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Inventory Audit of Texas A&M AgriLife Climate-Smart Agriculture Communication Materials

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Abstract

Climate-smart agriculture (CSA) aims to enhance productivity, build resilience to climate change, and reduce greenhouse gas emissions. It has been proposed as a foundational approach for agricultural systems to address the challenges of climate change while ensuring food security. While research has identified practices aligning with CSA, effective science communication and extension are essential for translating these discoveries into practical applications. Texas A&M AgriLife Extension Service plays a key role in this effort. The purpose of this study was to explore what educational materials about CSA are available from Texas A&M AgriLife Extension online outlets. Using a researcher-developed codebook, we conducted a quantitative inventory audit of online communication materials produced by Texas A&M AgriLife Extension. Key search terms such as “climate-smart agriculture,” “sustainable,” and “regenerative agriculture” were used to identify CSA practice materials. Results indicated that research publications were the most common type of content available, with few materials explicitly referencing CSA practices in their titles. The lack of easily accessible, action-oriented materials may limit extension agents’ ability to identify and share relevant information with producers. Further research is needed to assess the quality of and the level of trust in the content. These two factors influence people's decisions when sharing information. Further research is needed to evaluate how content availability affects extension agents' information-seeking and sharing behavior on CSA practices with farmers.

Keywords

Climate-smart agriculture, content analysis, Extension, science communication

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Introduction

Climatic factors such as solar radiation, temperature, and precipitation are crucial to agricultural productivity (James et al., 2014). Agricultural systems rely on the interactions between weather patterns and ecosystems, including soil, plants, and livestock. However, climate change is disrupting these patterns, making the agricultural industry increasingly vulnerable (Hatfield et al., 2020). To build more resilient food systems, the industry has undertaken significant efforts to conserve natural resources and mitigate climate-related risks. These efforts also aim to address concerns about the sector's environmental impact, particularly emissions that contribute to climate change (Freed et al., 2023).

Climate-smart Agriculture (CSA) is a concept introduced by the Food and Agriculture Organization of the United Nations (FAO) in 2010 during the Global Conference on Agriculture, Food Security, and Climate Change (Lou et al., 2024). It was proposed as a foundational approach for agricultural systems to address the challenges of global climate change for agricultural production and on-farm operations (Freed et al., 2023). CSA practices fall under three pillars: food security, adaptation, and mitigation. Food security refers to sustainably increasing agricultural productivity to improve economic access to safe, nutritious food sources that meet the dietary needs for a healthy lifestyle (FAO, 2008). Adaptation is building resilience to climate change, and mitigation means reducing or removing greenhouse gas emissions where possible (Freed et al., 2023). While these are independent pillars, CSA practices should not sacrifice or disregard one pillar to achieve another (Van Wijk et al., 2020). CSA practices can include, but are not limited to, cover crops, reduced tillage, maintaining waterways and improving water use efficiency, managing livestock waste, and implementing energy-efficient technology and machinery (United States Department of Agriculture [USDA], 2024). In the U.S, the adoption of these practices has been supported through initiatives such as the Climate-Smart Commodities Program (USDA, 2024) and the Inflation Reduction Act (Lalande, 2024). These programs have provided funding to support farmers in addressing climate change. Additionally, the Natural Resources Conservation Service (NRCS) has implemented programs that encourage the adoption of CSA practices (Guynn et al., 2024).

Agricultural extension services and science communication are the key to ensuring the advancements in CSA reach producers, turning science into the foundations of agricultural practices and impacting the daily lives of people worldwide (Parrella et al., 2023). Land-grant universities' extension services have a longstanding partnership with the USDA and NRCS (Prokopy & Power, 2015) and have been the primary institutions responsible for communicating CSA practices to local communities, ensuring the information is relevant to the needs of the farming community (Condon et al, 2023). Extension services engage directly with farmers, offering in-person workshops and guidance on adopting new practices. Although events such as field visits are considered highly effective and are often the preferred method of communication among producers, these events frequently involve communicating complex systems and concepts. To support understanding beyond the limited time of these events, supplemental educational resources and printed materials are essential (Brain et al., 2009).

To serve the agricultural sector statewide, there are multiple Texas A&M Extension Centers, with at least one county extension agent assigned to each county (Kelm, 2014). In addition to its county offices and research centers, Texas A&M Extension Services maintains an online presence through its websites and an educational online platform. The organization also engages audiences across various social media platforms, including Facebook, Instagram, X (formerly Twitter), YouTube, Spotify, and LinkedIn. These communication channels may serve as an educational structure to communicate CSA practices.

Although there are established communication channels and extension and education networks, it is unknown if they are producing communication or educational materials that contribute to the adoption of CSA practices, particularly considering the potential challenges of communicating climate-related topics. One such challenge is that CSA has sometimes been perceived as ambiguous or even used to "greenwash" agricultural products to appear more environmentally friendly than they truly are (Lalande, 2024). More broadly, climate change and related issues are often viewed as controversial, which can further limit communication on these topics (O'Neill & Nicholson-Cole, 2009; Powers et al., 2021).

Given the potential CSA has as a solution to climatic challenges Texas agricultural producers face, it is important to assess whether Texas A&M AgriLife has the communication resources available to help its county extension agents effectively educate farmers about these practices. Therefore, this study sought to evaluate the extent of CSA communication materials available through Texas A&M AgriLife Extension.

Literature Review

A strong consensus exists among scientists and professionals working within agriculture that climate change is a critical issue, although it remains a contentious topic among the U.S. public (Getson et al., 2021). Scientists feel a responsibility to provide information on these topics, but they acknowledge their views on climate change may differ from those of farmers and advisors, and that they should tailor information and delivery methods to effectively engage these audiences (Getson, 2021). Media, political, and public support is needed to advance climate change mitigation efforts and adoption strategies (Getson, 2021). The USDA has been funding research, extension, and education initiatives to help the agricultural industry become more resilient to climate change (Lalande, 2024). One of these investments was the USDA Partnerships for Climate-Smart Commodities program (USDA, 2024). The program was designed to help U.S farmers adopt climate solutions aligned with climate-smart agricultural practices, with $3 billion invested over 135 projects across the U.S. (USDA, 2024). The program covered many different commodity groups, with specialty crops and livestock and corn being some of the most represented commodities within the project and Texas being identified as growing climate-smart commodities is beef, cotton and small grains (USDA, 2024). While the Climate-Smart Commodities project had sufficient funding and projects, assistance for farmers to be involved focused on enrollment, with training materials being the least common type of assistance for farmers (USDA, 2024). To understand why training or informational materials may not be abundant in climate-smart programs, it is important to understand the current discourse toward CSA and potential barriers that may exist.

Examining the discourse and framing of CSA and CSA-related topics in the U.S. may reveal potential challenges and opportunities for communicating CSA (Diko et al., 2021). In 2009, research indicated the public may not have been ready for discussions about climate change causes and mitigation, as these topics could disengage the audience (O'Neill & Nicholson-Cole, 2009). Other studies have found a similar tension in communication about CSA. In a letter from the Institution for Agriculture and Trade Policy (IATP), 300 organizations were opposed to CSA (Lalande, 2024). Ben Lilliston, IATP climate director at the time, said, "The term 'Climate-Smart Agriculture' is really a marketing campaign for multinational agribusinesses and some governments that want to maintain the status quo" (Institute for Agriculture and Trade Policy, 2015, p. 1). He emphasized the need for clearer definitions of CSA practices to prevent corporations from using the label for branding or greenwashing, which is when something is marketed as more environmentally friendly than it actually is (Lalande, 2024). The inconsistent and ambiguous definitions for CSA have also been found in government documents and programs that have funded CSA implementation throughout the U.S. (Davila et al, 2024; Lalande, 2024). The media, through agricultural magazines, have also highlighted the economic burden CSA practices placed on farmers in the U.S., which could also contribute to possible challenges in the communication and adoption of CSA (Orton et al., 2024).

In the U.S., extension agents have used communication strategies focused on promoting CSA adoption and supporting farmers in improving production (Ikendi et al., 2023; Norton & Alwang, 2020; Wandersee et al., 2019). Extension professionals recognize they must use multiple information sources across various media to develop new programs and engage with clients effectively (Leal et al., 2020). The use of technology in distance education has been linked to extension agent success (Leal et al., 2020; Norton & Alwang, 2020). However, farmers continue to prefer traditional content such as printed materials including newsletters and extension publications (Leal et al., 2020; Norton & Alwang, 2020). Other studies have suggested that a balance of online extension publications and newsletters (linked to extension services websites) and printed material is needed, as not all farmers are equally connected to the internet (Norton & Alwang, 2020). Extension agents view downloadable fact sheets and brochures as content they would be very likely to use on a daily basis (Brain et al., 2009; Mastel, 2014), with research publications ranked as the most credible and trustworthy sources of information (Leal et al., 2020). Additionally, a multimedia approach from extension services can influence public opinion; therefore, extension programs should use digital graphics, videos, and audio-based content, which could significantly enhance outreach efforts and audience engagement (Leach, 2018).

Research on CSA material produced by land-grant universities is limited, though findings suggest that U.S. extension services have been urged to play a more active role in communicating climate-related scientific findings (Prokopy & Power, 2015). However, extension professionals face barriers in communicating climate information. They recognize climate change's potential impact on agriculture and are concerned about its effects and related challenges (Burnett et al., 2014; Diehl et al., 2017; Jones & Lenart, 2014). Barriers such as limited information resources, the prevalence of misinformation, and challenges in addressing potentially controversial topics hinder extension professionals' ability to communicate effectively about climate topics (Diehl et al., 2017; Leal et al., 2020). Social challenges also exist, such as the perception of others' wanting climate-related information and the perceived skepticism about the topic from those with whom extension agents interact (Becerra et al., 2016). While time to build the capacity to deliver CSA information exists (Worosz et al., 2024), access to local and relevant information that takes into account the client's current infrastructure and needs has been a challenge (Campbell & King, 2022). Beyond this specific context, other barriers impact Extension agents' ability to acquire career-specific competencies for their roles, such as lack of time, inadequate funding, ineffective training, educational resources, and credible information (Clifford & Monroe, 2018; Geston, 2021; Lakai et al., 2012).

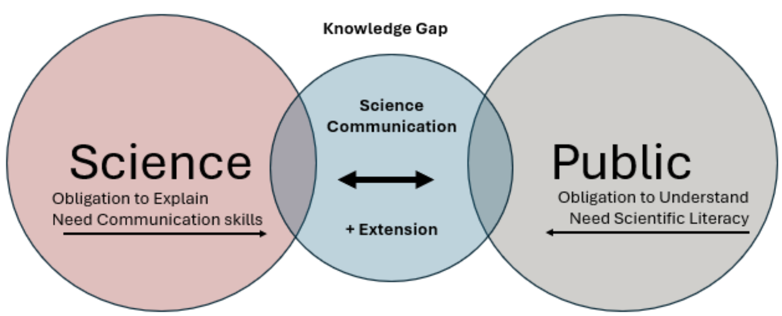
Within Texas, Texas A&M AgriLife Extension plays a key role in delivering information about agricultural innovations, such as CSA practices, to local producers (Leach, 2018). However, there is a significant gap in the literature regarding the types of communication materials used to convey CSA to various stakeholders through Texas A&M AgriLife, particularly those that support extension agents in sharing this information with producers.

Theoretical Framework

To understand how CSA practices are communicated, it is important to consider how science communication flows from research to the public and how these efforts support adoption. As science communicators and educators, extension agents facilitate the flow of information from scientists to the public by interpreting, translating, and sometimes simplifying scientific findings to convey key messages in ways that are easier to understand (Claessens, 2008). Traditionally, science communication has been credited with bridging a gap between experts, such as scientists, and non-experts, such as the general public (Cheng et al., 2008; Dijck & Alinead, 2020). The Gradient Model of Science Communication approach assumes experts possess knowledge, have an obligation to explain, and need communication skills to do so. (see Figure 1). This approach also assumes the public is less knowledgeable, has an obligation to understand, and must build their scientific literacy to do so (Cheng et al., 2008).

Figure 1

Adapted Conceptual Model Based on the Gradient Model of Science Communication by Hans Peter Peters (Cheng, et al., 2008)



However, the effectiveness of this communication is often hindered by the heterophilic gap, which describes the differences in knowledge, perspectives, and experiences between scientists or experts and the public (Porter & Dessai, 2017; Rogers, 2003). While this gap continues to challenge the goal of making science accessible and impactful for non-experts, science communication and extension aids in bridging the knowledge gap and can connect science to the public (O'Brien et al., 2024).

As communication has evolved, so has science communication and how scientific information flows to the public (Weingart et al., 2021). With the rise of news media, science has become a tool to enhance credibility and trust in information shared (Claessens, 2008). News outlets integrated storytelling into science communication, making complex concepts more relatable and helping people understand the broader impacts of scientific discoveries (Slosberg, 2024). There has also been a similar trend from governments and policies that have used science to build trust and reasoning when changing or introducing new laws and policies (Dijck & Alinead, 2020). The concept of trust has positioned scientists, policymakers, and the news media as gatekeepers of information, as described by the Institutional Model of Science Communication (see Figure 2; Dijck & Alinead, 2020). Social media platforms have transformed the Institutional Model of Science Communication, emerging as the central hub for information sharing. They enable information to be disseminated to wider publics rapidly and with little to no oversight (Dijck & Alinead, 2020; Moe et al., 2023). This shift has contributed to the development of the Networked Model of Science Communication, as illustrated in Figure 3 (Dijck & Alinead, 2020).

Figure 2

Institutional Model of Science Communication (Dijck & Alinead, 2020)

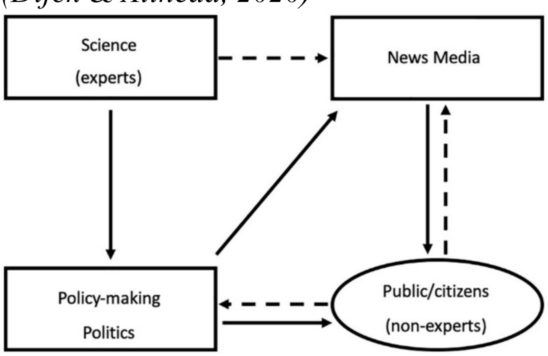
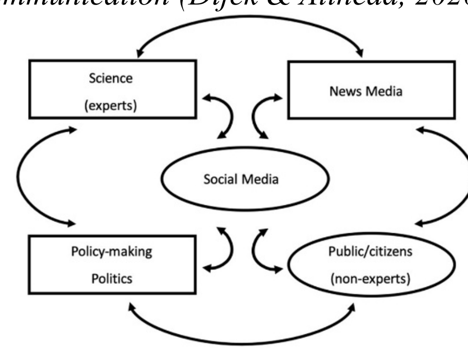


Figure 3

The Networked Model of Science Communication (Dijck & Alinead, 2020)



This study applied the Networked Model of Science Communication to examine what types of information are produced by different gatekeepers, including extension agents (Dijck & Alinead, 2020). While science communicators primarily translate scientific knowledge to raise awareness (Timothy et al., 2003), extension facilitates two-way learning between experts and the public (Klerkx et al., 2009). Rather than creating knowledge, extension leverages expert insights to empower individuals and communities, supporting the adoption of new practices and innovations (Black, 2000; Rogers, 2003). Communication materials further this process by deepening understanding (Rogers, 2003), positioning extension agents as gatekeepers alongside scientists and policymakers (Triplet, 2012). Using the Networked Model highlights the media and educational resources extension agents rely on to share information on CSA practices with farmers.

Purpose and Research Questions

The purpose of this research was to assess the quantity and types of communication assets produced by Texas A&M AgriLife Extension that could support county extension agents in communicating about CSA practices. By evaluating the availability of these resources, this study aims to identify strengths, weaknesses, and potential barriers that may limit extension agents' ability to access, share, or promote CSA-related knowledge. The following research objectives guided this study:

> **RO1:** Categorize the attributes of online communication materials related to CSA practices developed by Texas A&M AgriLife Extension
> **RO2:** Describe the types of communication materials used to disseminate information about CSA practices.
> **RO3:** Determine what CSA practices are represented through online communication materials that support different agricultural sectors.

Methods

To explore the quantity of information available to county extension agents at Texas A&M AgriLife Extension, a quantitative content inventory audit of online communication material was completed. A content inventory establishes the extent of communication material available and reveals patterns in content quantity and type (Land, 2014). Content inventories also include specific attributes of each piece, such as name, URL, subject matter, location, and format of each communication asset (Land, 2024). Using this approach determined the extent of available resources that could enhance county extension agents' ability to help farmers understand CSA practices and related foundational concepts. A content inventory audit also provides a summary of communication assets, offering insight into possible strengths and weaknesses (Winkler, 2018). This work was supported by the Sustainable Agricultural Systems Program grant from the USDA National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture.

Codebook Formation

To perform the inventory audit, a codebook was created to guide the search and collection of possible content. The following attributes were identified and recorded: channel, title, date of publication, cost, and URL. For content without titles, such as Facebook posts, written content was summarized in 14 words or fewer.

To establish the subject matter of the content collected, the following attributes were coded based on the information in the title of the communication asset: the CSA practice that it could contribute to, the type of agricultural sector it could support, and the format or type of communication that was used. Definitions of CSA practices were guided by the *Climate-Smart Agriculture and Forestry (CSAF) Mitigation Activities List for FY2025* (USDA NRCS, 2023). The following CSA practice codes were used: energy efficiency, forest management, land management, livestock management, natural resource management (NRM), soil conservation practices, sustainable cropping systems, waste management, and water management (see Table 1). There was also a category for communication assets that did not mention a pre-defined CSA practice.

Agricultural sector definitions were guided by the *USDA Agricultural Projections to 2032* (Interagency Agricultural Projections Committee, 2023) and summarized into the following sectors: cropping, forestry, horticulture, livestock, and natural resources (see Table 1). If more than two sectors were included, it was coded as “mixed operations,” and if it did not mention a specific operation, it was coded as “agriculture.”

Types of communication were also coded (see Table 1). Research publications were defined as peer-reviewed documents that present original research and are published in scholarly journals but captured through Texas A&M University online research library. Extension publications were identified as two-page summaries of research and information designed to be easily understood by farmers. Online courses were defined as educational modules, or structured learning labeled as a course on the Texas A&M AgriLife Extension online education resource library AgriLife Learn. Social media content included written digital posts and updates published through platforms such as Facebook and X. Podcasts were a form of information delivered through online audio platforms such as Spotify. Video content was established as audiovisual content published on social media platforms and YouTube. Finally, news and announcements included written updates, press releases, or stories published through AgriLife Today news outlet, typically used to highlight organizational news, research developments, or upcoming events.

Table 1

Attributes Assigned to Content

CSA Practice	Agricultural Sector	Type of Communication Asset
Energy efficiency	Cropping	Extension publication
Forest Management	Forestry	News and Announcements
Land management	Horticulture	Online courses
Livestock management	Livestock	Research publications
Natural Resources	Natural resources	Social media
Natural Resource Management (NRM)	Mixed operations	Podcast
No CSA Practice	Agriculture	Video

Sampling

An online search for content was conducted between January 5-10, 2025, and included content that was published on or before December 31, 2024. A preliminary search for Texas A&M AgriLife online platforms was conducted, which identified AgriLife Learn (agrilifelearn.tamu.edu), AgriLife Today (agrilifetoday.tamu.edu), and the Texas A&M University Scholars online research library (scholars.library.tamu.edu). For social media platforms where Texas A&M AgriLife could have multiple channels or pages, the term “Texas A&M AgriLife” was used to identify possible sources. Facebook, Twitter, Spotify, and YouTube accounts were identified as communication channels. Because Instagram and LinkedIn do not allow searches for content within a specific page, these platforms were not included as channels in this study.

The following search terms were used to find content within the identified online platforms: “Climate-Smart Agriculture,” “Regenerative Agriculture,” and “Sustainable.” These terms have strong links to CSA practices (Ashutosh et al., 2024) and ensured that all possible materials were found. From the content found through the initial search, only the items with the following terms within the title were included in the study: “Environmental,” “Weather,” “Drought,” “Carbon,” “Greenhouse gas,” “Renewable,” “Soil improvement,” “Conservation,” “Manure,” “Emissions,” and “Nitrogen.” Publications must have been created by AgriLife; content created by another outlet and shared by Texas A&M AgriLife was not included in the sample. This resulted in 254 items for further analysis.

Coder Training

Intercoder reliability was established following Krippendorf's (2004b) recommendations. Three coders attended a 30-minute training session to discuss definitions of CSA, agricultural sectors, and types of online communication material. Examples outside of the sample were provided to code as a group to ensure coders had an adequate level of understanding of the key variables. Before coders left the training, they were provided with the codebook, which included instructions, definitions, and coding categories for CSA practice, agricultural sectors, and types of publications. They were also given a list of content, which contained 10% of the items found through the online content search. The list contained the title, location, and URL for each item.

Following coder training, three coders independently coded the sample. Intercoder disagreements were handled through one-on-one training and feedback sessions. An online calculator called “ReCal3” (Freelon, n.d.) was utilized to calculate Krippendorf’s agreement coefficient alpha (Krippendorf, 2004a). Because sectors (Krippendorf $\alpha = .85$), CSA practice (Krippendorf $\alpha = 0.83$), and type of communication (Krippendorf $\alpha = 0.84$) involved some level of subjectivity, these were the only attributes for which intercoder reliability was established. All attributes had Krippendorf’s agreement coefficient alphas above 0.80, which indicates strong reliability for these variables (Neuendorf, 2017).

Data Analysis

Following the establishment of acceptance levels of intercoder reliability, the lead researcher went on to code the remaining content. Microsoft 365 Excel was utilized to collect, store, assign attributes, and analyze the data. CSA practice, sector, and type of communication attributes of the content were assigned and tabulated. Microsoft Excel’s built-in functions, including pivot tables, were utilized to conduct and summarize descriptive statistics, including frequencies. Summary data produced from the pivot table function were used to compare materials by type, date published, CSA practices, and to which agricultural sector they could contribute.

Limitations

This study has several limitations that should be considered when reading and interpreting the discussion and results. Due to time and resource limitations, the inventory audit was only conducted on online, public-facing communication materials that were published on Texas A&M AgriLife social media channels and websites. We acknowledge that Texas A&M AgriLife extension agents may develop their own communication materials and manage personal social media accounts, which they may use to share information on CSA practices not captured in this study. We also recognize that assigning communication attributes from information conveyed only in the content titles limits our ability to fully evaluate the contents of the communication materials.

Results

RO1: Categorize the attributes of online communication materials related to CSA practices developed by Texas A&M AgriLife.

Research objective one (RO1) was to categorize the attributes of online communication materials related to CSA practices developed by Texas A&M AgriLife, available to extension agents. Table 2 shows the attributes of the content found using the search protocol.

The most common type of content was research publications (*n* = 134, 52.8%) followed by social media (*n* = 56, 22.0%), then extension publications (*n* = 26, 10.0%). Announcements (*n* = 16, 6.3%) and news (*n* = 18, 7.1%) made up 13.8% of the content. Videos (*n* = 7, 2.7%), online courses (*n* = 4, 1.6%), and podcasts (*n* = 1, 0.4%) collectively accounted for the remaining 4.7% types of communication.

From the content found, 57.9% (*n* = 147) did not mention a specific agricultural sector and instead encompassed agriculture as a whole. Cropping (*n* = 55, 21.6%) and livestock (*n* = 30, 11.8%) were the most mentioned specific sectors, with 9.5% of the remanding content addressing forestry (*n* = 7, 2.8%), horticulture (*n* = 5, 2.0%), NRM (*n* = 5, 2.0%) or a mixture (*n* = 4, 1.6%). Similarly, 69.7% of the content (*n* = 177) did not mention a specific CSA practice. Among the identified practices, sustainable cropping (*n* = 20, 7.8%) was the most mentioned, though it accounted for only 7.8% of the content. Soil conservation (*n* = 17, 6.7%) and energy efficiency (*n* = 14, 5.5%) practices had a similar amount of content, with livestock management (*n* = 12, 4.7%), water management (*n* = 9, 3.5%), NRM (*n* = 4, 1.6%), and waste management (*n* = 1, 0.4%) all having less than 5%.

Table 2

Type of Communication, Sector, and CSA Practice of Communication Assets (N = 254)

Attribute	*f*	%	Mode
Type of Communication			Research Publication
Research Publication	134	52.8	
Social Media[a]	56	22.0	
Extension Publication	26	10.0	
News	18	7.1	
Announcements	16	6.3	
Online Course	4	1.6	
Sector			Agriculture
Agriculture	147	57.9	
Cropping	55	21.7	
Livestock	31	12.2	
Forestry	7	2.8	
Horticulture	5	2.0	
Natural Resources	5	2.0	
Mixed Operations	4	1.6	
CSA Practice			CSA Practice Absent
CSA Practice Absent	177	69.7	
Sustainable Cropping	20	7.8	
Soil Conservation	17	6.7	
Energy Efficiency	14	5.5	
Livestock Management	12	4.7	
Water Management	9	3.5	
NRM	4	1.6	
Waste Management	1	0.4	
Land Management	0	0.0	
Forest Management	0	0.0	

[a]Social Media category combined social media (*n* = 48), podcast (*n* = 1) and video content (*n* = 7).

RO2: Describe the types of communication materials used to disseminate information about CSA practices.

Research objective two (RO2) was to describe the types of communication materials used to disseminate information about CSA practices. Nearly 40% of the types of communication assets found were research publications but did not mention a CSA practice (*n* = 98, 38.6%; see Table 3). This included article titles such as *The Effects of Spatial Scale of Climate Scenarios on Economic Assessments: An Example From US Agriculture, and Farmers' Perception of Climate Change and Its Impacts on Agriculture.* Social media (*n* = 44, 17.3%) and news and announcements (*n* = 27, 10.6%) also predominantly did not mention a CSA practice with titles of content such as *Receiving the Largest Grant in History Climate-Smart Agriculture and Forestry Practices*. Research publications were also the most common type of content found for sustainable cropping (*n* = 11, 4.3%), energy (*n* = 9, 3.5%), and water management (*n* = 9, 3.5%)

practices (see Table 3). While water management practices were only communicated through research publications (n = 9, 3.5%), waste management practices were only referenced in one extension publication (0.4%). Extension materials were also the most common type of communication material found for livestock management (n = 8, 3.1%) and soil conservation (n = 6, 2.4%) practices (see Table 3). Soil conservation was communicated equally through social media content (n = 6, 2.4%). Sustainable cropping (n = 3, 1.2%), energy (n = 2, 0.8%), and NRM (n = 2, 0.8%) practices were also communicated through extension publications (see Table 3).

Table 3

*Frequency of Communication Material Used to Disseminate Different Types of CSA Practices (*N *= 254)*

CSA Practice	Research Publications		Social Media		Extension and Online Courses		News and Announcements	
	f	%	*f*	%	*f*	%	*f*	%
CSA Practice Absent	98	38.6	44	17.3	8	3.1	27	10.6
Sustainable Cropping	11	4.3	3	1.2	3	1.2	3	1.2
Soil Conservation	5	2.0	6	2.4	6	2.4	0	0.0
Energy	9	3.5	1	0.4	2	0.8	2	0.8
Livestock Management	2	0.8	1	0.4	8	3.1	1	0.4
Water Management	9	3.5	0	0.0	0	0.0	0	0.0
Natural Resource Management	0	0.0	1	0.4	2	0.8	1	0.4
Waste Management	0	0.0	0	0.0	1	0.4	0	0.0

X was the most common type of social media posts, followed by Facebook, then YouTube, with Spotify only having one piece of content (see Table 4). All online courses and extension content were found on AgriLife Learn (www.agrilifelearn.tamu.edu). Announcements and research publications were found on Texas A&M University Scholars (www.scholars.libary.tamu.edu). News and announcements were found both on *AgriLife Today* (www.agrilifetoday.tamu.edu), as well as Texas A&M University Scholars, with grant announcements being the common type of announcements found in this location.

Table 4

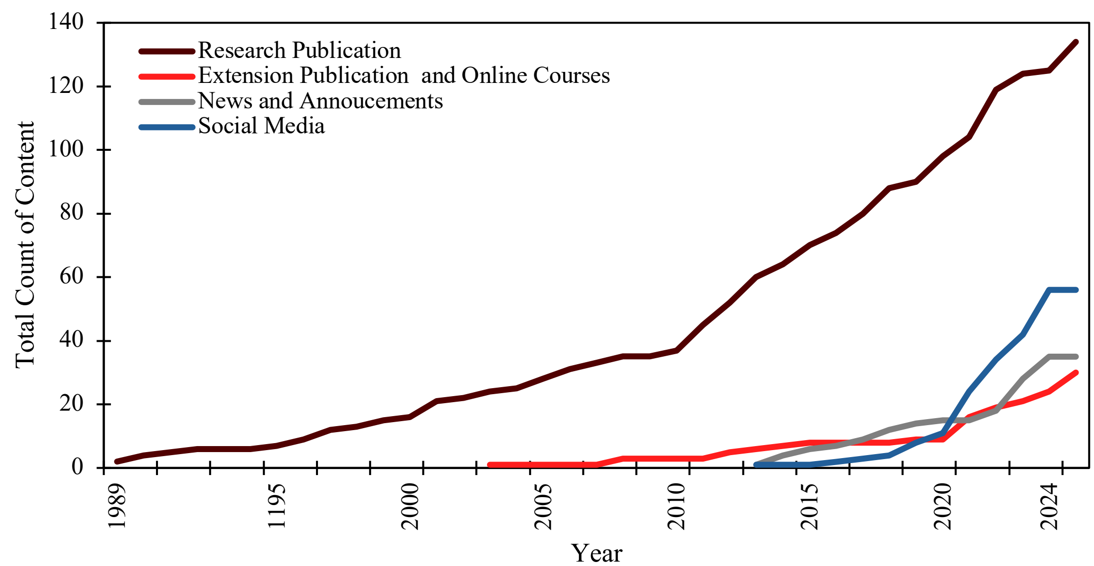
Location of the Different Types of Communication Material Used to Disseminate Different Types of CSA Practices (N = 254)

CSA Practice	Research Publications		Social Media		Extension and Online Courses		News and Announcements	
	f	%	*f*	%	*f*	%	*f*	%
Texas A&M Scholars	134	52.8	0	0.0	0	0.0	16	6.2
X	0	0.0	35	13.7	0	0.0	0	0.0
Facebook	0	0.0	13	5.1	0	0.0	0	0.0
YouTube	0	0.0	7	2.7	0	0.0	0	0.0
Spotify	0	0.0	1	0.3	0	0.0	0	0.0
AgriLife Learn	0	0.0	0	0.0	30	11.8	0	
AgriLife Today	0	0.0	0	0.0	0	0.0	18	7.0

As shown in Figure 4, content has been published since 1989. Research was the primary type of content until 2003 and continued to be the primary source of information with a sharp and continued growth after 2010. Online extension publications and courses started to be published in 2002, with slow growth until 2020, followed by a notable increase in available materials in subsequent years. Announcements and news content about CSA practices from Texas A&M AgriLife started later in 2013, with a rise in content from 18 to 35 between 2022 and 2024. Social media posts, including video and podcasts, also started in 2013 and followed a similar trend to that of news and announcements, with a rapid increase after 2021.

Figure 4

Accumulation of Types of Content on CSA Published from 1989 Through to 2024 (N = 254)



RO3: Determine What CSA Practices are Represented Through Online Communication Materials That Support Different Agricultural Sectors.

Almost 50% of the content found did not mention a specific sector or CSA practice (*n* = 127, 49.8%). The cropping sector had the most CSA practice communication material to support it (see Table 5). Communication material found for this sector included sustainable cropping (*n* = 18, 7.2%), soil conservation (*n* = 8, 3.1%), and water management (*n* = 3, 1.2%) practices. Communication material that did not mention a CSA practice (*n* = 24, 9.6%) was still found that could support this sector.

The livestock sector (*n* = 31) was the next most supported sector through communication material, although half of the content found for this sector did not mention a CSA practice (*n* = 15), for example, *Range Condition: Key to Sustained Ranch Productivity and Management and Economic Considerations for Beef Cow-Calf Producers During Challenging Markets or Adverse Weather Conditions* extension publications. Material that included a CSA practice for this sector primarily supported livestock management (*n* = 15, 4.7%) practices, with only one piece of content found for each of the following practices: energy (*n* = 1, 0.03%), soil conservation, and waste management (*n* = 1, 0.03%).

CSA material that could support the forestry sector only mentioned energy practices (*n* = 4, 1.6%), while horticulture was supported by one piece of content that mentioned a CSA practice, sustainable cropping (*n* = 1, 0.3%). Mixed operations were the least supported sector, with half of the material not mentioning a CSA practice (*n* = 2, 0.03%; see Table 5).

Table 5

*CSA Practices Represented Through Communication Material in Different Agricultural Sectors (*N *= 254)*

CSA Practice	Agriculture		Cropping		Livestock		Forestry		Horticulture		NRM		Mixed Operations	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
CSA Practice Absent	126	49.6	24	9.4	15	5.9	3	1.2	4	1.6	3	1.2	2	0.8
Sustainable Cropping	1	0.4	18	7.1	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0
Soil Conservation	8	3.1	8	3.1	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0
Energy	7	2.8	2	0.8	1	0.4	4	1.6	0	0.0	0	0.0	0	0.0
Livestock Management	0	0.0	0	0.0	12	4.7	0	0.0	0	0.0	0	0.0	0	0.0
Water Management	5	2.0	3	1.2	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4
NRM	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0	2	0.8	1	0.4
Waste Management	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0

Note. No CSA land management or forest management practices were found throughout all sectors.

Conclusions & Discussion

Given CSA's potential to help the agricultural industry address climate change challenges (Freed et al., 2023), it is essential that the science that informs these practices is accessible through resources that extension agents can easily locate and share with Texas agricultural producers (Sala, 2016). As an institution focused on enhancing research and extension, Texas A&M Extension Service plays a critical role in this process (Leach, 2018). Therefore, it is important to examine the types of information and resources available to extension agents that could support their efforts in educating farmers about CSA practices. The purpose of this study was to assess the quantity of communication material and types of content produced by Texas A&M AgriLife that could support Texas county extension agents in communicating CSA practices. The content inventory identified 254 pieces of content that were then analyzed to categorize their types, the agricultural sector present, and the CSA practices presented. These attributes were then used to recognize patterns and provide comparisons within the sample.

Overall, most communication was found in the form of research publications and did not mention a specific CSA practice. Research publications were the most common type of communication materials for sustainable cropping, energy, and waste management CSA practices. Due to the scientific nature of CSA, the substantial presence of research publications was expected. Social media was the second most abundant type of content, but considerably less than research publications. Soil conservation had mostly social media content, and livestock management practices had mostly extension publications and online courses. Additionally, there was also a notable gap in educational resources that could support extension agents sharing CSA practices with farmers in the form of online education courses or extension publications. These materials are critical in improving interpersonal communication (Rogers, 2003), which, along with workshops and seminars, are among the most preferred communication channels for producers (Orton, 2021; Triplett, 2012). This indicates that a balanced approach to communication material produced by Texas A&M AgriLife, recommended by Leach (2018), may not have been reached when communicating about CSA.

Science communication theories emphasize the need to translate scientific knowledge to bridge information gaps (Cheng et al., 2008; Claessens, 2008). Gatekeepers of this knowledge, such as scientists (Dijck & Alinead, 2020), acknowledge the importance of using diverse channels and strategies to reach varied audiences (Getson, 2022). While the Networked Model of Science Communication posits that social media has become a central hub for such engagement (Dijck & Alinead, 2020), this study suggests otherwise. This study found that research publications were the most abundant type of communication about CSA. Although social media was the second most abundant, it was considerably less, and a review of the social media content indicated it was predominantly news about staff and organizational achievements.

This finding suggests the flow of CSA information through Texas A&M AgriLife online communication platforms aligns more closely with the Institutional Model of Science Communication (Dijck & Alinead, 2020), where social media has not yet emerged as a central platform for communicating about CSA (see Figure 3).

Within this study, communication materials were primarily suitable for communication pathways between scientists, policymakers, and the news media, with limited resources available to support extension agents in bridging the gap between science and the public. This could limit Texas A&M Extension agents perceived behavioral control (Ajzen, 1991) in sharing information about CSA to producers and, in turn, increase agricultural systems' resilience to climate change.

Agricultural researchers who focus on climate risk mitigation agree that written research summaries, presentations, and websites are effective ways of communicating science, with research publications being a measure of the success of their research (Geston et al., 2018a). In contrast, extension publications are perceived as the least effective form of communication by these professionals (Geston et al., 2018a). This, combined with research publications being directly linked to promotion and tenure for scientists, could explain why research publications were the main source of information (Madden, 2004).

The final research objective for this study was to determine what CSA practices are represented through online communication materials developed by Texas A&M AgriLife that support different agricultural sectors. Almost 50% did not mention a CSA practice or a specific sector. Sustainable Cropping and Soil Conservation CSA practices had the most communication material, found mostly supporting the cropping sector. The next sector that was supported was livestock, with predominantly sustainable livestock management CSA practices. Other sectors, such as forestry, horticulture, and NRM, had minimal content mentioning a CSA practice that could support these sectors. These findings could be due to the limitations of this study, which only reviewed publicly available Texas A&M AgriLife resources and did not have the scope to look at internal communications or communication material Texas A&M AgriLife created but published on non-branded communication outlets. Although there is evidence (Dictson et al., 2015; Langford, 2011; Carney, 2014) that Texas A&M AgriLife is producing knowledge and communication materials targeted at these underrepresented sectors, this study found that such materials are not consistently available through Texas A&M AgriLife online communication channels. For instance, resources such as the *Riparian & Stream Ecosystem Education Program* (Dictson et al., 2015), and the article *Surviving Drought Through Agroforestry* (Langford, 2011) exemplify support for these sectors, they could not be found using this study's inventory audit procedure. Another possible reason few communication assets supporting sectors such as forestry, horticulture, and NRM were found could be linked to projects supported through the 2024 USDA Climate-Smart Commodities update, which identified cotton, beef, and grain as the top three climate-smart commodities produced in Texas (USDA, 2024). This focus may help explain why sustainable cropping systems, soil conservation, and sustainable livestock were the most frequently communicated CSA practices, as well as the limited representation of forestry and horticulture in this study.

Recommendations

This study found that much of the communication material produced by Texas A&M AgriLife about CSA was in the form of research publications. To help improve the flow of information from scientists to producers, Texas A&M AgriLife County Extension Agents, who are seen as a trusted source of information, should have access to a variety of communication materials. Leach (2018) also recommended that Texas A&M AgriLife move toward a more diverse approach to communicating with its stakeholders, such as producers. Specifically, creating short, printable educational resources focusing on specific CSA practices that can be distributed at events and field days would be an ideal endeavor. While in-person events are recognized as effective extension strategies, they require attendees to acquire a significant amount of information, which is often complex, in a short period of time (Dennis et al., 2025). Ensuring additional resources are available at events will improve deeper learning that is required to increase adoption of practices (Dennis et al., 2025; Kahneman, 2011).

The results also indicated that a few CSA practices are mentioned in the materials, which highlights the need to create more communication materials that address the range of CSA practices agricultural producers can employ. This could be due to the assumption that the communication assets' title was a true representation of the content of the material (Khan, 2023). We acknowledge that assigning CSA practices from what was mentioned in the title of the communication assets (rather than a full review of the content) is a limitation of this study. Further evaluation of the content within the communication assets may identify a broader range of communication materials that mention a specific CSA practice. Additional evaluation of the content would provide a more complete description of how CSA is being communicated and the quality of the materials.

This study was also limited to Texas A&M AgriLife public online communication channels. We did not have access to other content extension agents may access to gather information regarding CSA practices, such as personal resources or libraries. We did find evidence that Texas A&M AgriLife material had been created that was not captured in this study. For this reason, we recommend that Texas A&M AgriLife conduct an internal inventory content audit of possible communication assets that have not been made public through Texas A&M AgriLife-owned channels. We also recommend that future research assess the Texas A&M AgriLife research staff's, including extension agents, ability to contribute materials to public-facing Texas A&M AgriLife-branded and owned websites. Addressing potential barriers to resources and knowledge sharing within the organization will enhance the flow of information from scientists to the public (Cvitanovic et al., 2015). Furthermore, contributions to such communication efforts should be formally recognized in promotion and tenure evaluations of research and teaching faculty and staff, in addition to extension professionals.

While this study did assess the quantity of content, it did not assess the quality or trust in the information available. Just because information can be found does not mean it is usable or that the information is trusted enough to share with others (Dabrowski et al., 2014). An additional analysis of the trustworthiness of the information would help determine how well the content created meets the need for effective science communication. The Institutional Model of Science Communication (Dijck & Alinead, 2020) may serve as a useful framework for exploring how information flows from gatekeepers of information, such as scientists and policy makers, to agricultural producers. However, further research is needed to evaluate how other key information gatekeepers, such as extension agents, fit into this model when applied in the context of agricultural science communication.

Although there has been significant focus and investment in CSA practices prior to this study, changes in federal administration have led to inconsistencies in historical support

(Lalande, 2024). The Climate-Smart Commodity Program was largely responsible for funding the development of CSA practices (USDA, 2024). In 2025, the Trump administration transitioned that program into the Advancing Markets for Producers initiative (USDA NRCS, 2025). These changes may hamper the ability for this study to be replicated as the landscape of CSA changes because this terminology will not be widely used. However, this study could be replicated on other topics in agriculture beyond those directly connected to climate change and CSA practices. Doing so would allow researchers to determine whether the findings are consistent across different subject areas and ensure a wide range of agricultural science communication assets are being developed to support the broader agricultural industry.

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