# Agricultural Technical Service Providers and Rural Resilience: Adapting to Weather, Climate, and Water Challenges

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*Increasing temperatures and extreme weather events challenge agricultural production worldwide by reducing water availability and disrupting operational timelines. Extension educators and technical service providers (TSPs) provide critical assistance to producers. Yet they often face challenges in addressing weather- and climate-related issues due to limited climate literacy training, demanding workloads, and the sensitive nature of the topic. To better understand these challenges and job-specific needs gaps, we conducted a three-phase needs assessment–comprising six focus groups–to identify the needs of Wyoming TSPs in supporting producer decision-making regarding weather, climate, and water availability. Key findings include the need for additional training in climate and environmental sciences, enhanced climate communication skills, expanded place-based monitoring, more locally relevant outreach and education, improved data interpretation, forecasting, and information consolidation, and strengthened professional networks. By situating these findings within global conversations on agricultural resilience, knowledge transfer, and climate change, the study contributes recommendations for building trust, strengthening relationships, and advancing climate literacy and communication in climate-skeptical contexts. This work informs ongoing international efforts in capacity building and extension education, offering insights for Cooperative Extension Services and similar programs, particularly in rural and politically diverse contexts.*

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## Introduction

The frequency and severity of extreme weather events and temperatures have increased relative to historical averages in the western United States (Frankson & Kunkel, 2022; Smith, 2020). In high-elevation portions of the Intermountain West the prevailing rangeland and cropping systems (such as alfalfa and wheat) and the semi-arid climate place producers and their communities at significant exposure to weather and climate variability. Cooperative Extension Service (CES) professionals provide tools, resources, and strategies to agricultural producers to help them navigate critical decisions related to weather, climate, and water availability. However, CES professionals often face challenges in addressing climate-related concerns with their clientele due to their limited training, demanding workloads, or the sensitivity of the topic. This can be particularly true in rural and remote regions like the study area, where services are limited and locations are difficult to access.

CES professionals play a critical role in supporting farmers, ranchers, and rural communities. In partnership with producers, they address emerging challenges, promote new technologies, and work to improve nutrition, productivity, emergency preparedness, and natural resource conservation (United States Department of Agriculture [USDA], n.d.). In Wyoming, CES professionals often operate collaboratively within local networks of other agricultural and natural resource professionals to deliver technical services in conservation planning, education, and implementation on private, Tribal, and public lands (USDA, 2004). They are uniquely positioned to deliver climate-related place-based tools, resources, and strategies to agricultural producers because of their local expertise and trusted relationships. Identifying ways to assist them in supporting their clientele may be an effective way to support agricultural communities in rural and remote regions. CES professionals and other agricultural and natural resource professionals are collectively called Technical Service Providers (TSPs). For purposes of this study, TSPs are broadly defined to be CES professionals, conservation districts, private consulting firms, various USDA agencies, and state or federal land management agencies who provide agricultural producers with technical knowledge and assistance.

### Purpose and Research Questions

A needs assessment of TSPs was conducted to identify gaps in their knowledge, skills, and resources around weather, water, and climate.

Specific research questions included:

1. What are the priority weather, climate, and water topics, including challenges and opportunities, that TSPs face?
2. What strategies are TSPs currently using to navigate these priorities?
3. What gaps do TSPs experience in knowledge, skills, and resources needed to effectively navigate their priorities?

TSPs bring local expertise and trusted relationships, which are especially critical in rural and remote regions like those featured in this study, where producers need tailored resources and strategies. By translating cutting-edge research into actionable guidance, TSPs help ensure that decisions are informed by both science and local context. Although this study is place-based, its methods and findings are broadly relevant to rural agricultural settings internationally, particularly in remote mountainous regions. It offers a useful case study for understanding climate-related challenges in these landscapes, as described in the next section.

## Background and Context

### Regional Impacts of Weather, Climate, and Water Availability Changes

The Northern Great Plains and the Upper Missouri River Basin, which span five U.S. states and two Canadian provinces, are rich in natural resources vital to both the environment and local communities (Knapp et al., 2023). Water sustains key economic sectors including mining, agriculture, and tourism. The headwater systems in this region also serve as a vital water source for downstream users (Hansen et al., 2015; Wilson, 2012). Since 1900, the region's average annual temperature has risen by 1.6–2.6 °F, contributing to increased evapotranspiration, precipitation variability, reduced soil moisture, and more frequent droughts (Knapp et al., 2023). The Upper Colorado River Basin is experiencing a 20-year drought, while the Missouri River Basin experienced its most severe drought on record between 2000 and 2010 (Knapp et al., 2023).

Wyoming's weather and climate shifts reflect broader regional trends and are expected to continue producing cascading effects. These include increased spring and winter precipitation, a transition from snowfall to rainfall (Kunkel et al., 2022; Lindquist et al., 2019), and shorter durations of cover and soil moisture (Palmquist et al., 2016). Glacier shrinkage in mountain regions (DeVisser & Fountain, 2015; Thompson et al., 2011) exacerbates drought (Nicholson et al., 2018; Scasta et al., 2016), raises flood risk (Luce, 2018), and intensifies wildfire hazards (Loehman et al., 2017; Rocca et al., 2014; Westerling et al., 2011). Climate shifts also drive vegetation changes and increase vulnerability to pests and pathogens (Allen, 2011; Loehman et al., 2017), while degrading fish and wildlife habitats due to warmer water temperatures and blocked tributaries from the buildup of sandbars (Al-Chokhachy et al., 2013; Monteith et al., 2015). Altered water availability and timing of runoff are likely to impact entire social-ecological systems, including agricultural production.

### Agricultural Production and Climate Impacts

Agriculture is a cornerstone of Wyoming's economy, ranking third after mining and tourism, and generating approximately $2 billion annually. Vast rangelands sustain a robust livestock industry of primarily cattle and sheep. Major crops include hay, barley, wheat, and sugar beets (Lohrenz et al., 2023). Producers are instrumental in providing food, fiber, and forage while fostering environmental stewardship and rural development.

Climate variability and declining water availability increasingly threaten the long-term resilience of Wyoming's ecosystems and agricultural economy. Producers already face impacts from more frequent and severe droughts, which reduce forage quality and carrying capacity and destabilize operations (Scasta et al., 2015). Reduced grazing during drought also increases fuel loads and wildfire risk (Scasta et al., 2016). Ranchers further contend with diminishing grazing, limited winter feed, irrigation shortages, profit instability, and rising management challenges linked to parasites, pathogens, heat stress, and evolving forage species (Hamilton et al., 2016; Kachergis et al., 2014; Knapp et al., 2023). For croplands, longer growing seasons may be offset by temperature extremes, declining soil moisture, and increased competition from weeds and pests (Garcia et al., 2011). These pressures are expected to intensify with ongoing climate shifts.

### Agricultural Extension and Technical Service Providers: Challenges and Opportunities

Agricultural producers need reliable resources, forecasting, and support to anticipate and adapt to change. TSPs play a key role in offering place-based technical assistance, including accessible information, current research, technology, and guidance on water and land management. However, many hesitate to engage with their clientele on climate-related topics due to limited training (i.e., climate literacy), heavy workloads, budget constraints, or discomfort discussing controversial issues (Prokopy et al., 2015; Wiener et al., 2020). In Wyoming, where climate and water discussions can be politically sensitive, these challenges are especially pronounced (Keller et al., 2025; Marlon et al., 2023). This reticence on the part of TSPs to engage with their clientele contributes to the critical gap in access to usable, regionally relevant climate information for both TSPs and producers.

## Global Context

Although this study focuses on Wyoming, the environmental shifts it explores reflect broader global climate change disruptions. Agricultural systems worldwide are increasingly affected by extreme weather, shifting precipitation, and rising temperatures, though the nature of specific impacts varies by region and community. Localized agricultural TSP needs assessments like this one are essential for informing global climate resilience efforts. They offer context-specific insights to guide extension and education programs tailored to a setting's environmental, cultural, and institutional characteristics. In Wyoming, the specific characteristics relevant to this study are the inter-related challenges of rural remoteness and the politically sensitive nature of the climate change topic.

Evidence from sub-Saharan and southern Africa underscores the importance of locally responsive knowledge transfer in promoting climate-smart agriculture. Incorporating local considerations can facilitate adoption of drought-tolerant maize and improved legumes (Makate et al., 2019; Mugisha et al., 2025). Gender dynamics, social norms, and social capital further shape farmers' openness to innovation and agency (Silvert et al., 2022; Witinok-Huber & Radil, 2021). In low-resource settings, subsistence farmers face compounded vulnerabilities from limited access to adaptive tools, reliance on rain-fed agriculture, poor infrastructure, weak institutional support, and high dependency on agricultural livelihoods (Aragón et al., 2021; Orton & Lee, 2025; Thorlakson & Neufeldt, 2012). Extension programs that overlook local context are often less effective at knowledge transfer.

Some of these barriers to knowledge transfer exist in rural and remote regions in the Global North as well as the Global South. Geographic isolation and cultural differences can heighten these barriers to knowledge transfer and intensify the need for place-based strategies. Global efforts to strengthen community resilience and food security offer valuable lessons for U.S. agricultural TSPs, especially in rural and remote regions such as Wyoming. A focused examination of TSP capacities in this Wyoming case study follows.

## Theoretical Framework

A three-phase needs assessment framework–exploration, assessment, and utilization–was employed to identify priorities and inform CES programming in response to changing weather, climate, and water availability in Wyoming (Caravella, 2006; Donaldson & Franck, 2016). This approach centered TSP perspectives and fostered collaborative dialogue. For the assessment phase of the study, focus groups were used to generate in-depth insights, strengthen relationships between participants and researchers, and encourage co-creation of knowledge (Mertens, 2010). Focus groups are particularly effective for engaging multiple actors in a short timeframe and are well-suited for CES-related needs assessments (Donaldson & Franck, 2016).

## Methods

A three-phase needs assessment was conducted with data collection from June 2023 to May 2024 (Donaldson & Franck, 2016; Witkin & Altschuld, 1995). The process included background research (exploration), focus groups followed by data analysis (assessment), and the sharing and use of results for a subsequent grant (utilization). The focus groups enabled the study to examine both the current landscape ("what is") of TSP knowledge, skills, and resources, and the perceived needs ("what should be") for supporting agricultural production amid environmental change (Witkin & Altschuld, 1995).

### Phase 1 Exploration

Preliminary conversations with agricultural TSPs were used to determine whether existing training sufficiently prepared them to address clients' explicit and unvoiced questions about climate change. These discussions informed the purpose of this needs assessment, which was to document the weather-, climate-, and water-related challenges that TSPs currently face in their jobs and to identify the knowledge, skills, and resources they feel they lack that would enable them to serve their clientele more effectively.

Two target user groups of the information generated by this needs assessment were identified. The first is agricultural TSPs who would like to increase their weather, climate, and water knowledge. The second target user group is leadership within TSP organizations who are in a position to integrate weather- and climate-related programming into continuing education training for their employees. Clarifying the user groups helped define the scope of the assessment and types of information most relevant to resource prioritization in the Wyoming agricultural sector. This assessment may suggest to these user groups how best to prioritize resources to the benefit of their clientele.

### Phase 2 Assessment

In response to the identified gaps, the team conducted a foundational needs assessment to identify TSP's specific climate-related knowledge, skill, and resource needs. The assessment consisted of six two-hour regionally organized focus groups across Wyoming, which were used to generate actionable insights for both statewide strategies and place-based interventions. TSPs were selected as key participants due to their role in supporting farmers and ranchers.

#### *Participants*

Forty-nine Wyoming-based TSPs (23 women, 26 men) participated in the focus groups. They represented local, state, and federal agencies, non-profits, municipal services, and academia. Roles included conservation districts (24%), state government agencies (10%), federal agencies (39%), CES (20%), Tribal organizations (2%), Central Wyoming College (4%), and non-profits (4%). All worked professionally with communities on weather, climate, and/or water issues, and many engaged directly with agricultural producers or were producers themselves.

#### *Focus Group Data Collection*

Participants were purposefully selected based on their roles as agricultural TSPs and existing relationships with the research team. Invitations were sent via email with follow-up confirmation. Six focus groups (7-12 participants each) were held, five in person and one virtually due to adverse weather conditions. A CES Educator who was also a trained facilitator led discussions, supported by local, county-based CES informants who assisted with outreach and logistics. To ensure consistency across focus groups, a standard operating procedure was developed that included informed consent and a structured script consisting of eight core questions and associated prompts (see Appendix 1). The script was piloted with experienced out-of-state TSPs and refined for clarity. The study was classified as exempt by the University of Wyoming Institutional Review Board.

Sessions were audio-recorded and transcribed by one to three researchers. Participants also used sticky notes to share written ideas, supporting multimodal engagement and diverse communication preferences (see Figure 1). Refreshments were provided to foster a welcoming environment.

**Figure 1**

*Focus Group Participant Responses Compiled on a Sticky Board.*

***Qualitative Data Management and Analysis***

Transcripts and sticky notes were uploaded into Dedoose for analysis (Dedoose, Version 9.2.7., n.d.). A collaboratively developed codebook in Google Sheets supported consistent coding and review by two researchers (Roberts et al., 2019). Using a grounded theory approach (Glaser & Strauss, 1967), open, axial, and selective coding were applied to identify themes and conceptual linkages (Saldaña, 2021). Codes were refined collaboratively by the broader research team to eliminate redundancies. Although not participatory in initial design, the study incorporated participant feedback during analysis. Each focus group received a two-page summary of themes and key takeaways; 16 participants (32%) responded, informing final code refinement. All responses were de-identified and analyzed in aggregate and by focus group. Six focus groups were sufficient to reach data saturation and revealed broad thematic categories and place-based nuances. This multi-step process supports methodological rigor and meaningful engagement.

Several strategies were used to ensure trustworthiness as articulated by Lincoln and Guba (1985). Credibility was strengthened through participant validation, inter-coder reliability, and the facilitation of six groups across the state over one year. Dependability was supported by a standard operating procedure, a facilitation script, and a grounded theory analytic process. The three-phase needs assessment enhances transferability, particularly to other mountainous, rural agrarian, and climate-skeptical contexts where similar themes may be relevant even if not broadly generalizable. Finally, the collaborative and iterative involvement of researchers, practitioners, and participants supports confirmability by grounding the findings in the data and participant feedback.

**Phase 3 Utilization**

Findings were synthesized into an aggregate summary and shared via an Extension bulletin and infographic to promote transparency and accessibility (Hansen et al., 2025; Surber et al., 2025). Findings also informed a four-year USDA National Institute of Food and Agriculture project (awarded in 2024) focused on improving awareness, preparedness, and response to weather and climate variability in Wyoming's agricultural sector. Deliverables for this grant-funded project based on needs assessment findings are being developed for TSPs, agricultural producers, and state residents. Examples include soil health workshops and programming for community events such as farmers markets, K-12 school events, and State Fair; decision tools adapted from other locations to help producers incorporate weather and climate variability into their decision-making; and a local training on climate science and communication for TSPs. Grounding these activities in a foundational needs assessment increases the likelihood of meaningful uptake and application. Phase 3 utilization of the needs assessment findings is ongoing. At the conclusion of the project, monitoring and evaluation activities conducted throughout will allow assessment of how well project processes and outcomes have addressed the gaps identified in Phase 2.

## Results

Findings are summarized below according to the current and desired knowledge, skills, and resources that TSPs report needing to meet climate-related job demands. Gaps between 'what is' currently happening and 'what should be' are also highlighted to ensure the most effective support for producers moving forward (Donaldson & Franck, 2016; Witkin & Altschuld, 1995). The first section of focus group questions addressed TSPs' current priorities and strategies; the second addressed needs related to knowledge, skills, and resources.

**Current Priorities and Strategies**

Six codes surfaced as priority topics for Wyoming TSPs in their current work (see Table 1): (1) changing weather patterns, (2) infrastructure development and water availability for irrigation, (3) agricultural resilience and climate change preparation, (4) drought preparedness and adaptation, (5) policy, politics, and water rights, and (6) the financial and economic impacts of climate change (see Appendix 2, Table 1 for the full list of codes and their meaning).

TSPs were asked what their organizations or agencies were already doing to navigate these challenges. They highlighted the development of adaptable management processes and policies, outreach and education, data collection and consolidations, and assistance to producers with project implementation (see Table 1).

**Table 1**

*Current priorities and Strategies for Wyoming TSPs*

| Focus Group Question [code frequency by question] | Theme [code frequency by theme] | Theme Meaning |
|---|---|---|
| "What do you see as the most important weather, climate, and/or water topics for the Wyoming agricultural community in the future? Please describe." [130] | Changing weather patterns [33] | Considerations for how changing weather and climate patterns (e.g., hot, dry summers) may impact the growing season. For example, fire susceptibility, the timing of precipitation, earlier warming (fall-spring), late freezing, trees breaking, and climate responsiveness to wildlife vulnerabilities and habitat management. |
| | Infrastructure development and water availability for irrigation [31] | Consideration of how (changes in) water availability and drought, including the timing and amount of runoff and groundwater recharge, may impact irrigation needs. Also included in this theme was infrastructure related to flood control and storage, which impacts both water quantity and quality (e.g., post-wildfire runoff). |
| | Agricultural resilience and climate change preparation [28] | Preparing for change and improving agricultural resilience through diversifying practices on cow-calf operations, grazing management, soil health improvements, strategies for long-term drought, or improving forage supply and quality. |
| | Drought preparedness and adaptation [26] | Working with producers to manage current conditions and prepare for long-term drought toward increased capacity to adapt. |
| | Policy, politics, and water rights [11] | Maintaining vs selling off senior (agricultural) water rights. Communication and disagreements between the states. |
| | Financial and economic impacts of climate change [1] | The overall economic impacts of climate change on the agricultural sector and producers' bottom line (e.g., insurance costs, livestock feed and processing, etc.). |
| "When thinking about these important topics, what are you or other technical service providers already doing to navigate these challenges and opportunities?" [110] | Development of adaptable management processes and policies [51] | Development and implementation of programs/projects or plans to manage resources in the face of change and toward environmental resilience. For instance, improvements to rangelands through water storage development, grazing management including herd size. This includes emergency assistance programming. Currently TSPs offer emergency programs to assist producers experiencing climate crises such as historic snows, flooding, natural disaster, etc. (e.g. heavy equipment, animal feed). |
| | Outreach and education [36] | This includes community outreach and information/data sharing, research on alternative farming practices, and emergency assistance programs (if it involves education about existing programs). For instance, workshops and personal conversations. |
| | Data collection and consolidation [18] | Place-based monitoring, data collection, consolidation, and sharing of relevant data including cross-agency collaboration. |
| | Assistance to producers with project implementation [5] | Engagement in research specific to alternative farming practices. For example: water use efficiency, irrigation methods, alternative crops, cost shares. This theme also includes water storage infrastructure projects. |

Participants were also asked whether they currently felt adequately equipped with the skills, knowledge, and resources to address weather and climate variability and water availability in their work. Responses varied indicating a mix of preparedness levels: Skills: Yes (17), No (2), Sometimes (29); Knowledge: Yes (9), No (12), Sometimes (26); Resources: Yes (12), No (12), Sometimes (24). One TSP thoughtfully shared why responses to this question vary, *"Many of us deal with these issues regularly, have solid knowledge, and know what we don't know. While others in more isolated roles don't engage with the public around these topics and struggle to answer even basic questions"* [FG5, P4]. These varied responses reflect the different training, backgrounds, and experience levels of TSPs navigating weather, climate, and water-related challenges.

**Needs Related to Knowledge, Skills, and Resources**

Participants were asked to identify their weather, climate, and water-related job demand gaps in three areas: (a) data, information, and knowledge; (b) skills and aptitudes; and (c) resources. Six key themes emerged:

***Climate and Environmental Sciences Training***

TSPs identified a need for additional training on changing environmental conditions that affect water availability. Key topics included climate modeling, weather predictions, and fundamental climate science such as carbon cycling. Participants also emphasized the importance of training on effectively communicating data and predictions to clients to support place-based solutions. For example, one participant said: "*I wish more of us felt confident and comfortable enough to have those simple conversations [about weather and climate], so that when [producers] bring something up, [TSPs] feel confident enough to continue that conversation and see where it goes"* [FG3, P1].

Training in research and development of new technologies and infrastructure–such as pivots, irrigation structures, and beaver dam analogs was also highlighted. Specifically, TSPs stressed the need for developing and enforcing robust irrigation infrastructure and improving preparedness for extreme weather events like droughts. They viewed these measures as essential for community adaptation and resilience. One participant expressed a long-term perspective on producer preparedness: *"I was thinking of producers having drought plans with triggers in place–that's an outcome I would like to see"* [FG2, P5].

***Climate Communication Skills***

TSPs identified a need for stronger communication skills to effectively convey data, predictions, and forecasting to their clients and community organizations. They also emphasized the challenge of addressing climate skepticism, particularly regarding human-caused climate change in Wyoming. One participant noted: *"There's so much distrust and politics involved in climate that if you say 'climate,' producers say, nope, I'm out. But this is real, on-the-ground information producers need to know" [FG3, P2].* Another participant highlighted the difficulty of discussing climate change without sparking controversy: *"Not everybody's on board with the concept and explaining it in a way that doesn't become heated is a challenge. Sometimes we lose their interest. We're voluntary, so we really need them on board with us" [FG4, P3].*

***Place-based Monitoring***

When asked about their clients' data and information needs, TSPs emphasized the importance of farm- and ranch-specific monitoring tools tailored to local conditions. Producers prefer site-specific instrumentation, reflecting a broader distrust of generalized models and external data sources that may not align with their lived experiences. As one participant explained: *"One thing we hear from our clients [producers] is that we need to use more site-specific weather data to make management adjustments. Producers are concerned about using analysis that's too broad, that the data doesn't accurately reflect their allotment" [FG3, P3].*

Many TSPs in Wyoming live in rural areas, often on farms or ranches, with spouses managing daily operations while they work in town. This firsthand connection enhances their understanding of producers' needs and reinforces their interest in locally relevant data and instrumentation. Focus group participants unanimously supported expanding weather stations and other monitoring tools, including stream gages, SNOTEL sites, and soil surveys.

***Outreach and Education***

TSPs emphasized the need for more locally relevant information–such as livestock marketing tools and cost-saving correlations–to better assist producers. They also noted a shortage of qualified state and federal agency personnel available to support producers. One participant highlighted this gap: *"More local [Farm Service Agency] representatives for outreach and education are needed. We rely on a gal over in [community] that doesn't make it here very often. There's a big gap that we could help fill with our clientele" [FG3, P5].*

In addition to direct producer support, TSPs stressed the importance of community education to encourage ownership of conservation practices. They recommended that researchers and CES specialists work alongside them to educate producers preparing for increasingly frequent weather and climate challenges. They also suggested involving TSPs and students in research projects to enhance knowledge-sharing and practical application. Once research is conducted, TSPs emphasized the need to translate findings into actionable management tools. As one participant put it: *"There's a lot of research out there... But if we can't get it to the people that are doing the work, it's useless"* [FG6, P2]. Another reinforced this point: *"What's the point of having information if you can't get that information to the people who need it?"* [FG2, P4].

***Relationship-building***

TSPs emphasized that engagement with clients on weather and climate topics relies heavily on online sources and social networks, including professional societies, peer-organizations, and direct producer connections. They expressed a need to strengthen networking and collaboration skills to improve communication and knowledge-sharing in these areas. To facilitate relationship-building, TSPs suggested brown bag lunch webinars and climate communication workshops, which could expand their understanding of available resources and enhance data accessibility. One participant underscored how collaborative data-sharing could free up time and funding for other priorities: *"If we start sharing data, we have a lot of organizations looking at the same lane. When we cut that overlap, there's now money for other things that help fix the issues we're all dealing with" [FG5, P5].* Finally, TSPs stressed the importance of building trust and aligning common goals among groups working on water-related challenges, recognizing that stronger collaboration could significantly enhance community resilience.

***Data: Interpretation, Forecasting, and Information Consolidation***

TSPs emphasized the need for support in interpreting raw data and transforming it into usable outreach products to help producers respond to changing water availability and increasing natural disasters. One participant explained: *"When thinking about interpreted data, producers like to hear how much rain came down or what's the soil moisture. But for many producers, understanding what the data means for them and how to apply it to management is crucial" [FG2, P1]*. This underscores the necessity of providing relevant, accessible, and actionable knowledge to support management decisions. As one participant noted: *"Translating data into actionable steps–but making it very clear what needs to be done to address the issue–is essential" [FG1, P1].*

Actionable knowledge moves beyond systematic investigation to bridge research and extension practices. It is defined as knowledge that supports real-world implementation and influences behaviors, perceptions, and decision-making (Argyris, 1993). Similarly, actionable science refers to data, analysis, and forecasts that are predictive, accepted, and understandable enough to inform decision-making, including investment strategies (United States Environmental Protection Agency [USEPA], 2009). Both concepts reflect TSPs' need for thoughtful, place-based information sharing tailored to the communities they serve.

TSPs also stressed the need for better forecasting–particularly 3-6 months projections–to improve planning. One TSP described the practical value of even basic forecasting: *"These projections might be as simple as whether an area will get colder or hotter, or how much moisture will be available in the spring*" [FG4, P2]. In the longer term, TSPs were more focused on the challenges of long-term decision-making than improved forecasting. As one participant explained: "*If we are using these models, and assuming they are accurate, it would be good to know what producers may want to adapt in their operations over the next 5 to 10 years"* [FG1, P8]. Another participant noted the challenges of long-term adaptation, *"It's easy to change what you plant if there's a market, you just switch crops next year. Adjusting breeding schedules, spring and fall calving, and turnout schedules is harder. Changing allotment use is an even more complex, multi-year process"* [FG1, P8].

Finally, TSPs expressed a need for a centralized data hub or resource library to improve access to raw data and management tools. They recommended collaborating with climate experts to ensure effective interpretation and utilization tailored to producers' needs. As one participant summarized: *"We need one place to get all the information, whether it's news, legislative changes, or how policies will affect farmers and ranchers in Wyoming"* [FG1, P7].

## Discussion

This study identified critical weather, climate, and water availability needs among TSPs serving Wyoming's agricultural community. Participants emphasized the importance of clear and actionable scientific outputs, along with support for data interpretation, forecasting, and information consolidation, to help producers translate data into practical, place-based management strategies. They also called for education initiatives, peer-learning opportunities, and demonstration projects to showcase effective data use and strengthen resilience. Participants asked for training to enhance their environmental science and climate literacy and to improve communication with producers about sensitive topics such as climate change. They also emphasized the value of placing more local monitoring devices to build trust in the data and increase operation-specific relevance. Finally, relationship-building surfaced as a cross-cutting priority, with providers noting that stronger networks and collaborative structures would enhance their capacity to support producers and their communities.

Three overarching takeaways emerged linking this study to broader literature. First, trust is essential for effective knowledge transfer (Orton & Lee, 2025). Focus group participants often spoke of the longstanding relationships that they have with producers. Peer-learning and bottom-up approaches that leverage existing TSP networks can build on this foundation to expand adaptation and the use of new tools and practices. Second, existing relationships (i.e., social capital) are equally critical for climate communication, where sensitive topics require careful framing and credible messengers (Silvert et al., 2022; Witinok-Huber & Radil, 2021). TSPs and researchers can strengthen these networks to foster trust and improve delivery of climate information, including forecasting tools. Third, climate literacy training, including youth development programs such as internships, can strengthen trust, enhance knowledge transfer, and build foundational climate science literacy (Anderson & Feder, 2020; Miller et al., 2021).

A key limitation of this study is its reliance on existing relationships for focus group recruitment, which may have introduced bias and excluded some perspectives. However, the study employed a rigorous qualitative approach to identify collective themes, ensuring broad representation of TSPs working on weather, climate, and water challenges in Wyoming. The overarching takeaways around trust, relationships, and climate literacy training provide a foundation for actionable recommendations and broader implications for CES programming and decision-making.

## Recommendations

This needs assessment points to a few key recommendations. First, Wyoming agricultural TSPs who have longstanding relationships with agricultural producers are well-positioned to engage in difficult conversations with their clientele about changing climate conditions. TSP trainings and programming on weather and climate should recognize and lean into these existing trust relationships between TSPs and producers to ensure effective knowledge transfer.

Second, TSPs welcome both informal exchanges and structured peer-to-peer learning opportunities to address identified needs gaps. Many acknowledged their own knowledge, skill, and resource gaps, while others expressed confidence in their expertise. Several knowledge gaps raised during the focus group sessions were addressed by peers in real time; participants found this informal peer learning to be especially valuable. Consistent activities–such as webinars, brown bag lunches, or local demonstration plots–should build on existing social networks and provide safe spaces for dialogue on controversial climate topics.

A final key recommendation is to prioritize translating complex climate data into practical guidance that both TSPs and producers can readily apply. This translation must be paired with consistent training to strengthen climate literacy and communication, ensuring that tools are not only clear and actionable but also trusted and transferable across diverse agricultural contexts. Together, locally relevant, practical data outputs and enhanced climate literacy are foundational to informed decision-making and resilience at farm and community levels.

## Implications

The focus group method used here offers a replicable framework for identifying challenges and enhancing knowledge exchange across regions. This approach shows the value of place-based decision-support tools and centralized climate resource hubs adaptable to diverse agricultural contexts.

The insights developed here extend beyond Wyoming, offering guidance for TSPs and research teams internationally in designing climate-specific educational programs and tools that improve climate literacy, communication, and usability. Global extension contexts corroborate the importance of identifying local needs, respecting cultural norms, and sustaining consistent engagement to build trust and support climate-smart adoption. Applying these lessons can strengthen preparedness and resilience across varied agricultural settings, particularly in climate-skeptical communities. The focus group needs assessment used here provides a replicable framework for understanding challenges and improving knowledge exchange across regions.

## Conclusion

This needs assessment can be adapted to other local contexts, to strengthen resilience and climate preparedness internationally. By engaging TSPs and producers in the co-design and implementation of climate-smart tools and programs, extension systems can strengthen trust, improve climate literacy, and translate complex data into actionable guidance. As a result, agricultural communities are better equipped to meet the evolving challenges of weather variability, climate change, and water availability.

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# Appendices

## Appendix 1. Focus Group Discussion Script

Approved Study - University of Wyoming IRB Protocol No. 20230531KH03583

Focus Group Discussion Script & Questions

Facilitator/recorder name:_______________

Date: _________________________

Location:______________________

### Wyoming Agricultural Technical Service Provider Weather, Climate, and Water Availability Needs Assessment

### A. Introduction & Opening Remarks *(10 min)*

### B. Ground Rules *(2 min)*

- Everyone's perspectives are heard and respected
- There are no right or wrong answers
- There are many people here and it is important that we hear the views and experiences of everyone - so please speak up and share your voice and thoughts on the questions and listen to others when they are speaking.
- Each participant will maintain the privacy of the participation and responses of others in the group
- All cellular phones are placed in silent or vibrate mode. If you must respond to a call during the session, please step out of the group and rejoin us as quickly as you can.

### C. Introductions - Icebreaker *(5-10 min)*

Let's start with brief introductions (facilitator select one method)

- Let's go around the room and introduce ourselves including name, organization, and involvement with climate science data in your work. *OR*
- Pair up and introduce yourself including your name, organization, and involvement with climate science data in your work (2-3 rounds).

Are there any questions before we start? *[Pause and respond to questions]* Thanks again for participating, we will now begin the focus group discussion and start the recording.

**D. Focus Group Discussion Questions:** *(60-90 min in total)*

**Facilitator Note – Key things to remember as you are facilitating:**

(1) Prompt the discussion with questions like, "What about you? What was different for you? "What was the same?" Or "Who has a different opinion or experience?"

(2) Before you move on from each question ask participants: <u>Is there anything else anyone wants to add?</u>

(3) Only explicitly ask 'prompts' when the main question topics are not answered/discussed or there is a lull in the conversation and further motivation is required.

(4) Always ask 'sub-questions'.

<u>**Discussion Questions:**</u> *(10-15 min per question category - can be shorter if fully answered)*

1. What do you see as the most important weather, climate, and/or water topics for the Wyoming agricultural community in the future? Please describe. *(10 min)*

*Prompts:*

a. Gaining access to useful climate-science related information, resources, and training

b. Working with ag producers/land managers to adopt new practices, technologies, and/or beliefs and behavior changes specific to climate-related information

c. Water related: Timing and frequency of precipitation, type of precipitation (rain vs snow); Increased flooding and/or drought events; Water quality

2. When thinking about these important topics, what are you or other technical service providers already doing to navigate these challenges and opportunities? *(10 min)*

3. Current information sources *(10 min)*

a. What are your primary information sources for weather, climate, and/or water topics? (e.g., National Weather Service, the weather channel, the farmers' almanac, manuals, online websites, newspaper, radio)

b. If you have questions about weather, climate, and/or water topics, who in your network would you contact for additional information or help? Please provide examples. Individuals? Organizations/Agencies?

4. When thinking about these topics, what kind/type of additional data or information would you like to have? *(15 min)*

   a. Is this the same as what your colleagues would say? Or different? If it is different, please explain.

      1. Is this the same as what your clients would say? Or different? If it is different, please explain.

      2. Where or how would you imagine your clients getting access to these data or information?

      3. Do folks in this area feel like they need more weather stations? Please describe.

**Read as intro to the next 3 questions:** The next three questions are very similar to each other. The first one asks you whether you (and your peers) current **knowledge** about weather and climate meets climate related demands in your position(s), the second asks about whether your **skills** are adequate, and the third asks whether you have enough **resources** to do your job. *(Ask each question for participants/peers, then can go back and ask about clients/producers collectively (part c) -> e.g., What additional skills and/or data/knowledge and/or resources do your clients/producers need?)*

5. Current **knowledge** *(10 min)*

   a. Does your current knowledge meet your climate science-related job demands? For your peers?

      1. What additional knowledge would be helpful to meet those demands?

      2. What additional knowledge/info/data do your clients/producers need?

6. Current **skills** *(10 min)*

   a. What about your current skills? Do your current skills meet your perceived climate science-related job demands? For your peers?

   b. What additional 'skills' would be helpful to meet those demands?

   c. What additional 'skills' do your clients/producers need?

7. Current **resources** *(10 min)*

a. What about your current resources? Do the resources you have access to meet your perceived climate science-related job demands? For your peers?

b. What additional 'resources' would be helpful to meet those demands?

c. What additional 'resources' do your clients/producers need?

8. To end, we want to know what you think are the best next steps, for all of us together, to support your efforts in building weather/climate awareness among your clientele *(15 min)*

a. What are the next steps, including key research, that would be useful to build agricultural resilience with your clients? What types of outcomes are most useful/usable?

b. How might UW researchers/extension specialists be involved?

c. What steps are required in building community resilience in the face of the topics discussed, specifically changes in water availability.

9. Is there anything else you'd like to add?

Thanks for your time and expertise!

## Appendix 2. Complete Data Analysis Table

Table 1 contains all qualitatively analyzed thematic codes by focus group question, including their meaning and frequency. This analysis was completed using Dedoose software and google sheets for collaboration and iteration.

**Table 1**

*Complete list of thematic codes and meanings for each focus group question.*

| Focus Group Question [total number of codes recorded] | Theme [code frequency by theme] | Meaning |
|---|---|---|
| "What do you see as the most important weather, climate, and/or water topics for the Wyoming agricultural community in the future?<br>Please describe." [132] | Changing weather patterns [35] | Considerations for how changing weather and climate patterns (i.e., hot, dry summers) may impact the growing season. For example, fire susceptibility, the timing of precipitation, earlier warming (fall-spring), late freezing, trees breaking, and climate responsiveness to wildlife vulnerabilities and habitat management. |
| | Infrastructure development & water availability for irrigation [31] | Consideration of how (changes in) water availability and drought, including the timing and amount of runoff and groundwater recharge, may impact producer's irrigation needs. Also included in this theme was infrastructure related to flood control and storage which impacts both water quantity and quality (e.g., post-wildfire runoff). |
| | Agricultural resilience & climate change preparation [28] | Preparing for change and improving agricultural resilience through diversifying practices on cow-calf operations, grazing management, soil health |

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| | | improvements, strategies for long-term drought, or improving forage supply and quality. |
| | Drought preparedness & adaptation [26] | Working with producers to manage current conditions and prepare for long-term drought toward increased capacity to adapt. |
| | Policy, politics, and water rights [11] | Maintaining vs selling off senior (agricultural) water rights. Communication and disagreements between the states. |
| | Financial and economic impacts of climate change [1] | The overall economic impacts of climate change on the agricultural sector and producers' bottom line (e.g., insurance costs, livestock feed and processing, etc.). |
| "When thinking about these important topics, what are you or other technical service providers already doing to navigate these challenges and opportunities?" [110] | Development of adaptable management processes and policies [47] | Development and implementation of programs, projects, or plans to manage resources in the face of change and toward environmental resilience. For instance, improvements to rangelands through grazing management including herd size. |
| | Outreach and education [36] | This includes community outreach and information/data sharing, research on alternative farming practices, and emergency assistance programs (if it involves education about existing programs), For example, workshops and personal conversations). |
| | Data collection and consolidation [18] | Place-based monitoring, data collection, consolidation, and sharing of relevant data including cross-agency collaboration. |
| | Assistance to producers with project implementation or emergency assistance [9] | Engagement in research specific to alternative farming practices. For example: water use efficiency, irrigation methods, alternative crops, cost shares. This theme also includes water storage infrastructure projects. This includes emergency assistance programming. Currently, TSPs offer emergency programs to assist producers experiencing climate crises such as historic snows, flooding, natural disasters, etc. (e.g., heavy equipment, animal feed). |
| "What are your primary information sources for weather, climate, and/or water topics? (e.g., National Weather Service, the weather channel, the farmers' almanac, manuals, online websites, newspaper, radio)" [175] | Data collection & storage/management [175] | Historic and/or existing data collection and management (e.g., SNOTEL sites, stream gages, soil surveys, conservation districts). There was mention of both state and federal databases and instrumentation. |
| | Online resources & weather forecasting [38] | Activity outputs (e.g., Cattlefax); (Social) media (Facebook, Twitter, NWS Riverton, newspaper, radio, local new); Online (UN Lincoln, websites, Weather Bug) |

| | | |
|---|---|---|
| "If you have questions about weather, climate, and/or water topics, who in your network would you contact for additional information or help? Please provide examples. Individuals? Organizations/Agencies?" [29] | Social capital [29] | Existing relationships and personal contacts for example landowners or professional societies. |
| "When thinking about these topics, what kind/type of additional data or information would you like to have?" [211] | Place and operation-based monitoring [176] | There is a need to increase the overall understanding of place-based/locally relevant change through increased instrumentation and monitoring. Including how to improve streamflow forecasting and soil monitoring. Examples of instrumentation included: weather stations, stream gauges, soil monitoring probes, SNOTEL sites, storm radar imagery, longer-term predictions/projections, and invasive species counts). Specific suggestions related to research and outcomes to track the effectiveness of monitoring tools, such as methaneSAT, to improve management actions. |
| | Consolidation and interpretation of data [15] | TSPs indicated the need for a temporal data analysis to compare historical trends and incidences of severe weather to current patterns. This relates to the overall interest of TSPs to have a single place to access relevant, interpretable information specific to Wyoming, such as a virtual data hub (i.e., to locate news, legislative changes, impacts on producers, local data). |
| | Outreach and education toward increased monitoring and behavior change [7] | Suggested the need for producer outreach and education to expand local data monitoring and improve client utilization. Data that provides evidence or incentivization for producers to change behavior (e.g., livestock marketing tools, correlation between product and provider cost savings). |
| | Improving emergency alert systems [7] | Suggested needs for improved emergency alert systems information. An example is the increase of connectivity and effectiveness of red flag warning systems for better client accessibility. |
| | Complete USDA soil survey [6] | TSPs indicated that they need the completion of the USDA soil survey and additional Web Soil Survey (WSS) data in carbon county and other areas. |
| "Does your current knowledge meet your climate science-related job demands?" and "What additional knowledge would be helpful to meet those demands?" [50] | Training and support for data interpretation & use [21] | A need for training in statistics, data analysis, and interpretation, specifically related to effectively turning results into useful tools and information for producers. This included the need for more knowledge about the possible on-farm impacts of long-term change. |

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|---|---|---|
| | Understand & fill personal knowledge gaps [23] | TSPs suggested that they "don't know what they don't know" and needed more knowledge to help understand and fill existing information/data gaps relevant to their jobs. They also indicated the need for more knowledge of basic climate science concepts (e.g., carbon cycle and related topics), information at the science-policy interface towards adaptive management, and improved data from groundwater forecasts. Lastly the need for more knowledge regarding irrigation districts and water usage (i.e., ditch names, ditch owner, etc.) to effectively prepare water users for changing conditions. |
| | Facilitated relationship building [6] | TSPs indicated that they needed to build and strengthen peer networks to increase knowledge of resources available. |
| "Do your current skills meet your climate science-related job demands?" and "What additional skills would be helpful to meet those demands?" [49] | Technical skill building [29] | Training to help make meaning from data results, specifically how to effectively calculate, interpret, and/or present data. Technical skills mentioned included: ArcGIS, climate/predictive modeling skills, weather spotter, data analysis, web design, story mapping. |
| | Improved climate communication skills [11] | TSPs indicated the need for more skills to support information sharing across diverse audiences and to get key knowledge out to those that need it most. Additionally, to build agricultural resilience with clientele through targeted communication. |
| | Enhanced networking & collaboration skills [9] | TSPs expressed the need for skills to improve networks/collaboration between TSP organizations and agencies, including how to increase the diversity of voices involved in conversations. |
| "Do the resources you have access to meet your perceived climate science-related job demands?" and "What additional resources would be helpful to meet those demands?" [91] | Increased monitoring devices and updated/accurate equipment inventories [28] | TSPs suggested that more weather stations and improved monitoring resources were needed to effectively guide producers in decision making (e.g., SNOTELs, stream gauges). Additionally, an inventory of resources including a list of equipment available to producers when needed. |
| | Increased personnel and improved time management [17] | The need for more staff, specialists, and technical assistance was specified (e.g., FSP representatives, technical expertise, one-on-one consultation to fill out USDA programs forms, and develop/implement long-term plans). Additionally, better time management was highlighted. |
| | Improved and diversified education, outreach, and training opportunities [15] | TSPs indicated that they needed better education, outreach, and marketing systems. Specific suggestions were made for a weather spotter class, training on the long-term impacts of climate, and additional materials that describe implementation of climate smart agriculture practices. More opportunities for regional meetings and peer-to-peer learning were also specified. |

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|---|---|---|
| | Data and information consolidation and accessibility [31] | TSPs suggested that they needed resources for credible information and data interpretation to effectively guide producers in decision making. They shared that there is a lot of raw data and only so much that one person can do; an efficient way to collect and interpret data would be useful. Some suggestions included the creation of a data hub and message board for climate science and management use. They also specified that improvements to data accessibility and interpretation are required for both TSPs and their clients such as archival data and historic trends. |

| | | |
|---|---|---|
| "When thinking about these topics, what kind/type of additional data or information do you think that your clients/producers would like to have?" [56] | Place- and operation-based monitoring and information consolidation [18] | The indication that TSP clientele, i.e. producers, are interested in place- or farm-based monitoring (e.g., Farm-based systems, On-site, and WIFI-based Monitoring). TSPs said that their clients would like to see more instrumentation such as weather stations, stream gauges, long-term predictions/projections, SNOTEL sites, storm radar imagery, forecasts, etc. set up on their farms. Additionally, clients desire information on the extended predictions for weather and climate data (including seasonal, 3–6-month outlooks, and competing commodity markets). |
| | Outreach and education [17] | Clients desire more user-friendly and interpretable information and outputs, technology, and data/websites. This includes more information on the USDA Farm Service Agency programs and deadlines |
| | Assistance to producers with project implementation [21] | This included guidance on the implementation of diverse projects that address challenges producers are facing on their farms and outputs/outcomes that are interpretable, adaptable, and solution oriented. This theme calls for producer-centered research, outreach, and implementation. |

Additional questions to understand key actions for the future, elements to building community resilience, and ideas on how to most effectively utilize and shape research questions and goals moving forward.

| Focus Group Question [overall code frequency by question] | Theme [code frequency by theme under each question] | Meaning [across codes] |
|---|---|---|
| Keys to building community resilience for a warming future [61] | Improving relationships (building trust) and communication [24] | TSPs suggested a focal aspect of building community resilience related to relationship building and data sharing across TSP organizations. They also indicated that relationships across the board needed to be improved, including between agricultural and non-agricultural communities, between TSPs, with government agencies, and researchers. The sentiment that building trust and |

| Focus Group Question [overall code frequency by question] | Theme [code frequency by theme under each question] | Meaning [across codes] |
|---|---|---|
| | | encouraging collaboration would increase community resilience was highlighted. |
| | Education focused [21] | TSPs suggested a focus on community education and buy-in to conservation practices to build community resilience. Further, a focus on creating hope for clients about climate change through communication and education was shared. |
| | Irrigation infrastructure, development, enforcement, and compliance [14] | TSPs suggested that the development and enforcement of irrigation infrastructure are needed to build community resilience. TSPs suggested that preparation for extreme weather events (e.g. drought) is needed to build community resilience |
| | Making resilience actionable/realistic: Translating data into actionable steps [2] | TSPs expressed actionable items (i.e., making data actionable, educating producers, and demonstration projects) to build community resilience. |
| Need/goals for future research agendas [65] | Action oriented research & development [32] | TSPs suggested research outcomes that investigate current farming practices and how they can be improved under future climate conditions and resource conflicts. TSPs suggested that researchers should be involved in bringing climate science into range forage research. TSPs suggested that finding feasible alternatives, follow farming as a type of research/outcome. Additionally, they want research on landscape resilience and adaptation on locally relevant scales. TSPs also suggested research for the development of low-tech methods (pivots, irrigation, different practices, Zeedyk structures, beaver dam analogs, DBAs). TSPs also suggested that there should be an investigation into how the installation of water-related infrastructure (wells, pivots, etc.) is affecting responsible groundwater/land use. |
| | Education & outreach [21] | TSPs suggested that TSP peers and colleagues and students should be involved in research projects. TSPs suggested that they want to maintain and further develop networks between organizations to stay informed on climate and weather-related issues. TSPs suggested that researchers/specialists should help TSPs educate clients on how to prepare for more frequent weather/climate events. |
| | Management implementation & behavior change toward community resilience [12] | TSPs indicated that there is a need to keep agricultural operations in Wyoming to establish community resilience.<br><br>TSPs suggested that they want research and access to long term drought trends and records. TSPs also suggested that researchers/research should keep data in models up to date with current science and results. |

| Focus Group Question [overall code frequency by question] | Theme [code frequency by theme under each question] | Meaning [across codes] |
|---|---|---|
| | | TSPs suggested that researchers/specialists from University of Wyoming should prioritize weather and climate-related research with management implications that are relevant to practitioners.<br><br>TSPs suggested that researchers/research should help local leaders and officials prioritize and set up feasible or sound policies, goals, and implementation plans.<br><br>TSPs indicated that there is a need to educate and develop programs (e.g. through research on ag. economics and climate smart practices) to incentivize client behavioral change to establish community resilience. |