Rural Broadband and Precision Agriculture: A Frame Analysis of United States Federal Policy Outreach under the Biden Administration

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Abstract: Global food security requires sustainable and resource-efficient agricultural production. Precision agriculture may provide the tools needed to intensify agricultural production while prioritizing sustainability; however, there are barriers such as initial investments, knowledge gaps, and broadband access that may hinder adoption. Many rural areas in the United States lack the appropriate infrastructure for broadband access needed for precision agriculture, indicating government policies are needed to expand broadband access. The purpose of this qualitative research study was to develop a conceptualization of the current frames used by the Biden administration in communications related to rural broadband and precision agriculture. The methodological framework used was frame analysis. Data were initially analyzed inductively for overall gestalt and subsequently analyzed with abductive coding. Five overarching frames were identified during the data analysis process: broadband access and economic issues, garnering support for broadband expansion, urgency and equity surrounding broadband, expanding beyond the rural, and broadband infrastructure and the agricultural sector. The findings revealed broadband access associated with the Biden administration expanded beyond rural areas, recognizing that cities also face broadband access and affordability issues. There was a lack of discourse, however, surrounding rural broadband policy and precision agriculture, which may downplay its importance in agricultural sustainability.

Keywords: outreach; precision agriculture; policy; rural broadband; social sciences

1. Introduction

Sustainable and resource-efficient agricultural production is required to ensure global food security in the 21st century as population and living standards increase [1]. Yet, intensive conventional agriculture is responsible for a large portion of biodiversity loss and climate change, among other long-term environmental damage, that may limit agricultural production in the future [1–4]. Precision agriculture, a farm management system that utilizes numerous technologies to optimize resource input and maximize output [5], may provide the tools needed to intensify agricultural production while prioritizing sustainability [6]. Common examples of precision agriculture technologies include data collection (e.g., remote sensing), data processing (e.g., geographical information systems), and application (e.g., variable rate application) [7].

Precision agriculture emerged in the mid-1980s to manage fertilizer distribution and has since evolved into an information-based management system that has been successfully applied in crop production, horticulture, livestock production, and pasture and turf management [5]. The widespread development of internet and mobile technologies around 2010 enabled precision agriculture to develop web services resulting in technologies like high resolution imagery and computer-assisted equipment [8]. According to Liu et al. [9],...
“the development of precision agriculture technology is one of the most promising ways to raise farming efficiency and achieve environmental, social, and economic sustainability”.

The United States (U.S.) leads the globe in precision agriculture technology adoption [7]. Among more industrialized countries in the Global North, Australia, Canada, Germany, Finland, Denmark, and Sweden also have high rates of precision agriculture adoption [7]). Farm size is an important factor in decision to adopt precision agriculture technologies, and farms in the U.S., Australia, and Canada tend to be larger than other countries, leading to an increased adoption of precision agriculture [7]. In lesser industrialized countries in the Global South, precision agriculture technologies were used to some extent by Argentina, Brazil, South Africa, and Turkey, and have increased in popularity over the last decade [7].

Precision agriculture has numerous social and environmental benefits; however, the benefits of precision agriculture are not easily quantified due to the diversity of application across multiple scenarios [5]. For example, environmental benefits of precision agriculture compared to traditional agriculture include the potential to mitigate agricultural greenhouse gas emissions [2], reduce waste from fertilizer and pesticide application, and preserve water quality [3,10]. Social benefits are often measured through aspects of sustainability that influence society, such as water pollution, greenhouse gas emissions, and biodiversity loss [10]. Precision agriculture technologies also have an opportunity to directly or indirectly play a role in the future of global food security by improving the farm management system [10]. For example, crops nutritional quality can be influenced by precision agriculture since factors like fertilizer application impact quality. In addition, precision agriculture may increase profitability for farmers [10] and improve the quality of their work environment [5]. van Evert et al. [10] explored the application of precision agriculture technology on olive production, which is major crop in Greece, and potato production in relation to sustainability, social profit, and profit. Precision agriculture reduced potassium fertilizer by 31%, phosphate fertilizer by 59%, and lime by 86% for olive production. Pesticides were reduced by 23% and nitrogen fertilizer was reduced by 15% in potato production, and profits increased by 21%.

There is great potential to use precision agriculture to increase sustainability but the initial financial investment [11], knowledge gaps [12], lack of awareness of its benefits [13], and broadband access may hinder adoption [11]. Precision agriculture can only be adopted by farmers who have access to broadband due to the technological requirements [1]. Although lack of broadband access is often associated with countries that have developing economies [14], many rural areas in the U.S. do not offer access to broadband due to a lack of adequate infrastructure [15]. According to the 2019 Broadband Deployment Report, high-speed fixed service internet was only accessible by 26% of rural U.S. residents in 2017 [15].

Governmental policies are needed to promote responsible and sustainable agricultural production [4]. Lieder and Schröter-Schlaack [1] called for governments to “take on a proactive role in [. . .] providing the necessary infrastructure” for smart farming. Recent research on precision agriculture has focused on identifying farmer barriers to adoption [13,16], often framed through Rogers’ [17] diffusion of innovation theory which explores how to reduce barriers to adopting an innovation and how populations perceive the receptivity of innovations to their lives [18,19]. However, policy-related barriers to technology adoption needed for precision agriculture have rarely been explored. Exploring discourse around broadband policy, specifically related to precision agriculture technology adoption, may reveal gaps in outreach as well as help assess what populations may be excluded from discourse, thereby limiting the equitable effects of an innovation [20]. Thus, the purpose of this study was to explore U.S. policies and associated outreach on broadband access implemented under the Biden administration in an effort to identify policy gaps that could be remedied to ensure rural farmers in the U.S. have the ability to adopt precision agriculture.
Overview of U.S. Broadband Policy in the Trump and Biden Administrations

Issues within U.S. broadband networks have been recognizable for years with broadband services in the U.S. costing more than other economically-comparable countries. Millions of U.S. citizens cannot access or afford broadband services, and the companies providing broadband networks do not face much competition [21]. The COVID-19 pandemic exacerbated these issues and helped bring concerns about broadband access to the forefront of many political conversations, affirming just how important internet connectivity is to the U.S. economy and to prosperity within rural communities [22,23]. In 2020, as a direct result of the COVID-19 pandemic, there has also been increased attention on broadband access in the U.S. due to concerns around equity and the digital divide, in which disadvantaged communities have been left behind in an increasingly technological society [24].

The onset of the COVID-19 pandemic originally occurred in the Trump administration, but 18 months later, the country under the Biden administration remains deluged with the threat of COVID-19 and the rising Delta variant of the virus. Thus, examining broadband policy and how it evolved within and beyond the Trump presidency should shed light on broadband policy trajectory and future directions for expansion as COVID-19 pushed broadband access further onto the political stage.

The Trump administration proposed an infrastructure package of $1.5 trillion of state, local, and private investments which would be spent on broadband expansion and other infrastructure developments [25]. This proposal did not advance within Congress and ultimately failed. In 2019, the Federal Communications Commission (FCC) created the Rural Digital Opportunity Fund (RDOF), reorganizing an existing rural broadband subsidy program, aiming to provide broadband to more than six million homes and businesses that did not have broadband access [25]. The RDOF aimed to expand broadband access specifically to rural areas during the pandemic as well as remove federal barriers to telehealth and virtual learning services [24]. In addition to the RDOF through the FCC, the Trump administration announced the U.S. Department of Agriculture would invest $86 million in rural broadband expansion through loans to telecommunications providers to build and expand broadband services in Alabama, Arkansas, Iowa, Illinois, Indiana, Tennessee, Texas, and Wisconsin [23]. In 2020, the USDA ultimately invested $744 million in broadband expansion across 172,000 homes, 19,000 rural businesses and farms, and more than 500 health care, educational, and other community facilities in 34 states [23].

The 2020 Presidential election in the U.S. further advanced political discussions surrounding rural broadband access by comparing the candidates’ positions on broadband expansion. Both candidates supported broadband expansion but through different mechanisms. Much of the candidates’ policy plans were influenced by their approaches to technology innovation: Trump focused primarily on reducing governmental economic barriers, while Biden felt the government could partner with industry to set a technology and innovation agenda [25]. Additionally, Biden positioned himself as a tough regulator of technology industries and focused innovation policy on social betterment goals including revitalizing distressed communities and supporting opportunities for disadvantaged groups [25].

During his campaign, Biden promised to expand broadband access to every citizen and committed to invest $20 billion in rural broadband as part of an infrastructure package. Additionally, he planned to triple USDA rural broadband grants and partner with municipal utilities industries to increase broadband in rural areas [25]. Once Biden was elected, his administration proposed a $2.3 trillion infrastructure package which included $100 billion to connect all U.S. citizens to broadband [21]. In this proposal, the government would take a larger role in improving high-speed internet service, signaling a new direction in broadband policy, which had previously been left to private companies. The administration shifted policy direction toward government intervention in an effort to reduce costs to consumers rather than subsidizing broadband providers to build networks, a move catalyzed through “recognizing that poverty is a bigger indicator of lack of access than geography” [21]. This
shift in discourse represented a policy change from focusing on only broadband access but also broadband affordability [22].

In 2021 the U.S. Senate passed the infrastructure bill with an uncommonly bipartisan vote split [26]. The bipartisan infrastructure bill represented the largest package of digital initiatives and the largest single investment in broadband expansion in the history of the U.S. [27]. The bill contained $65 billion for broadband access to rural areas, low-income families, and tribal communities, with money made available through grants to states [28].

Digital infrastructure is a key driver in the U.S. economy and global competitiveness, as well as an important aspect of quality of life for U.S. citizens [25]. Expanded broadband access in rural areas is needed to ensure “connected agriculture technologies . . . [for] greater productivity and profitability for small producers . . . and undermin[es] potential advancements in food security, food safety, and environmental sustainability” [29]. While precision agriculture technologies have potential for increasing the environmental sustainability of production agriculture, precision technologies require high-speed internet connections to facilitate the collection and transmission of large amounts of data, a barrier for many agricultural producers in rural areas [29]. As broadband access evolves on the political stage, a conceptualization of the current frames used to communicate about broadband policy may help drive current and future directions for universal broadband access, as well as industries, innovations, or populations that might be excluded from these conversations.

2. Materials and Methods

The purpose of this qualitative research study was to develop a conceptualization of the current frames used by the Biden administration in communications related to rural broadband and precision agriculture. Research questions guiding the current study included:

1. What frames does the Biden administration use when discussing broadband policy?
2. What do the broadband policy frames used by the Biden administration imply is important to the current policy discussion?
3. What do the broadband policy frames used by the Biden administration exclude from discussion?
4. To what extent are the broadband policy frames used by the Biden administration associated with precision agriculture?

2.1. Methodology: Frame Analysis

The methodological framework for the current study was frame analysis, a method for analyzing policy topics initially developed through the work of Schön and Rein [30]. Frame analysis is a tool for understanding “the construction of meaning and its effects . . . and the responsiveness of the strategic use of ideas” [31] within a policy discussion through focusing on “human interaction, discourse, and the social construction of reality” [32]. Frames are important concepts for understanding policy processes, specifically within problem identification and agenda formation, as a framework to politicize policy discussions by helping relate policy outcomes to individuals’ and groups’ value systems [33]. Epistemologically, frame analysis moves away from an objectivist, positivist worldview toward the constructivist tradition concerned with the social construction of meaning [31,34]. Frame analysis draws attention to the way politicians and other actions shape public perceptions around an issue by communicating recommendations for problems through broad cultural metaphors and resources in the public sphere [35]. Within frame analysis, policy concepts, such as climate change or broadband access, are viewed not as a set of facts surrounding an issue but rather a concept used by stakeholders to construct, identify, and gain support of certain policy positions while simultaneously creating a policy community related to the current issue [35].

Frame analysis often involves two key tasks: identifying how meaning has been constructed around a specific policy context and identifying how certain frames affect policy actors’ behavior and political outcomes [31]. One framework for analyzing the discourse around a specific topic within the policy realm is the frame institutionalization
process (FIP). The FIP can “capture the struggle of meaning within policy processes and distinguish between the varying influences of different frames over space and time” [31]. Institutionalization of a frame often references institutional change at the macro-level; however, institutionalization can also involve a discussion in which a policy frame slowly gains influence and regulative presence and function. Examining the extent to which a policy frame becomes institutionalized, in combination with thick descriptions of frames, can help capture the construction of meaning for a concept or issue within the public political sphere [31].

The FIP consists of four stages: (1) reaching the political agenda; (2) support from a coalition of actors or key actors; (3) official acknowledgement; and (4) formal institutionalization [31] (Figure 1). The first stage, reaching the political agenda, occurs when a frame enters into policy discussions and are explicitly discussed in relevant political venues. In the second stage, support from a coalition or key actors, a frame is expressed by relevant key actors, such as politicians or spokespersons, and advocated for by the actors. The third stage, official acknowledgement, occurs when a frame is expressed in official governmental statements or when actors participating in the policy debate acknowledge the frame by releasing statements in favor of or dissenting with the frame. In the final stage, formal institutionalization, a policy frame becomes expressed formally, often through legislation [30].

![The Frame Institutionalization Process (FIP) Ladder. Adapted from Björnehed & Erikson [31].](image)

Rural broadband policy has only recently entered widespread public consciousness; however, with the advent of the Biden administration and the broadband access issues exacerbated by COVID-19, broadband expansion has quickly climbed the FIP ladder. However, this stage can be described as “official acknowledgement” within the frame institutionalization ladder [31], as the Biden administration appointed Vice President Kamala Harris to oversee the broadband expansion directive. Additionally, rural broadband expansion straddles the line between official acknowledgement and formal institutionalization through the Bipartisan Infrastructure Bill recently signed into law in November of 2021 by President Biden. Analyzing the discursive construction of frames related to rural broadband and precision agriculture can both foreshadow future policy directions and contentions as well as illuminate potential areas left out of current discourse.
2.2. Data Collection

Data collection occurred on 16 July 2021 for all documents from the Biden administration’s communication and outreach documents related to broadband policy. Only documents from the start of the Biden administration in January of 2021 to the data collection date were analyzed. This data collection range included communications announced regarding the Bipartisan Infrastructure Framework that was being negotiated in Congress at the time of data capture (16 July 2021). The framework was aimed at “transformational and historic investments in clean transportation infrastructure, clean water infrastructure, universal broadband infrastructure, clean power infrastructure, remediation of legacy pollution, and resilience to the changing climate” [36]. A search was conducted for “rural broadband” on whitehouse.gov for the administration’s communication and outreach documents. Analysts searched the resulting documents for references to broadband, rural communities, and precision agriculture. Those without reference to these concepts were excluded from data analysis. Data collection included 24 communication and outreach documents on the whitehouse.gov website, including press briefings, fact sheets, remarks by Vice President Harris, and announcements for key events.

2.3. Data Analysis

Data were initially analyzed inductively for overall gestalt. Abductive coding, an iterative process involving a combination of inductive and deductive reasoning followed using research questions to guide an in-depth analysis of the data [37]. Data were analyzed separately by two coders using open coding, followed by axial coding, where the researchers made connections between codes derived from the open coding process [38,39]. Data analysts used MAXQDA software version 20.2.2 for analysis through the constant comparative method, which included identifying axial codes present in multiple transcripts [40]. Interrater reliability (IR) was conducted to determine agreement for code development between the two coders before the analysis process began [41]. Analysts calculated interrater reliability after coding two sets of identical documents, resulting in Cohen’s kappa of 0.86 and 0.71, which were deemed adequate based on literature [42]. After calculating interrater reliability, analysts met to determine convergences and divergences between developed codes. Full analysis then ensued, with each analyst coding separate documents with codes discussed throughout the coding process. Finally, codes were debriefed with a third researcher to ensure transferability of the results.

3. Results

Overarching frames identified during the data analysis process were broadband access and economic issues, garnering support for broadband expansion, urgency and equity surrounding broadband, expanding beyond the rural, and broadband infrastructure and the agricultural sector. Table 1 provides an overview of each frame and key findings contextualizing each frame.

Table 1. Frames and key findings.

| Frame                                      | Key Findings                                                                                   |
|--------------------------------------------|-------------------------------------------------------------------------------------------------|
| Broadband access and economic issues       | • Affordable, high-quality, and reliable broadband is needed                                    |
|                                            | • Americans pay more for internet than other comparable countries                              |
|                                            | • The lack of internet providers makes market price higher                                     |
|                                            | • Low-income and marginalized neighborhoods may encounter landlord arrangements with internet providers that inhibit renters from infrastructure expansion |
|                                            | • Inability to access affordable and reliable broadband limits economic sectors like healthcare, jobs, and education |
Table 1. Cont.

| Frame                                      | Key Findings                                                                 |
|--------------------------------------------|-----------------------------------------------------------------------------|
| Garnering support for broadband expansion  | • Non-partisan issue                                                         |
|                                            | • An urgent issue across America (e.g., rural, low-income, inner city)       |
| Urgency and equity surrounding rural broadband | • “The new electricity” because broadband is needed for the modern economy |
|                                            | • Rural areas and tribal lands lack access                                    |
|                                            | • Racial disparities in access to broadband                                  |
| Expanding beyond the rural                 | • Terminology shifted from “rural broadband” to “universal broadband infrastructure,” expanding the target audience |
| Broadband infrastructure and the agricultural sector | • Accelerating precision agriculture                                          |

3.1. Broadband Access and Economic Issues

The most common frame used within communication and outreach documents by the Biden administration was broadband access and economic issues. These outreach artifacts often framed access to broadband as an economic issue. Emphasis was placed on the high cost of internet in the U.S. and future direction:

President Biden believes that building out broadband infrastructure isn’t enough. We also must ensure that every American who wants to can afford high-quality and reliable broadband internet. While the President recognizes that individual subsidies to cover internet costs may be needed in the short term, he believes continually providing subsidies to cover the cost of overpriced internet service is not the right long-term solution for consumers or taxpayers. Americans pay too much for the internet—much more than people in many other countries—and the President is committed to working with Congress to find a solution to reduce internet prices for all Americans, increase adoption in both rural and urban areas, hold providers accountable, and save taxpayer money.

There were also economic disparities related to broadband access:

More than 200 million U.S. residents live in an area with only one or two reliable high-speed internet providers, leading to prices as much as five times higher in these markets than in markets with more options. A related problem is landlords and internet service providers entering exclusivity deals or collusive arrangements that leave tenants with only one option. This impacts low-income and marginalized neighborhoods, because landlord-ISP arrangements can effectively block out broadband infrastructure expansion by new providers.

The economic frame for broadband access emphasized its impact on the various economic sectors, including healthcare, education, and small businesses, often situated in the COVID-19 context. For example:

Broadband impacts our economy. It impacts our education system, our healthcare system. And I’m talking about small business owners who don’t have the literal bandwidth to grow their businesses; students who can’t study at home, who have to drive to the local McDonald’s, to the parking lot, to get access to their WiFi; seniors who haven’t seen their doctor because, in the middle of a pandemic, telemedicine is not an option for them.

In addition, response to the COVID-19 pandemic highlighted the need for adequate broadband in the home:

There are areas like broadband, which maybe is not a physical bridge, but one third of the country doesn’t have access to broadband. So that impacts workers—
workers who have been working from home; kids who are trying to learn at home; parts of the country where they can’t have jobs where they’re working remotely.

Similarly, response to the COVID-19 pandemic emphasized the need for adequate broadband to participate in healthcare. For example:

Live in a remote or rural area without a vaccine near you? [. . . ] we will announce a call-in number designed for people without broadband or cell phones where we will help people make appointments and remove other barriers preventing them from getting vaccinated.

There was also a sense of urgency surrounding broader needs for broadband in education—“kids can’t do their homework without access to the Internet. You know, some of us had Encyclopedia Britannica. Well, let me tell you, that is a day gone by”. There was a similar sense of urgency regarding the survival of small businesses:

For a small business to actually survive, much less thrive, they need access to high-speed Internet to be able to move their product, to advertise their product, and to engage with their customers.

3.2. Garnering Support for Broadband Expansion

The most common frame found in the communication and outreach documents was garnering support for broadband expansion. Rural and universal broadband expansion was framed as a bipartisan issue by the Biden administration. Emphasis was placed on helping the American people, specifically rural communities, regardless of political affiliation. For example:

The President doesn’t believe that’s a political issue. Whether it’s roads, railways, bridges, access to broadband—access to broadband is an issue that is certainly the case—a challenge, I should say, in inner cities and lower-income communities, but is also an issue across rural America—many parts of the country that are redder, in the political sense, and have more predominantly Republican populations. I think what our focus is going to be on is continuing to communicate the different components of these—this package and how it’s going to specifically help the American people.

Support for rural broadband was also directly stated as a bipartisan issue. For example:

He’s going to make the argument for why [. . . ] investing in broadband—including in rural areas—are all not only commonsense areas where we’ve seen and continue to see bipartisan support and, in fact, bipartisan urgency [...] but they’re also really important to people, to communities all across the country right now.

3.3. Urgency and Equity Surrounding Rural Broadband

Rural broadband was also framed as an urgent and current issue. The urgency for rural broadband was expressed through defining broadband as “the new electricity”. Population statistics, including the percent of rural U.S. citizens who do not have access to broadband, were often used to express urgency. For example:

I can tell you this: Every single business leader I’ve talked to applauds the fact that this package is more than just roads, bridges, and water. Like, come on, 35 percent of Americans in rural areas don’t have broadband. You cannot have a modern economy without that.

There was also an urgent need to make broadband more affordable for rural U.S. citizens. Access and affordability issues were identified frequently within the outreach documents. For example:

The world runs online. And yet, millions of Americans, many of whom live in rural America, do not have access to broadband. And if they do, it is not affordable.
Framing rural through the lens of numerous social considerations expressed the intersection of broadband access with other equity issues. Emphasis was placed on rural areas and tribal lands who lack access to broadband. For example:

More than 35 percent of rural Americans and Tribal communities lack wired access to broadband at acceptable speeds. The Bipartisan Infrastructure Framework invests $65 billion, including through USDA rural broadband programs, to make high-speed internet available to all Americans, bring down high-speed internet prices across the board, and provide technical assistance to communities seeking to expand broadband.

There were also racial disparities in broadband access. For example:

It’s a national disgrace that African American families are 9 percent less likely to have high-speed Internet than their white peers, and Latino Americans are 15 percent less likely.

Rural broadband was framed as an investment by the Biden administration. Emphasis was placed on the need for broadband to engage in daily activities, furthering the importance of increased accessibility as a result of broadband expansion. For example:

Finally, we need strong investments in our broadband infrastructure. We’ve seen more clearly than ever before that high-quality, affordable broadband isn’t a luxury, but it’s a necessity for education, jobs, and healthcare. But millions and millions of Americans don’t have access to broadband, particularly in rural communities.

Racial disparities were also included in the discussion about investment:

[ . . . ] the President [ . . . ] is leading us to build back better, that means we need to do so more inclusively and ensure that these investments that we are making—in broadband, in housing, in the care economy, in water—are in every community in America: rural, tribal, urban, communities of color, and reaching everyone across America.

3.4. Expanding beyond the Rural

The communication and outreach documents by the Biden administration also framed more general needs of rural broadband and expanding the conversation beyond rural areas. Rather than discussing “rural broadband” as used in previous administrations, the Biden administration began shifting toward the use of “universal broadband infrastructure”. This frame shift included audience expansion, such as “connect every American to reliable high-speed internet,” rather than specifically focusing on rural citizens. Another example of the audience shift was from Vice President Harris: “The President and I are determined to make sure that every person in our country can access broadband and afford it”.

3.5. Broadband Infrastructure and the Agricultural Sector

The communication and outreach documents by the Biden administration framed rural broadband as important for precision agriculture in one statement:

Broadband internet is the new electricity. It is necessary for Americans to do their jobs, to accelerate precision agriculture, to participate equally in school learning and health care, and to stay connected.

Any other mentions of agriculture in the communication and outreach documents referred to the Bipartisan Infrastructure Framework rather than broadband specifically. For example:

President Biden is calling on Congress to invest in protection from extreme wildfires, coastal resilience to sea-level rise and hurricanes, support for agricultural resources management and climate-smart technologies, and the protection and
restoration of major land and water resources like Florida’s Everglades and the Great Lakes.

While the Biden administration emphasized the importance of investments in infrastructure for protecting against environmental degradation and supporting agricultural and climate-smart technologies, broadband was not explicitly connected to these issues. With the transition away from rural broadband specifically toward urban broadband expansion, fewer communications documents related broadband expansion with the sustainability potential presented by precision agricultural technologies.

4. Discussion

Precision agriculture has numerous social and environmental benefits [5] but barriers to implementation, such as broadband access, must be addressed to enable widespread and equitable adoption [11]. The Bipartisan Infrastructure Bill signed into law by the Biden administration includes the expansion of broadband around the U.S., which has the opportunity to increase precision agriculture adoption, especially in rural areas currently affected by limited internet access. This study adds to the literature by exploring U.S. policies and associated federal outreach documents on broadband access implemented under the Biden administration so researchers may understand current and future directions for universal broadband access, as well as industries, innovations, or populations that might be excluded from these conversations and policies.

The Biden administration’s push for broadband access expanded beyond rural areas, recognizing that cities face broadband access and affordability issues as well [21]. Universal broadband considerations due to educational needs was of particular importance considering the need for internet access to engage in school during the COVID-19 pandemic [24]. Looking beyond rural areas for broadband access moves the policy argument away from focusing on an availability gap, where there are no networks available to provide baseline services, to the adoption gap, in which people from low-income areas have access to broadband, but cannot adopt it due to affordability issues [22]. Broadening the conversation to include both availability and adoption (affordability) may widen the potential impact of universal broadband policy. However, though universal broadband expansion shifts the conversation to include increasing access and affordability to all constituents, shifting from a rural to a more urban and universal discourse may actually exacerbate current disadvantages within rural communities, especially those based on socioeconomic class.

The Biden administration has made progress on increasing rural broadband access and affordability within the first year in office. As of November of 2021, the Biden administration began accepting applications for loans and grants for those in rural communities to gain access to high-speed internet [43]. The USDA plans to administer up to $1.15 billion through this program to increase rural broadband access. Funds were made available for this program through the Bipartisan Infrastructure law, which allocated resources for the Rural Development Broadband ReConnect program [44]. This program specifically “furnishes loans and grants to provide funds for the costs of construction, improvement, or acquisition of facilities to provide broadband service in eligible rural areas [44].”

The USDA [23] previously framed innovations surrounding rural broadband expansion as a way to increase environmental sustainability through dissemination and adoption of precision agricultural technologies. With the transition away from rural broadband to universal broadband infrastructure in current policy outreach, rural agricultural populations risk losing momentum for broadband expansion due to changing policy emphases. Rural constituents may then become more disadvantaged due to the changing policy emphases and subsequent infrastructure developments. Though the Biden administration emphasizes the importance of broadband access for all U.S. citizens, rural and tribal communities consistently have lower access rates to broadband infrastructure [45]. However, incorporating precision agriculture more directly in policy discussions may re-emphasize the importance of broadband access in rural areas, those most connected to agricultural production, and limit the potential negative consequences of a broader policy discussion.
Universal broadband access is an important issue, but should not exclude rural constituents from the conversation as broadband access affects rural citizens most acutely. The Biden administration has created a funding line specifically for rural broadband access through the ReConnect program; however, the framing of the universal broadband narrative risks diluting the rural broadband issue by only looking at broadband access without acknowledging geographical considerations critical for equitable distribution of broadband resources.

There are several limitations that must be acknowledged prior to interpretation of the results. First, the coders’ knowledge and previous experiences may influence how they interpreted frames, and it is possible that frames would have been assigned differently by coders with different knowledge and backgrounds. Both coders study science communication with a particular focus on the environment and natural resource conservation, which should be considered in the interpretation of results. Additionally, one coder focuses on identity and culture in their research, specifically within culturally-responsive and equitable approaches, further impacting the identification and explication of frames present in the policy outreach documents. Additionally, limitations inherent to qualitative research include an inability to generalize results beyond the context of the study—the current study provides a description of outreach policy documents from the beginning of the Biden administration to the time of data collection (16 July 2021). Thus, results should not be interpreted beyond the time-bound and context-bound setting of the study. It is intended as a baseline assessment to inform future research using quantitative, qualitative, and mixed-methods approaches.

Acknowledging these limitations, the results of the frame analysis provided important implications and future research directions for precision agriculture policy outreach and discourse. The policy discussion surrounding broadband access only included a single mention of rural broadband and agriculture as a way to accelerate precision agriculture. Increasing adequate and affordable broadband access in rural areas, which was highlighted in the policy discussion, may help expand precision agriculture adoption; however, the lack of discourse surrounding precision agriculture may downplay its importance in agricultural sustainability. Marrying the concepts of agricultural sustainability and precision agriculture within the broadband policy discourse may increase bipartisan acceptance of related policies within the public sphere. In addition, the environmental and social benefits of precision agriculture may not be recognized by the broader public when broadband policy communication forgoes the subject. Without pressure from policy makers and the public to expand precision agriculture throughout the rural U.S., adoption may be slow or minimal, hindering associated environmental sustainability.

It is possible the lack of discourse surrounding rural broadband policy and precision agriculture is associated with the shift in policy frames from the Trump to the Biden administration. The Trump administration framed their policy around rural broadband, specifically through the United States Department of Agriculture grants and initiatives [25]. The Biden administration included urban areas without affordable access to broadband in their policy discussion, which broadened the conversation from a gap in rural availability to a gap in affordability [25]. The Biden administration also shifted from a focus on rural broadband to universal broadband, expanding the policy reach and audiences [21]. Future research should compare the communications and outreach between the administrations to determine if this shift impacted policy discourse, and what that means for precision agricultural policy moving forward.

Precision agriculture exists at the nexus of production agriculture, sustainability improvements, and broadband access [1,5]. Incorporating frames within each concept may increase the adoption of precision agricultural practices and emphasize the importance to policymakers of how expansions in precision agriculture can enhance solutions to social issues, such as broadband access. Future studies may also benefit from determining how to place precision agriculture at the forefront of agricultural policy discourse and associated outreach. Placing precision agriculture at the forefront of broadband discourse may help emphasize the importance of adopting sustainable farming practices that are an acceptable
approach within the production agriculture industry, as well as emphasize the connections between environmental sustainability and digital technologies within agriculture [9].

Using a frame analysis combined with a historical overview helps communicators and innovators view adoption in a new way. While the diffusion of innovations [17] has been a primary theory through which technological innovations are viewed, it provides a limited view of adoption, putting the impetus for adoption on the consumer while making surface-level adaptations to the innovation to improve adoption. However, within U.S. political discourse surrounding broadband, discussion of barriers has shifted from accessibility to affordability. While still aligned with tenants of Roger’s [17] theory, science innovators should recognize the ways in which their innovations impact broader social issues, paying attention to how innovations may introduce unintended consequences, such as loss of jobs, within a social sector.

For broadband access, increasing the affordability of broadband can not only increase jobs in rural areas, but increase the sustainability of production agriculture and improve the global perception of production agricultural practices. Findings from the current study emphasize how a lack of access to broadband infrastructure may significantly impact economic and social contexts of countries with pre-industrialized economies, also known as developing economies, in rural areas with limited digitization of technology, such as Colombia [46], Panama [47], and Venezuela [48]. Agri-food systems within the rural territories of socially vulnerable countries, often located within the Global South, differ greatly in technological resources from industrialized agri-food systems where agricultural innovations are predominately developed [49]. Technologies related to the digitalization of agriculture, such as the Internet of Things (IoT), Big Data, blockchain, and artificial intelligence offer potential for the advancement of such agri-food systems. Due to differences in accessibility and infrastructure, a comprehensive rural broadband policy could position developing agri-food systems to become more connected to the globalized market in order to produce better quality food, increase the environmental sustainability of the agricultural sector, and increase the efficiency of natural resource use and conservation across the globe.

Several barriers exist to adopting precision agriculture technologies, outside of broadband access. These include technical issues for the equipment itself, disconnect or lack of compatibility between the precision agriculture equipment and the farm operation, concerns regarding the misuse of agricultural data, managing the large amounts of data precision agriculture provides, lack of user-friendly designs and interfaces, and high costs of implementation [50]. Looking globally, gaps in the adoption of precision agriculture technologies primarily exist among small- to medium-farm operations in lesser industrialized countries in the Global South [51]. These operations do not used motorized mechanization in agriculture, so precision agricultural technologies are limited increasing the advantages perceived by adopting precision agriculture and are too complex to implement based on the resources available to these farmers [50]. While the southern United States has one of the highest rates of adoption of precision agriculture globally [7], there are ways to further increase the sustainable adoption of precision agriculture technologies.

From this perspective, in order to enhance precision agriculture adoption in the United States specifically, the Biden administration may also want to increase the observable advantages to precision agriculture technologies, provide programs and resources to train farmers on the operation of precision agriculture, and clearly communicate about measures taken to ensure data privacy for farmers using precision agriculture data collection and allocation procedures. Specifically, a legal framework outlining product liability and safety, and data privacy, access, and security is crucially important [3]. Framing and implementation of digital agricultural technologies should also be closely tied with achieving desired sustainability targets, specifically for environmental protection and conservation to counter hesitations of adopting due to potential negative environmental impacts [3].

Adoption should not only be seen as reducing a barrier to the consumer for the sole purpose of disseminating an innovation; rather, innovations should be viewed within their complex contexts and be used as a leverage to improve social and environmental
sustainability in the future. Frame analysis is a method that can be used to determine where innovations might be best leveraged to improve sustainability across social and environmental spheres by determining past and future directions of policy discourse, and asking the question of what might be missing to improve equitable consequences of an innovation [20].

5. Conclusions

The overarching frames identified in this analysis (broadband access and economic issues, garnering support for broadband expansion, urgency and equity surrounding broadband, expanding beyond the rural, and broadband infrastructure and the agricultural sector) are likely to drive future policy around broadband access. Policy outreach and discourse around broadband only mentioned precision agriculture one time even though precision agriculture is at the forefront of agricultural sustainability. Though preliminary in nature, the results of this study may provide a fresh lens through which to examine policy discourse through frame analysis. As meaning is constructed around rural broadband, politicians have the opportunity to shape public perceptions of the importance of sustainability by communicating about precision agriculture in the public sphere. In addition, while access to affordable and accessible broadband is important in discourse and may expand precision agriculture adoption, policymakers also need to put precision agriculture at the forefront of their outreach discourse to shift frames from official acknowledgement to formal institutionalization [31].

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