Building Tomorrow's Climate-Ready Workforce

A Landscape Analysis

January 13, 2025

ICF

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Executive Summary

The National Oceanic and Atmospheric Administration's (NOAA) Climate-Ready Workforce (CRW) program supports the creation of jobs through sectoral partnerships focused on enhancing climate resilience. The program follows a successful model from the Economic Development Administration (EDA), called the Good Jobs Initiative. The "good jobs" model hinges on identifying in-demand sectors with high-quality jobs. While climate resilience and adaptation are not yet firmly established fields, more cities and states are assessing their climate risks and planning to take action. Essentially the climate-ready workforce is growing. However, a central challenge for the NOAA CRW program is characterizing this demand.

This report summarizes a pilot study for the NOAA CRW program designed to assess gaps in jobs and workforce development and to compare those gaps to employment trends. The report is based on input from over 175 professionals in federal agencies (16), state and regional governments (11), city or local governments (16), academia (9), nonprofits (22), and private companies (25). Using NOAA's Steps to Resilience as an underlying framework, qualitative data is derived from surveys, a conference workshop, discussion groups with professionals in diverse institutional settings, and document analysis. These data are compared to employment trends derived from the Bureau of Labor and Statistics (BLS) Standard Occupational Handbook. Three central needs for the climate-ready workforce stand out.

Transferable skills and work-based learning are critical for training and development of the climate-ready workforce. Activities to enhance climate resilience take place through established sectors (e.g., energy, transportation, and urban planning.) Transferable skills include, among others, navigating decision-making processes (especially in government); managing collaborative teams and projects; writing grants; and organizing engagement between communities, technical experts, and decision-makers. These transferable skills are not only important to the success of climate resilience activities but also make professionals generally more employable. Many skills are learned on the job, and more work-based learning models and programs are needed, especially for engagement.

Engagement is integral to all steps of activities to enhance climate resilience. Engagement can mean community engagement (important for justice and equity); knowledge and practice transfer among professionals; and securing buy-in for complex public infrastructure projects with social, environmental, and economic benefits. The ability to take action to reduce climate risks hinges on interaction between professionals in different spaces and the public and stakeholders those professionals serve.

More jobs in new fields and expanded forms of technical assistance are needed to support implementation of complex, multi-benefit resilience projects. In some cases, there is simply a lack of organizations or professionals with the experience to build resilience projects that incorporate new nature-based technologies. Climate resilience projects are getting stuck in regulatory review and/or not making financial sense. In other cases, the aforementioned gap in transferable skills, including engagement, renders climate service and technical assistance efforts incomplete.

Preliminary analysis of BLS employment trends suggest that jobs are not expected to meet all of these demands. Because there is no established climate resilience or climate adaptation occupation, it is difficult to assess job growth in the climate-ready workforce. Nevertheless, key occupations are projected to decline or keep pace, as opposed to grow. For example, many cities and states struggle with crippling floods brought on by more intense rainfall and/or sea level rise. Hydrologists can help assess these risks as part of analyzing flood control options, and civil engineers are critical for designing feasible, cost-effective, and nature-based stormwater

improvement projects. Hydrologist jobs are projected to decline in comparison to average growth across all fields, and civil engineering jobs are expected to grow only slightly more than average. Urban and regional planner jobs, which require skills in navigating government decision-making processes and community engagement processes, are projected to grow at an average pace. By comparison, electrician jobs are expected to grow almost twice the average across all fields, likely due to investment in renewable energy. The Inflation Reduction Act (IRA) and the Infrastructure Investment and Jobs Act (IIJA) provide more than $50 billion[1] specifically geared toward climate resilience and adaptation[2] efforts. Jobs in important fields are not tracking to support these investments.

The NOAA CRW program is poised to address important gaps integral to advancing climate adaptation. More jobs are needed in all phases of climate resilience activities, especially jobs that support taking action, like design, engineering, construction, and permitting (Figure 1). Even as climate adaptation becomes an established profession, transferable skills and sectoral expertise are important to career attainment and, relatedly, successful and equitable climate resilience activities. Because climate resilience is an iterative and continual process, career attainment in the climate-ready workforce is intimately tied to supporting social learning and relationship-building, two outcomes linked to climate equity and community resilience. Moreover, employment can be a benefit to and incentive for communities to undertake climate adaptation in the first place.

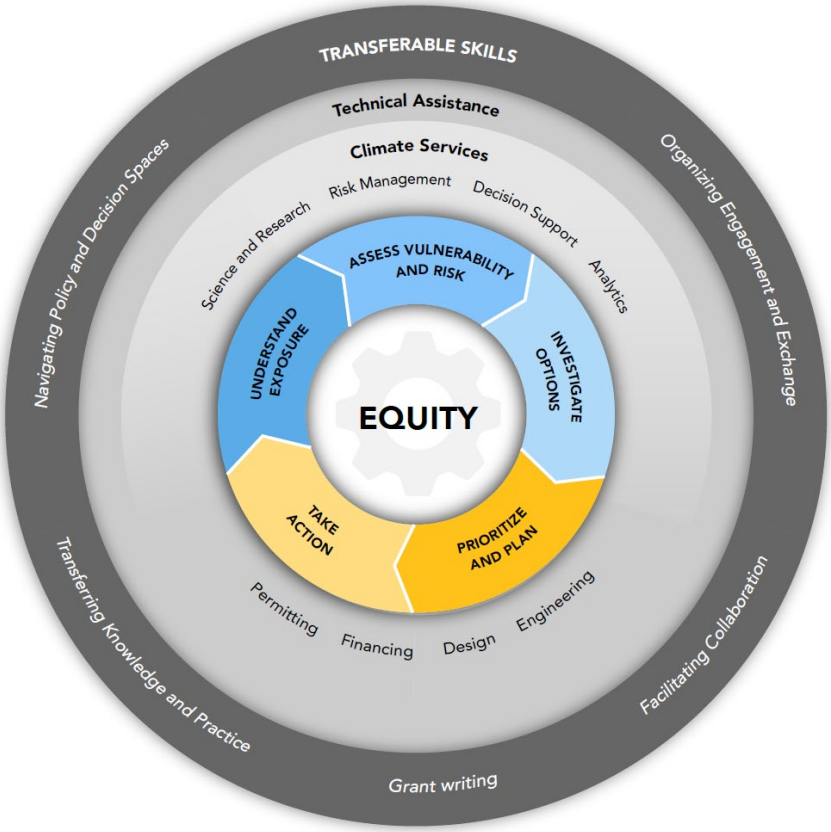


Figure 1. Skills and Capabilities To Support the Steps to Resilience

[1] Executive Office of the President, 2023.
[2] Based on Grade et al. (2023) and IPCC (2022), we define climate resilience as "the capacity to cope with, respond to, and recover from climate hazards," and climate adaptation as "actions taken to minimize or avoid impacts from and exploit opportunities presented by actual or expected climate conditions."

Introduction

Cities, states, tribes, and federal agencies in the United States (US) are responding to the impacts of climate change and extreme weather events.[3] In 2019, jobs related to these efforts were valued at $2.4 billion,[4] and in 2020, those same efforts were estimated to employ 4.1 million people.[5] The Inflation Reduction Act (IRA) and the Infrastructure Investment and Jobs Act (IIJA) are stimulating even more jobs in this field, investing more than $50 billion[6] specifically in climate resilience and adaptation.[7] Funding will support response efforts in disadvantaged communities that are marginalized by underinvestment and overburdened by pollution.[8] In response to this demand, the National Oceanic and Atmospheric Administration (NOAA) started the Climate-Ready Workforce (CRW) program as a competitive grant and technical assistance program funded through the IRA.

NOAA CRW supports the creation of sectoral partnerships to train and place program participants in good jobs[9] that enhance climate resilience. The use of sectoral partnerships to facilitate workforce development is a proven strategy as shown through the Economic Development Administration's (EDA) Good Jobs Challenge. Sectoral partnerships are designed to include relevant partners before workforce solutions are developed, target in-demand sectors with high-quality jobs, and consider the economic realities of an area when assessing workforce demand and training needs. Partnerships also increase the likelihood of individuals being placed into good jobs after program completion given the partnerships' connection to real-time employer demand. Yet, a central challenge for NOAA CRW and related programs is to identify what fields of professional practice are most needed to increase community resilience in all sectors of the country.

Since 1995, the number of regional, sectoral, and tribal programs providing climate services is growing.[10] These programs employ scientists,[11] planners,[12] and boundary spanners[13] (i.e., professionals working across disciplinary or science-to-society boundaries). A number of formal evaluations and informal reflections on lessons learned from these efforts highlight the importance of working across scales of government; different types of organizations (government, nonprofit, academic, and private); and different forms of scientific, technical, and cultural knowledge. Consequently, professionals working in the field of climate resilience and adaptation use numerous terms to describe their work: resilience planning, adaptation planning, and climate services, to name a few.[14] The distinction between these terms ranges from highly specialized (meaningful mainly to experts or practitioners within the field) to generic. However, adaptive risk management and social learning continue to be central, underlying concepts related to resilience-building and climate adaptation.

[3] Jay et al., 2023.
[4] McGinn, 2021.
[5] Bertrand, 2021.
[6] Executive Office of the President, 2023.
[7] Based on Grade et al. (2023) and IPCC (2022), we define climate resilience as "the capacity to cope with, respond to, and recover from climate hazards," and climate adaptation as "actions taken to minimize or avoid impacts from and exploit opportunities presented by actual or expected climate conditions."
[8] 40% of this investment must benefit disadvantaged communities that are marginalized by underinvestment and overburdened by pollution.
[9] The term "good jobs" refers to the Good Jobs Principles developed by the U.S. Department of Labor (2025).
[10] Wasley et al., 2023; Fast Track Action Committee on Climate Services (FTAC), 2023.
[11] Lemos et al., 2019; Parris et al., 2016.
[12] Ibid.
[13] Bednarek et al., 2018.
[14] MitFLG, 2024.

NOAA's Steps to Resilience synthesizes many different versions of the process of adaptive risk management used in diverse sectors and locations throughout the world (Figure 2). The Steps to Resilience is not intended as a universal decision-making process and often is not executed in the same sequence. Rather, the Steps to Resilience highlights the central concept that, in the face of uncertain futures, people act on risk-based information, monitor what happens, learn from the experience, and adjust future actions based on what has been learned.[15] While the Steps to Resilience is not one-size-fits-all, the progression in the Steps to Resilience and other similar frameworks is the basis for efforts to assess progress on climate adaptation and resilience-building. Specifically, the Intergovernmental Panel on Climate Change (IPCC) and the US National Climate Assessment (NCA) both highlight that more work has been done to understand exposure; assess risk and vulnerability; and investigate options, including developing plans for how to cope with and adapt to climate change. By contrast, cities, states, tribal and community-based organizations, and other decision-makers are only recently implementing those plans (i.e., taking action) , and those actions are not considered sufficient to reduce the amount of expected risk from climate change.[16,17] In recognition of the need to support implementation, technical assistance programs by governmental and nongovernmental organizations are rapidly expanding.[18] Technical assistance efforts include diverse forms of public and commercial climate services and new forms of support to address newly identified needs, such as engineering,[19] construction, grant writing, and development of financing mechanisms to implement the range of actions in climate adaptation and resilience plans.

Jobs related to climate resilience and adaptation now provide diverse avenues for employment. However, it is difficult to characterize in-demand jobs and workforce development needs despite the dual urgency to reduce climate impacts already faced by many communities and the need to link that climate response to sustained career opportunities. The difficulty of characterizing these workforce needs stems from the diverse background of people supporting climate resilience and

Figure 2. NOAA's Steps to Resilience

[15] NRC, 2011; Bidwell et al., 2013.
[16] Lempert et al., 2018; Wasley et al., 2023; Berrang-Ford et al., 2021.
[17] While not identical, the NCA uses a sequence similar to what is illustrated in the Steps to Resilience. See Box 31.1 in Wasley et al., 2023.
[18] MitFLG, 2024.
[19] ASCE and NOAA, 2023; Parris et al., 2023.

adaptation efforts, the diverse organizational and institutional settings where climate resilience efforts take place, and the still-emerging ways professionals define work in this space.[20]

The goals of this pilot study are to assess gaps in jobs and workforce development for NOAA CRW and to compare those gaps to employment trends. The Approach section describes the methods used to gather input from a diverse range of professionals leading and/or supporting climate resilience and adaptation efforts. The Results section summarizes findings and recommendations for advancing workforce development. Finally, the conclusion outlines directions for future research and program development.

Approach

This methodology was conceived as a pilot study to inform future phases of program design and evaluation for NOAA CRW. In this case, the climate-ready workforce is defined as "good jobs that enhance climate resilience" based on two criteria. First, the Department of Labor identifies "good jobs" as those that address benefits; diversity, equity, inclusion, and accessibility; empowerment and representation; job security and conditions; and pay, among other factors. Second, NOAA identifies a range of objectives and activities related to enhancing climate resilience[21] that align with the Steps to Resilience. Because the Steps to Resilience represents a comprehensive synthesis of many previous climate resilience-building and climate adaptation efforts and because the Steps to Resilience can be easily aligned with climate adaptation assessments like the NCA, this study draws heavily on the Steps to Resilience as a basis for defining the activities associated with a climate-ready workforce (see further detail below). Given the focus on climate resilience, NOAA does not include climate mitigation activities as part of the climate-ready workforce, except where the climate resilience measures also reduce greenhouse gas emissions.

This analysis was conducted in six phases:

1) An informal survey and workshop with members of the US Global Change Research Program (USGCRP) Federal Adaptation and Resilience Group (FARG)
2) A workshop at the 2024 National Adaptation Forum (NAF)
3) Discussion groups with professionals working on resilience and/or adaptation initiatives across the United States
4) Qualitative analysis of resilience plans and workforce development research
5) Qualitative analysis of input from FARG, NAF, and the discussion groups
6) Qualitative analysis of the Bureau of Labor and Statistics (BLS) Occupational Handbook

Participation in the discussion groups was voluntary. To protect personally identifiable information of participants, results are anonymized.

[20] Executive Office of the President, 2022; MitFLG, 2024.
[21] See pages 4–5 of the Notice of Funding Opportunity for NOAA CRW.

Discussion With FARG

FARG fosters interagency collaboration among the 15 different agencies[22] participating in USGCRP. As part of its efforts to improve information systems and coordinate climate services, FARG created an inventory of federal resilience-related programs. FARG also played a pivotal role in the Federal Framework and Action Plan for Climate Services (2023).[23] A survey was deployed with the help of FARG conveners, containing both multiple choice and open-ended response questions. Multiple choice questions were based on capabilities relating to the Steps to Resilience[24] and used keywords developed for the US Climate Resilience Toolkit ("the toolkit"). A total of 72 FARG members from 16 different agencies responded to the survey. Survey results were presented to the group in a workshop on March 21, 2024. Notes from the workshop discussion and the open-ended questions in the survey were incorporated in the analysis in the final stage of this work (see the Document Analysis section).

NAF Workshop

A two-hour workshop on the climate-ready workforce was held in May 2024 at NAF. The session was attended by 91 people from 75 organizations, ranging from local (15), state (9), and federal (15) governments to academia (8), nonprofits (17), and private companies (9). NOAA provided a brief, introductory presentation on the context, goals, and objectives for NOAA CRW. NAF participants come from varied backgrounds and use different definitions and frameworks for resilience, compared to FARG members who interact regularly. Thus, a common scenario related to climate resilience work was presented to focus the discussion (see Appendix C). A combination of polling and facilitated group discussion was used to gather input among participants. Mentimeter was used to poll participants with multiple choice and open-ended response questions. Multiple choice questions were used to provide a consistent structure across all participants and support interpretation of the open-ended responses. Responses to the following open-ended questions were used in the final stage of analysis (see Document Analysis section):

- Which capacity is the biggest gap in the climate-ready workforce?
- Which of these workforce barriers is most pressing?
- How would we know if our workforce is ready?

Discussion Groups

Discussion groups were convened with professionals working in all phases of the Steps to Resilience. The first discussion group included federal program managers who participate in FARG. In this discussion group and all subsequent groups, participants provided additional contacts for future discussion groups. NOAA CRW program managers also provided contacts, including grantees of the program. In total, we held eight discussion group sessions with 20 participants from city (1), state (2), and federal (5) agencies; nonprofits (5); universities (1); and private companies (6).

For each discussion group, an initial presentation provided information on the project, including background on climate resilience, goals for the landscape analysis, and working definitions (see Document Analysis section). Unlike the NAF session, a specific scenario for climate resilience

[22] The 15 agencies participating in the USGCRP are: Department of Agriculture, Department of Commerce, Department of Defense, Department of Energy, Department of Health and Human Services, Department of Homeland Security, Department of Housing and Urban Development, Department of the Interior, Department of State, Department of Transportation, Environmental Protection Agency, National Aeronautics & Space Administration, National Science Foundation, Smithsonian Institution, and U.S. Agency for International Development.
[23] FTAC, 2023.
[24] Gardiner et al., 2019.

work was not provided to constrain the discussion because participants worked in a variety of sectors (e.g., urban planners focused on coastal adaptation and researchers focused on workforce development). This approach allowed us to reach more people across the study period and helped identify both sector-specific and universal concerns. We posed the following questions of each group:

- What capabilities do you feel are most needed [for resilience work]?
- What skills are most critical for a climate-ready workforce?
- What has been the most important or successful element to hiring people to work on climate?
- What has been the most important or successful element to climate-ready workforce development?

The first two questions were posed as both multiple choice and open-ended questions. As with the NAF session, multiple choice questions were used to provide a consistent structure across all participants and support interpretation of the open-ended responses. Multiple choice questions were similar to the NAF questions and based on the Steps to Resilience.

Document Analysis

A document analysis was conducted to analyze text from open-ended responses from the FARG survey and NAF workshop, notes from the discussion groups, climate adaptation and resilience plans, and documents relating to the climate-ready workforce. The codebook was developed based on a preliminary review of the FARG and NAF workshops and subsequent iterative discussions with NOAA CRW program managers (see Appendix A).

Early versions of the codebook consisted of around 40 codes, organized under the primary codes of Technical Assistance, Climate Services, Resilience Planning, and Equity. Multiple sources,[25] including input from FARG, find significant overlap and confusion between the meaning and use of terms like technical assistance, climate services, and resilience planning. Consequently, we revised the codebook to have only two tiers, with the primary tier based on three broad, workforce-related categories — knowledge, capabilities, and skills (KCS). KCS are defined in the codebook and for the discussion groups as follows:

- **Knowledge**: a body of information and/or principles held by individuals or within an institution, which informs and enables their work. An underlying framework or concept held by institutions on which their work/product is based.
- **Capabilities**: the functional abilities or processes through which an organization executes its mission and recruits people to its workforce, drawing on employee skills, assets, and other resources.
- **Skills**: learned powers, or developed aptitudes or abilities, that an individual uses regularly to meet the requirements of their job.

The secondary codes were more expansive and based on our discussion with FARG, the workshop at NAF, and terms from the Steps to Resilience. As highlighted above, using KCS as a primary tier was considered important for conceptually linking programmatic functions (i.e., capabilities) and job requirements (i.e., knowledge and skills). For example, coproduction is recognized as an important crosscutting element throughout climate resilience and adaptation practice. A foundational element of coproduction is engagement, namely interaction among scientists, communities, local

[25] Wasley et al., 2023; MitFLG, 2024.

governments, and/or other stakeholders.[26] Effective engagement, in turn, requires skills such as facilitation, mediation, and meeting organization. For example, the first two Steps to Resilience ("understand exposure" and "assess vulnerability & risk") involve knowledge of climate and socio-ecological-technological systems. Producing actionable climate information often stems from capabilities such as climate modeling and risk assessment, both of which require skill in mathematical modeling.

The codebook was refined through multiple rounds of review between ICF and NOAA CRW program managers to eliminate redundancies and to create working definitions[27] for each coded term. Definitions for the secondary code category were derived from the fifth NCA glossary, the IPCC glossary, and other relevant sources. The resulting codebook includes 54 secondary codes: 18 codes for knowledge, 25 codes for capabilities, and 11 codes for skills (see Appendix A).

Two inter-rater reliability tests were performed to assess agreement between coders, using Fleiss' kappa as a measure of agreement.[28] Coding was performed in CommentWorks, a proprietary tool developed by ICF. Three coders reviewed two documents: a Notice of Funding Opportunity (NOFO) from FEMA's Building Resilient Infrastructure and Communities (BRIC) program[29] and a press release regarding the Washington state CRW grant,[30] which were chosen based on their relevance to the climate-ready workforce. FEMA BRIC is one of the largest sources of funding for climate resilience projects in the United States, and the press release from the Washington state CRW grant provides a project description of relevant activities.

The first test yielded a very low score (-0.8) because one coder assigned far more codes (approximately 3.5 times the first coder) to far more segments of text. Following this test, text in both documents was bracketed into segments to standardize what was being coded by each coder. Segments were identified using expert judgment and text structure (paragraph and line breaks) to help determine changes in topic or focus. The second text yielded far better overall agreement (0.33). Of the 54 codes, there was strong agreement for 36 codes (1.0), moderate agreement for 15 codes (0.32), and poor agreement for only three codes (training and workforce development, climate resilience, and climate adaptation). Following the second test, coders met to refine the definitions and clarify interpretation of the three codes with poor agreement to establish consistency in coding going forward.

Three coders then coded the remaining 16 documents, discussion group transcripts, and NAF session results. The documents were selected for analysis based on their relevance to the climate-ready workforce, including funding announcements, climate resilience and adaptation plans (government-led and community-based), climate resilience program descriptions (government-led and community-based), and green jobs reports[31] (see Appendix B). Text in each document was bracketed into segments using expert judgment and text structure (e.g., paragraph and line breaks). Segments were typically one- to two-sentence chunks of text, enabling coders to assess context without relying on pure word association for coding. Using CommentWorks, the three coders identified the one or two most relevant primary and associated secondary codes for

[26] Based on Grade et al. (2023), coproduction is defined as "The integration of different knowledge systems and methodologies to systematically understand phenomena, systems, and processes."
[27] Collecting standardized definitions for each term strengthens the codebook by reducing variability in word association and niche understanding. Definitions were pulled from the fifth NCA glossary (Grade et al., 2023), as well as from relevant literature and dictionaries.
[28] Laerd Statistics, 2019.
[29] FEMA, 2023.
[30] SBCTC Communications, 2024.
[31] "Green jobs" differ from "good jobs that enhance climate resilience" in that they include jobs related to greenhouse gas mitigation, decarbonization, renewable energy, and other environmental jobs (e.g., ecosystem restoration design).

each bracketed segment. Coding produced data on the terms most frequently used within and across all sources (documents, workshops, and discussion groups), and within and across each primary code category (KCS).

BLS SOC and Occupational Handbook Analysis

An analysis of employment trends was conducted using data from the Bureau of Labor Statistics (BLS).[32] The BLS Standard Occupational Classification (SOC) codes is a federal classification system that organizes jobs into occupational categories to analyze occupations in the United States. A preliminary search of the SOC codes[33] using "climate change" as the primary term yielded few results. Expanding the search to related terms, such as "resilience," "hazard mitigation," and "climate," returned few results. For example, in both searches, "geographer" was the only job that referred to climate, as part of the Earth system and not in reference to climate within a building or workplace environment. The searches validated an underlying assumption and drive for this pilot study. Namely, it is difficult to find what constitutes "climate resilience jobs" because neither climate resilience nor climate adaptation are formally recognized as occupations. Consequently, the SOC codes were not considered a valuable data source for examining job trends.

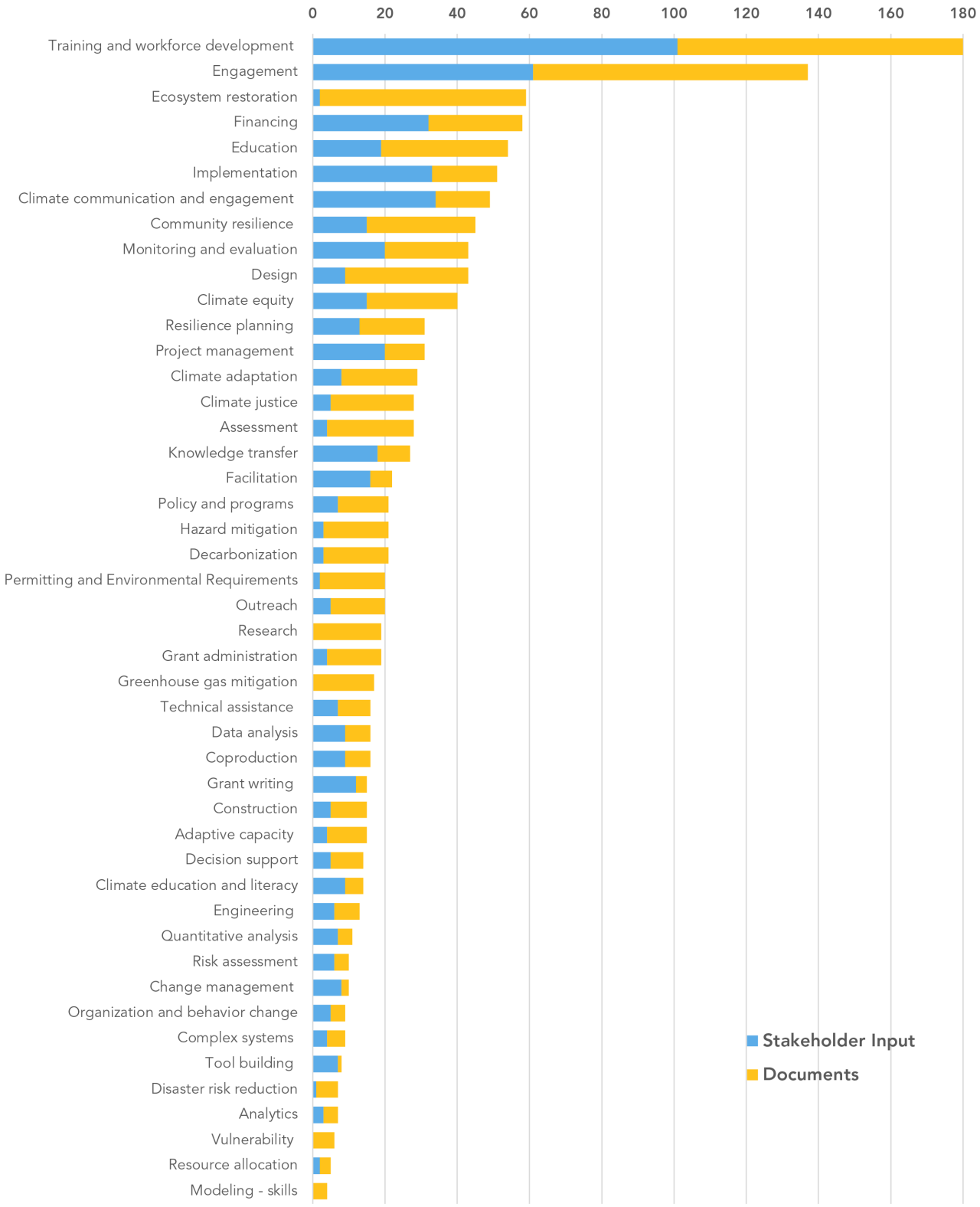
Conversely, the BLS Occupational Outlook Handbook ("the Handbook") provides expanded occupation descriptions and projected trends for each occupation. Searching the Handbook using the term "climate change" identified a broader list of relevant professions than the SOC codes, including environmental scientists and specialists, environmental engineers, and electricians. A total of 14 additional professions were selected based on the professional background of discussion group participants and the "similar occupations" tab for the initial results searching for "climate change" (see below).

Results

Code frequency data were grouped into two main sources: input from FARG, NAF, and the discussion groups, and documents relevant to the climate-ready workforce (Figure 3). Three groups of data emerge: 1) themes from both sources (e.g., training and workforce development); 2) themes predominantly highlighted by professionals working in climate resilience (e.g., project management); and 3) themes predominantly evident in document data (e.g., ecosystem restoration).

[32] https://www.bls.gov/ooh/
[33] U.S. Bureau of Labor Statistics, 2017. 2018 SOC Definitions. https://www.bls.gov/soc/2018/soc_2018_definitions.pdf.

Figure 3. Frequency of Most Common Themes Across Documents and Stakeholder Input



"Training and workforce development"[34] and "engagement" are the two most frequently coded terms. "Engagement" is an especially prevalent theme if you consider closely related codes. For example, "climate communication and engagement," "facilitation," "climate equity," and "community resilience" are all codes whose definitions relate to "partnership or outreach between institutions (governments and other organizations) and communities" (the broad definition for "engagement" adopted for coding). For coding, "climate communication and engagement" and "facilitation" are considered skills held by individuals as opposed to "engagement" as an organizational capability. Climate equity is not exclusively engagement as it also requires attention to governance and power dynamics, culture, and distribution of benefits in relation to disproportionate harms. However, a central principle of climate equity involves strengthening participation of disproportionately impacted and underserved communities in decision-making processes related to building climate resilience (i.e., procedural equity).[35] Similarly, social ties developed through community engagement help build community resilience by improving information flow during and after climate-related events. Beyond these top two codes, there is a lot more variation in the use of terms. However, there is compelling evidence that "implementation" is a primary focus of the climate-ready workforce, consistent with the objectives of NOAA CRW and the findings of the fourth and fifth NCAs.

"Implementation" is among the top six codes and, when considering several closely related codes, stands out as the third most prevalent theme. For example, in the Steps to Resilience, "Take Action" can mean implementing a program to notify homeowners of a pending flood. However, "Take Action" can also mean implementing complex infrastructure projects that incorporate social and ecological elements — e.g., a multimillion-dollar waterfront improvement project that, among other things, provides flood protection, restores ecosystem habitat, improves public space, and creates access to outdoor cooling. Public infrastructure projects often involve multiple stages of design, feasibility analysis, cost-benefit analysis, and permitting prior to construction (see Appendix D). In this context, "ecosystem restoration," "financing," "monitoring and evaluation," and "design" (all among the top 11 codes[36]) directly relate to implementation. In the Steps to Resilience, Take Action is briefly described as: "Do what it takes to secure funds to implement the first task in your plan … As you complete each task, check to see if your actions are producing the results you expect. Continue to monitor, review, and report on your project." Thus, "implementation" is considered the third most prevalent theme in the data.

Beyond the top three themes, significant variation exists in the coded data, consistent with diverse and sometimes overlapping terminology used in the field of climate resilience. The discussion below is based on these convergent themes and highlights insights from practitioners regarding where and how to support the climate-ready workforce by enhancing climate resilience.

[34] Green jobs reports were included in the document analysis and include references to training and workforce development for a broader suite of jobs than the climate-ready workforce. However, even without including data from the documents, training and workforce development remains one of the top two most frequently mentioned codes by a large margin.
[35] Marino et al., 2023.
[36] There is a notable gap and far more variation in codes coded fewer than 35 times.

Training and Workforce Development

Professionals note the importance of training not just in specialized climate topics but also in transferable skills like facilitating collaboration and grant writing. In reference to the 2009 American Recovery and Reinvestment Act, one professional noted,

> *"[s]tudents spent time and money training for jobs that didn't exist, and colleges invested in training programs that didn't pay off. The most important thing is ensuring that people we train come out with broad, transferable skill sets."*

Another professional noted the importance of transferable skills for stable employment, "…they're more likely to be employable for the long term and have skills they can continue to build on while working towards middle-class or better wages. So, having a broad set of skills allows people to take advantage of job opportunities and increase access and mobility into the middle class." Existing training programs, especially in higher education,[37] still fall short in providing comprehensive training on climate change and related knowledge.

Vocational and on-the-job training are important to obtain and keep job opportunities. By providing students and current workforce trainees with hands-on work experience, retention rates increase, and students/trainees become more experienced and hirable for in-demand jobs. Apprenticeships prepare more students for the workforce, and these programs can be aligned with climate resilience jobs.[38] One education professional cited the success of work-based learning models at community colleges:

> *"I think this is something community colleges do really well, and why a program like Tribal Stewards can thrive at a community college. There is a prioritization for work-based learning and an expectation of time and energy put towards that. Most of our programs have a collaborative work experience or an internship requirement. All of our trades programs have extensive lab time and hands-on learning. These experiences are undervalued. At four-year institutions, these experiences are often reserved for senior capstone projects or high-achieving students. We need to think about how to get work-based learning into the first or second year. Real work-based experiences for students early on, such as internships, career exploration, and undergraduate research, are crucial. The challenge is figuring out how a first-generation student can get this experience as early as possible in their field of study."*

[37] Hora, 2023.
[38] Rosen, 2023.

Many practitioners feel that knowledge and skills related to climate resilience should be mainstreamed into existing fields. When asked what barriers still remain for a climate-ready workforce, one practitioner answered: "Mainstreaming climate resilience practice! [Defining] the goal as 'new' jobs is unworkable. Help [people] see climate as part of their existing work!" The *Climate Change Business Journal* estimates the climate resilience and adaptation job industry to be worth $2.4 billion.[39] However, work by the Environmental and Energy Studies Institute (EESI) and the American Society for Adaptation Professionals (ASAP) also notes that longstanding professionals working in adaptation only recently referred to themselves as adaptation professionals after years of working on related activities. The work of enhancing climate resilience and advancing climate adaptation happens through established sectors, per the design of NOAA CRW.

Many feel that more defined career opportunities exist in established sectors (e.g., water, energy, etc.) as opposed to primarily focusing on climate resilience. A professional working in the coastal sector highlighted the need for sector-specific climate training, "I think there's a foundational education piece [missing] … [Workers] need to have a firm understanding of their sector. Real estate professionals, for example, will have a different perspective on how climate change impacts their business. It's also about fostering an environment of learning within their sector … Creating that environment of learning post-project is crucial in the professional space, beyond traditional education."

Engagement

Engagement is a central facet of climate resilience and adaptation. The fifth NCA emphasizes the importance of community engagement throughout climate resilience and adaptation efforts as essential for achieving climate justice and equity.[40] The Steps to Resilience reflects this emphasis by illustrating equity as a central element important to all phases of resilience-building (Figure 2). Engagement in the problem identification phases of the Steps to Resilience ("understand exposure" through to "investigate options") has been extensively studied, focusing on the importance of coproducing climate knowledge (see Key Message 31.5 of Wasley et al.). Professionals from FARG, NAF, and the discussion groups refer to engagement not just in these early phases but also in taking action.

A recurrent theme involves building or maintaining political will for advancing resilience measures among different actors (e.g., policymakers, regulators, project proponents, and residents supported by the actions in question). During the NAF session, professionals connected this point to climate equity, noting the distinction between engagement in a broader sense (e.g., working in teams and/or across organizations) and with underserved communities. Both forms of engagement are important and complementary for resilience-building efforts. In light of research highlighting the importance of knowing when and how to avoid engagement fatigue in communities,[41] important skills for engagement include relationship- and trust-building, respect, conflict resolution, and collaboration. Training and hands-on learning on all facets of engagement (among resilience project teams and for empowering communities) is crucial to the climate-ready workforce. This training can draw on experience and leading practices by adaptation professionals.

[39] McGinn, 2021
[40] Wasley et al., 2023; Marino et al., 2023.
[41] Wasley et al., 2023; Lemos et al., 2018.

Engagement between professionals in the climate-ready workforce is important for a central element of adaptive risk management — knowledge transfer. Integrating themes related to hands-on learning, engagement, and taking action, one professional notes,

> *"Sharing challenges and how they've been met is crucial. We don't do this enough, but it's key to moving forward with implementation. It's not just about data and science, but the process and experience."*

Implementation

To advance implementation, the climate-ready workforce needs to foster strong project leaders and new fields focused on construction. Professionals echo the findings from the fourth and fifth NCAs (from 2019 to 2023), citing a lack of progress toward implementing large-scale climate resilience measures. In that same time span, federal funding to support implementation of resilience projects grew by billions of dollars with the advent of programs like FEMA's BRIC,[42] NOAA's Climate Resilience Regional Challenge,[43] and many others. Professionals from FARG, NAF, and the discussion groups cite the need for strong project leaders or champions to successfully see a project through from securing financing to breaking ground to evaluating the project for future growth.

In leading climate resilience projects, professionals find it necessary to navigate regulatory constraints and the complexities of building new forms of infrastructure. One professional notes,

> *"…regulatory groups struggle to learn from other areas and pilot projects, causing delays in project authorization. Another issue is the lack of experienced firms in green infrastructure and nature-based solutions, especially in California, Oregon, and Washington. Projects aren't getting bids because firms either lack the equipment or experience. This results in regulatory issues, long authorization times, and high costs, making projects more expensive than gray infrastructure and often undoable."*

Similarly, reports from the County of Los Angeles highlight the need to upskill many of their workers and increase training programs to ensure workers are prepared for the changing workforce and able to implement new projects and programs.[44]

Strengthening the climate-ready workforce by expanding jobs associated with implementation can increase community resilience in less obvious ways. One professional notes, "Architects and engineers … engage with underserved communities to create preliminary designs based on community input … Many of [the architecture and engineering] students stay in the regions, and companies often hire them for final design and implementation stages. This helps retain young talent in vulnerable areas. This model provides a dual benefit of workforce development for students

[42] Building Resilient Infrastructure and Communities | FEMA.gov.
[43] NOAA Climate Resilience Regional Challenge.
[44] LACI et al., 2021.

and community engagement, building trust in the long-term." Climate resilience projects can provide multiple benefits from reducing multiple hazards to providing active public space for recreation and well-being. Professionals in the climate-ready workforce already see an additional outcome toward which progress can be monitored and evaluated. As one professional noted, "[y]ou need to show similarities and the cumulative impact and rate of return on that investment, helping develop your workforce. This isn't necessarily a skill, but it ties into implementation and showing the value added for these programs, particularly in the communities they're targeting."

BLS Analysis

Based on data from the BLS Handbook, jobs are not projected to meet the demands of the climate-ready workforce (Table 1). Of the selected jobs, electricians stand out with the highest projected growth relative to the other selected jobs. These jobs are expected to grow 11% between 2023 and 2033, which is 7% above the overall projected job growth rate of 4%. The BLS Job Outlook page for electricians attributes this robust growth to the rise of alternative energy technologies like solar power, illustrating a greater emphasis on climate mitigation than climate resilience and adaptation.[45]

Table 1: BLS Job Outlooks for Resilience

Occupation (SOC code)	Employment, 2023	Projected employment, 2033	Projected change, 2023-2033	Difference between specific occupation projection and overall projected growth (4%)
Electricians (47-2111)	779,800	864,100	11%	7%
Natural sciences managers (2637722)	100,100	107,600	8%	4%
Agricultural engineers (17-2021)	1,900	2,000	8%	4%
Environmental engineers (17-2081)	41,300	44,200	7%	3%
Environmental scientists and specialists, including health (19-2041)	84,600	90,700	7%	3%
Environmental science and protection technicians, including health (19-4042)	33,900	36,200	7%	3%
Civil engineers (17-2051)	341,800	363,900	6%	2%
Atmospheric and space scientists (19-2021)	9,900	10,500	6%	2%
Geoscientists, except hydrologists and geographers (19-2042)	26,000	27,400	5%	1%
Urban and regional planners (19-3051)	45,200	47,100	4%	0%
Geological technicians (19-4043)	9,200	9,500	4%	0%
Hydrologists (19-2043)	6,500	6,700	3%	-1%
Environmental engineering technologists and technicians (17-3025)	14,200	14,500	2%	-2%
Hydrologic technicians (19-4044)	3,200	3,300	2%	-2%

[45] Electricians: Occupational Outlook Handbook, U.S. Bureau of Labor Statistics

BLS data underscore the need for growth related to implementation. For example, in addition to our data, a report developed for the National Institute of Standards and Technology (NIST), American Society for Civil Engineers (ASCE), and NOAA[46] found many municipalities across the United States are grappling with how to design stormwater infrastructure to be resilient to the expected increase in extreme precipitation. To ensure their communities are resilient to these events, specialists such as hydrologists and engineers are needed to implement adaptive solutions. BLS data suggest varied growth in relevant fields. Hydrologist, environmental engineering technologist and technician, and hydrologic technician jobs are expected to grow at rates 1%–2% slower than the average growth rate across all fields (Table 1). According to the BLS website, these jobs are expected to grow slowly due to an anticipated increase in artificial intelligence. While AI may create efficiencies in mathematical modeling associated with understanding flood patterns, specialized expertise is needed to develop models that account for a changing climate (not just the assumption of a stationary one).

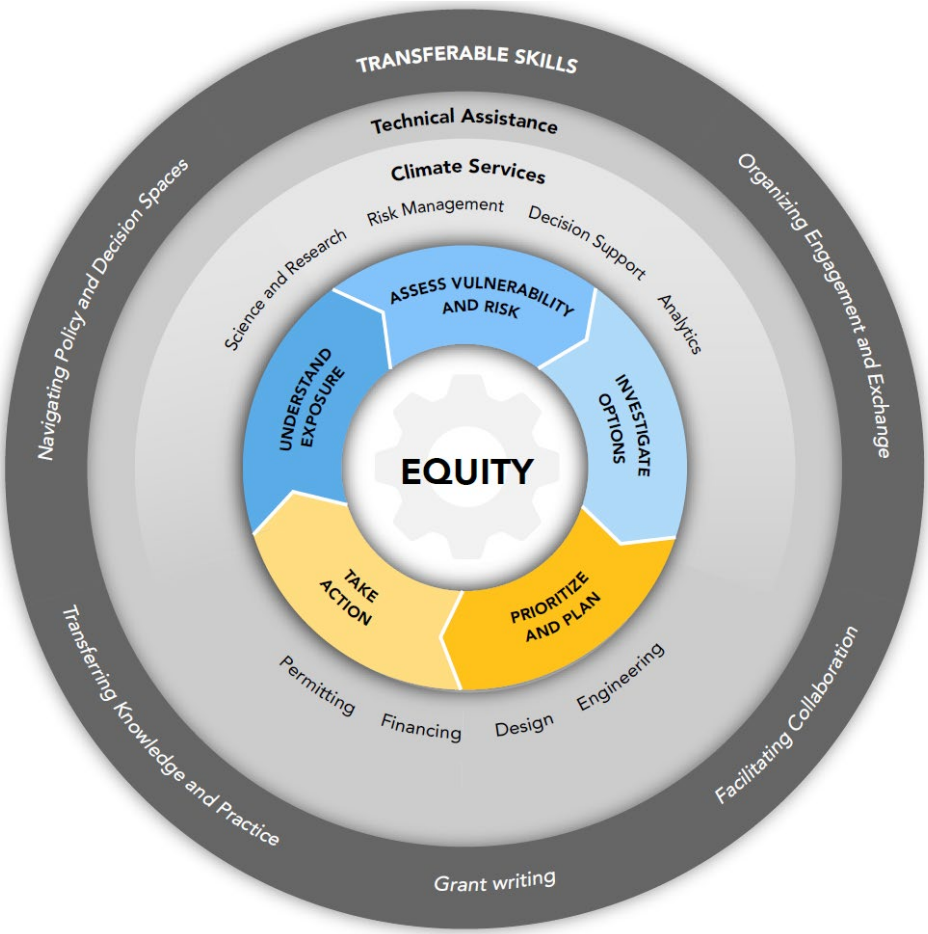
BLS projections heavily influence workforce planning, as organizations often look to this data when determining hiring priorities. Given that the BLS data do not signal an urgent need to expand roles like urban planning, environmental engineering, or hydrology, it may inadvertently underplay the workforce expansion required for the climate-ready workforce. This analysis underscores a key takeaway from the coding and discussion group analyses: There is not enough support or investment in the general workforce for resilience work.

Conclusions

The NOAA CRW program is poised to address important gaps integral to advancing climate adaptation. Based on input from over 175 climate adaptation and resilience professionals, more jobs are needed in all five phases outlined in the Steps to Resilience, especially jobs that support implementation of climate resilience projects, like design, engineering, construction, and permitting (Figure 4). Even as climate adaptation becomes an established profession, transferable skills and sectoral expertise are important to career attainment and, relatedly, successful and equitable climate resilience activities. Because climate adaptation is an iterative and continual process, career attainment in the climate-ready workforce is intimately tied to supporting social learning and relationship-building, two outcomes linked to climate equity and community resilience. Moreover, employment can be a benefit to and incentive for communities to undertake climate adaptation in the first place.

[46] Burgos et al., 2024.

Figure 4. Skills and Capabilities To Support the Steps to Resilience



Learning about and participating in activities to enhance climate resilience is a valuable service in that it can be a springboard to jobs in established sectors and, therefore, a path to upward mobility. Over the past 10-15 years, a number of programs started using training as a form of capacity building. As part of supporting the National Disaster Resilience Competition (NDRC), the Rockefeller Foundation organized Resilience Academies[47] with over 40 different jurisdictions looking to plan and implement complex, multi-benefit resilience projects. Other states and jurisdictions used the model to convene their own academies (e.g., the states of Connecticut and Illinois). The GreenGov Council recently established the PA Climate Network, a key component of which is a training program that provides knowledge about climate science, impacts, and resilience opportunities in Pennsylvania, all with a focus on taking climate action.[48] Similarly, the Climate Smart Communities Initiative (CSCI) funded by NOAA organizes trainings focused on NOAA's Steps to Resilience for climate adaptation professionals.[49] While the GreenGov Council and CSCI training programs are geared toward professionals, the US Environmental Protection Agency offers a training called the Crisfield Resilience Academy for residents in the frontline community of Crisfield, Maryland. Residents over the age of 15 with an interest in environmental issues can receive a stipend and a

[47] The Resilience Academies were designed to "facilitate exercises and presentations intended to build … capacity to design projects that address systemic shocks and stresses, deliver multiple benefits, and ultimately achieve the resilience dividend." The Resilience Academy: A Model for Implementing Resilience. Accessed 1/14/25.
[48] https://www.pa.gov/agencies/dgs/programs-and-services/greengov/pa-climate-network.html. Accessed 1/14/25.
[49] Training and Workforce Development – Climate Smart Communities Initiative. Accessed 1/14/25.

certificate of completion. As noted in the section on Training and Workforce Development, hands-on learning programs like these help expand skill sets, thereby increasing individuals' competitive advantage for employment and mobility into the middle class. Being broadly employable builds adaptive capacity in individuals. The rise of training programs to help advance climate resilience reflects a potentially underappreciated outcome of climate adaptation efforts, beyond impact and risk reduction, that the NOAA CRW program model can monitor and evaluate. Namely, training and workforce development is a service to people and communities.

A standardized system of assessing capacity- and knowledge-based needs for climate service and technical assistance would help coordinate support for communities without sacrificing contextually specific factors. In the FARG survey, 40% of respondents said that their program focuses on "decision support for implementation," as opposed to "decision support for planning." Yet few FARG members support the capabilities and capacities identified by professionals as important to implementation: monitoring and evaluation (25%), grant writing support (12%), finance training and support (10%), and regulatory compliance (7%). As mentioned at the outset, the climate-ready workforce is rife with expert terminology for niche forms of technical assistance and climate services (e.g., decision support, scenario planning, robust decision-making, etc.). While these approaches have important conceptual underpinnings, the proliferation of terms makes it difficult to coordinate and deploy technical assistance, a dire consequence in light of the thousands of lives and homes already lost to climate hazards. A more standardized system to identify and characterize capacity and knowledge needs could help to equitably distribute climate services and technical assistance. The Steps to Resilience can support systematic needs assessment by providing cohesive (not universal) definitions of terms and an overarching concept of climate resilience decision-making processes. Actual climate service and technical assistance efforts, when provided, can still be culturally competent and empowering to communities through scoping and trust-building phases.[50] As part of building a standardized system, the Steps to Resilience could be linked to capacity-based models like the Resilience Maturity Model in FEMA's National Resilience Guidance.[51] Whereas the Steps to Resilience are rooted in concepts of adaptive risk management (i.e., they are knowledge-based), the Resilience Maturity Model reflects a progression of capacities of people and communities related to, among other things, governance, collaboration, program and project development, and leadership. For example, from the start, the Steps to Resilience encourages the identification of a climate champion, a leader who can work with a planning team to assess climate risk and make recommendations on how to address it. Leadership is a capacity identified in the Resilience Maturity Model. Synthesizing the knowledge-based capabilities and capacity-based outcomes in the respective frameworks into a system for identifying climate service and technical assistance needs can help ensure that expert terminology is not a barrier to the climate-ready workforce or the communities it supports.

The climate-ready workforce is steadily growing. While estimates of potential climate-ready workforce jobs exist, identifying a baseline number of jobs and a means to track those jobs remains a work in progress. Nevertheless, the number of sectors and scales of government integrating climate resilience into their work is growing. The dimensions of that work are expanding beyond knowledge work (e.g., science and research) to include capacities that are tangibly linked to sustainable development, like managing the implementation of public infrastructure projects with social, economic, and environmental benefits. The demand for climate-ready jobs is growing alongside a concomitant demand to leave behind climate resilient communities for future generations.

[50] NOAA, 2024.
[51] FEMA, 2024

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Appendix A: Codebook

KCS	Theme	Coding frequency across all sources
Knowledge	Data analysis	7
	Emergency preparedness building	1
	Coproduction	7
	Risk assessment	4
	Exposure	0
	Vulnerability	6
	Adaptive capacity	11
	Hazard mitigation	18
	Disaster risk reduction	6
	Climate equity	25
	Climate justice	23
	Community resilience	30
	Climate adaptation	21
	Greenhouse gas mitigation	17
	Decarbonization	18
	Climate education and literacy	5
	Complex systems	5
	Organization and behavior change	4
Capabilities	Engagement	76
	Financing	26
	Decision support	9
	Emergency management	1
	Education	35
	Technical assistance	9
	Monitoring and evaluation	23
	Training and workforce development	79
	Resilience planning	18
	Implementation	18
	Design	34
	Engineering	7
	Permitting and environmental requirements	18
	Construction	10
	Modeling	3
	Grant administration	15
	Resource allocation	3
	Outreach	15
	Analytics	4
	Ecosystem restoration	57
	Assessment	24
	Change management	2
	Project management	11
	Knowledge transfer	9
	Policy and programs	14

KCS	Theme	Coding frequency across all sources
Skills	Grant writing	3
	Tool building	1
	Quantitative analysis	4
	Qualitative analysis	2
	Modeling	4
	Facilitation	6
	Meeting organization	2
	Conflict resolution	0
	Mediation	0
	Climate communication and engagement	15
	Research	19

Appendix B: Document Analysis

Documents reviewed for key themes in climate resilience:

- Federal Climate Program Inventory - Tracker.xlsx
- White House FTAC

Documents coded:

- FEMA BRIC NOFO
- WA CRW Grantee Press Release
- LA 2045 Climate Action Plan
- Request for Applications: Agriculture and Food Research Initiative Competitive Grants Program Education and Workforce Development
- NIFA Climate Adaptation and Resilience Plan
- USDA Forest Service Urban & Community Forestry IRA NOFO
- Climate Program Office NOFO
- Environmental and Climate Justice Community Change Grants Program
- NFWF NCRF Grants
- Coastal Habitat Restoration and Public Access Improvement at Rincon, PR
- Land Use Adaptations to Wildfires in Unincorporated Communities in Colorado
- Climate Resilience Regional Challenge Project Summary: USVI
- Puerto Rico Priority Climate Action Plan
- LACI Green Jobs Report
- Burning Glass – Growing Quality Green Job
- RBD Climate Action Competency Framework
- ASAP's Knowledge & Competencies Framework for Climate Change Adaptation and Climate Resilience Professionals
- EESI Adaptation and Resilience Jobs White Paper

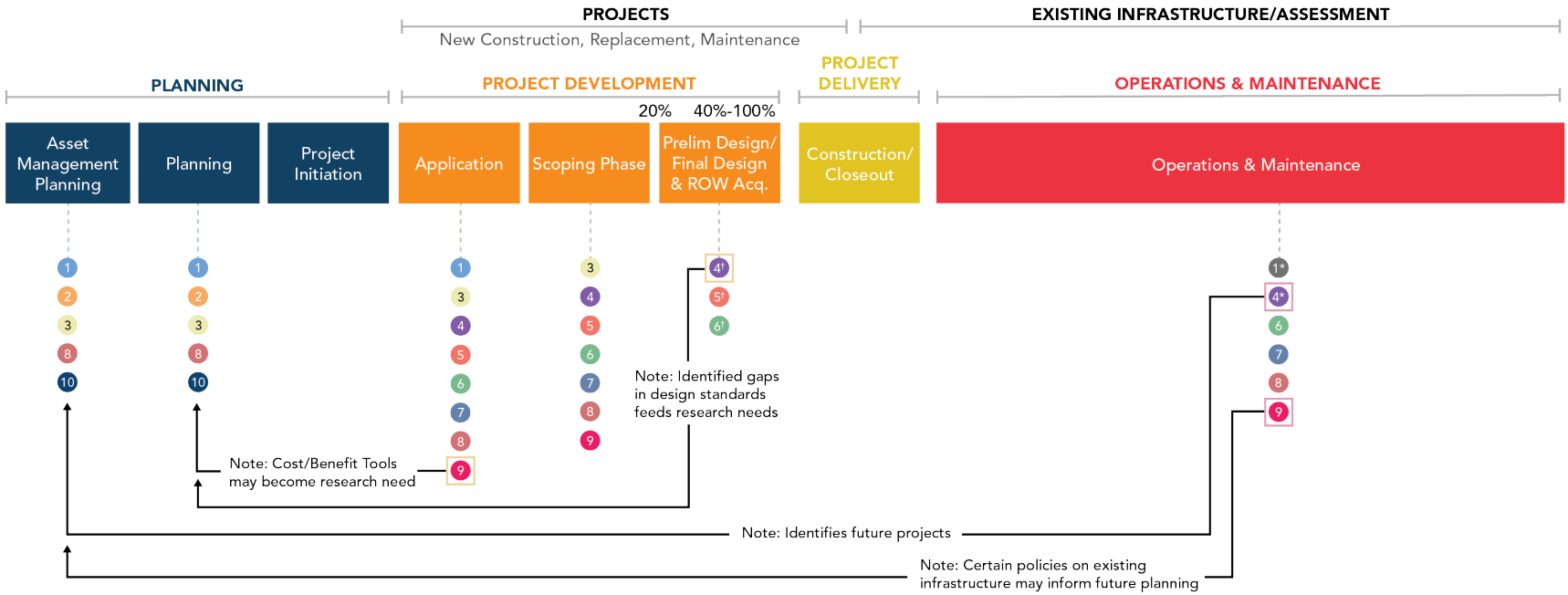
Appendix C: Common Scenario for Resilience-Related Work

The following text was presented to NAF participants:

"A metropolitan planning organization and an emergency management agency are developing a regional plan for blue-green infrastructure and community engagement in underserved areas. This project aims to identify project areas that would benefit from blue-green infrastructure to mitigate climate hazards. The community engagement process will involve community leaders and existing groups encouraging them to share insights and concerns within the watersheds. Based on both stakeholder feedback and site modeling, the project team will create a blue-green infrastructure plan to determine best available locations and produce a report with preliminary cost estimates for implementation."

Participants were asked which capabilities and skills would be necessary in the above scenario.

Appendix D: Integration of Resilience Plan Strategies Into Virginia Department of Transportation's Existing Business Practices



LEGEND

1. Data and Research Plan
2. Coordination and Outreach Plan
3. Methodology for determining Asset Vulnerability
4. Adaptive Design Criteria
5. Other Physical Enhancement Measures
6. Natural and Nature-Based Resilience Measures
7. Operational, Maintenance, and Emergency Management Resilience Measures
8. Administrative and Policy Resilience Measures
9. Feasibility and Cost Effectiveness Methodology
10. Resilience Needs Incorporation into Current Investment Processes and Programs

*Identify existing drainage/flooding problems through participatory input and mapping to generate pipeline of needs

†Adaptive design criteria, physical enhancement measures, and natural and nature-based measures are to be finalized prior to permit acquisition

Source: VDOT, 2024.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