exact test of nonrandom independence was used to compare the two categorical variables as it is an appropriate test for a small sample size or an inadequate expected cell count.

2.5.5 MATRIX CODING QUERIES

These data were also used in a word frequency query to understand the regional perceptions of stakeholders. Matrix coding queries are used to visualize a specific case or combination of cases with certain attribute values, and the results are used to conduct word frequency queries. Matrix queries are used to eliminate double coding, while also permitting the overlapping of codes when assigned to specific overlapping content. A matrix coding query quantified specific actors or cases that were coded to a specific context and illustrated themes within the data. To form the coding query, the location of the case was specified (i.e., transcript: specific actor, type of actor, region) and then a specific coded content was identified (NVivo 11 2022). The matrix data was used to create bar graphs and charts to record and illustrate which actors mentioned specific content.

2.5.6 WORD FREQUENCY QUERIES AND HIERARCHY CHARTS

Word frequency queries were used to illustrate the most commonly occurring words or concepts within the data. Typically, word repetition analyses are used in social and communication sciences. Word repetitions model community dynamics and sentiments by analyzing and categorizing textual and spoken content into empirical categories and to quantify the interaction as positive and negative (Ferster et al. 2021; Unkelbach et al. 2019). Word frequency queries have been used to model literature searches, social media content, sentiment analyses (Danowski et al. 2021; Ferster et al. 2021), news coverage, intergroup biases

(Unkelbach et al. 2019), and the actionable motivations (Ferster et al. 2021) of communities by analyzing the textual frequency and word commonalities.

The word frequency queries were generated from the coded transcripts. The queries required a minimum word length of three characters and combined with words that have the same stem (i.e., "talk" and "talking") (NVivo 2021). Individual word frequency queries were conducted on coded interview transcripts, regional meeting transcripts, email, and survey data for each FFP(TD) actor. Repeatedly occurring words that were not relevant to the search such as conjunctions, prepositions, or adjectives were added to a "stop words" list and excluded from the query results. Word frequency queries were exported as word clouds, which are visual representations of the textual data. The most frequently occurring words appear the largest in the cloud. This model usually highlights larger goals and interests. Specific words within these queries informed whether the high intensity repetitions were meaningful within the context of the data.

Word frequency query results were visualized using a sunburst hierarchy chart (NVivo 2022). Hierarchy charts illustrate coding patterns and frequency (NVivo 2022). Sunburst hierarchy charts are radial tree maps or pie charts that present the data as rings, with the innermost ring being coded highest or most frequently in the hierarchy. The rings are divided into segments according to size of the largest contributing group at each coding level. A hierarchy chart was created to visualize the personnel types that identified barriers to the adoption of climate-smart technologies most frequently.

2.6 FINDINGS

The following section details the findings from the significance test for the text search query using the Fisher's exact test to determine if there was statistical significance between actor type and mention of climate change or conservation. This section also includes results and thematic analysis associated with the matrix and word frequency query for barriers to adoption of climate-smart practices and technology.

2.6.1 TEXT SEARCH QUERY

The text search query indicated that few actors mentioned the paired phrase climate change or any of the related concepts (Table 6).

The most frequently mentioned words and phrases were “climate change” and “conservation.” Climate change was mentioned by eight actors (5.44%) including two professor and extension specialists, two farmers, two government employees, and two other researchers (Table 6). Meeting and follow-up interviews (i.e., questions about increased hurricane intensity, soil and water erosion, drought affecting production in the region) prompted responses about climate change and sustainability but did not explicitly use the exact phrase. “Conservation” was mentioned more frequently by individual actor; the word’s context was mentioned broadly in relation to climate change. Conservation was mentioned most by government employees (36.36%, n=4), and less so by other researchers (32.00%, n=8), extension agents (31.58%, n=6), professor and extension specialists (30%, n=3), farmers (22.73%, n=15), and crop consultants (18.75%, n=3) (Table 6).

Table 6: Text Search Query Of "Climate Change" And "Conservation." Data from meeting and interview transcripts, emails, surveys, and other documents.

	ACES (EA) (n =19)	Crop Consultant (CC) (n=16)	Professor and Extension Specialist (ER) (n=10)	Farmer (F) (n=66)	Government Employee (G) (n=11)	Other Resea-rcher (OR) (n=25)	Total *(n=147)*
Climate-smart	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	12.00% (n=3)	(n=3)
Sequestration	0.00% (n=0)	0.00% (n=0)	10.00% (n=1)	1.52% (n=1)	9.09% (n=1)	0.00% (n=0)	(n=3)
Carbon Footprint	0.00% (n=0)	12.50% (n=2)	0.00% (n=0)	1.52% (n=1)	0.00% (n=0)	0.00% (n=0)	(n=3)
Carbon Credits	5.26% (n=1)	6.25% (n=1)	0.00% (n=0)	4.55% (n=3)	0.00% (n=0)	0.00% (n=0)	(n=5)
Global Warming	0.00% (n=0)	0.00% (n=0)	10.00% (n=1)	1.52% (n=1)	0.00% (n=0)	8.00% (n=2)	(n=4)
Regenerative Agriculture	5.26% (n=1)	6.25% (n=1)	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	(n=2)
Carbon Markets	0.00% (n=0)	6.25% (n=1)	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	(n=1)
Ecosystem Services	0.00% (n=0)	0.00% (n=0)	20.00% (n=2)	0.00% (n=0)	0.00% (n=0)	0.00% (n=0)	(n=2)

Climate Change	0.00% (n=0)	0.00% (n=0)	20.00% (n=2)	3.03% (n=2)	18.18% (n=2)	8.00% (n=2)	(n=8)
Conservation	31.58% (n=6)	18.75% (n=3)	30.00% (n=3)	22.73% (n=15)	36.36% (n=4)	32.00% (n=8)	(n=39)
Total	(n=8)	(n=8)	(n=9)	(n=23)	(n=7)	(n=15)	

Fisher's exact test finds that the p-value to be large (0.3903), which indicates we do not have sufficient evidence of a statistically significant association between actor type and the words climate change and conservation.

2.6.2 WORD FREQUENCY QUERY AND HIERARCHY CHART

Sixteen (24.24%) participating farmers mentioned barriers to adoption of climate-smart technology (i.e., knowledge application, implementation, cost) (n=297, 35.40%), followed by the 3 professor and extension specialists (n=201, 23.96%), the 25 other researchers (n=169, 20.14%), the 19 extension agents (n=70, 8.34%), the 16 crop consultants (n=61, 7.27%), and the 11 government employees (n=41, 4.89%) (Figure 5 and 6). Much of the data includes the farmer perspective as they mention barriers to adoption more than other actors. Examining the context in which the terms climate change and conservation are used, and their association with barriers to adoption, produced three major themes: 1) desire for farmer specific knowledge and information; 2) implementation of conservation technologies and practices; and 3) cost of the technologies and practices, as well as other financial barriers (Figure 5).

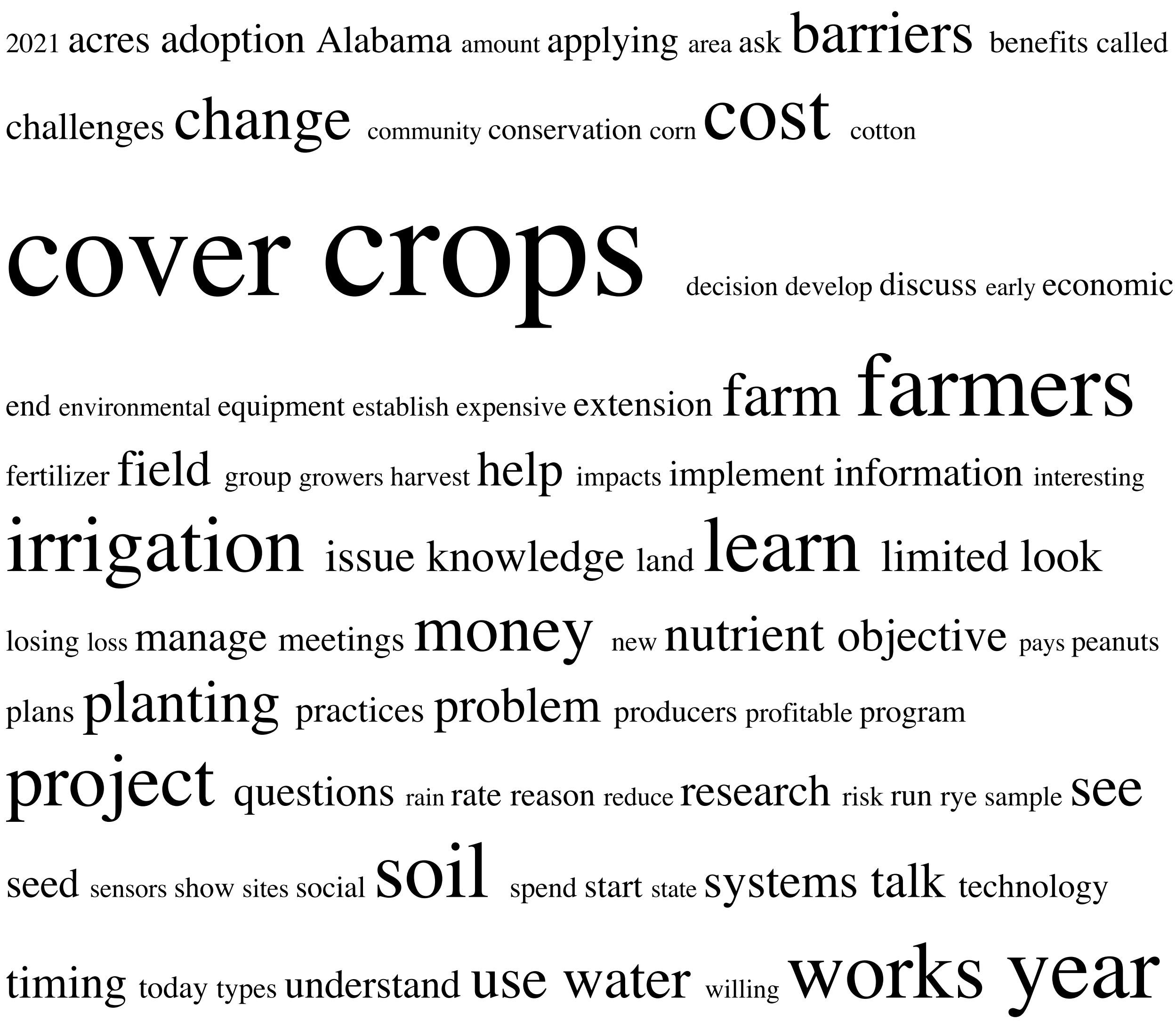

Figure 5: Word Frequency Query of FFP(TD) Barriers to Adoption. Data were retrieved from meeting and interview transcripts, emails, surveys, and other documents. Words that appear larger occur more frequently within the data.

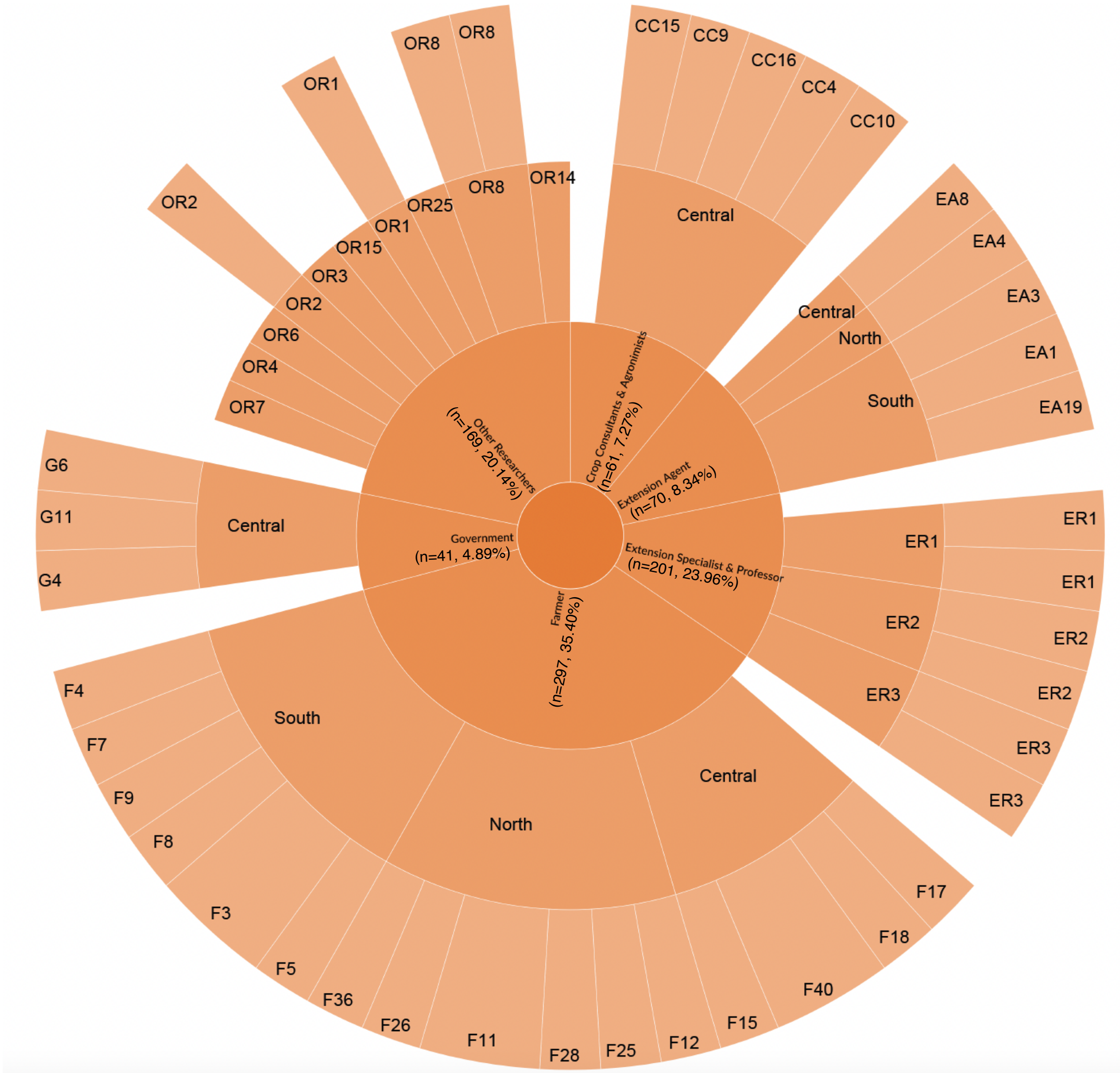

Figure 6: Sunburst Hierarchy Chart for FFP(TD) Barriers to Adoption. Each ascending circle represents a pie chart of actors, regions (if applicable), and actor type that was coded for barriers to adoption. The pseudonyms for participant role include farmer (F), crop consultant and agronomist (CC), government employee (G), extension agent (EA), professor and extension specialist (ER), and other researcher (OR). There are two levels of ER and OR codes because returning research and extension team members were interviewed twice, in 2021 and 2022.

Examining Figure 6, the inner most ring or top of the hierarchy signifies specific actors who mentioned barriers to adoption, the second ring represents the region, if applicable, and the third, bottom of the hierarchy, identifies those actors by pseudonym. The larger segments within each ring represent members from the FFP(TD) who were interviewed on a yearly basis (i.e., cooperator farmers, research, and extension team). The sunburst chart visualizes which actors contributed most to identifying barriers to adoption. For example, of the 16 farmers which mention barriers to adoption, fewer producers from the Central region identified this (Central=4, South=6, North=6). However, much of the data which is displayed in the sunburst chart is drawn from Central participants (n=26).

THEME 1: INDIVIDUALIZED KNOWLEDGE AND INFORMATION APPLICATION

Alabama (n=55) specific considerations were mentioned by the FFP research and extension team, but less so by other FFP(TD) actors such as farmers and crop consultants. Regional-based barriers were reported by farmers in concern for the applicability of research and the publications produced by extension and the University. More specifically, there was an expressed urgency for ACES to produce and to disseminate regional, tailored climate-smart information to row crop farmers in the Southeast region to apply on specific operations. Crop consultants, government employees, farmers, and extension agents focused on the importance of location-based learning communities and information by targeting *extension* (n=50) programming to better answer farmer's conservation *questions* (n=65) and develop *research* (n=70) that is more applicable. When considering *research,* FFP members focus on the context (i.e., data collection, methods, analysis) associated with the project while FFP(TD) members noted gaps (i.e., irrelevance, size, scope, region specific) in university research and extension content. During a follow-up interview, a farmer explained his frustration with extension generated research:

> *I wish things were better but quite frankly … I just feel like extension in Alabama has … lost a lot of following in the last years because they've* [done] *by and large what I would say as unpractical research … it was hard to find an application from what I considered the real world. And, well ... I think that extension hopefully is headed in the right direction now ... there's a certain disconnect between actual producers and what I consider the quote unquote real world and academia. -F28*

Farmers and government employees placed emphasis on the need to build a learning *community* (n=25) to address specific conservation concerns. Community-building might enhance the FFP(TD) ability to *learn* (n=149)*, talk* (n=83)*,* and *discuss* (n=44) the technologies, and to better *understand* (n=58) and to develop *knowledge* (n=70) about potential avenues for adoption. However, there was more emphasis on the challenges associated with *farmers* and *producers* (n=215) perceptions about the lack of commitment to conservation. During a follow-up interview a cooperator farmer explained challenges for producers and suggested an incremental approach to learning:

> *Farmers don't wanna try new things and add aggravation to something that is already hard. Let farmers see that it is a system approach rather than something they have to undertake* [all] *at one time … farmers don't think like that … so you have to train farmers, and simplify it, and make it something that is attainable. So, somehow, we have to teach them and build into some areas where they can fail so they can learn how to succeed. -F40*

Limiting factors exist for the university that create an added challenge for developing future programming (i.e., research, extension, education). These limitations include the cost of producing research, the applicability of research to specific regions, the way in which information is disseminated, the lack of technical support for climate-smart technology adoption, and the effort required of participants to commit to conservation practices (i.e., cover crops, irrigation).

Different regions of Alabama approach individualized knowledge application differently. Farmers in all regions argue that research produced by extension is not applicable to their operations. They find that the university either produces information which is too broad, or they struggle with application of climate-smart technologies on their operations. Extension agents in the South mention a lack of trust in the Alabama extension but trust the Georgia and Florida extension systems to provide guidance about conservation technologies. Therefore, producers will likely turn to crop consultants or a bordering state's extension (i.e., Florida, Georgia) instead. Different arguments emerged from the research and extension team, as well as government employees, in the Central region of the state who advocated for development of a knowledgebase through the university's research. Government employees and a crop consultant expressed the trust in the extension system to produce research that is reliable. Thus, there is a dissonance between information production and application the government and research and extension perceive to be helpful, and what producers and extension agents experience and expect.

THEME 2: IMPLEMENTATION OF CONSERVATION TECHNOLOGIES AND PRACTICES

Crop (n=311) specific concerns such as seeding, fertilizer, and herbicide rates; planting and terminating dates; technology and equipment adaptation; and seeding mixtures were frequently repeated by the FFP research and extension team, as well as FFP(TD) stakeholders. Challenges associated with implementing these *practices* include establishing *cover*[s] (n=260), *irrigation* (n=152), and other climate-smart *technolog*[ies] (n=44) to preserve *soil* (n=152) and *nutrient* (n=85) quality and *manage*[ment] (n=66). Associated complications include learning and applying the nuances of conservation technology use such as timing, rates, termination, and costs. Management of conservation practices is mentioned most by the FFP research and extension team, which emerged in conversations about incentive payment allocations and the instrumentalization of nutrient management planning on farms, whereas FFP(TD) participants struggle with implementation. During a follow-up interview, a crop consultant explained the management challenges of cover cropping systems:

> *You know time is another thing … they don't necessarily … know timing of cover crop planting might interfere with some harvest operations, and you know what's going to take precedence, harvest their summer crop or plant table winter crops, so obviously they're gonna harvest, so things like that are …more difficult -CC16*

Some implementation concerns are related to *timing* (n=74), which were first identified by the FFP(TD) in an interactive activity during the introductory meetings. To some extent these concerns were addressed by the FFP research and extension team in later field days. Several time specific challenges were also noted such as planting dates, or more specifically, when to *start* (n=44) or *establish* (n=31) the crop or cover crop and irrigation systems. In a follow-up interview, an extension agent described the challenges faced when implementing conservation practices and technologies:

> *I mean it's a timing issue, and I think it's … twofold* [it's] *a timing and it's a knowledge issue you know, this is what I'm … used to. And once you always do it and you're changing that to a new* [technology or practice] *and there's always that learning curve or window … what time do I do it, how much do I do it, and so I think that's the biggest thing is ... the difference and change is probably the hardest part. -EA8*

Other general concerns related to timing included the need for labor if the conservation practice and technology application were time consuming, the investment of effort to learn about the practice or technology, and the time to attend information meetings and field days.

There are also complications associated with managing climate change and conservation goals in a timely manner. These goals, such as carbon sequestration and management, and cover crop implementation, are heavily encouraged by the USDA but often not feasible due to producer's financial challenges. One farmer explained the struggle of implementing sustainable *irrigation* (n=152) suggestions, such as irrigation tax credits, by the government without regard for the potential challenges that producers may endure with as they adopt conservation practices and management:

> *Yes, there are some huge problems we are going to face … government is either going to tell us that we are going to have to face or we're gonna have to figure it out somehow ... What am I gonna do? And you start talking to people because other people have the same problem with irrigation you know? I guess every little nitpicky little part of farming ... how are we going to solve this problem? Solve all the world hunger by 2050? The whole world is going to starve to death if you don't produce 300 bushels of corn! We are all thinking in the back of our minds, still farming for that, I don't know if that is reality. -F15*

Timing is a challenge among practitioners (i.e., crop consultants, NRCS, SWCC) not only for their recommendations to farmers but also for the research they produce. This challenge translates to producers as they struggle with a variety of complications such as planting and terminating dates and adjusting schedules for government regulations such as cover cropping and carbon management. These concerns with timing are rarely addressed by university research or cooperative extension.

With respect to regionality, the research and extension team, as well as government employees in the Central region, acknowledge the challenges with knowledge building for implementing conservation technologies and practices. Much of the context of these conversations focus on preparing farmers to implement cover cropping, irrigation, and nutrient management on their operations. Crop consultants in the Central and South regions note the opportunity cost of timing (i.e., technology education, planting dates, seeding and fertilizer rates) as a large barrier to applying these technologies, especially with cover cropping and smart irrigation. Farmers in the Central and South region express concerns about adapting to increasing pressures from the government to implement conservation practices on their farms. Moreover, there is a relatively consistent concern across the FFP(TD) to apply the next best stewardship practice to conserve land and natural resources, despite challenges in the knowledge building process.

THEME 3: COST AND OTHER FINANCIAL BARRIERS

Financial concerns were the third most common barrier to adoption of climate-smart technologies and practices. *Money* (n=119), *economic* (n=46), *expensive* (n=30), and *pay* (n=25) were frequently repeated words. For farmers, their primary concerns are making money and saving money. The FFP research and extension team acknowledges finances as a limitation but focuses on how climate-smart technologies may save money without empirical evidence. Thus, a crucial component of the FFP(TD) project is to appropriately source and allocate incentive payments to offset the cost of adoption. Monetary barriers are well-known limitations, that prevent the implementation of new practices, but indications of these constraints were mentioned less frequently than anticipated. During a follow-up interview a farmer indicated that a common concern is lack of disposable income to experiment with conservation practices:

> *Well, I mean it just all goes back to cost whether it's, you know, cost of seeds, the cost of equipment to either get it incorporated, or cost of equipment to get it planted or getting crops planted into cover crops … I don't have unlimited money to where I can throw it in this quote, unquote, experiment and we're*

> *just trying to experiment with what we've got to figure out what works with what we're doing without having to spend just tremendous amounts of money to play with this. And so, I mean that's the thing, well maybe in 20 years, we'll be a little more financially secure where we could do more, you know, where we just dump out money to experiment... but I'm just not in the place to do that yet. -F28*

Farmers also report that the *risk* (n=31) of implementing conservation practices and conservation technologies was not worth the financial commitment. During an initial interview, a cooperator farmer argued that increasing conservation training and demonstrations should be encouraged and funded by NRCS because of the financial limitations of most operations:

> *So, we need ... NRCS and different entities that can* [financially support cover crops] *because some people don't want to spend money on the chance that it might not work. Tragically, a lot of cost share programs, unless you get them when they are big enough, they're not worth enough…you're not making a large impact. And I wish that is not the case because I wish there was a lot of money to go around. But that's just the reality. You are gonna have to find people that are passionate about making soil better than when they found it. -F40*

There is a consensus among all actors, regardless of region, that money and finances are a large barrier to adoption. Farmers in all regions are concerned with the investment required to adapt conservation technologies and practices to their operations. Despite their willingness to attend meetings, and their desire to be environmental stewards, many of the complications related to the approach of conservation technologies which are associated with money. Both the research and extension team and government employees in the Central region recognize these challenges as they advocate for the use of incentive payments to encourage the adoption of best practices to combatting climate-related pressures.

2.7 CONCLUSION AND FURTHER RECOMMENDATIONS

2.7.1 PURPOSE

This research used a mixed methods approach to determine how Alabama row crop producers and associated stakeholders perceive climate-change and the barriers and limitations that might prohibit the adoption of climate-smart technologies and practices. A text search and word frequency query were used to assess the language used by FFP(TD) participants and their ability to articulate climate change impacts and the barriers to climate-smart technology adoption. Word frequency and text search analyses have previously been used in a diverse context. We used word frequency to examine a sustainable intensification project focused on the barriers to climate change technology adoption. This novel strategy was used to estimate the perceptions and values of both the research-extension team and the broader FFP(TD).

2.7.2 KEY FINDINGS

CLIMATE CHANGE: PHENOMENA ASSOCIATION

Though there are relatively few mentions of the phrase "climate change," there was more frequent use of related words and phrases, especially conservation. Nevertheless, we fail to reject the null hypothesis that there is no association between actor type and mentions of "climate change" and "conservation." Barring crop consultants and extension agents, few members of the FFP(TD) expressed an awareness or concern for climate change and the repercussions. While producers identified the effects of climate change on their operation, their responses lacked frequency of concern which contrasts the general climate change acknowledgement by the larger agriscience community (Fusco et al. 2020; Houser et al. 2020). The lack of language implying a connection between intensified weather patterns to climate change challenges on farms, may inhibit acceptance of the need for conservation practices and willingness to adopt technologies as actors may not associate the phenomenon with sustainable production.

INDIVIDUALIZED KNOWLEDGE AND INFORMATION APPLICATION

The low frequency of the use of the words "climate change" and related conservation phrases, other barriers may inhibit the adoption of climate-smart technologies. This lack of mentions may be reflecting the (1) lack of knowledge of the existence climate change, (2) failure to acknowledge and accept the consequences of climate change, or (3) the acceptance of climate change but refusal to acknowledge it in public due to political aversions and community biases. Using individualized approaches, targeting regional concerns and specific operations, which encourage participation from producers may assuage some of the complications associated with implementing conservation practices. Participants desire community building strategies with research and extension to reduce learning gaps (i.e., irrelevance, size, scope, region specific) and rebuild trust in the extension system. Individualized knowledge and information application is necessary for the FFP(TD) to bridge the gap between the impact of mindless adoption and purposeful action which is transferrable to practitioners to combat the pressing challenges of climate change.

IMPLEMENTATION OF CONSERVATION TECHNOLOGIES AND PRACTICES

The most commonly occurring words were *cover* or *cover crop*, indicating the challenges with implementation, biomass production, and termination. Concern about implementation can be seen as an opportunity for extension to target building knowledge and support for the management of conservation practices. Creating sustainable agriculture must be implemented at the landscape level; the benefits climate-smart technologies and practices (i.e., ecosystem services, climate resilience) have no real impact regionally if they are only adapted on few farms throughout the state. Thus, the FFP research and extension team might consider trying to bridge the gap between concerns about the implementation of conservation technologies and practices and effective solutions which enhance climate resilience (i.e., cover cropping, water conservation, nutrient management). This directly relates to how the research and extension team collects, delivers, and applies research to the FFP(TD) which is relevant and easily applied.

COST AND OTHER FINANCIAL BARRIERS

Financial challenges were some of the top barriers to adoption, but less so than knowledge application and other conservation technology concerns. Monetary constraints are some of the hardest to tackle, thus implementing conservation programs that target the social, economic, and environmental challenges of climate change might encourage sustainable adaptation and enable producers to incrementally implement these technologies and practices. A portion of the FFP(TD) funding was set aside for incentive payments for cover crop implementation, to encourage and support farmers in the adoption process. However, the sustainability of the commitment after receiving these incentive payments is unclear. Increasing incentive programs among row crop producers may encourage farmers to implement test plots of climate resilient strategies and to address the commonly occurring financial challenges. Promoting financial security for producers might reduce stress and create more opportunities to encourage the development of cooperative learning networks to create agricultural communities which are resilient to climate change. The relief of the pressures of monetary constraints may enhance communal efforts to increase sustainability success and support as less pressure is dedicated to financing conservation practices.

2.7.3 LIMITATIONS

Our subject base was homogenous and included mostly white, male, farmers, although a few ACES employees identified as women or Black. The age and economic status of each participant was not recorded for the project. The gender metric is limited as the meeting and field day check-in procedure included only two gender identities.

Limitations exist for kappa values and percent agreement. If coders leave most of a document uncoded there was high percentage agreement on content without codes, however due to its likelihood of occurring by chance the kappa coefficient will be low. If the transcript lacks codes, but there is high agreement on the content coded, the percent agreement and kappa value would both be high; this is unlikely due to chance. Thus, it was important that the inter-reliability of coding agreement was discussed and reinterpreted as a team, so the results of the comparison query are specific to content coded and not coded.

Currently, climate change is a hotly debated topic in the United States and tends to be politically charged. Most of the FFP(TD) participant base tends to lean conservative, which may influence their perceptions and acceptance of climate change. The broad political and social aversion to accepting climate change may have influenced the number of mentions of climate and climate-related terminology (Table 6).

2.7.4 RECOMMENDATIONS FOR SUSTAINABLE INTENSIFICATION

Prioritizing conventional practices resulting in short-term rewards is likely to result in long term depletion of natural resources, as suggested by the agricultural technology treadmill. Gould, Pellow, and Schnaiberg (2004) suggest prioritizing building social and economic support for producers that might inform natural resource utilization and reduce further environmental degradation by sustainably intensifying production systems.

Participation in the intensification of technology adoption may provide benefit for early adopters, but complexities exist in production and financial burdens (Dexter 1977; Gould et al. 2004). The failure of producers to synthesize recommendations about climate-smart practices will create challenges for increasing sustainability. Yet these conservation practices may push producers into a SI treadmill. In other words, sustainable intensification may be a treadmill of its own. Despite encouraging social welfare, inclusion of underserved populations, and environmental conservation, sustainable intensification, in a sense, still operates based on financial constraints which is propelled by capitalist accumulation. Consequently, few viable avenues exist, which are increasingly complex, for these row crop producers to transition as they are fully invested into capital intensive agriculture. A concern among producers for sustainable intensification is costs and financial obligation as well as infrastructure availability (Mouratiadou et al. 2021). This intensification pressures the FFP research and extension team to provide incentives and knowledge for these producers to adapt climate-smart practices. New technologies and practices will continue to be developed and it is expected that they too will be implemented to some degree, which may expand natural resource exploitation and alter the labor-intensive market structure inadequate regard for environmental stewardship (Gould et al. 2004). Using the SI as a conservation growth framework may encourage some producers to adapt to climate change, but it is not without increasing costs (e.g., time, knowledge, commitment).

CHAPTER 3: CO-DEVELOPING STRATEGIES, PRACTICES, AND TECHNOLOGIES FOR AGRO-CLIMATE RESILIENCY AMONG AGRICULTURAL STAKEHOLDERS IN ALABAMA

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3.1 ABSTRACT

The Future of Farming project (FFP) is a 6-year transdisciplinary study designed to demonstrate the benefits of and facilitate knowledge about climate-smart technologies (i.e., cover crops, variable rate irrigation, and moisture sensors) that will bolster soil health and improve water and nutrient use efficiency in the face of climate change. The National Science Foundation has emphasized convergence science to synergistically solve complicated, persistent issues that require the deep integration of multiple disciplines. Convergence science is a diverse and innovative research process used to solve "vexing" problems and inspire new scientific inquiry, innovation, and application. The interrelated concept of co-development of knowledge, a goal-oriented, dynamic, learning strategy to transdisciplinary research, motivates technical experts, who may greatly influence financial and agronomic decision making. Allowing for the joint development of interactive, pluralistic, solutions to complex problems with producers as co-researchers. Co-development strategies encourage the reinterpretation of previously accumulated knowledge and experience building producer's adaptive capacity and holistically address climate change. Co-inquiry provides an essential link to producer-stakeholder partnership and informs the design, implementation, and critical reflection of productive engaging learning strategies to climate-smart technology adoption.

3.2 INTRODUCTION

3.2.1 CO-DEVELOPING AGRICULTURAL CHANGE

Traditional "top-down" methodology in research-extension commonly creates gaps in knowledge for users as sharing advanced, technical extension research with producers in this way rarely results in information absorption (Prokopy et al. 2015; Vines 2018). Recently there has been a pivot to transdisciplinary, peer-to-peer, and person-centered learning styles that deviate from top-down knowledge dissemination and is suggested to improve material retention and technology adoption (Hod and Ben-Zvi 2018). Transdisciplinary research deconstructs multi-level ideas to holistically expand beyond individual disciplines using a shared conceptual framework to create knowledge that transforms traditional boundaries and perspectives (Alvargonzalez 2011; Collin 2009; National Research Council 2014; Nicolescu, 2014).

The mechanisms by which knowledge, participation, and collaboration are used during co-development are undertheorized and weakly defined. We suggest that co-development be interpreted as a goal-oriented, dynamic learning strategy situated within transdisciplinary research. Where practitioners and technical experts with diverse expertise jointly develop and engage in interactive, pluralistic solutions to complex problems such as those which can be applied to climate-based pressures in agriculture (Akpo et al. 2013; Kirono et al. 2014; Podesta et al. 2013). Co-development of knowledge encourages the reinterpretation of previously accumulated knowledge, experiences, and self-identification (i.e., personal ties to research) to holistically engage in and construct comprehensive, resilient communication. Collaborative research has the potential to foster a dialogue about climate-smart technology and to develop an understanding of the limitations and barriers that inhibit implementation (Bartles et al. 2013).

3.2.2 CO-DEVELOPMENT AS CONVERGENCE TAKES PLACE

Convergence is the result of creating and sustaining, collaborative solutions that transcends traditional siloed disciplines. Traditionally, there is a divide between social and natural sciences. Sustainability requires coordination between humans and their ecosystems (Stock and Burton 2011). In the past five years, the National Science Foundation (NSF) has emphasized the important of convergence science to solve the most complicated and persistent issues (National Research Council 2014) such as climate change complications in agriculture. Convergence science is a societally oriented, diverse, and innovative research process that requires deep integration of multiple disciplines (NSF 2020; Roco 2020), as well as a collaborative cultural shift among scientists. Convergence a departure from traditional, siloed discipline-based practices, requires enhanced communication within the research team (Cannon 2020). Finally, convergence requires disciplinary engagement such as joint publications and co-developed research methods (NSF 2020). Thus, convergence and the co-development approaches work in conjunction and increase researcher and participant collaboration. Convergence is the product of the integration and representation of co-development and transdisciplinarity in the research process. Ensuring engagement through a transdisciplinary process establishes credibility, relevance, and legitimacy (Leitch et al. 2019). Convergence may require transdisciplinary cross-fertilization of economic, behavioral, and social sciences and aimed at creating, transferring, and integrating knowledge across multiple dimensions in a deep and sustained manner (Cannon 2020; National Research Council 2014; NSF 2020).

Transdisciplinary research requires the deconstruction of multi-level ideas to holistically expands beyond individual disciplines and using a shared conceptual framework. The goal is to construct knowledge in a way that transforms traditional boundaries and perspectives. The Transdisciplinary Future of Farming Project (FFP[TD]) uses a *convergence* approach to *co-develop* knowledge about climate-smart technologies and practices with and among Alabama row crop producers and agricultural stakeholders. The approach is aimed at holistic, complex problem solving by first co-identifying the nature of the problem and then using its theoretical and critical elements to address said problem in pragmatic and systematic ways (Chen 1975; NSF 2020).

The FFP(TD) sub-project used word frequency queries to identify the perceptions of climate change and sustainability among participants. The objective of this paper is to explore the facilitation of interactive learning opportunities and peer-to-peer learning in the co-development of knowledge about climate change as well as the methods for information dissemination. Few agricultural research studies have used this approach (FineResults Research Services 2022; Geza et al. 2022; Novák et al. 2021). Thus, the FFP(TD) serves as a novel representation of language patterns among farmers, Natural Resources Conservation Services (NRCS) agents, Alabama Cooperative Extension Agents, crop consultants and the Future of Farming core research and extension team (Prasad et al. 2020). Deep and sustained collaboration among research participants fosters an engaging, ground-up approach to sustainability and climate mitigation in the Southeast US. Drawing on participants language we aim to identify the challenges and needs for establishing collaborative, engaging ways to maximize the effectiveness of content creation (i.e., workshops, panels, field activities), discussion, and implementation of climate-smart technologies and practices at team events.

3.2.3 BACKGROUND

The "Future of Farming" project (FFP) research and extension team includes five primary investigators: three professor and extension specialists (ER) (i.e., soil science, nutrient management, precision agriculture), one research professor (OR) (i.e., rural sociology), and one external consultant (OR) (i.e., agricultural economist). The FFP team also includes several graduate students and post-doctoral researchers (OR). The larger objective of the study is to demonstrate the benefits of climate-smart technologies including cover crops, variable rate irrigation, and moisture sensors to bolster soil health and improve water and nutrient use efficiency.

The FFP(TD) has three major components. First, to demonstrate climate-smart technologies using a comprehensive comparison of "business as usual" practices and "aspirational" conservation techniques. Second, to create learning nodes in three regions of the state, North, South, and Central, in which stakeholders meet with the research and extension team (i.e., field days) to exchange knowledge about the technologies. And third, to encourage the adoption of climate-smart technologies via an incentive payment program. The Future of Farming project is monitored by Alabama Soil and Water Conservation Committee (SWCC), and the Alabama office of (NRCS-USDA) (Natural Resources Conservation Service).

The FFP team collaborates with row crop farmers, Alabama Cooperative Extension agents (ACES), crop consultants (CC), NRCS (G), and other relevant stakeholders (referred here after as the Future of Farming Transdisciplinary team or FFP[TD]) to develop socio-climate knowledge and to evoke sustainable action and adoption of cover cropping, variable rate irrigation, and nutrient management. Transitioning from traditional top-down learning strategies and toward co-development encourages producers and stakeholders to collaboratively learn from each other. Co-learning with farmers and other Alabama stakeholders about climate resiliency strategies may encourage buy-in and the implementation of the climate-smart technologies and practices. The co-development process is critical to the FFP because feedback from participants is needed to alter and improve the research process as well as methods used to disseminate co-created information.

3.3 METHODS

Matrix coding queries, word frequency queries, and hierarchy charts were used to explore the perceptions of co-development of knowledge, convergence, and engagement. As described below, data are from FFP(TD) field days, follow-up interviews, meetings, surveys, and email. These data were collected between August 2020-Feburary 2021.

3.3.1 RECRUITING

The research and extension team (FFP) recruited project cooperators and participants from three regions of the state using previously established connections and contacts from the Alabama Cooperative Extension System (ACES). The participant base expanded over the course the project as new members joined.

3.3.2 RESEARCH AND EXTENSION MEETINGS

Fifteen investigator meetings took place to reflect on the project's goals, meeting structure, and participant collaboration (Appendix B). The meetings were video recorded, and a field journal was used to record observations. An interview protocol was created for the core FFP team (Appendix B). The core faculty (n=6) were interviewed annually using similar questions. Year one interviews targeted information about previous experience, soil conservation, project goals, and the transdisciplinary and co-development processes. Year two interviews focused on water conservation, team strengths and weaknesses, and goal adaptations. These internal interviews served to realign the objectives of the project and focus FFP attention toward underdeveloped areas or aspects of the project. All meetings and interviews were recorded and transcribed. Reflexive surveys were disseminated to FFP members after each set of meetings, except nutrient management, to assess project objectives, meeting success, and developing indicators of technology and practice adoption.

3.3.3 FUTURE OF FARMING REGIONAL MEETINGS

Initial background visits, regional meetings, and observations of producers, cooperator farmers, and other stakeholders took place during the first year of the project, 2020. These meetings were socially distant and conducted through Zoom to respect the university guidelines for COVID-19, which were lifted in 2021. All participants of the project signed a video and photo release statement which was approved by the Auburn University Office of Human Research (IRB# 20-207 EX 2004). Observations were handwritten in field notebooks, video recorded in the field with the Shure MOTIV MV88+ equipment and App and transcribed using Microsoft dictation immediately after the meetings.

Regional meetings included a mixture of engagement strategies to collect data on the perceptions of climate-smart technology, identify barriers to adaption, and encourage peer-to-peer exchange with project participants and primary investigators (Table 7).

Four separate rounds, 11 total, of regional Future of Farming meetings occurred. These meetings addressed project introduction (fall and winter of 2020), cover crop demonstrations (fall of 2020 and spring of 2021), irrigation demonstrations (summer of 2021), and nutrient management (winter 2021) (Appendix B). No meeting was held in the North region for nutrient management due to scheduling conflicts with potential meeting participants. Nutrient management data from the Central and South region were compared despite the absence of North field day data.

Table 7: Engagement Activities and Activity Descriptions for Regional Meetings. Included introductory information, cover cropping, smart and variable rate irrigation, and nutrient management.

Engagement Activity	Description
FFP email updates and Facebook group	Created by the FFP research and extension team for the FFP(TD) to update participants on project progress and upcoming meetings.
FFP(TD) peer-to-peer discussions	Non-prompted conversations with FFP(TD) surrounding meeting content information.
FFP research and extension discussions	Directed by the core members of the FFP research and extension team for participants.
FFP(TD) on-farm visits and trials	Production information supplied by the host producer for the FFP(TD).
Field day guest speakers and presentations	Invited by the FFP research and extension team to share research or product information with FFP(TD).
FFP debriefing sessions and surveys	Post field-day feedback for content, engagement, and participation among the FFP research and extension team.

3.3.4 FIELD DAYS

The recruitment method was a nonprobability sampling of subjects and their acquaintances using snowball sampling technique, traditionally referred to as a "community reference system" (Falk and Harrison 1998). The recruitment process resulted in a homogenous sample of participants (Strunk and Mwavita 2020). Participants were required to sign in at the beginning of all FFP(TD) meetings and provide demographic information. The participants, excluding the research extension team, were relatively homogenous as most identified as white males (Table 8). FFP producer demographics relate closely to principal producer demographics of the state (National Agricultural Statistics Service 2017).

Table 8: Socio-Demographics of Farmers at Regional Meetings and Follow-Up Interviews as Compared with Alabama Primary Producer Demographics.

	FFP(TD) Workshops	FFP(TD) Follow-Up Interviews	Alabama Principal Producers*
Race			
White	98.48% (n=65)	94.12% (n=16)	90.98% (n=48,279)
Black/African American	0.00% (n=0)	0.00% (n=0)	6.67% (n=3,537)
Asian	0.00% (n=0)	0.00% (n=0)	0.21% (n=109)
Native Hawaiian Pacific Islander	0.00% (n=0)	0.00% (n=0)	0.03% (n=16)
Native American	0.02% (n=1)	5.88% (n=1)	1.15% (n=608)
More Than One Race	0.00% (n=0)	0.00% (n=0)	0.97% (n=514)
Total	100.00% (n=66)	100.00% (n=17)	100.00% (n=53,063)
Hispanic			
Yes	0.00% (n=0)	0.00% (n=0)	0.85% (n = 453)
No	100.00% (n=66)	100.00% (n=17)	99.15% (n=52610)
Identified Gender			
Female	1.52% (n=1)	0.00% (n=0)	10.20% (n=4,393)
Male	98.48% (n=65)	100.00% (n=17)	89.80% (n=38,670)

* State statistics drawn from the National Agricultural Statistics Service 2017: Female Producers - Selected Producer Characteristics: 2017; Male Producers - Selected Producer Characteristics: 2017; Selected Farm Characteristics by Race: 2017; and Hispanic, Latino, or Spanish Origin Producers - Selected Producer Characteristics: 2017.

Each participant was assigned a pseudonym by their occupation or role in the project. This followed a Code Number system, (Table 9). Further, all participants are referred to using they/them pronouns, to protect their identifying features.

Table 9: Pseudonym Key for The Code Number.

Code	Description
CC	Crop Consultant
EA	Extension Agent
ER	Professor and Extension Specialist
F	Farmer
G	Government Employee
OR	Other Researcher

3.3.5 FOLLOW UP INTERVIEWS

Twenty-seven follow-up interviews were conducted and transcribed for 7 cooperative extension agents (ACES), 18 farmers including the FFP(TD) cooperator farmers (F), 4 crop consultant (CC), and 3 government employees (G) (Table 10).

Follow-up interviews after regional meetings with 46 FFP(TD) members North region (n=9), Central region (n=27), and South region (n=10) were conducted. Participants were reached via email, text messages, and telephone. An interview protocol was developed for farmers, government employees, crop consultants, and Alabama Cooperative Extension agents (Appendix A). The current conservation management practices and programs used by each producer were also videoed and photographed. We asked participants about the current and past operations, climate-based perceptions, and sustainability goals (Appendix A). These protocols included prompts about soil and water conservation, sustainable technologies, information access and design, meeting content, and suggestions for the FFP. The interview questions provided insight into participant's perceptions of the effects of climate change and the limitations that may inhibit climate-smart technology adoption.

Table 10: Follow-Up Interviews Recorded, Transcribed, and Coded by Region.

	Farmer (F)	ACES (EA)	Government (G)	Crop Consultant (CC)	Professor and Extension Specialist (ER)	Other Researcher (OR)	Total
North	6	3	-	-	NA	NA	9
South	7	3	-	-	NA	NA	10
Central	4	1	3	5	3	11	27
Total	17	7	3	5	3	11	46

3.4 ANALYSIS

3.4.1 TRANSCRIPTIONS AND THEME GENERATION

The analysis was completed in NVivo 11 (2021) and all data were uploaded to the software. All FFP(TD) *actors* (i.e., producers, crop consultants, ACES, government, other researchers, professor and extension specialists) for North, South, and Central regions were converted to cases. Cases are 'units of analysis' that hold information (i.e., attributed to the type of actor or personnel in the FFP[TD] project) (NVivo 2022).

All data were transcribed and uploaded into NVivo 11. The analysis of project data was completed in two separate parts. Transcripts of participant's interviews and meetings were categorized to establish thematic ideas or codes. The codes were driven by 1) our research question: to identify challenges to the needs for establishing collaborative, engaging ways to maximize the effectiveness of climate-smart technologies and practices content creation, discussion, and implementation at team events. Additionally, code were from 2) project objectives at large, 3) themes from the literature, and 4) emergent from the data itself.

An iterative version of open coding using Wolcott's Method (Creswell & Poth 2017) was completed by highlighting information in the description, identifying regularities, contextualizing data by suggestions with the literature, and comparing cases. The coding process took place in NVivo 11 and was conducted in a two-person team (Creswell & Poth 2017). Three rounds of coding occurred: initial, axial, and tertiary and were conducted in three-person teams. Initial coding was used to determine Central themes and selective coding was used to develop theme relationships (Appendix C). The second round of coding was more specific and required less cross communication between the coders. However, during axial coding, thematic ideas were cross-referenced with data from FFP(TD) team meetings and interviews. Participants were interviewed during the theme generation process to confer larger concepts that govern decision-making and perception. Tertiary, the final round of coding, was completed to finalize the codes used for analysis; these codes were the most specific to the project objectives. Coding comparisons were made by the three-person rural sociology sub-team during each phase until consensus was reached. Regular sub-team meetings took place in between each round of coding to establish thematic accuracy and collaborative coding efficiency.

3.4.2 KAPPA VALUES, PERCENTAGE AGREEMENT, AND INTER-CODING RELIABILITY

Using a coding comparison query we determined the inter-rater agreement between the coders using the Cohen's kappa coefficient and percentage agreement (Fleiss et al. 200; NVivo 2022). The Cohen's kappa coefficient assesses the agreement between two qualitative coders who classify items into mutually exclusive categories relative to agreement by chance. The coefficient is adjusted by the expected agreement by chance, and it is represented with a probability between 0 and 1 (Fleiss et al. 200; NVivo 2022).

$$\varkappa = P_0 - P_e / 1 - P_e$$

P_0: the amount of agreement between two coders (equivalent to the 'percentage agreement' calculated by NVivo 11)

P_e: is the probability of chance agreement

A coefficient ≤ 0 indicates no coding agreement whereas 1 indicates complete or perfect coding agreement. Fleiss et al. (2003) suggests high agreement is between 0.75-1.00, moderate agreement is between 0.41-0.75, and poor agreement less than < 0.40. The kappa coefficient is comparable to percentage agreement, which reports the percentage of contingent codes divided by the total number of units within a transcript.

$$(x + y^*)/z = \%$$

z= total characters in transcript

x= characters *not* coded by either coder

y= characters coded by both coder

*Does not incorporate codes by one coder only

An interview transcript from an extension agent (F8: 11/16/20) and the introductory meeting in North Alabama (C2: 02/17/21) were randomly chosen to report inter-coder reliability. The coding comparison query suggests the average kappa value for all codes attributed to F8 was 0.89 and the percentage agreement was 97.60%. According to Fleiss et al. (2003) this coding agreement was high. The coding comparison query suggests the average kappa value for all codes attributed to C2 was 0.67, and the percentage agreement was 99.78%. These results are indicative of medium to high coder agreement. The percentage agreement was recorded in the higher threshold while the kappa coefficient was lower but more moderately comparable. We attribute the high agreement to continuous discussion among coders, regular meetings among our 3-person team, and recoding discrepancies after a consensus was reached.

3.4.3 MATRIX AND WORD FREQUENCY QUERIES

Following the coding procedure, two types of queries were conducted. First, a matrix coding query was used to quantify specific actors or cases that are coded to a specific context, which shows themes within the data. Coding queries are used to cross-tabulate the intersection of coded content which are then displayed by word frequency queries. To form a coding query the location of the case was specified (i.e., transcript: specific actor, type of actor, region) and then specific coded content was identified (NVivo 2022). The matrix data was used to create bar graphs and charts to visualize which actors mentioned specific content. Matrix queries ensure double coding or overlapping does not occur.

Second, word frequency queries (WFQ) were used to illustrate the most commonly occurring words or concepts from the matrix coding queries. Typically, word repetition analyses are used in the social sciences, as well as education, history, and communications (Chróinín & Coulter 2012; Haggar 2020; Unkelback et al. 2019). Word repetitions model community dynamics and sentiments by analyzing and categorizing textual and spoken content into empirical categories and classifying the interaction as positive or negative (Ferster et al. 2021; Unkelbach et al. 2019). Word frequency queries have been diversely used to analyze literature searches, social media content, news sources and literature, sentiment, and professional socialization (Chróinín & Coulter 2012; Danowski et al. 2021; Ferster et al. 2021; Haggar 2020). More commonly, news coverage has been analyzed using textual frequencies to examine commonalities among influencers, perceptions, intergroup biases (Unkelbach et al. 2019), and actionable motivations (Ferster et al. 2021), as well as the context of fake news (Haggar 2020).

The word frequency queries were based on a required minimum word length of three characters, and they were combined with stemmed words (i.e., "talk" and "talking") (NVivo 2021). Individual word frequency queries were run on coded interview and regional meeting data for each FFP(TD) actor. Words that were not relevant to the search such as conjunctions, prepositions, or adjectives were added to the "stop words" list and excluded from the query results. Word frequency queries were exported as word clouds to visually represent the textual data and to illustrate the most frequently occurring words that appear in the respective cloud. This approach allowed us to pinpoint and interpret larger goals and interests, which may be present in certain cases (i.e., among actors) and absent in others. These queries informed whether high frequency repetitions are meaningful within the context of the data.

3.5 FINDINGS

The first two word frequency queries target the FFP research and extension team responses to the challenges associated with the co-development of knowledge and transdisciplinarity. The final query targets the FFP(TD) with a focus on engagement. A goal is to identify the challenges associated with establishing collaborative, engaging, ways to maximize the effectiveness of technology transfer (Figure 7). Using matrix coding queries major themes emerged from workshop, interview, meeting, email, and survey data. The queries included themes from challenges in the co-development of knowledge, challenges within transdisciplinary research, and engagement as an identified need.

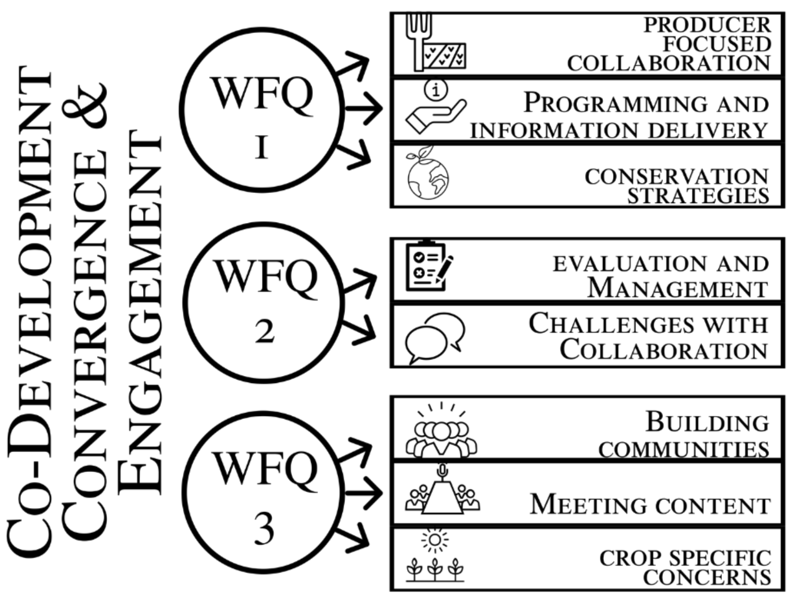

Figure 7: Co-development, Convergence, and Engagement. Summary of the themes associated with the three-word frequency queries.

3.5.1 WORD FREQUENCY QUERY 1: CHALLENGES ASSOCIATED WITH CO-DEVELOPMENT AMONG FFP

WFQ1 mentions from other researchers (n=25, 27.04%) and professor and extension specialists (n=518, 72.96%) in transcripts, emails, surveys, and other documents coded as challenges **and** co-development (Figure 8) found three key themes: 1) producer focused collaboration, 2) FFP extension meeting programming and information delivery, and 3) conservation strategies.

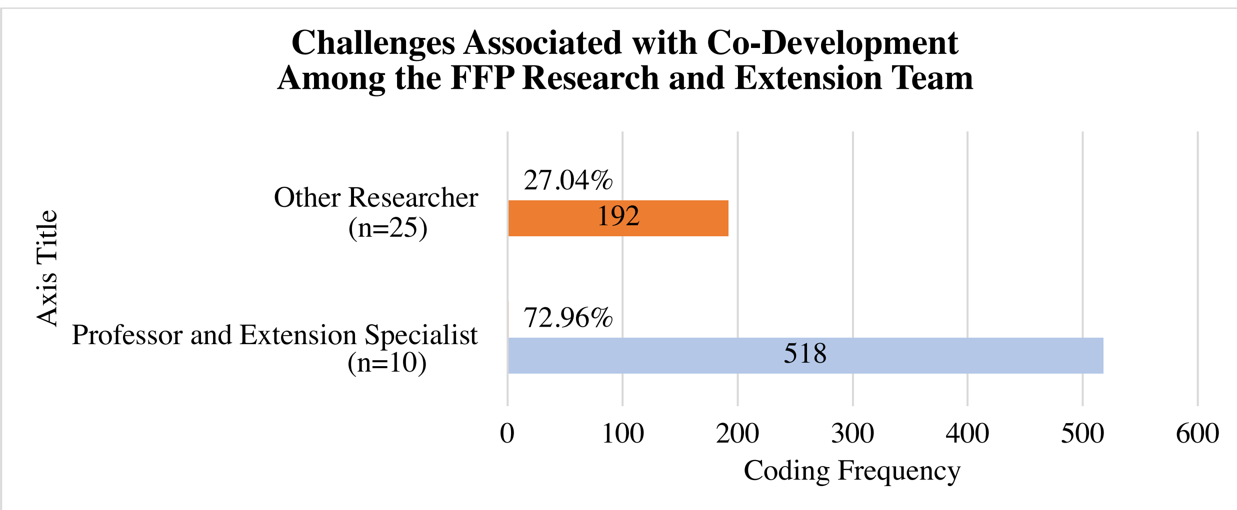

Figure 8: Challenges Associated with Co-Development Among the FFP Research and Extension Team. A matrix coding query of the FFP who mentioned the challenges of co-development.

THEME 1.1: PRODUCER FOCUSED COLLABORATION

Farmers (n=446) appeared the most in the query, which indicates the broad objective among the FFP to serve and collaborate with producers, despite the challenges. The repetition of *engagement* (n=102) and producer-oriented strategies for the co-production of knowledge suggest interests in addressing conservation adoption in collaborative *groups* (n=138) or *teams* (n=51). ER2 explains the importance of engagement in an annual interview: *"The value of these interactions and engagement processes that play a key role on, you know, knowledge co-creation and co-innovation adaptation, you know, is a skill development." Extension* (n=77) is mentioned less than *farmers* (Figure 9). Prioritizing *Alabama* [Farmers](n=50) encourages extension to tailor research for regional producers rather than publish research which is irrelevant to the Southeast region. Co-development and collaborative extension programs promote *interactive* (n=62) methods which might engage farmers.

THEME 1.2: FFP EXTENSION MEETING PROGRAMMING AND INFORMATION

WFQ1 indicates *meetings* (n=214), *project* (n=152)*, learn* (n=119), *questions* (n=105), *knowledge* (n=74)*, research* (n=58), *information* (n=53)*,* and *results* (n=34) were important aspects of co-development (Figure 9). A Future of Farming researcher explains the importance of engagement project planning:

> *It's not just about creating change but creating change that's sustainable, that these networks continue to thrive after the project is over that's the real successes. Can those projects those groups continue to communicate amongst each other when we're not there to force the conversation and be willing to share knowledge and information? So that's a challenge -R8*

The second theme illustrates the importance of planning meetings with tailored information to address producers concerns and needs. The influence of collaborative strategies is emphasized by the repetition of *engagement* (n=102)*, interactive* (n=62)*,* and *demos/demonstration* (n=75), all of which are characteristics of effective co-development strategies (Whyte 1989). These strategies facilitate knowledge building communities (Hod and Ben-Zvi 2018) and they can neutralize power issues by ensuring participants are integrated into the research process. Establishing inclusive groups builds communication channels that increase participation in all aspects of the research and may encourage the acceptance of conservation strategies.

THEME 1.3: CONSERVATION STRATEGIES

Finally, *cover* crops (n=198)*, irrigation* (n=139)*,* and *nutrient* (n=40) were present indicating that education, about and implementation of, *conservation* (n=30) *management* (n=89) (i.e., cover cropping, conservation tillage, irrigation) and associated technologies and practices require co-development for adaptation (Figure 9). As suggested by WFQ 1, challenges associated with implementing *irrigation, conservation,* and *cover crops* (n=216) may be addressed via aspects of co-developing knowledge to collaboratively influence their adoption and introduction success.

The research extension team directly referenced co-development objectives for collaboratively increasing *environment[al]* (n=44) sustainability. ER1 advocated for including relevant content to assuage complications with conservation applications stating, *"we really just want to have an in-depth discussion about what those challenges are, what benefits you see from cover crops, and what type of research needs to be done to address those."* During a FFP research and extension planning meeting a professor and extension specialist explained that:

> *We are going to facilitate among the participants* [which] *should allow them to identify cost effect relationship … allow them to say hey you know I never realized … that cover crops are doing this or that irrigation is doing that on my nutrients; so hey I have to change; or oh, I really need to try this new thing because now I know that this is what I'm doing and that's the negative effect or the positive effect. -ER2*

Figure 9: Challenges Associated with Co-Development. A matrix coding query of the research and extension team who were coded for challenges AND co-development. Words that appear larger occur more frequently.

3.5.2 WORD FREQUENCY QUERY 2: CHALLENGES ASSOCIATED WITH CONVERGENCE FFP

WFQ2 used language coded as challenges **and** convergence from other researchers (n=117, 33.82%) and professor and extension specialists (n=229, 66.18%) from transcripts, emails, surveys, and other documents (Figure 10). The query represents challenges associated with integrating multiple scientific disciplines. Two major themes were generated from the word frequency query 1) evaluation and management and 2) challenges with collaboration.

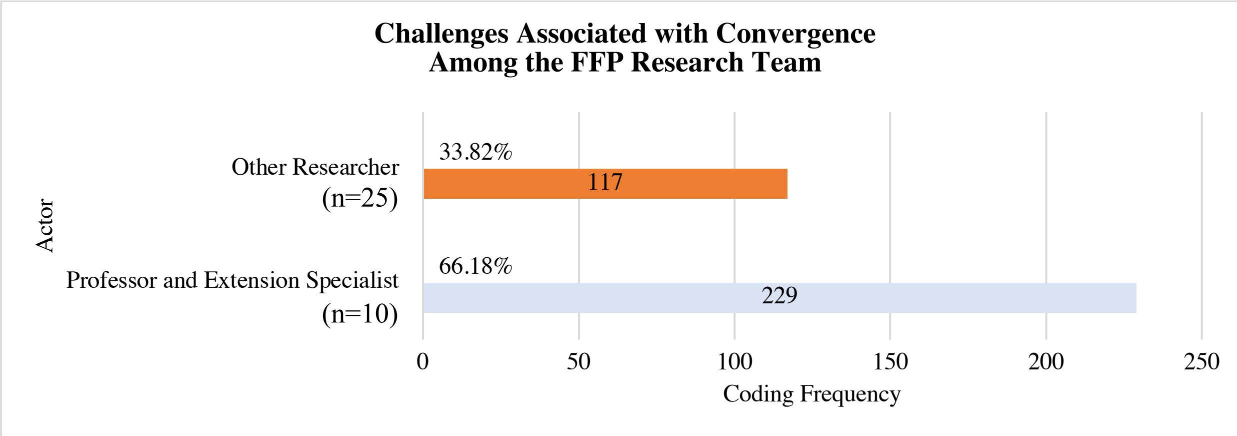

Figure 10: Challenges Associated with Convergence Among the FFP Research Team. A matrix coding query of the research and extension team members who mentioned challenges with convergence.

THEME 2.1: EVALUATION AND MANAGEMENT

The primary theme among challenges with transdiciplinarity is project management as indicated by the repetition of *project[s]* (n=152), *data* (n=94), *research[ers]* (n=69), and *meetings* (n=44). A professor and extension specialist explains the difficult nature of collaboration among different disciplines:

> *... we do have some strong personalities on this project like I've never experienced before being on a research project and so it's very challenging to manage um with certain PI's not getting along and not agreeing on how research should be performed ... That is by far the biggest challenge for me on this project and I don't know the best way to overcome it but that's my challenge -ER1*

Managing, or *facilitate[ing]* (n=21), transdiciplinarity requires collaboration while fully integrating multiple *system[s]* (n=26), or disciplines, to address vexing problems. Reaching convergence requires advice, communication, and empowerment across all participating disciplines, including stakeholders, to sustain *collaborat[ive][ion]* (n=26) interaction (Roo 2020). To build trust among researchers requires coordination that takes a variety of forms.

Establishing confidence among researchers and participants includes troubleshooting and adjusting to a variety of meeting modalities (Cannon 2020). Such as updating and accommodating for multi-media sources such as in-person meetings, conference calls, email briefs, reports, and social media.

A sub-theme of evaluation includes limiting factors that may influence decision-making such as *money* (n=17) and *cost[s]* (n=17). Though not as frequent as data and research concerns, finances are mentioned as a challenge, monetary constraints may limit teaching and learning opportunities (i.e., demonstration location, research financing, travel expenses).

The transdisciplinary process is initially fostered by the research team but requires production, in the form of research, outreach, and teamwork, from both the *scientist[s]* (n=22) and participant *group[s]* (n=54) as the project evolves and progresses. Thus, consistent project evaluation as a form of management ensures researchers and participants are equally represented throughout the project. Management ought to include information and direction for adopting climate-smart technologies such as monitoring, implementing, and incentivizing *nutrient[s]* (n=58), *cover* (n=45), *crops[ing]* (n=47), *irrigation* (n=40), and *soil* (n=37). Project administration with and for participants encourages opportunities for developing research and adopting conservation practices.

THEME 2.2: CHALLENGES WITH COLLABORATION

Challenges with collaboration are also influenced by the *data* (n=94) (i.e., production, collection, responsibility), the *process[es]* (n=26), and the *plan[ning]* (n=14) required to produce, organize, and publish research. Traditionally, research is completed in silos by experts. Transitioning from a siloed approach to a collaborative approach is difficult. Collaboration requires effort from multidisciplinary *team[s]* (n=87) to work *together* (n=41) and *commit* (n=20) to the project. Thus, the goals of convergence*: engage[ment][ing]* (n=39)*, adoption[ing]* (n=38) *communicat[ions][ors]* (n=20) are often challenging to establish (Figure 11). Professor and extension specialist R1 advocated for transparency, timeliness, and organization for shared data collection: *"I had to deal with the fact that my expectations for other people … if you're going to deliver me data, and I'm going to use your data, I need you to make sure that I know what it means like you can't just give me a data set and then expect me to just miraculously know what treatment one is…"* Other FFP research and extension members express the same concern, as well as the importance of team responsibility. Professor and extension specialist ER2 argues *"I'm not going to take the responsibility of all the field work because we both need the data; if I am the only one person needing the data I don't have to deal with this mess, I just do the things that I have been able to do for years, so then is the ethics you know going back to the trust ..."* To an extent, increasing commitment to collaborative data creation and sharing influences the content of *meeting[s]* (n=82)*, demos/demonstrate[ed][ion]* (n=41), and *management[ing]* (n=26) content. Nevertheless, cooperation requires trust, and must be fostered collectively to be sustained equally by all participating members.

Transdiciplinarity requires deep integration of project involvement from researchers with participants. Such *commit[ment]* (n=20)*,* was inspired by an open dialogue and *social[ness]* (n=23)*,* to dissect issues and encourage problem-solving within the FFP(TD). Dedication to engagement encourages solutions to intellectual questions in a transdisciplinary context that address the constraints and goals of the FFP(TD) project (National Research Council 2014; NSF 2020). Dialogue surrounding commitment is fostered by building trust among participating disciplines and must be continuously established. The convergence approach challenges scientists to be open to not only in establishing holistic project objectives, but also in supporting and building bonds with other team members.

Figure 11: Challenges Associated with Convergence. A matrix coding query for the research and extension team who were coded for the intersection of challenges AND convergence from meeting and interview transcripts, emails, surveys, and other documents.

3.5.3 WORD FREQUENCY QUERY 3: THE NEED FOR ENGAGEMENT

WFQ3 of engagement **and** identified needs represented the intersection of statements that identify increased engagement as a need for developing the FFP(TD). The research team mentioned these paired codes most frequently including professor and extension specialists (n=66, 42.31%), followed by crop consultants (n=25, 16.03%), other researchers (n=23, 14.74%), ACES (n=22, 14.10%), farmers (n=16, 10.26%), and government employees (n=4, 2.56%) (Figure 12). Three main themes emerged from the engagement needs word frequency query: 1) building communities, 2) meeting content, and 3) crop specific concerns.

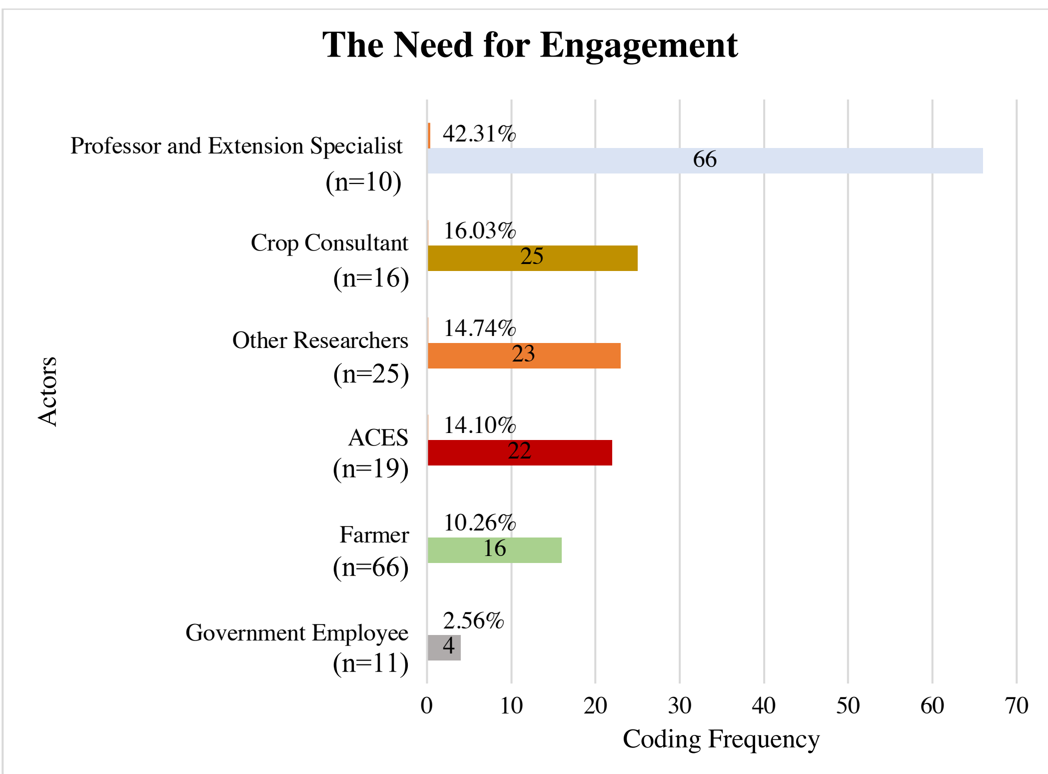

Figure 12: Engagement Codes as an Identified Need FFP(TD). A matrix coding query for the FFP(TD) who mentioned engagement as an identified need.

THEME 3.1: BUILDING COMMUNITIES

FFP(TD) values community centered characteristics which promote communal learning and knowledge building. Fostering engagement, such as *talking* (n=34) and *share[ing]* (n=32), as well as *seeing* (n=29) conservation opportunities, allowed participants and the research and extension team to *exchange* (n=6) *stories* (n=12) and to learn from each other (Figure 13). The results also emphasize the value of *social[ness]* (n=15) and *community* (n=8) building which will not only improve rapport among researchers and participants, but increase trust in the engagement and peer-to-peer learning process, as well. Though participants do not use the specific phrase co-development, they do advocate for engagement as a means of solving complex conservation and sustainability problems. Most participants value *interaction* (n=16) and *learn[ing]* (n=18) through their experiences. For instance, F26 drew attention to peer-to-peer learning saying, *"Well, for me, when I was doing it was the personal experience you know being on the farm and seeing what other people were doing."*

THEME 3.2: MEETING CONTENT

Developing usable and relevant meeting content has the potential to open new avenues of learning outside traditional settings such as social media or informational videos. The transition from primarily face-to-face interaction to the increased use of social media and web access was described by crop consultant (CC4) during a follow-up interview, *"... a lot of these guys ... will do some of their own homework on the internet and ... you know social media and other things like that are becoming more standard ... to reach out to peers that may not be their neighbor next door ..."* This comment directs attention to the importance of the *research* (n=16) published by *Auburn* (n=8) as well as *universities* and *academia* (n=6) broadly. As *media* (n=12), *meeting[s]* (n=41), and *information* (n=8) were frequently mentioned, the FFP(TD) might consider novel approaches to disseminate research which captivate participants attention.

Most participants expressed trust in sources from the internet, but only if it provided tailored guidance for implementing conservation practices. A crop consultant (CC10) explains the rift in trust between university research and consumers of that research during a follow-up interview, *"…I think there has to be … almost cooperative trust between growers, academia, and industry … to develop information."* Participants may not understand the importance of the active learning process, as growers are accustomed to receiving nonpractical information from the research and extension team in a top-down manor. Few participants mentioned 'co-development' specifically but appreciate engagement and peer-to-peer learning methods. FFP(TD) participants preference for engagement was likely due to the continuous encouragement and discussion with the FFP research and extension team about developing strategies to promote engagement. The desire for collaboration directly relates to the discussion of *meeting[s]* (n=41) content and *information* (n=8) dissemination through nontechnical sources such as the *media* (n=12), *Facebook* (n=8), *website[s]* (n=8), and *phone* (n=6). During a follow-up interview a farmer (F26) explained the preference for engaging, face-to-face, meetings stating "*Yeah, again that's a personal interaction that I learn a lot from … but seeing in the younger generation, just go on their phone or laptop and do it, … it's hard to get 'em to come to those kinds of meetings anymore."*

THEME 3.3: CROP SPECIFIC CONCERNS

Participants desire collaborative ways be used to address *crop* (n=28) specific concerns. It was suggested that identifying proper conservation techniques requires effort from the community to produce recommendations that are applicable to individual operations. A repeated concern was lacking skills to manage *fertility* (n=6) and *nutrients* (n=6) (i.e., *nitrogen*), as well as more specific concerns regarding technical expertise (i.e., *irrigation* [n=8], *cover* [n=30] cropping). Producers struggle with choosing proper crops and cover crop mixtures that are suitable for their soil as an other research explained during a FFP(TD) debriefing:

> *I heard one person say something about water holding capacity. Well increasing your water holding capacity means that you don't have to use as much irrigation, which in the end, saves you money, … and then somebody said something about nutrients. Well, if you use sunn hemp, and you put nitrogen out there, that's going to save how much you have to apply on your crops, so everything is interrelated. So building on these scenarios so making sure they understand that systems approach, it all starts with this* [and] *their time is money. It's not just about their cover crops, see. -OR1*

In short, collaboration to develop content that addresses crop specific concerns about adopting conservation practices and technologies is important to participants and the research and extension team.

Figure 13: The Need for Engagement. A matrix coding query was run for the FFP(TD) who mention engagement as an identified need from meeting and interview transcripts, emails, surveys, and other documents. Words that appear larger in the word cloud occur more frequently within the data.

3.6 CONCLUSIONS AND RECOMMENDATIONS

The conclusion is split into three separate sections: 1) key findings from word frequency queries one, two, and three, 2) limitations, and 3) project recommendations. Summarized are the most important takeaways from co-development, convergence, and engagement, and suggestions for transdisciplinary research teams.

Word frequency queries are advantageous ways of showing larger themes which develop in textual data. Few agricultural or conservation motivated works have used word frequency queries to develop guidance and suggestions for improving knowledge retention and collaboration between research teams and participants (Danowski et al. 2021; Ferster et al. 2021). Using the results of qualitative coding and word frequency queries the Future of Farming Project can increase research and practitioner knowledge (i.e., crop consultants, government, Alabama Cooperative Extension) of the importance of co-learning strategies and environments for conservation and learning environmental resilience.

3.6.1 CO-DEVELOPMENT

Producers are often absent from decision making for the mitigation process as most research agricultural adaptations are technical and model dependent (Crane et al. 2011). To date, there is no fixed or specific framework or recommendation for the application of participatory action research within transdisciplinary projects (Fals-Borda & Rahman 1991). However, collaborative refinement of and reflection on project objectives and target goals with participants ensures they are included in the research process. Researchers ought to adapt projects to bolster social capital and develop strong connections with those they aim to serve (Crane et al. 2011). Accommodating potential networks might include integrating research participants in decision-making, data generation, and information dissemination (Fals-Borda & Rahman 1991). In a transdisciplinary project, it is as much of the participants responsibility, and in their best interest, to collaborate with the research team to ensure that long-standing challenges are met by developing individualistic recommendations for solving complex crop related issues. Though the research and extension team can encourage participants to invest in transdisciplinary projects such as the FFP(TD) the effects of collaboration are only as great as the effort which is set forth.

3.6.2 CONVERGENCE

Cooperation between diverse researchers can be advantageous when broadly addressing compelling problems. Collaboration, often vaguely defined, is a complex process that transcends typical linear information developing, integration, and diffusion, posing challenges to establishing engagement and sustaining the process in larger institutions (Cannon 2020; National Research Council 2014; NSF 2020). Reaching convergence is largely dependent on project size, scope, and members with no one size fits all approach. Convergence promises that new avenues and conceptual frameworks, networks, and solutions will be developed as it inspires a dynamic research process with large application opportunity (NSF 2020; Roco 2020). Convergence was coded primarily among the research team due to its target nature among the FFP. Sustaining the goal of integrating disciplines is integral to the research extension team but participants should also be aware of the convergence process to ensure the collaboration of multiple disciplines.

Convergence research motivates unique problem solving while fully integrating the expertise of multiple disciplines into a new, pivotal products (Cannon 2020; National Research Council 2014; NSF 2020). The convergence approach to research may lend itself to more robust advice, academic empowerment, governmental and community advocacy, and public policy (Cannon 2020; National Research Council 2014). Engaging in convergence through collaboration between the primary investigators and their participants provides an essential link to knowledge creation. Though difficult to develop, convergence is more time consuming and intricate than traditional linear information development and dissemination, it emphasizes the importance of participatory action research. Prolonged cooperation allows sustained interaction across multiple disciplines for exploring new avenues and promoting unique solutions, conceptual frameworks, and solutions that can be manipulated for solving the challenges of climate mitigation (NSF 2020).

3.6.3 ENGAGEMENT

Largely, collaboration is desired among the research team and participants. Participants often do not have background knowledge about on the benefits of co-development process which may discourage their likeliness to advocate for the incorporation of engagement in research. However, their desire for peer-to-peer learning emphasizes the desirability of farmer-oriented, regional strategies and informs the research and extension team about the perceptions of producers which are specific and can be applied to individual operations. Word frequencies may provide guidance to the research team to not only include participants in the process but work to transcend beyond traditional extension methods and holistically incorporate all actors into research. This research process may be used to develop conservation strategies and aid in regenerative agriculture.

3.6.4 LIMITATIONS

Limitations exist for kappa values and percent agreement. If coders leave most of a document uncoded there is high percentage agreement on content without codes, however due to its likelihood of occurring by chance the kappa coefficient will be low. If the transcript lacks codes but there is high agreement on the content coded the percentage agreement and kappa value would both be high; this is unlikely due to chance. Thus, it is important that the process of coding agreement is discussed and reinterpreted as a team, so the results of the comparison query are specific to content coded and not coded. The inter-coder reliability process is important not only for analyzing the confidence of thematic generation and comparison but can be used as a training metric to realign coding expectations (NVivo 2022). Qualitative coding is a subjective process. However, training to establish coding accuracy bolsters the reliability of thematic representation. Jointly developing coding definitions, concepts, and systematically reviewing for accuracy increases reliability and establishes subjectiveness amongst research partners.

3.7 RECOMMENDATIONS

The findings from this study suggest that FFP team implements more collaborative strategies to teach participants, as well as researchers, about not only conservation but also transdisciplinarity. There is copious evidence which details weak linkages in information dissemination among universities, industry, and practitioners in a top-down extension practice, emphasizing the importance to transition to a co-development approach (Prokopy et al. 2015; Vines 2018). It is of critical importance to build trust among participant communities to branch research-based information and increase mitigation. It is suggested that transdisciplinary teams examine and work with shared characteristics (i.e., regional concerns) among participants as they are direct indicators of project objectives and progress. For example, dynamic and active learning strategies such as storytelling, producer lead discussion, and interactive exercises can improve knowledge retention, and increase participant engagement (Whyte et al. 1989). The FFP research team ought to consider and improve field day structure, as well as content, during workshop planning meetings to be more collaborative and engaging. Increasing participation and investment might ensure meeting leaders don’t default to lecture style teaching with research participants.

For other transdisciplinary projects, research teams ought to meet regularly to discuss project objectives, progress, and target goals. Achieving convergence transcends traditional research methodologies to create more collaborative, integrated approach to solving complex socio-ecological questions. Integrating participants into the research process deepens their commitment to the project and investment into research. Alabama row crop producers are the target audience for the FFP, and the material generated from and for the project ought to address the concerns of its participants. Transdisciplinarity incorporates the integration of the idea of person-centeredness, which can deepen relationships and trust within and among participants (Aubusson et al. 2007; Hod and Ben-Zvi 2018). The creation of knowledge allows participants to experience and explore the learning process and content themselves. It is suggested for future climate-smart research that producers, crop consultants, government agents, and extension contribute collaboratively toward to the data collection and results of the project to properly align the interests of those the project intends to serve.

CHAPTER 4: EPILOGUE

4.1 EXPECTATIONS AND REFLEXIVITY

During this research, I accepted the challenge of how difficult and broad a 2-year thesis would be. According to the literature, farmers learn best in a localized setting where co-learning is encouraged (Arshad et al. 2016; Bartels et al. 2013). Using a participatory structure, I believe, encouraged an engaging space for the project stakeholder to share knowledge and consider vexing issues. Our collaboration not only built a relationship between farmers, government employees, and crop consultants in each of the three-participating regions, but also among the Future of Farming research and extension team itself.

4.2 OWNING SUBJECTIVITY

As a liberal woman from the North, I may house differing opinions than the targeted research group. I am not a farmer, none of my direct family members are farmers, nor are we from the South. Thus, I am unfamiliar with the discourse and dialect of Southern row crop producers. To respect my research partners, I indevoured to control my emotional attachment to a research topic that was, at times, sensitive. I realize subjectivity is always present based on one's epistemological and ontological assumptions and may influence data collection, analysis, findings, and conclusion. I have worked on farms and in gardens in the past, primarily as a farmer or ecologist that are of smaller size in comparison to commercial row crop farms. The FFP(TD) was my first immersion into a sociological role on a farming project. My undergraduate background was in economics and remote sensing, so I was unfamiliar with rural sociology. I took sociology classes in graduate school to improve my skill set. However, I do have previous experience collaborating with farmers on a socio-ecological project that was part of my undergraduate degree. My unique background, which includes environmental science and environmental economics from the University of New Hampshire, benefited my analysis sociologically. This allowed me to approach the research process from an outsider's perspective.

To establish reflexivity, the Future of Farming Team, and the subgroup of rural sociologists on the project, which included, McKayla Robinette, Dr. Michelle R. Worosz, and myself, engaged in constant reflection. I established reflexivity through journaling and triangulation: the sharing of interview transcripts with participants and researchers. The implementation of co-development and convergence allows for FFP research and extension team transparency and accountability. The FFP rural sociology group met once a week to discuss our progress and to evaluate data collection, analysis, and findings (i.e., coding reliability, theme generation, participant communication, team reflexivity). These specialized meetings among the rural sociology subgroup were also used to advise the direction of the project such as developing workshop design, content, and modality for FFP(TD) events and field days. Constant contact (i.e., emails, text messages, phone conversations, meetings) between the rural sociology group, the FFP research and extension team, and the FFP(TD) participants ensured communication and encouraged the co-production of material.

Transparency in data collection and analysis was developed by establishing rapport through prolonged engagement and constant communication with participants. I constantly reflected on the research process, subjectivities, and bias to work on my sociological skill set. Advice from FFP primary investigators supported my research and provided directionality for educational and social content (i.e., educational posters, presentations, participatory activities) as I created research posters for conferences, domestically and internationally, and I crafted manuscripts intended for publication. The collaborative nature of the project allowed for a continuous rapport with participants and the central research team, as their feedback was continuously sought out. Despite the difficult nuances of contacting participants, follow-ups interviews were regularly conducted following project field days; moreover, as the project progressed, participants were more comfortable with sharing their experiences and asking questions. The follow-up interviews gave participants a sense of structure and ensured their concerns about and desires for the project were addressed. I tried to represent the participants and cooperators as accurately as possible by constantly involving them in the research process and designing collaborative learning environments and workshops to ensure their opinions, perceptions, and goals were addressed by the FFP.

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APPENDIX A: INTERVIEW QUESTIONS

FARMER (F)

Structure of the Interview

1. Quick introduction of Hannah and McKayla
2. IRB
    a. Everything we talked about at the first meeting in Hartford, AL still holds
    b. All information will be kept confidential and only accessed by Hannah, McKayla, and Dr. Worosz
3. What is your background?
    a. How long have you been farming?
    b. How long have you been farming this land?
    c. How long has the farm been in your family?
    d. How big is your farm?
        i. Acres
        ii. One plot or spread out
    e. Do you own the land or rent it?
        i. Who is the owner if renting
        ii. How much say does the owner (if renting) have in your farm decisions?
    f. Have you participated in research before with your farm?
        i. Has seed or chemical companies ever conducted trials
        ii. Has there been any research university or extension research done on your farm?
        iii. Were you able to voice your opinion in these projects? How did you respond during these projects?
    g. How are your yields in a year?
        i. Do they average the same year to year?
        ii. How do you compare to your neighbors?
        iii. How have the recent rains impacted you?
4. How did you learn to be a farmer?
    a. What are your educational backgrounds?
    b. Did you go to college?
    c. Were you in 4-H or FFA? Any other organizations?
    d. What made you decide you wanted to be a farmer?
5. Perceived Behavioral Control Questions
6. Perceived Costs and Benefits
7. General Knowledge

Perceived Behavioral Control

On your farm, what is your greatest soil conservation concern?

What do they want out of this relationship with AU and extension?

1. Where are you most likely to turn for information or advice about soil conservation?

a. How comfortable do you feel expressing your needs and concerns with this person? Do you trust this person explicitly, or do you have reservations about your relationship?

i. Do you feel comfortable voicing disagreement or confusion with this person?

1. What would this look like?

ii. How likely are you to question their recommendations?

iii. What qualities/requirements/characteristics/attributes do you look for in finding a source of information?

b. What happens when you are presented with a new method and you do not like it or feel comfortable using it?

c. What type(s) of information or advice about soil conservation have you not been able to access?

d. What resource/ information site has been the most useful and why? Which one has been the least?

2. What is/are the [strategies, practices, or technologies] that you think would best address your greatest soil conservation concern?

a. What, new, [strategies, practices, or technologies] do you see as most compatible with your existing operation?

b. What, new, soil conservation [strategy, practice, or technology] are you most likely to try?

i. What challenges would you anticipate?

3. Can you tell us a story where you felt the most successful in your operation related to your conservation methods? Are you proud of it?

a. Of the [strategies, practices, or technologies] skills that you currently have, what would you most like to strengthen?

4. Are there [strategies, practices, or technologies] that you would most like to learn about?

Perceived Costs and Benefits

On your farm, what strategies, practices, or technologies might have the greatest impact on soil conservation?

1. What is/are the [strategies, practices, or technologies] that have been most successful to date?

a. How do you evaluate the success of this [strategies, practices, or technologies]?

2. What, new, [strategies, practices, or technologies] is/are likely to have the greatest outcomes on your farm?

a. What changes would you need to see to consider the [strategies, practices, or technologies] effective?

b. What characteristics would it need to have to continue using the [strategies, practices, or technologies]?

c. What might cause you to stop using the [strategies, practices, or technologies]?

3. What is the most significant barrier or challenge that might prevent you from implementing a new [strategies, practices, or technologies]?

a. What new conservation-based strategy, practice, or technology are you least likely to try?

4. What barriers and challenges have you had in communication?

General Knowledge

In your opinion, what do you see as the greatest soil conservation issue across the Southeastern region?

Hannah and McKayla are new to the SE row- crop and would like your opinion on what the industry looks like.

How do the farmers see the region and what do they think is possible/ should be done in the region? How do they think the other farmers will perceive it? If money and other constraints weren't an issue.

1. What soil conservation strategy or practice do you see as most important in Southeastern US row crop production?
    a. If Southeastern row crop producers adopted this strategy or practice, what ought to be the expected soil conservation outcome?
    b. What might prevent row crop producers from the using this soil conservation practice?
2. How do you think others—row crop producers, extension, agronomists—would perceive this soil conservation strategy?

Are there any other questions/ comments concerns for us?

How would you improve upon the meeting you attended?

COOPERATOR FARMERS (F)

Structure of the Interview

1. Quick introduction of Hannah and McKayla
2. IRB
    a. Everything we talked about at the first meeting in ________, AL still holds
    b. All information will be kept confidential and only accessed by Hannah, McKayla, and Dr. Worosz

Farm History

Practices, weather, and changes?

2. What is your background?
    a. How long have you been farming (general)?
        i. What is the size of your operation?
            1. Acres
            2. One plot or spread out
        ii. Does anyone farm with you and how are they connected to the operation?
            1. How long has the farm been in your family?
    b. How did you learn to be a farmer?
        i. What is your educational background?
            1. Were you in 4-H or FFA? Any other organizations?
        ii. What made you decide you wanted to be a farmer?
    c. Describe the farm or farms that is part of your operation
        i. How long have you been farming <u>this land/these pieces</u>?
        ii. Do you own the land or rent it?
            1. How much owned; how much rented?
                a. Who is the owner if renting?
                b. How does the landowner(s) influence your farm decisions? [Formal contracts, handshakes]
        iii. Who is the primary decision-maker(s) for the farming operation as a whole? Are decisions collaborative?

Conservation Practices

1. How did your yields compare to 2020/ years before?
    a. Do they average the same year to year?
        i. What makes them differ?
    b. How do you compare to your neighbors?
    c. Have you noticed weather changes over the years?
        i. Have you had to adapt to certain weather changes with technology or practice changes?
        ii. Which ones?
    d. Has drought, excessive rain, hurricanes, or erosion been a problem on your farm?
        i. Has this worsened over the years?
2. How did you become interested in conservation practices?

3. What practices/technologies do you currently use (VIR, soil moisture probes, cover crops, other)
    a. When did you start using X?
    b. Why did you start using this practice X?
        i. What was the purpose of implementing this practice?
        ii. Did you have any problems during the adoption process? Why do you think that was?
        iii. Can you see any benefits from using this practice?
    c. What other conservations practices/technologies did you try, then stop using?
        i. Why?
            1. What would make it possible for you to try it again?
4. Are there conservation practices that you'd like to use but do not do so currently?
    a. Why?

Perceived Behavioral Control

On your farm, what is your greatest soil conservation concern?

What do they want out of this relationship with AU and extension?

1. Where are you most likely to turn for information or advice about soil and water conservation?
    a. How comfortable do you feel expressing your needs and concerns with this person? Do you trust this person explicitly, or do you have reservations about your relationship?
        i. Do you feel comfortable voicing disagreement or confusion with this person?
            1. What would this look like?
        ii. How likely are you to question their recommendations?
        iii. What qualities/requirements/characteristics/attributes do you look for in finding a source of information?
    b. What happens when you are presented with a new method and you do not like it or feel comfortable using it?
    c. What type(s) of information or advice about soil conservation have you not been able to access?
    d. What resource/ information site has been the most useful and why? Which one has been the least?

What is your greatest water and soil concern on your farm and why?

    a. Has this answer changed over the years?
    b. Would your neighbors/region agree with you?

3. What is/are the [strategies, practices, or technologies] that you think would best address your greatest soil and water conservation concerns?
    a. What, new, [strategies, practices, or technologies] do you see as most compatible with your existing operation?
    b. What, new, soil conservation [strategy, practice, or technology] are you most likely to try?
        i. What challenges would you anticipate?
4. Can you tell us a story where you felt the most successful in your operation related to your conservation methods? Are you proud of it?

a. Of the [strategies, practices, or technologies] skills that you currently have, what would you most like to strengthen?

5. Are there [strategies, practices, or technologies] that you would most like to learn about?

Perceived Costs and Benefits

On your farm, what strategies, practices, or technologies might have the greatest impact on soil conservation?

1. What is/are the [strategies, practices, or technologies] that have been most successful to date?
    a. How do you evaluate the success of this [strategies, practices, or technologies]?
    b. Which have been least successful?
2. What, new, [strategies, practices, or technologies] is/are likely to have the greatest outcomes on your farm?
    a. What changes would you need to see to consider the [strategies, practices, or technologies] effective?
    b. What characteristics would it need to have to continue using the [strategies, practices, or technologies]?
    c. What might cause you to stop using the [strategies, practices, or technologies]?
3. What is the most significant barrier or challenge that might prevent you from implementing a new [strategies, practices, or technologies]?
    a. What new conservation-based strategy, practice, or technology are you least likely to try?
4. What barriers and challenges have you had in communication
5. How will your attitude/practice change in regard to soil conservation now that you hold a large stake in a statewide project to protect Alabama soils.

General Knowledge

In your opinion, what do you see as the greatest soil conservation issue across the Southeastern region?

How do the farmers see the region and what do they think is possible/ should be done in the region? How do they think the other farmers will perceive it? If money and other constraints weren't an issue.

1. What soil conservation strategy or practice do you see as most important in Southeastern US row crop production?
    a. If Southeastern row crop producers adopted this strategy or practice, what ought to be the expected soil conservation outcome?
    b. What might prevent row crop producers from the using this soil conservation practice?

Commitment to the Project and Future Implications

1. Have you participated in research (test plots/ chemical trials) before the Future of Farming project?
    a. Has seed or chemical companies ever conducted trials?
    b. Has there been any research university or extension research done on your farm?

c. Were you able to voice your opinion in these projects? How did you respond during these projects?

2. To the best of your ability how would you define the goals and objectives of this CIG project in your own words?
    a. For you, what is the most important aspect of the project?
3. How did you become affiliated with this project?
    b. Do you have close connections with the PIs on this project or extension?
    c. How were you asked to participate in the project?
    d. What were your main concerns when agreeing to become a cooperator farm?
    e. Do you have any major concerns/worries for the project?
        i. Do you feel certain portions of the projects are underrepresented or lacking?
    f. How much land do you have that is dedicated to the project?
        i. Which practices/technologies will you be implementing?
4. How do you interpretate the role of cooperators on the project?
    g. Communication, contacts, technology and idea showing…
5. How might you encourage your peers/neighbors to become engaged and active participants of this project?
    h. Do you believe your commitment and other cooperator farmers (N,S,C) to this project relies upon your attendance at reginal events?
    i. How could your encouragement of the attendance of others help the goals and progress of this CIG project?
6. In which way can you motivate yourself and others to be conservation advocates in the future?

ALABAMA COOPERATIVE EXTENSION SYSTEM (ACES)

Extension Interview Questions

As discussed during the workshop, the IRB still holds in this context. All confidential.

- Start with a bit about your background?

Background

What is your academic degree and job title?

How long have you been in Extension Agent?

Do you have any experience with a conservation project (co-development of knowledge) like this?

- When we had the Extension zoom meeting a couple of weeks ago,
    - What is your impression of farmers perception of Extension?
    - Are there row crop farmers that Extension does not work with or does not reach?

Broad Soil Conservation Prompts

General Knowledge

In your opinion, what do you see as the greatest soil conservation issue across the Southeastern region?

- What soil conservation strategy or practice do you see as most important in Southeastern US row crop production?
    - If producers adopted this strategy or practice, what ought to be the soil conservation outcome?
    - What might prevent producers from the using this soil conservation practice?
- How do you think other extension agents, agronomists and crop consultants would perceive this soil conservation strategy?

Perceived Behavioral-Control

Of the row crop growers that you work with, what is their greatest soil conservation concern?

- What is/are the [strategies, practices, or technologies] that you think would best address these soil conservation concerns?
    - What, new, [strategies, practices, or technologies] do you see as most compatible with their existing operations?
    - What, new, soil conservation [strategy, practice, or technology] are your producers most likely to try?
        - What challenges would you anticipate?
- Where do your producers turn for information or advice about soil conservation?
    - Who
    - External sources (perhaps internally?)
    - What type(s) of information or advice are they unable to get?
- What soil conservation [strategies, practices, or technologies] do your producers currently use that impress you most?
    - Of the [strategies, practices, or technologies] skills that your producers currently have, what would you most like to see them strengthen?
    - Are there [strategies, practices, or technologies] that you would most like to learn about?

Perceived Costs and Benefits

Of the farms that you work with, what strategies, practices, or technologies might have the greatest impact on soil conservation?

- What is/are the [strategies, practices, or technologies] have been most successful to date?
  - How did you evaluate the success of this [strategies, practices, or technologies]?
    - What does success look like?
- What, new or innovative [strategies, practices, or technologies] is/are likely to have the greatest outcomes on these farms? (most potential)
  - What changes would you need to see to consider the [strategies, practices, or technologies] effective?
  - What characteristics would it need to have for you to recommend using the [strategies, practices, or technologies]?
  - What might cause you to stop recommending using the [strategies, practices, or technologies]?
- What do you see as the top 3 barriers or challenges preventing your producers from implementing a new [strategy, practice, or technology]?
  - What new conservation-based strategy, practice, or technology do you think producers are least likely to try? (why?)

CROP CONSULTANT (CC)

As discussed during the workshop, the IRB still holds in this context. All confidential.

- Start with a bit about your background?

Background

- What is your academic degree and job title?
- How long have you been in crop consultant?
- Do you have any experience with a conservation project (co-development of knowledge) like this?
- How do farmers first get in contact with you?
    - What demographic of farmers do you work with?
    - What is your impression of farmers perception of Extension/ consulting firms?
    - Are there row crop farmers that crop consultants do not work with or does not reach?

Broad Soil Conservation Prompts

General Knowledge

In your opinion, what do you see as the greatest soil conservation issue across the Southeastern region?

- What soil conservation strategy or practice do you see as most important in Southeastern US row crop production?
    - If producers adopted this strategy or practice, what ought to be the soil conservation outcome?
    - What might prevent producers from the using this soil conservation practice?
- How do you think extension agents and other crop consultants would perceive this soil conservation strategy?

Perceived Behavioral-Control

Of the row crop growers that you work with, what is their greatest soil conservation concern?

- What is/are the [strategies, practices, or technologies] that you think would best address these soil conservation concerns?
    - What, new, [strategies, practices, or technologies] do you see as most compatible with their existing operations?
    - What, new, soil conservation [strategy, practice, or technology] are your producers most likely to try?
        - What challenges would you anticipate?
- Where do your producers turn for information or advice about soil conservation?
    - Who
        - Who regularly seeks your advice?
        - Do they use 2^{nd}, 3^{rd} opinions?
    - External sources (perhaps internally?)
    - What type(s) of information or advice are they unable to get?
    - What kind of information are you or your company unable to get?
- What soil conservation [strategies, practices, or technologies] do your producers currently use that impress you most?

- Of the [strategies, practices, or technologies] skills that your producers currently have, what would you most like to see them strengthen?
- Are there [strategies, practices, or technologies] that you would most like to learn about?

Perceived Costs and Benefits

Of the farms that you work with, what strategies, practices, or technologies might have the greatest impact on soil conservation?

- What is/are the [strategies, practices, or technologies] have been most successful to date?
  - How did you evaluate the success of this [strategies, practices, or technologies]?
    - What does success look like?
- What, new or innovative [strategies, practices, or technologies] is/are likely to have the greatest outcomes on these farms? (most potential)
  - What changes would you need to see to consider the [strategies, practices, or technologies] effective?
  - What characteristics would it need to have for you to recommend using the [strategies, practices, or technologies]?
  - What might cause you to stop recommending using the [strategies, practices, or technologies]?
- What do you see as the top 3 barriers or challenges preventing your producers from implementing a new [strategy, practice, or technology]?
  - What new conservation-based strategy, practice, or technology do you think producers are least likely to try? (why?)
    - How would you recommend we recruit more farmer participants?
      - Social media, extension meetings, newsletter, email…

GOVERNMENT NRCS-USDA AND SWCC QUESTIONS (G)

As discussed during the workshop, the IRB still holds in this context. All confidential.

- Start with a bit about your background?

Background

- What is your academic degree and job title?
- How long have you been working with NRCS?
- Do you have any experience with a conservation project (co-development of knowledge) like this?
- How do farmers first get in contact with you?
    - What demographic of farmers do you work with?
    - What is your impression of farmers perception of Extension/ consulting firms?
    - Are there row crop farmers that crop consultants do not work with or does not reach?

Broad Soil Conservation Prompts

General Knowledge

In your opinion, what do you see as the greatest soil conservation issue across the Southeastern region?

- What soil conservation strategy or practice do you see as most important in Southeastern US row crop production?
    - If producers adopted this strategy or practice, what ought to be the soil conservation outcome?
    - What might prevent producers from the using this soil conservation practice?
- How do you think crop consultants, extension, and other NRCS agents would perceive this soil conservation strategy?
- What about NRCS as a state agency assists farmers/producers the most with soil conservation?
- Are any farmers/producers uneasy about asking for help through NRCS?
- Do you have good rapport with your clients?

Perceived Behavioral-Control

Of the row crop growers that you work with, what is their greatest soil conservation concern?

- What is/are the [strategies, practices, or technologies] that you think would best address these soil conservation concerns?
    - What, new, [strategies, practices, or technologies] do you see as most compatible with their existing operations?
    - What, new, soil conservation [strategy, practice, or technology] are your producers most likely to try?
        - What challenges would you anticipate?
- Where do your producers turn for information or advice about soil conservation?
    - Who
        - Who regularly seeks your advice?
        - Do they use 2nd, 3rd opinions?
    - External sources (perhaps internally?)
    - What type(s) of information or advice are they unable to get?

- What kind of information are you or your company unable to get?

- What soil conservation [strategies, practices, or technologies] do your producers currently use that impress you most?
  - Of the [strategies, practices, or technologies] skills that your producers currently have, what would you most like to see them strengthen?
  - Are there [strategies, practices, or technologies] that you would most like to learn about?

Perceived Costs and Benefits

Of the farms that you work with, what strategies, practices, or technologies might have the greatest impact on soil conservation?

- What is/are the [strategies, practices, or technologies] have been most successful to date?
  - How did you evaluate the success of this [strategies, practices, or technologies]?
    - What does success look like?
- What, new or innovative [strategies, practices, or technologies] is/are likely to have the greatest outcomes on these farms? (most potential)
  - What changes would you need to see to consider the [strategies, practices, or technologies] effective?
  - What characteristics would it need to have for you to recommend using the [strategies, practices, or technologies]?
  - What might cause you to stop recommending using the [strategies, practices, or technologies]?
- What do you see as the top 3 barriers or challenges preventing your producers from implementing a new [strategy, practice, or technology]?
  - What new conservation-based strategy, practice, or technology do you think producers are least likely to try? (why?)
    - How would you recommend we recruit more farmer participants?
      - Social media, extension meetings, newsletter, email…

FUTURE OF FARMING TEAM QUESTIONS YEAR 1 (MAY 21, 2020-MAY 21, 2021)

(OR/ER)

Core Team Questions
As discussed during the workshop, the IRB still holds in this context. All confidential.

- Start with a bit about your background?

Background

- What is your academic degree and job title?
- Have you always worked in the SE?
- How long have you been in Extension Agent/Professor/Economist?
- Do you have any experience with a conservation project (co-development of knowledge) like this?
- What drew you to this project?

Broad Soil Conservation Prompts
General Knowledge
In your opinion, what do you see as the greatest soil conservation issue across the Southeastern region?

- What soil conservation strategy or practice do you see as most important in Southeastern US row crop production?
  - If producers adopted this strategy or practice, what ought to be the soil conservation outcome?
  - What might prevent producers from the using this soil conservation practice?
- What, new or innovative [strategies, practices, or technologies] is/are likely to have the greatest outcomes on these farms? (most potential)
  - What constitutes the [strategies, practices, or technologies] effective for you to recommend?
    - Cost
    - Nutrient management
  - What might cause you to stop recommending using the [strategies, practices, or technologies]?

Perceived Behavioral-Control
Of the row crop growers that you work with, what is their greatest soil conservation concern?

- What is/are the [strategies, practices, or technologies] that you think would best address these soil conservation concerns?
  - What, new, [strategies, practices, or technologies] do you see as most compatible with their existing operations?
  - What, new, soil conservation [strategy, practice, or technology] are your producers most likely to try?
    - What challenges would you anticipate?
- How do farmers perceive this soil conservation strategy?
  - Is there a piece of information/technique that many be tentative about or refuse to try?
  - What is your largest challenge when working with farmers to implement these conservation practices?

- Have you dealt with non-compliant farmers? What have you done?

- Do you ask where your producers turn for information or advice about soil conservation?
    - Who
    - External sources (perhaps internally?)
    - Extension, AU library, news…
    - What type(s) of information or advice are they unable to get?
- What soil conservation [strategies, practices, or technologies] do the producers you work with currently use that impress you most?
    - Of the [strategies, practices, or technologies] skills that your producers currently have, what would you most like to see them strengthen?
- What [strategies, practices, or technologies] do the producers you work with currently use that is most harmful to their operation [soil health, nutrient availability…]?

Perceived Costs and Benefits

Of the farms that you work with, what strategies, practices, or technologies might have the greatest impact on soil conservation?

- What is/are the [strategies, practices, or technologies] have been most successful to date?
    - How did you and your cooperating farmer evaluate the success of this [strategies, practices, or technologies]?
        - What does success look like? Tell a success story…
        - Have any projects not been successful or failed?
- What do you see as the top 3 barriers or challenges preventing your producers from implementing a new [strategy, practice, or technology]?
    - What new conservation-based strategy, practice, or technology do you think producers are least likely to try? (why?)

FUTURE OF FARMING TEAM QUESTIONS YEAR 2 (MAY 21, 2021-MAY 21, 2022)

(OR\ER)

Core Team Questions
As discussed during the workshop, the IRB still holds in this context. All confidential.

- Start with a bit about your background?

Last time that we met, we spoke about soil conservation. This time we would like to ask for your opinions relater to water.
Broad Soil/Water Conservation Prompts
General Knowledge
In your opinion, what do you see as the greatest water conservation issue across the Southeastern region?

- What water conservation strategy or practice do you see as most important in Southeastern US row crop production?
  - If producers adopted this strategy or practice, what ought to be the water conservation outcome?
  - What might prevent producers from the using this water conservation practice?
- What, new or innovative [strategies, practices, or technologies] is/are likely to have the greatest outcomes on these farms? (most potential)
  - What constitutes the [strategies, practices, or technologies] effective for you to recommend?
    - Cost
    - Nutrient management
  - What might cause you to stop recommending using the [strategies, practices, or technologies]?

Perceived Behavioral-Control
Of the row crop growers that you work with, what is their greatest water conservation concern?

- What is/are the [strategies, practices, or technologies] that you think would best address these water conservation concerns?
  - What, new, [strategies, practices, or technologies] do you see as most compatible with their existing operations?
  - What, new, water conservation [strategy, practice, or technology] are your producers most likely to try?
    - What challenges would you anticipate?
- How do farmers perceive this water conservation strategy?
  - Is there a piece of information/technique that many be tentative about or refuse to try?
  - What is your largest challenge when working with farmers to implement these conservation practices?
  - Have you dealt with non-compliant farmers? What have you done?
- Do you ask where your producers turn for information or advice about water conservation?
  - Who

    - External sources (perhaps internally?)
    - Extension, AU library, news…
  - What type(s) of information or advice are they unable to get?
- What water conservation [strategies, practices, or technologies] do the producers you work with currently use that impress you most?
  - Of the [strategies, practices, or technologies] skills that your producers currently have, what would you most like to see them strengthen?
- What [strategies, practices, or technologies] do the producers you work with currently use that is most harmful to their operation [nutrient availability…]?

Perceived Costs and Benefits

Of the farms that you work with, what strategies, practices, or technologies might have the greatest impact on water conservation?

- What is/are the [strategies, practices, or technologies] have been most successful to date?
  - How did you and your cooperating farmer evaluate the success of this [strategies, practices, or technologies]?
    - What does success look like? Tell a success story…
    - Have any projects not been successful or failed?
- What do you see as the top 3 barriers or challenges preventing your producers from implementing a new [strategy, practice, or technology]?
  - What new conservation-based strategy, practice, or technology do you think producers are least likely to try? (why?)

<u>Project Status</u>

- Now that we're into the 2nd year, how do you perceive your role on this project?
  - In your perception, has your role changed? (how? why?)
  - Is there an aspect of your role that you would like to change? (why?)
  - What is the most important feedback that you've received about your role in the project? (why was it important to you?)
  - What are your personal goals for the next 1-2 years of the project?
- Team dynamics on all large projects are complex.
  - What is the most difficult aspect for you? (why?)
  - What would you most like to change? (why?)
  - How might the team go about making this change?
  - What seems to be working best? (why?)
- Have you received any feedback from producers or other stakeholders?
  - Has this feedback influenced your approach to the project?
  - Has this feedback influenced your opinion about the way the project ought to be organized or operate?
    - Do you see a way to change the project to address this feedback?
- Have you listened to (or read) any of stakeholder interviews?
  - What sticks out for you as an important comment? (why?)

APPENDIX B: FFP(TD) MEETING SCHEDULE

Table 11: Future of Farming Meeting Dates by Region.

Date	Participants	Attendance	Content	Length
07/20/20	FFPRET	NA	Introduction & Project Prep	1:00:00
08/28/20	FFP(TD)	n=5	External Advisor Introductions	1:45:42
09/09/20	FFP(TD)	n=35	Key Extension Informational	0:58:23
09/24/20	FFP(TD)	n=21	South Stakeholder Informational	2:05:49
12/07/20	FFP(TD)	n=21	North Stakeholder Informational	1:41:00
12/09/20	FFP(TD)	n=17	Central Stakeholder Informational	4:00:00
12/11/20	FFPRET	n=9	Introductory Debrief	2:38:00
01/25/21	FFPRET	n=9	Cover Crop Field Day Prep	1:28:13
02/05/21	FFPRET	n=4	Collaborative Methods	1:08:52
02/08/21	FFPRET	n=11	Cover Crop Field Day Prep	2:53:00
02/17/21	FFP(TD)	n=25	Central Cover Crop Field Day	4:00:00
03/03/21	FFP(TD)	n=23	South Cover Crop Field Day	4:00:00
03/08/21	FFP(TD)	n=20	North Cover Crop Field Day	4:00:00
03/17/21	FFPRET	n=10	Cover Crop Field Day Debrief	1:44:00
04/09/21	FFPRET	n=7	Cover Crop Field Day Debrief	3:00:00
04/24/21	FFPRET	NA	Year End Debrief & Potluck	2:12:49
05/10/21	FFPRET	n=5	PI Collaborative Methods	0:52:26
05/13/21	FFPRET	n=14	Incentive Payments	0:59:34
05/21/21	FFPRET	n=10	Irrigation Field Day Prep	1:45:00
06/03/21	FFP(TD)	n=25	Central Irrigation Field Day	4:15:00
06/15/21	FFP(TD)	n=22	South Irrigation Field Day	3:30:00
07/15/21	FFP(TD)	n=27	North Irrigation Field Day	3:30:00
10/08/21	FFPRET	NA	Irrigation Debrief	2:00:00
11/02/21	FFPRET	n=5	PI Collaborative Methods	1:30:00
11/16/21	FFPRET	n=9	Indicators	4:00:00
11/29/21	FFPRET	n=8	Nutrient Mgt Field Day Prep	1:25:00
12/02/21	FFP(TD)	n=31	Central Nutrient Mgt Field Day	4:00:00
12/07/21	FFPRET	n=45	Nutrient Mgt Field Day Prep	1:30:00
12/09/21	FFP(TD)	n=38	South Nutrient Mgt Field Day	1:00:00

Key: FFPRET (Future of Farming Project Research and Extension Team) and FFP(TD) transdisciplinary Future of Farming Project.

APPENDIX C: CODE BOOK

Table 12: Code Book Definitions for Actors and The Specific Role They Play in The FFP(TD).

Concept	Actor Type	Definition
Actors		Role in the FFP (cases)
	1. Crop Consultants and Agronomists	1. Employed by the agricultural industry or a private company (i.e., Greenpoint Ag, Yara)
	2. Extension Agents	2. These are personnel who are in the counties only
	3. Extension Specialist and Professors	3. These are personnel that are embedded in the University and academic departments
	4. Farmers	4. Row crop producer
	5. Government Employees	5. Natural Resources Conservation Service, United States Department of Agriculture, Soil and Water Conservation Committee
	6. Other Researchers	6. Faculty, Students, and Post-Doctoral memebers

Table 13: Primary codes

Participant	Subcode/ definition	Theoretical connection	Connection to research question
Farmers	1. Opportunities 2. Identified needs 3. Name drops 4. Trails (facilitated, process, worked, not worked, observed)	1. What farmers want to achieve 2. Required for implementation success 3. To establish connections 4. What's been done previously	1. LB, NL 2. LB 3. NL, CK 4. CK, CM LB
Future of Farming Team	1. Unique skills 2. Past experience 3. Weaknesses 4. Co-development of knowledge, 5. Future goals 6. Convergence	1. Skills which are beneficial to the FFP 2. Have they done a similar project in the past? 3. What are they struggling with? 4. Goals of the project which incorporate our participants 5. Goals of the project which incorporate other research team members 6. Suggests primary investigator collaborator between subdisciplines	1. CK 2. CM 3. CK 4. CK 5. CM 6. CM
NRCS/Cooperative Extension/Crop Consultants	1. Opportunities 2. Identified needs 3. Name drops 4. Trails (facilitated, process, worked, not worked, observed) 5. Opinions	1. What NRCS/Cooperative Extension/Crop Consultants want to achieve 2. Required for implementation success 3. To establish connections 4. What's been done previously they have administered 5. Specific predispositions	1. LB, NL 2. LB 3. NL, CK 4. CK, CM 5. LB
Method of Interview	1. Video call, phone, text, face to face	1. Data collection method may influence answers	

Key: Limitations and barriers are that inhibit adoption of climate-smart technologies **(LB)**, ways in which communities can create a network of farmer learning sites **(NL)**, co-develop knowledge about climate-smart technologies **(CK)**, and Co-develop methods to dissemination information **(CM).**

Table 14: Secondary Codes.

Participant	Subcode/definition	Theoretical Connection	Research Question Connection
Farmers	1. Adaptation in adoption	1. This is intended to mean that the producer could not adopt as intended, so he/she changed the approach or technology in some way to make it workable	1. LB
	2. Awareness	2. NRCS Obj 6: Determine barriers and limitations of adoption. Knowing that they need to know something, includes climate change	2. CK, CM
	3. Barriers to adoption	3. Something that producer cannot get around - it's an obstacle that stops adoption	3. LB
	4. Behavior	4. NRCS Obj 6: Determine barriers and limitations of adoption. This is about a trait, not adoption per se	4. LB, NL
	5. Connections	5. New social connections among all stakeholders	5. NL, CK, CM
	6. Name drops	6. Identify who the interviewee speaks with and refers to - mentions by name	6. NL, CK
	7. Practice or technology change	7. Producers' practice change or new technology investment because of new research-extension team information	7. CK
	8. Data interpretation	8. How producers understand data/info from project	8. CK, CM
	9. Identified needs	9. Specific needs/wants	9. LB
	10. Knowledge	10. NRCS Obj 6: Determine barriers and limitations of adoption	10. CK, NL
	11. Limitation in adoption	11. A restriction but something that can be managed. It's a shortcoming or weakness (compare to barrier which stops adoption)	11. LB
	12. Opportunities	12. What CIG can do for the farmer potential research, engagement strategy.	12. NL, LB, CM, CK

	Something that might benefit the farmer. I wish I know about XYZ. Farmers identifying things that the R/E can be doing	
13. Peer-to-peer	13. Producer knowledge sharing (peer-to-peer communication)	13. NL, CK, CM
14. Practice or technology change	14. Producers' practice change or new technology investment because of new research-extension team information	14. CK, CM
15. Trails (administered, not worked, process, worked)	15. Explanation of on-farm trials and their success	15. LB, CK, CM
16. Incentive payments	16. References how to determine incentive payments	16. LB
17. Application of knowledge	17. Application of co-production and gaps between knowledge and action	17. CK, NL
18. Collaboration	18. Time investment, risks, and costs	18. CK, CM, NL
19. Participation	19. Inclusion and integration	19. CK, CM, NL
20. Power differences	20. Explain the hierarchy of participants and PI’s	20. LB
21. Trust relationship building	21. Communication, interaction, and engagement processes	21. CM, LB
22. Cooperative Extension programming- producer feedback	22. Cooperative extension programming changed in response to producers' feedback	22. LB, CK
23. Research design	23. Cooperative extension programming changed in response to Research-Extension Team meeting and/or conversation	23. LB, CM
24. Science	24. Knowledge of the science behind a particular practice or technology	24. CK, CM
25. Data interpretation	25. How producers understand data/info from project	25. CK, CM

	26. Knowledge inadequate	26. Lack of sufficient knowledge surrounding the topic	26. LB
	27. Motivation	27. Motivation to be part of a transdisciplinary project or participant in co-development of knowledge.	27. CK, NL
	28. Application of knowledge	28. Refers to co-developed knowledge. Purpose of co-developed knowledge is to develop solution-based, socially relevant, and usable knowledge.	28. CL, NL, CM
	29. Engagement strategy working	29. Success in collaborative engagement	29. CM, CK, NL
	30. Engagement strategy not working	30. Failure in collaborative engagement	30. LB, CM
	31. Reflexivity	31. Continuous, formative, evaluation	31. NL, CK, CM
	32. Team building	32. Evaluate connections and participation	32. NL, CM
	33. Teamwork, leadership, and support	33. Evidence of leadership	33. NL, CK
	34. Understand problem, objective, and methods	34. Signifies learning	34. CM, CK
Future of Farming Team (cooperative extension professors, other researchers)	1. Unique skills	1. Skills bringing to project	1. CK, CM
	2. Challenges	2. Identified difficulties in project	2. LB
	3. Concerns	3. Worries within project	3. LB
	4. Past experience	4. Work specific to peer-to-peer learning or convergence	4. CK, CM
	5. Weaknesses	5. Limitations to leading project	5. LB
	6. Co-development of knowledge	6. Behavior	6. CK, CM
	7. Future implications	7. Targets for post project implementation	7. CM, CK
	8. Convergence	8. Behavior	8. CM, CK

	9. Target goals	9. Goals for project	9. LB, NL, CM, CK
	10. Incentive payments	10. Opinions on how payments should be distributed	10. LB, CM
	11. Research design	11. Quality of planning	11. LB, CM
NRCS/ Cooperative Extension/Crop Consultants	1. Adaptation in adoption	1. Producer could not adopt as intended, so he/she changed the approach or technology in some way to make it workable	1. LB
	2. Awareness	2. NRCS Obj 6: Determine barriers and limitations of adoption. This is knowing that they need to know something, Includes climate change	2. CK, CM
	3. Barriers to adoption	3. Something that producer cannot get around - it's an obstacle that stops adoption	3. LB
	4. Behavior	4. NRCS Obj 6: Determine barriers and limitations of adoption. This is about a trait, not adoption per se.	4. LB, NL
	5. Connections	5. New social connections among all stakeholders	5. NL, CK, CM
	6. Name drops	6. Identify who the interviewee speaks with and refers to - mentions by name	6. NL, CK
	7. Practice or technology change	7. Producers' practice change or new technology investment because of new research-extension team information	7. CK
	8. Data interpretation	8. How producers understand data/info from project	8. CK, CM
	9. Identified needs	9. Needs and wants.	9. LB
	10. Knowledge	10. NRCS Obj 6: Determine barriers and limitations of adoption	10. CK, NL
	11. Limitation in adoption	11. A restriction, but something that can be managed. It's a shortcoming or weakness, (compare to barrier which stops adoption)	11. LB

12. Opportunities	12. What CIG can do for the farmer: potential research, engagement strategy. Something that might benefit the farmer. I wish I know about XYZ. Farmers are identifying things that the R/E can be doing, but are not yet	12. NL, LB, CM, CK
13. Peer-to-peer	13. Producer knowledge sharing (peer-to-peer communication)	13. NL, CK, CM
14. Practice or technology change,	14. Producers' practice change or new technology investment because of new research-extension team information	14. CK, CM
15. Trails (administered, not worked, process, worked)	15. Explanation of on-farm trials and their success	15. LB, CK, CM
16. Incentive payments	16. Referencing how to determine incentive payments	16. LB
17. Application of knowledge	17. Application of co-production and gaps between knowledge and action	17. CK, NL
18. Collaboration	18. Time investment, risks and costs	18. CK, CM, NL
19. Participation	19. Inclusion and integration	19. CK, CM, NL
20. Power differences	20. Explain the hierarchy of participants and PI's	20. LB
21. Trust relationship building	21. Communication, interaction, and engagement processes	21. CM, LB
22. Cooperative Extension programming-producer feedback	22. Cooperative Extension programming changed in response to producers' feedback	22. LB, CK
23. Research design	23. Cooperative Extension programming changed in response to Research-Extension Team meeting and/or conversation	23. LB, CM
24. Science	24. Knowledge of the science behind a particular practice or technology	24. CK, CM

	25. Data interpretation	25. How producers understand data/info from project	25. CK, CM
	26. Knowledge inadequate	26. Lack of sufficient knowledge surrounding the topic	26. LB
	27. Motivation	27. Motivation to be part of a transdisciplinary project or participant in co-development of knowledge.	27. CK, NL
	28. Application of knowledge	28. Refers to co-developed knowledge. Purpose of co-developed knowledge is to develop solution-based, socially relevant, and usable knowledge.	28. CL, NL, CM
	29. Engagement 30. Strategy working	29. Success in collaborative engagement	29. CM, CK, NL
	30. Engagement strategy not working	30. Failure in collaborative engagement	30. LB, CM
	31. Reflexivity	31. Continuous, formative, evaluation	31. NL, CK, CM
	32. Team building	32. Evaluate connections and participation	32. NL, CM
	33. Teamwork, leadership, and support	33. Evidence of leadership	33. NL, CK
	34. Understand problem, objective, and methods	34. Signifies learning	34. CM, CK
Method of Interview	Video call, phone, text, face to face	1. Data collection method may influence answers	

Key: Limitations and barriers are that inhibit adoption of climate-smart technologies **(LB)**, ways in which communities can create a network of farmer learning sites **(NL)**, co-develop knowledge about climate-smart technologies **(CK)**, and co-develop methods to dissemination information **(CM).**

Table 15: Tertiary Codes.

Parent code	Sub code 1	Sub code 2	Sub code 3	Definition
Actors				Role in the FFP (cases)
	1. Crop consultants and agronomists	1. Employed by the agricultural industry or a private company (i.e., Greenpoint Ag, Yara, etc.)		
	2. Extension agent	2. Agents who are in the counties only		
	3. Extension specialist and professor	3. Professors and extension specialists who are embedded in the university and academic departments		
	4. Farmer	4. Row crop producer		
	5. Government	5. NRCS, USDA, SWCC		
	6. Other researchers	6. Faculty, students, and post docs		
FFP research and extension team				Specific to the core FFP team
	7. Co-development	7. Needs to represent collaboration, knowledge exchange and integration		
	8. Challenges	8. Focuses on individual members' challenges, tough to understand, balance time. This the		

	"how do we do that" speed bumps
9. Concerns	9. Specific statements about concerns. Worries about another team member or farmers' understandings. This is a worry, but also something that can be over come
10. Convergence	10. Statements about collaboration and emphasis, some about breakdown on collaboration
11. Future implications	11. How to use this project to further their careers
12. Previous experience	12. Any opportunity or employment which provides insight into their position in the FFP
13. Research design	13. Research design changed in response to feedback from producers
14. Target goals	14. Individual or team goals relating to FFP project objectives
15. Unique skills brought to the table	15. Something specific to their profession or past experiences which

		provide insight into their roles		
	16. Weakness unsure	16. This is what the person does not know, struggles in getting the job done.		
Incentive payments				Relating to need, compensation, discussion, or allocation of incentive payments
Indicators				Indicators of adoption and limitations of the FFP
	17. Adoption		17. Of climate-smart technologies or practices	
		17.1 Adaptation in adoption	17.1 This is intended to mean that the producer could not adopt as intended, so he/she changed the approach or	

		technology in some way to make it workable
	17.2 Barriers to adoption	17.2 This is to represent something that producer cannot get around - it's an obstruction that stops adoption
	17.3 Limits to adoption	17.3 Something which does not provide a direct barrier to adoption but is a bump in the road or consideration
	17.4 Practice or technology change	17.4 Producers' practice change or new technology investment because of new research-extension team information, reduces chance of adoption
18. Application challenges		18. Of climate-smart technologies or practices
	18.1 Rate	18.1 Seeding, irrigation, nutrient specific
	18.2 Timing	18.2 Of seeding application, planting cover crops, irrigation scheduling, etc.
19. Behavior		19. NRCS obj 6: determine barriers and limitations of adoption. This is about a trait, not adoption per se.

		19.1 Opinions research and extension	19.1 Producers' opinions of the research information and extension programming	
	20. Connections		20. New social connections among all stakeholders	
		20.1 Name drops	20.2 Identify who the interviewee speaks with and refers to - mentions by name (if there's a connection in goes into connection)	
	21. Practice of technology change	21. Producers' practice change or new technology investment because of new research-extension team information		
Sustainability				Indicates an adoption which will combat the issues of climate change in agriculture
	22. Adaptations to climate change	22. Cover cropping, VRI, nutrient management, etc.		
	23. Evidence of climate change	23. Flooding, erosion, drought, etc.		

	24. Reluctance to associate with climate change	24. Explains evidence of climate change and fails to associate with "climate change"		
	25. Temperature or weather change	25. General reference of historical weather patterns		
Transdiciplinarity				Refers to research and learning among and with multiple disciplines which transcends traditional boundaries
	26. Process	26. How to advocate or carry out transdisciplinary research		
		26.1 Understanding problem, objective methods	26.1 Does the participant or FFP member understand the importance of convergence	

26.2 Teamwork, leadership, and support	26.2 Support and leadership supporting teamwork, establishing roles and responsibilities
26.3 Team building	26.3 Has to do with team dynamics and encouraging teamwork
26.4 Reflexivity	26.4 Continuous, formative, evaluation
26.5 Problem identification, goal setting, and research design	26.5 Identifies a project amongst FFP objectives which needs to be completed
26.6 Opportunities	26.6 What FFP(TD) can do for the farmer - potential research, engagement strategy. Something that might benefit the farmer. I wish I know about XYZ. Farmers are identifying things that the r/e can be doing, but are not yet
26.7 Identified needs	26.7 These are specific needs/wants. Something that is nice

		to know is coded as opportunity
	26.8 Engagement	26.8 Creating bottom-up opportunities which foster active learning strategies
	26.9 Peer-to-peer	26.9 Producer knowledge sharing (peer-to-peer communication)
	26.10 Engagement-strategy	26.10 Learning strategy or practice which fosters engagement and active learning
	26.11 Engagement-not working	26.11 An engagement practice which is not proven to be affective and why
	26.12 Application of knowledge	26.12 Refers to co-developed knowledge. Purpose of co-developed knowledge is to develop solution-based, socially relevant, and usable knowledge.
27. Motivations	27. Motivation to be part of a transdisciplinary project or participate in co-development of knowledge.	
28. Co-development	28. Has to do with synergistic problem	

	solving with and for producers and project stakeholders	
29. Science	References environmental science, engineering, social science, etc.	
30. Research design	Research design changed in response to feedback from producers	
31. Knowledge		31. NRCS obj 6: determine barriers and limitations of adoption.
	31.1 Knowledge-inadequate	31.1 The represented knowledge is not fulfilled or completely missing
	31.2 Data interpretation	31.2 How producers understand data/info from project
	31.3 Awareness	31.3 NRCS obj 6: determine barriers and limitations of adoption. This is knowing that they need to know something, includes climate change
	31.4 Information	31.4 Data, environmental, policy, incentive, etc.

	31.5 Extension programming-team feedback	31.5 Extension programming changed in response to research-extension team meeting and/or conversation
	31.6 Extension programming-producer feedback	31.6 Extension programming changed in response to producers' feedback
32. Challenges	32. Preventions from addressing the objectives of the FFP(TD)	
	32.1 Trust and relationship building	32.1 Communication, interaction, and engagement processes
	32.2 Power differences	32.2 May reproduce as personal conflicts, lack of information, or barriers
	32.3 Participation	32.3 Inclusion and integration
	32.4 Collaboration	32.4 Time investment, risks, and costs
	32.5 Application of knowledge	32.5 Application of co-prod and gaps between knowledge and action