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"We use it … and we need it now": An assessment of internet and technology use among farm owners and managers

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Abstract

Many agricultural producers live and work in rural areas that have been left behind in broadband internet expansion. A lack of digital inclusion of agricultural communities can stymie agricultural producers' participation in e-commerce and marketing, use of precision agriculture, and access to information. To better understand how farm owners and managers access the internet and their digital skills, we conducted a mixed-methods research project using focus groups (N = 4) with participants (n = 26) living in four North Carolina (NC) counties in 2023. We used thematic analysis to qualitatively analyze the focus group data. To quantitatively assess emerging themes, we then conducted a survey of farmers (n = 113) at a statewide farm show in NC in 2024. We calculated descriptive statistics for the survey data, including

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demographics (gender, race, crops or livestock produced, acreage farmed) and experience with devices, social media, and troubleshooting. We identified three overarching themes: (1) experiences with internet and digital technologies; (2) impacts of internet access and digital technology, including farmers' reflections on the critical need for internet connectivity for farm operations and perceptions of negative consequences of not having adequate connectivity; and (3) sentiments toward internet, specifically farmers' frustration with the current state of connectivity options and opinions on initiatives to improve connectivity. Findings reveal an imperative for better digital inclusion of farms and agricultural communities across NC.

Keywords
agriculture, farmers, internet access, internet use, digital technology, computers, smartphone, computer literacy

Introduction and Literature Review

Researchers have moved from documenting differences in access to technology—the "digital divide"—toward a more holistic approach focused on digital inclusion. Digital inclusion emphasizes access to the internet and technology *as well as* the skills and knowledge that allow "all individuals and communities [to] have the information technology capacity needed for full participation in our society, democracy, and economy" (National Digital Inclusion Alliance, n.d., para. 3). Access to information has been identified as a determinant of health and is increasingly being recognized as a precursor to other social determinants of health (Early & Hernandez, 2021; Graham et al., 2024). Drawing on a social ecological framework, researchers have highlighted the importance of digital skills as well as demonstrated how policies, infrastructure, and community characteristics can influence digital inclusion (Jahnel et al., 2022; Katz & Gonzalez, 2016).

There are substantial discussions in the literature on rural broadband and the importance of digital skills for agriculture and community development (e.g., LoPiccalo, 2022; Syafuddin & Meidina, 2023). Agricultural producers often live and work in rural areas, which have historically faced challenges with broadband infrastructure and, in some cases, any internet access. Precision agriculture, social media marketing, e-commerce, and agritourism are all important parts of modern food systems and influence economic development in agricultural and rural areas. For example, the U.S. Department of Agriculture (USDA) estimated that broadband connectivity, along with the inclusion of precision agricultural technologies, could generate a minimum of US$47 billion annually in economic benefit (USDA, 2019). However, economic development is stymied where internet is not available, is

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Ethical Statement
This study was approved by the East Carolina University and Medical Center Institutional Review Board (#22-001454). Focus group participants provided verbal informed consent and survey participants provided verbal informed consent prior to participation in the study.

Declaration of Conflicting Interest
All authors declare that they have no conflicts of interest.

not fast enough, or requires knowledge and skills that are not readily available.

North Carolina (NC) is a state with a large rural population, and agriculture represents an important part of the economy. NC's rural population is the second largest in the country (Cline, 2023). Agriculture contributes more than US$111 billion annually to the state's economy and is the second-largest land-use category in NC, accounting for 20% of the state's land and open-water area (NC Natural Heritage Program, n.d.; Walden, 2024). In 2021, the NC Department of Information Technology released a report on internet connectivity and farms, finding that 90% of the 1,250 respondents said reliable high-speed internet is "extremely important" or "very important" for conducting farm business (NC Department of Information Technology, 2021).

In the United States, there have been substantial federal and state investments to bring broadband and digital skills to rural areas, including farms. These investments have included emergency COVID-19 response (e.g., Baker et al., 2021; Cofie et al., 2022) funds to install broadband service in areas that have not had service (e.g., Valentín-Sívico et al., 2023), and, more recently, educational efforts to improve digital skills (e.g., National Telecommunications and Information Administration, 2025). Indeed, the American Rescue Plan Act (ARPA) has provided billions of dollars to advance digital inclusion, including in rural areas. Using federal and state funds, NC's Division of Broadband and Digital Opportunity has supported assessment, mapping, planning, and infrastructure development as part of a statewide effort to bring broadband internet to rural areas and across the state.

Researchers have called for greater focus on analyzing internet outcomes, which involves the impacts internet use has on individuals, groups, and society (Scheerder et al., 2017). While prior research has examined digital inclusion among migrant and seasonal farmworkers specifically, including access to and costs of internet for farmworkers in NC (Lee, 2024), less is known from the perspectives of owners and managers regarding their experiences with internet access. Thus, to address this gap in the literature, inform digital inclusion efforts in rural areas, and advance technology deployment and precision agriculture efforts, we sought to explore digital inclusion among NC farm owners and managers. Specifically, we used both qualitative and quantitative data to address the following research questions:

(1) What are NC farm owners' and managers' experiences using the internet and digital technology?
(2) How does access to digital technology impact NC farm owners and managers?
(3) What are NC farm owners' and managers' perceptions related to internet infrastructure in rural farming communities?

The focus on owners and managers offers a unique perspective on the digital inclusion challenges experienced by the agricultural community and highlights the need to consider the digital technology and internet needs of both farmworkers and owners.

Research Methods

We used a sequential exploratory mixed-methods design, in which we conducted qualitative research via focus groups to inform a subsequent survey, which we used to quantify themes identified in the qualitative data. This project was part of a broader statewide effort to understand digital inclusion for agriculture and agricultural workers in NC, funded by the Institute for Museum and Library Services. The project and related data collection tools were informed by an advisory panel representing multiple sectors and lived experiences, including broadband infrastructure, library sciences, and digital inclusion. The East Carolina University and Medical Center Institutional Review Board approved the study's procedures (#22-001454).

Next, we describe the design and implementation of the qualitative data collection, followed by the design of the quantitative data collection. We then describe the analysis of both types of data.

Qualitative Data

To better understand farm owners' and managers' perspectives and experiences with digital access, digital literacy, and digital technology use, we col-

lected qualitative data through focus group discussions.

Focus Group Discussion Guide Development
Study team members designed a focus group discussion guide, and state partners and advisory panel members reviewed it. The guide consisted of 23 core questions. We included questions in five domains: digital access, digital literacy and resilience, searching for information, information sources utilized, and demographic questions. The focus group guide is available in an institutional repository (Bloss, 2025).

Qualitative Data Collection
We held focus group discussions from January 22 to March 28, 2023. County Cooperative Extension agents, who regularly interact with and provide programming to farm owners and managers, assisted us in recruiting focus group participants. Two members of the research team (JN, EH) conducted the four focus group discussions using a semi-structured discussion guide. Both facilitators received training in conducting focus group discussions. We held focus group discussions at county Cooperative Extension offices or, in one case, at a private room in a restaurant. We audio-recorded focus groups (average length: 64 minutes) and professionally transcribed them using a smooth verbatim protocol. Participants received a US$30 gift card and a meal.

Focus group discussions took place in four NC counties, for which we have replaced the actual county names with pseudonyms to maintain participants' confidentiality: Banks, Crawford, Reynolds, and Sanders. We selected these counties based on their distribution across the state's three regions (western, central, and eastern) and their agricultural diversity. Banks County, located in western NC, is predominantly white non-Hispanic/Latine, and approximately half of its population lives in a rural area. Crawford County, located in central NC, is predominantly white non-Hispanic/Latine, and nearly a third of the county's residents identify as Black/African American. Almost all the county's population lives in a rural area. Reynolds County, also located in central NC, has one of the highest numbers of farms in the state. The county is predominantly white non-Hispanic, with approximately 15% of residents identifying as Hispanic/Latine. More than half of the county's population lives in a rural area. Sanders County, located in eastern North Carolina, is among the top counties in NC for agricultural sales. The population of Sanders County is relatively diverse, with approximately half of residents identifying as white non-Hispanic/Latine, about 25% as Black/African American, and about 20% as Hispanic/Latine. About half of the county is designated as farmland or forestry, and most of the population lives in a rural area. Across all four counties, a majority of farms are owned or operated by a family.

Quantitative Data
To further examine digital access, digital literacy, and digital technology use among North Carolina farm owners and managers, we developed and administered a cross-sectional survey informed by findings from the qualitative phase of the study.

Survey Development
The information garnered from the focus groups informed the development of the survey questions. Thematic findings that informed survey items relevant to the present study included access to and use of digital technology (e.g., the internet and computing devices) among owners and managers. Software and device/internet troubleshooting questions were adapted from existing items (Pieterse et al., 2018; Santo et al., 2018). The study team developed additional sections of the survey, including questions on demographic information, device access, and library use. The advisory panel reviewed a draft of the survey codebook for face and content validity. The panel members received a draft of the codebook for them to provide an initial round of written feedback. After receiving the feedback, the study team met with the advisory panel to review the feedback and gain additional insights to help refine the codebook. We pilot tested the survey with one farm owner and additionally received feedback on the survey from someone with farming experience who currently provides programming to farm owners and managers. The survey codebook is available in our institutional repository (Bloss, 2025).

Survey Items

Device access was assessed using three items, where participants could respond with "Yes," "I can borrow one," or "No." Items included "I have my own laptop or desktop computer," "I have my own smartphone," and "I have my own tablet."

Social media use was assessed through one question: "Do you use any of the following?" Participants were able to select one or more of the following: "Facebook," "GroupMe," "Instagram," "WhatsApp," "Snapchat," "TikTok," "YouTube," or input their own answer through an "Other" option.

Device and internet troubleshooting were assessed through six statements: "When there is a problem with my phone, computer, tablet, or other device, I know how to solve it"; "When there is a problem with my internet connection, I know how to solve it"; "If I don't know how to solve a problem with my device (e.g., phone or computer) or internet connection, I know who to ask for help to resolve it"; "I am afraid of using my phone, computer, tablet, or other device. I try not to ruin anything"; "I adopt new technologies such as new apps, devices, or software easily"; and "I tend to use apps, devices, or software that I am familiar with rather than learning new ones." Participants could indicate "Yes," "Sometimes," or "No" for each statement.

Quantitative Data Collection

We utilized a cross-sectional survey design to assess farmer internet access and use. We recruited participants at a farm show in NC from January 31 to February 2, 2024. Trained data collectors approached participants as they entered or left exhibition areas, pesticide applicator recertification classes, and association meetings, and the data collectors completed a consent form with all participants prior to starting the survey. Participants completed surveys on Apple iPads using the Qualtrics offline app. Participants received a US$25 gift card upon survey completion. We required participants to be over the age of 18 and to be NC residents. A total of 113 farmers from 35 (out of 100) counties in NC completed the survey.

Qualitative and Quantitative Data Analysis

Qualitative data analysis entailed a thematic coding approach. Two members of the research team first worked together to code focus group transcripts using the annotation/comment feature in Microsoft Word. Three members of the research team (LC, EH, JN) next created a preliminary codebook using deductive codes from the interview guides and inductive codes that emerged from the transcripts. Then JN and EH applied the preliminary codebook to two transcripts. The coders compared their coding, reached consensus, and refined the codebook as needed. The two coders then applied the codebook to the remaining focus group transcripts using NVivo software (version 14), with members of the research team meeting regularly to discuss discrepancies. Upon coding completion, members of the research team (EH, JN, ER) used the code outputs to develop summaries and matrices comparing the perspectives of the farmers by location. Three authors (LC, EH, JN) then used the coding matrices to identify themes, which could collapse or cross codes in the matrices. The themes were identified using an immersion-crystallization process that seeks to give meaning to the data based on reflection and probing for alternative interpretations of participants' views on and experiences with internet and digital technology (Borkan, 2022). Regarding positionality, the analysis team had representation by gender and racial identity, level of formal education (from BS to PhD), and disciplinary background, including anthropology, education, the humanities, and public health.

For the quantitative data analysis, we extracted the data from Qualtrics and re-coded it for ease of use in analysis programs. We used SPSS V.29.0.1.0 (IBM, Chicago, Illinois) to analyze data. We utilized descriptive statistics, such as frequency distribution, to summarize variables. Because survey participants' ages were not collected and convenience sampling was used, additional statistical analyses beyond descriptive statistics were not performed. We treated data as missing at random and used pairwise deletion; that is, we only omitted missing responses for the variables of interest for each descriptive analysis.

Results

Focus group participant demographics are reported in Table 1. Most participants were male (69%), white (96%), and between 50 and 59 years old (46%). Table 2 shows the demographics of survey participants. Survey participants were mostly male (83%) and white (92%). The most commonly produced crops and livestock raised were soy (43%), corn (35%), and beef cattle (34%).

Our qualitative results fell into three overarching themes. The first theme captured farmers' experiences with the internet and digital technologies. The second related to their perceptions of positive and negative impacts of using internet and technology. The third captured farmers' sentiments relating to the internet and technology. Survey results provided additional insight regarding the themes.

Table 1. Focus Group Participants' Demographic Characteristics (*n* = 26)

Demographic characteristic	*n*	%
Gender		
Men	18	69.2
Women	8	30.7
Race		
White	25	96.0
Black/African American	1	4.0
Age[a]		
29 & younger	1	4.5
30-39	3	13.6
40-49	0	0
50-59	10	45.5
60-69	5	22.7
70 & older	3	13.6
FORHP Classification[b]		
Rural	9	40.9
Not Rural	13	59.1

Note. FORHP stands for Federal Office of Rural Health Policy (Health Resources & Services Administration 2022). We used participants' zip code to determine if they live in a rural or non-rural county based on FORHP classifications. Not all participants provided all demographic information; thus, categories do not add up to the total.
[a] Total sample size for age is 22 because age was not reported from four of the participants.
[b] Total sample size for FORHP classification is 22 because zip code was not reported from four of the participants.

Theme 1: Farmers' Experiences with Internet and Digital Technologies

Focus group participants described four distinct experiences with the internet and digital technology: the locations where they use the internet, the internet providers available to them, the types of computing devices they use to connect to the internet, and their ability to troubleshoot internet and computing technology issues.

Theme 1.1: Internet Use Locations

Participants reported using the internet daily, accessing it via cellular data or Wi-Fi networks at home and at work. For many participants who lived on their farm property, these are one and the same. For example, a Banks County farmer mentioned, "The hotspot is at our house, and the

Table 2. Survey Participants' Demographic Characteristics (*n* = 113)

Demographic characteristic	*n*	%
Gender		
Men	94	83.2
Women	19	16.8
Race		
White	104	92.0
Black/African American	7	6.2
Native American	2	1.8
Crop Produced/Livestock[a] Raised		
Soy	48	42.5
Corn	39	34.5
Beef	38	33.6
Wheat	31	27.4
Tobacco	26	23.0
	$\bar{x}$	*Sd*
Acreage Farmed	774.95	1,123.4

Note. All participants were ≥18 years of age.
[a] Participants could select multiple responses, so sample adds up to over 100%. Table only shows the top 5 most frequently reported crops produced/livestock raised from the survey results.

service is fine." Additionally, some participants shared that they use cellular data while driving (e.g., GPS) or running errands around town and that they travel to various public buildings (e.g., church, local McDonald's, public library) to access reliable Wi-Fi.

Theme 1.2: Available Internet Providers

All four counties had various options for internet service providers that provided cellular data and home and business internet. However, participants noted having limited options in what internet service provider they could choose due to coverage gaps in their areas. A Sanders County farmer stated,

> When I went into Verizon to purchase another cell phone as a hotspot for our business, I was sitting and discussing with the clerk, and she said, "Here at our Verizon store, Verizon doesn't even cover" because they have terrible service there.

Table 3. Survey Respondent Device and Troubleshooting Characteristics

Survey question	Total (113) % (*n*)
Computing device access	
Have own smartphone	95.6 (108)
Have own tablet†	61.6 (69)
Have own laptop	85.8 (97)
Social media use	
Facebook	72.6 (82)
GroupMe	5.3 (6)
Instagram	36.3 (41)
WhatsApp	13.3 (15)
Snapchat	28.3 (32)
TikTok	25.7 (29)
YouTube	70.8 (80)
Device/internet troubleshooting	
Can solve problems with device	35.4 (40)
Knows where to go for tech assistance	79.6 (90)
Afraid of using devices	5.3 (6)
Uses new technologies easily*	52.7 (59)
Tend to use familiar technologies*	52.7 (59)
Can solve problems with Internet	38.1 (43)

* Sporadic missingness for these variables resulted in a denominator of 112 for the calculation of the percentages.

Participants from all four focus groups stated they have tried multiple providers, but most do not meet the minimum needs of the user base. For example, a farmer reported, "I've tried dial-up. We've tried satellite dishes. None of them work well enough, really, when you start sending a lot of data" (Banks County).

Theme 1.3: Internet Accessible Computing Devices Used

Across all focus groups, participants mentioned cell phones as the main device they use to access the internet. Additional devices included laptops, tablets, smart TVs, credit card machines, and security cameras. A Crawford County participant shared how they own produce refrigerators that connect to the Internet: "Our refrigeration system for produce runs off Wi-Fi, so we can operate it off our phones and make sure the system hasn't shut down."

The pervasiveness of cell phones, laptops, and tablets among our focus group participants was consistent with our survey findings (Table 3), in which a majority of farmers reported owning smartphones (96%), laptops (86%), and tablets (62%).

Theme 1.4: Capacity to Troubleshoot Internet and Device Issues

Findings from focus groups and surveys revealed mixed results regarding farmers' ability to troubleshoot issues with the internet and devices, such as phones and computers, and their comfort level adopting new technologies. Some focus group participants shared that they try to fix technology and internet problems themselves, "I usually try to fix it myself. It's got to be really bad for me not to be able to fix it myself" (Reynolds County). Others shared that they reach out to family members (e.g., their children, niblings, spouse) or customer service for support. One explained, "You don't have to know everything. You just need to know people you can call" (Sanders County).

Less than half of the survey respondents (Table 3) reported knowing how to solve problems with their devices (35%) or their internet connection (38%), while a majority (80%) reported knowing how to ask for help with solving a problem

with their device or internet (Table 3). Additionally, half of the survey participants (Table 3) indicated that they adopt new technologies easily (52%).

Theme 2: Impacts of Digital Technology on Owners and Managers

Focus group participants shared various ways digital technology has positively and negatively impacted their work as farm owners and managers. Positive impacts included promoting their business, sharing industry information, and accessing agricultural apps; negative impacts included safety concerns, time burdens, and business and operational challenges.

Theme 2.1: Positive Impacts

One positive impact was the ability of farmers to establish an online presence to promote their businesses. One Sanders County farmer stated, "We primarily use Facebook for our business. We need that online presence." Farmers reported using a variety of social media sites, whether for professional or personal reasons. Survey results (Table 3) indicated that Facebook was the most popular platform among participants, utilized by over two-thirds (73%). At least a third of survey participants used Instagram (36%), with 28% reporting using Snapchat and 26% reporting using TikTok. Participants reported using social media to learn about other businesses with which they may want to interact; for example:

> I use social media, Instagram, Facebook kind of like a private detective. [When] I'm looking for something, I want to know before I go there if they are going to offer my service. Is it worth me driving 120 miles to do that? I need to know about the farm and what they're offering me. (Reynolds County)

Farmers' use of social media to promote their businesses helped some stay connected with their clients during the COVID-19 pandemic. A Crawford County farmer mentioned "keeping up with your clientele through social media and being able to advertise what's still going on on your farm, even with the pandemic, and still offering services and what you're selling just on a different setup."

Additional benefits mentioned include maintaining farm security, managing crop diseases, and using agriculture-based apps. A Crawford County farmer shared how they use the internet and digital cameras for security surveillance of their property: "I have cameras set up on my equipment, around my equipment, and I also use the internet on my trail cameras." Other participants described how digital technology helps farmers share information with industry professionals who can provide technical assistance and guidance. A Crawford County farmer explained,

> We've got what seems to be a disease problem for the soil; being able to take a picture of it on the phone and text it to our vendor helps him to identify what he's got to sell us to supply, whatever our crop is.

A few participants shared how agricultural apps have helped them with various farm-related needs. For example, another Crawford County farmer stated,

> There are a lot of agriculture apps we use for farming. One is called Picture This, which is a weed identifier if you can't identify the weed by common knowledge. Then, Farm Logs, they'll keep track of rainfall and planting dates and things like that.

Some participants described how access to the internet assists farmers with searching for information online and accessing continuing education, such as staying up-to-date with required training. Focus group participants reported relying on Google and YouTube to find information: "Whether I'm working on something and trying to figure something out with the tractor … maybe something's going on with what I'm planting … I try to research and kind of look between YouTube and Google" (Crawford County). Both our focus group and survey findings indicated that YouTube is widely used among farmers, with approximately 71% of survey participants reporting use (Table 3). While YouTube is classified as a social media site, our focus group findings suggest farmers utilize it as

a search engine: "We use a lot of YouTube to look up that stuff and try to fix your own equipment" (Banks County). In terms of pursuing continuing education, a Reynolds County farmer stated, "We have to stay on top of so many hours for our lagoon permit, and some of that is offered online. So, we're able to log in to keep us up-to-date."

Theme 2.2: Negative Impacts

Most of the impacts shared by participants focused on challenges they endure due to inadequate internet infrastructure in their communities. Four common negative impacts were poor internet quality, safety concerns, time burdens, and business and financial operation challenges.

Theme 2.2.1: Poor internet quality

The reliability and quality of internet service varied for participants and often depended on their location. Participants shared that Wi-Fi signals in their homes did not extend to their farm fields, so they relied on cellular data to complete internet-dependent tasks while out on the farm. However, several participants shared that even cellular data signals can be weak or nonexistent when out in the fields, leaving them with no internet access at all. One participant from Banks County described, "The other day, I was at a shrubbery farm, and I turned my phone on. I told my nephew it [the phone] actually laughed at me, didn't have anything [signal]." Participants reported consistently weak or unreliable internet connections with their Wi-Fi services; for example, "The Wi-Fi is pretty slow for your laptop." Some indicated that they limit the number of devices connected to the Wi-Fi router to use the internet, or reduce video stream quality to participate in online meetings, due to limited bandwidth. For example, a Banks County farmer explained,

> The hotspot is at our house, and the service is fine. I've tried using it a couple of times for Zoom with work. I just have to lower my video settings to the lowest possible resolution, and every device in our house has to be turned off except for my computer.

Theme 2.2.2: Safety concerns

Participants described how a lack of reliable internet has created safety issues. Several participants expressed concerns about trespassing and theft from their properties and the desire to install live-streaming security cameras; however, they reported being unable to follow through due to insufficient internet connectivity. For example, one farmer mentioned, "It would be nice to put your video cameras on it for security, but it's unreliable" (Banks County). One participant mentioned how unreliable internet adversely affects the quality of farm-related tasks, such as filing reports:

> I can't believe that we don't address it more. It should be a priority. It's dangerous for one. Farmers can't input reports like they should. Or they could, but they don't want to take the headache of driving somewhere to do it, so you don't get what you really need in reports. (Banks County)

In addition to the professional safety concerns shared, participants identified several personal safety concerns. A participant from Reynolds County mentioned how many farmers and other community residents have decided to get rid of their landlines at their houses and rely on Wi-Fi calling via their cell phones for communication. Participants described how their dependence on cell phones for communication becomes concerning and potentially dangerous when the internet service is slow or is not working properly. For example, one participant from Banks County mentioned her mother's inability to contact people for assistance (e.g., family members, emergency medical services), saying, "She depends on the [landline] phone because her cell phone doesn't work. Well, the AT&T [landline] phones go out constantly, and she has nothing, no phone, no internet, no telephone, no nothing. It's a safety issue." Also, insufficient access to high-quality internet was perceived to affect healthcare access in rural communities. As explained by a Banks County participant,

> Medicine is absolutely going tech. It's been going tech for years, but our patients [in this county] can't because they can't hook up to the

> internet. … Patients in rural communities are one hundred percent left behind in all the technology that's benefitting everybody else.

Theme 2.2.3: Time burdens

Farmers reported that inadequate internet connectivity has resulted in undue time burdens. Many participants mentioned that, due to the lack of internet connection, they had to print out physical copies of work documents to fill out initially and then spend extra time digitizing the information. A Reynolds County farmer stated,

> A lot of our documents, where we keep data sets, are cloud-based. If we are down at the barn taking yearly measurements on our cattle and wanting to input them into our Excel documents that are cloud-based, we can't do that down at the barn. We have to print off a hard copy at the house, write it down at the barn, and then go and enter all that data back in instead of doing it all at one time. That's a huge time-consuming thing, but we obviously can't work cattle up in the house.

Additionally, farmers reported having to spend extra time driving to a secondary location, such as their church or a McDonald's, to download or share documents (e.g., via email). A Banks County farmer mentioned, "I go to the church that I attend. We have high-speed internet and Wi-Fi there when I have to send and receive documents, download documents, and that kind of thing."

Theme 2.2.4: Business and financial operation challenges

Farmers reported that internet connectivity is insufficient to operate their businesses or modernize their business practices effectively. For example, a Sanders County farmer explained,

> At home, it works okay most of the time, but here [at my farm business], sometimes we're completing transactions through our system, it'll stall. It's kind of embarrassing with a customer when you've got to wait a second for the thing to catch up. I've been on the phone with Star on two occasions, and what we've determined is we have about one-third of the strength we need here to do what we need to do.

Farmers expressed a desire to purchase new equipment and labs for their farms but explained that they cannot do so due to insufficient internet access. A Reynolds County farmer shared,

> We do IVF embryo work on cattle at our facility, and down at the barn where we work the cows, we don't have Wi-Fi. It was going to be really expensive to get a second router down there. It'd be helpful for the technicians who do that work to have that. Some of the high-tech cattle equipment, vet equipment uses Wi-Fi and Internet. Being able to have a second hub on that farm, separate from the house where there's Wi-Fi, would be really good for us.

While farmers mentioned that having an online presence through websites was beneficial for their businesses, they also shared the challenges they experienced when attempting to create or update their websites. One challenge shared by participants was that the website loads slowly, making it hard for them to update the site. A farmer from Reynolds County shared, "We also would like to get into having a website for the cattle operation, but I probably unplug or restart our Wi-Fi once a day." In addition to the internet connectivity challenges with website development and maintenance, a lack of digital technology skills (such as website construction) was identified as an additional barrier farmers face in operating and modernizing their businesses. A Sanders County farmer described, "I would like to update my website. I would like to put movement and sound on several websites. … It's very costly, and I don't know those skills."

Farmers reported that the lack of sufficient internet access in their communities causes them to spend extra money. Participants described differences in financial situations and lifestyles between those with high-quality, reliable internet and those without. For example, one farmer in Banks County stated, "The rest of the world, they're not spending the money that we spend to

try to achieve things that we shouldn't have to. The internet cost is high that you get, we spend more money than a normal person." Another financial challenge experienced by farmers was lost revenue and profits due to equipment failures (such as animal feeders, water dispensers, and refrigerator systems for produce). Farmers shared that there is technology available that can monitor their equipment and help prevent financial losses through early detection, but many have not invested in it due to unreliable internet connections. One farmer from Reynolds County stated,

> There's a lot of areas that could be improved with raising chickens to put sensors on the feeders, the waterers, the curtains even. Being a mile and half down the road, there was a lot of feed that was destroyed or gone bad. There was a lot of things that could have helped if there would have been internet and communication back and forth to the house to let us know we've got a problem with the feeder in chicken house number four. Automation means a whole lot, I think.

Theme 3: Owners' and Managers' Sentiments Toward the Internet Infrastructure

Farmers' attitudes toward the internet infrastructure in their counties varied among focus groups. Those from Banks County expressed the most frustration with their area's current internet options and connectivity compared to other counties, with one Banks County farmer stating, "I mean, it doesn't matter where you're at. It's all terrible." They also voiced vexation over political decisions and, at times, the lack of action on investing in rural broadband. One Banks County farmer stated, "We're surrounded by a half million acres of [a] National Forest. The government has plenty of places to put towers, and I don't understand it. I mean, that's a priority with the politicians, but it's all talk, no action." A common sentiment among Banks County farmers was the urgency for addressing internet connectivity challenges: "We use, and we need it, but the most important thing is the urgency that you present this to people who can make something happen. … We need it, and we need it now." Farmers in Crawford County also expressed frustrations with their county's current state of internet connectivity. For example, one farmer said, "CenturyLink wasn't offered in my area where I am at, but everybody around me has. I had to go with satellite internet, and that sucks. It really sucks."

In Sanders County, farmers acknowledged that their internet needs were not being met; however, they also perceived that internet companies were doing their best, given the unique challenges of being located in a rural county. One participant shared,

> They're doing the best they can do with what they have. I know our local provider several years ago got a grant to help with rural infrastructure. I was speaking with someone just the other day, and they said they needed the grant money to help make it work because they would never get the return back.

One common sentiment among all the counties was the necessity of having high-quality, reliable internet access, "If the internet is down, it would be like cleaning your house when the water pump is down. You cannot clean your house. It stops you. Even when you're trying just to dust, you need water running" (Sanders County).

Discussion

In this mixed-methods study, we found that technology is an integral part of day-to-day business operations for NC farmers. Participants in our study emphasized that internet connectivity is critical for farms and that they need enhanced access now. They expressed an urgent need for better internet access for farms and agricultural communities across NC, resonating with a prior report of NC farms (NC Department of Information Technology, n.d.). Farmers in our study prioritized communication with other businesses and customers using social media and business websites; finding information online, particularly technical assistance and how-to videos; and technology-enhanced production and security practices. Our findings are consistent with other recent research conducted with direct market farmers, agritourism operators, and users of precision technology in agriculture

(Cui, 2014; D'Antoni et al., 2012; Hollas et al., 2022; Pesci et al., 2023, 2024).

Participants in our study were keenly aware that their access to markets and advanced production and security practices is limited by the lack of affordable, reliable internet and a paucity of options among internet service providers (ISPs). With adverse impacts on safety, time, and financial resources, inconsistent connectivity negatively affects the economic well-being of NC farmers, according to our study participants. Our findings indicate that inadequate internet access imposes real costs that can stymie the economic well-being of agricultural producers and communities. This is consistent with previous studies that highlighted the economic benefits of broadband access in agricultural communities. For example, LoPiccalo (2022) found that higher internet speeds can reduce farm operating costs and significantly increase crop yields, especially for corn and soybeans. Another study found a positive impact between download speeds and farmland sale prices, where a one megabit per second (Mbps) increase in download speed raised farmland sale prices by 0.27% (Qu et al., 2025); this finding is important for farmers who own their land, as farmland constitutes one of the biggest components of a farmer's financial assets and investments. The relationship between broadband access and the success of farm business operations can further be considered a determinant of health. In addition to improving economic mobility for the agricultural community through education and employment, internet access promotes health by connecting people with health information, health services, and digital health including telemedicine (Early & Hernandez, 2021; Graham et al., 224).

This study provides insight into NC farmers' digital skills and corresponding training needs. Approximately half of the survey respondents felt that they did not adapt well to new technologies, preferring to use familiar ones. Less than half of respondents felt they could troubleshoot their devices and resolve internet issues if they experienced them. As internet infrastructure improves in agricultural communities and advanced production practices (e.g., precision agriculture technologies, apps, and devices) become more accessible to a wide range of farmers, training will be needed to build digital skills and resilience. Prior research suggests that early adopters of new technology tend to have good access to information and perceive that the technology benefits their specific agro-climatic environment (Chavas & Nauges, 2020). Thus, in order for new technologies to be widely adopted as they become available, farmers must perceive a positive net benefit to consider learning and adopting technologies and must have access to appropriate information resources and channels.

This work amplifies and builds on existing recommendations for addressing internet connectivity infrastructure and the digital inclusion of farms and agricultural communities across NC. A convergence of research findings emphasizes the imperative need to improve data systems to identify farm locations that would benefit from internet connectivity, adopt and implement policies to reduce costs of building or upgrading infrastructure, and identify and implement "last-mile" solutions to provide internet connections in rural areas (NC Department of Information Technology, n.d.). Potential solutions include fiber-to-farm, fixed wireless, hotspot lending, and Cooperative Extension–led digital skills workshops that help farmers stay current with the latest advancements in digital technologies, such as artificial intelligence, big data, and precision agriculture (Cofie et al., 2022; Keerthi et al., 2025). Federal and state policymakers should also consider how farm locations are classified as broadband-serviceable locations for network infrastructure upgrades and how to improve data quality in state infrastructure planning maps.

Strengths and Limitations

There are strengths to this study, including its rich data collection in multiple counties across NC, rigorous qualitative analysis, and ability to share participant voices. However, there are also some limitations. Our data are specific to NC, its farming, and its policies related to digital inclusion. Thus, our findings may not be directly applicable to other states. The survey used convenience sampling at a widely attended farm show in the state capital of Raleigh. Thus, it does not necessarily represent people who did not attend, which could have an influence on the results. For example, the farmers

who attended the farm show could be more digitally connected or less digitally connected than those who did not attend. We did not collect the ages of survey participants, other than confirming they were 18 or older. This precludes our ability to look for differences by age. We suggest that future research collect and compare responses by age to examine how farmers' age affects digital literacy and resilience.

The focus groups for each county also utilized convenience sampling, and the findings could be biased toward farmers who are more engaged with Cooperative Extension or have stronger opinions about connectivity. However, the focus groups were often organized around other events and thus did not only include people who had strong opinions about internet access. Lastly, most of the participants in the study were white men (and older, in the case of survey respondents), and different challenges or barriers could emerge with greater participation among women and greater diversity in racial and ethnic identities. However, despite this and our use of a convenience sample, the demographics of our participants do generally reflect the older, whiter, and more male demographics of NC producers according to the 2022 U.S. Census of Agriculture (USDA, 2024).

Future research should consider the experiences of women and those with other racial and ethnic identities, comparative studies where different policies or grant programs are being implemented, and how other rural populations might support our findings or reveal alternative themes. For example, rural schools and hospitals may face similar infrastructure and skills challenges, but individuals working in these settings could offer different perspectives from the farmers in our study. Further insights may also be gained by studying "leapfrogging" technology from lower-resource settings and exploring potential next-generation infrastructure, including emerging technological solutions for internet infrastructure on farms.

Conclusions

Internet access on many NC farms is not sufficient to support modern farming needs and may hinder economic development in agricultural communities. Farmers in NC have a range of digital skills and resiliency, with about half of the participants reporting that they can use new technologies easily. In discussions about the use of technology on farms, a lack of reliable, affordable internet access remains perhaps the biggest issue for the NC farmers in our study. Broadband infrastructure efforts and alternative options for remote areas should ensure that farmers and agricultural communities are included in planning and implementation.

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