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Climate Change Adaptation of Infrastructure: Institutional Support in Rural Alaska

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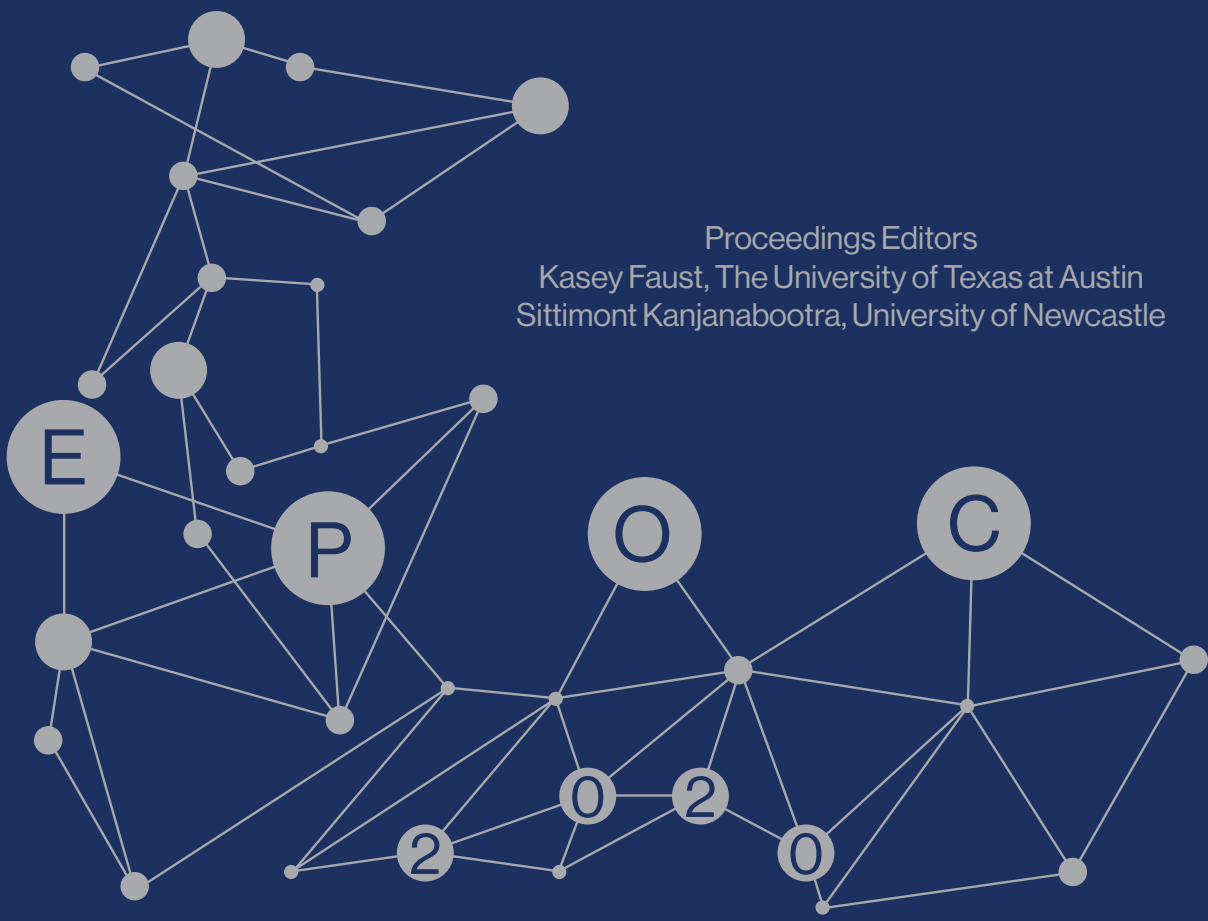

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CLIMATE CHANGE ADAPTATION OF INFRASTRUCTURE: INSTITUTIONAL SUPPORT IN RURAL ALASKA

ABSTRACT

As climate change impacts intensify, communities in rural Alaska are undergoing and adapting to changes to infrastructure from increased permafrost thawing, flooding, and coastal erosion. Climate change adaptation, defined as a process, action, or outcome in a system to better adjust to actual or expected climate change impacts, is needed to address significant structural failures and safety concerns. Despite the recognition of the need for support from stakeholders and adaptation of infrastructure, the level of adaptation activity remains limited and inconsistent across regions and communities in rural Alaska. We address this need by identifying drivers and barriers of adaptation based on stakeholder perspectives (N=25). Stakeholders included people who work for government agencies, non-profits, engineering firms, or academic institutions in rural Alaska. Results show that strong community leadership and flexibility of funding conditions were drivers to adaptation of infrastructure. Further, results show that the high cost of technology and infrastructure and lack of access to and stipulations on funding were barriers to adaptation of infrastructure. These drivers and barriers emphasize the importance of adaptation processes that effectively accommodate the unique contexts of addressing impacts in rural Alaska. Results demonstrate the need for national adaptation funding and policy that encourages local decision-making power. Specifically, results outline the need for adaptation funding and policy that supports the collaboration of Alaska based institutions and rural Alaska communities in adaptation.

KEYWORDS

Infrastructure, Climate Change, Institutional Drivers, Adaptation Governance

INTRODUCTION

Climate change is causing rapid transformations in the Arctic with increased permafrost thawing, flooding, and coastal erosion (Clement et al. 2013; Cochran et al. 2013; Keil and Knecht 2017; Keskitalo 2009). Alaska Native communities, who are primarily located in rural Alaska, are especially impacted and undergoing changes to infrastructure (Ford et al. 2010; Galloway Mclean 2009). Infrastructure in this research includes land transportation (i.e., roads, airports), buildings (i.e., public and private buildings, housing), marine (i.e., docks, seawalls), water (i.e., dams, reservoirs), and wastewater (i.e. treatment facilities, storm drains) infrastructure. Construction of infrastructure in rural Alaska is significantly more expensive and the construction season is shorter (Marino 2012). Up to fifty percent of households experience overcrowding (Peirce 2009; Pindus et al. 2017). Additionally, rural Alaska

disproportionately lacks basic sanitation infrastructure (Hennessy et al. 2008). Further, energy costs are significantly higher, increasing utility costs of necessities including water, sanitation, and heating. Existing infrastructure concerns in rural Alaska are exasperated by climate change impacts. Intensified flooding and erosion have led to safety concerns as a result of significant impacts to infrastructure including structural failures and physical damage (Bronen 2010; Instanes et al. 2005). For example, the community of Newtok experienced very rapid erosion, with reports of over 80 feet per year of embankment erosion leading to the relocation of Newtok (Denali Commission et al 2019). The relocation of Newtok is a large scale example of adaptation, defined as a process, action, or outcome in a system to better adjust to actual or expected climate change impacts.

The need for adaptation of infrastructure in Alaska is clear. In 2019, a statewide assessment of 187 remote Alaska communities, at high risk for infrastructure impacts from erosion, flooding, and thawing permafrost, was released (UAF 2019). The assessment identified 144 communities as having high risk of infrastructure impacts and provided guidance for community members, policymakers, and government agencies making decisions on the adaptation of infrastructure. To address the rapid rates of change in rural Alaska and high risk of impacts to infrastructure, the report called for financial support from federal and state agencies for site-specific research with communities considered highly threatened. Further, government and academic stakeholder agencies were called upon to develop data storing and decision-making tools that aim to unify efforts (UAF 2019). In addition to practitioner reports, an academic review of literature of climate change impacts in the Arctic demonstrated a need for new governance mechanisms and institutional frameworks to address impacts, including impacts to infrastructure (Landauer and Komendantova 2018). However, despite these alarming calls from practitioners and academics for support and need for adaptation of infrastructure, the level of adaptation activity remains limited and inconsistent across regions and communities in rural Alaska (Landauer and Komendantova 2018; Marino 2012; UAF 2019). For instance, some rural Alaska communities are relocating or rebuilding their infrastructure (e.g. Newtok), other communities (e.g. Akiak, St. Michael, Quinhagak) experiencing high risks to infrastructure are not receiving adequate support to address impacts to infrastructure (Marino 2012; Meeker 2017). Furthermore, even communities who have received higher levels of financial and technical support for relocation (e.g. Newtok), relative to other communities, the adaptation process for relocation has been slow and under-resourced (Marino 2012).

The limited and inconsistent adaptation activity indicates that there are barriers preventing adaptation and the inconsistent presence of adaptation activity indicates that there are drivers supporting adaptation (Bierbaum et al. 2013; Eisenack et al. 2014; Moser and Ekstrom 2010). Barriers are obstacles that impede climate change adaptation, yet can be overcome with concerted efforts (Barnett et al. 2015; Moser and Ekstrom 2010). In Alaska, the barriers to adaptation are primarily attributed to the need for institutional capacity to support adaptation. Institutionally there remains limited financial and logistical capacity to provide guidance and support for identifying and addressing community level climate change impacts (Meeker 2017). In example: the development of

community specific risk assessments of climate change impacts was hindered by the lack of funding available to produce scientific data to assess risks to infrastructure and in turn develop an adaptation plan. Further, when funding is available to communities in rural Alaska, local capacity to manage grants is typically limited and requires additional logistical support that granting agencies are not intended to provide. Despite the presence of barriers, there are drivers which strengthen and accelerate climate change adaptation (Thaler et al. 2019). In Alaska, the drivers to adaptation are primarily attributed to strong financial support and local capacity to carry out adaptation, including proper training and/or support to fill out adaptation paperwork (Marino 2012; Meeker 2017).

While there is a strong presence of literature concerning drivers and barriers of adaptation, there remains limited literature specific to the adaptation of infrastructure. Further, adaptation of infrastructure literature does not take an integrated approach to adaptation of infrastructure. Instead, it primarily focuses on the assessment of risk and potential adaptation strategies from economic or technical perspectives only (Melvin et al. 2017; Stewart et al. 2014). Economic and technical assessments of adaptation of infrastructure are valuable for adaptation planning and policy. However, there is a need to explicitly identify drivers and barriers of adaptation of infrastructure beyond risk and cost models to take an integrated approach to adaptation of infrastructure. Institutional, physical, environmental, and socio-cultural dimensions of drivers and barriers are equally important to capture to identify the wide spectrum of factors that affect the adaptation of infrastructure. The relocation of communities reveals that more drivers and barriers play a critical role including institutional and socio-cultural dimensions (Marino 2012). For instance, results show that flexibility in the granting and management of funding was a key institutional driver and strong community leadership and active communication with community stakeholder were key socio-cultural drivers of adaptation of infrastructure. This research addresses these gaps by identifying the socio-cultural, institutional, economic, physical, and environmental dimensions of drivers and barriers by asking: *What are the drivers and barriers of adaptation of infrastructure for stakeholders working in rural Alaska communities?* The limited and inconsistent levels of adaptation activity across rural Alaska signals that there are variations in levels of support of adaptation shaped by drivers and barriers.

INFRASTRUCTURE ADAPTATION DRIVERS AND BARRIERS

As impacts intensify, climate change research has focused on the importance of drivers and barriers to adaptation to understand how to better support climate change adaptation (Barnett et al. 2015; Eisenack et al. 2014). Existing literature has identified trends in underlying drivers and barriers. One dominant trend across infrastructure adaptation drivers and barriers research is that institutions responsible for adaptation must be flexible to ensure that infrastructure adaptation takes place. Common drivers that impact institutions include agency of stakeholders, leadership, and stakeholder commitment (Dilling et al. 2017). Common barriers that impact institutions include limited budgets, path dependency, and public support (Bierbaum et al. 2013; Dilling et al. 2017).

In a case study comparison of adaptation across Australia, researchers identified underlying drivers and barriers to climate change adaptation in a comparison of six case studies (Barnett et al. 2015). The comparison of the case studies identified path dependency as a primary barrier (Barnett et al. 2015; Eisenack et al. 2014). Path dependency recognizes the resistance to changing existing processes or embracing new approaches due to the established processes that influence adaptation (Barnett et al. 2015). Another case review in this study recognized an institutional barrier by emphasizing that the water management companies needed to adapt to continue to provide water were not adapting. The reason for this was the existing structures in place (i.e., rules, norms, infrastructure) are hard to change. Further, two case studies in England and Ireland aimed to understand the drivers and barriers to green infrastructure as adaptation strategies (Matthews et al. 2015). This research examined drivers or barriers to using green infrastructure for adaptation. Institutional factors were discussed as the primary barrier, highlighting the difficulties in coordinating the interactions of government agencies responsible for infrastructure development. Similar to other case studies, one of the primary barriers identified was path dependency, which limited the ability of institutions to deviate from the dominant mechanisms of decision making to adapt to climate change impacts (Matthews et al. 2015). Climate change adaptation literature concerning drivers and barriers highlights the importance of understanding institutional factors that drive or support infrastructure adaptation. This is especially evident in the dominance of path dependency as a barrier. Stakeholder perspectives are needed to understand how institutions are navigating adaptation in through projects and as an institution. An understanding of the drivers and barriers of adaptation from the perspective of key decision makers provides the unique opportunity to identify multiple dimensions of drivers and barriers.

RESEARCH METHODS AND METHODOLOGY

This research used qualitative methods to complete 25 interviews with stakeholders. Stakeholders were chosen from diverse sectors since adaptation decisions are made at both public and private levels. Stakeholders worked for state and Federal government agencies (54%), private industry (21%), academic institutions (17%), or non-profits (8%) (Table 1). Stakeholders were initially identified through a review of climate change adaptation plans and journal articles concerning climate change adaptation in rural Alaska (CCHRC 2017; GAO 2009; Marino 2012; Meeker 2017). Stakeholders were selected based on the condition that their work impacts climate change adaptation or disaster risk reduction planning of infrastructure in rural Alaska communities. Infrastructure adaptation in Alaska involves stakeholders from across disciplines and organizations whose work may not directly involve infrastructure, yet influences the development of infrastructure adaptation projects.

Table 1. Stakeholder Participant Affiliations

Stakeholder Type	**Stakeholder Affiliation Percentage (n=25)**	**Examples of stakeholder affiliated organizations and agencies**
Government	54%	Department of Transportation, Army Corp of Engineers, State of Alaska, FEMA
Private Industry	21%	Engineering, construction and planning firms
Academic Institutions	17%	University of Alaska Fairbanks, University of Alaska Anchorage
Non-profit	8%	Alaska Native Tribal Health Consortium, Alaska Sea Grant

Interviews with Stakeholders and Analysis

Semi-structured interviews were conducted from Summer 2019 to Spring 2020 and lasted for one to two hours. Stakeholders were initially contacted through email and were asked to be interviewed over the phone or in-person at a location where the participant felt most comfortable. The diverse stakeholders typically involved in adaptation of infrastructure limited the ability to identify all appropriate participants. Snowball sampling was used to identify over half of the participants by asking if there were additional stakeholders they thought would be important to include as participants in this research. Theoretical saturation was reached at twenty-five interviews (Palinkas et al. 2015). Prior to conducting interviews, the interview protocol underwent review by the Iowa State University Institutional Review Board (IRB No. 19-202). Due to the low risk nature of the research, the data collection procedures, and data privacy and protection were approved under an expedited review.

During the interviews, participants were asked questions aimed at understanding stakeholders' work in rural Alaska, such as: "*Can you describe the work you have done concerning environmental risk response in rural communities you have worked with*?" Participants were also asked, "*Can you expand on any specific work you or your organization has supported concerning infrastructure?*" to further identify examples of how their work is a part of each phase in the adaptation process of infrastructure. Based on participants' responses, questions concerning drivers and barriers of infrastructure adaptation were asked, such as: "*Can you tell me about the drivers that support [adaptation work identified by participant]*?" Follow-up questions targeted each dimension of adaptation drivers and barriers to ensure all aspects were captured. Each interview was recorded and transcribed verbatim or recorded through written notes. Interviews were coded using narrative analysis in NVivo software to organize data analysis of dimensions of drivers and barriers and phases of adaptation of infrastructure. The data was deductively analyzed into macrocodes based on the sustainable livelihoods framework, including socio-cultural, institutional, economic, physical, and environmental dimensions of infrastructure adaptation drivers and barriers. Socio-cultural dimensions related to the view, values and beliefs of individuals or groups, lack of risk awareness and interests, and information and resource sharing. Institutional dimensions related to institutional capacity,

governmental and organizational resources and policies, and legal restrictions. Economic dimensions related to economic resources for daily life. Physical dimensions related to the physical capacity, including the built environment, tools, and equipment. Lastly, environmental dimensions related to the natural environment, natural resources, and climate. Each macrocode was then inductively analyzed and organized into 10 driver microcodes and 10 barrier microcodes (Table 2).

Reliability in Data Collection and Analysis

Reliability in data collection was developed through observation and participation in community, regional and international meetings concerning climate change adaption in Alaska. The first author observed a community meeting in rural Alaska where the community was addressing risks from increased erosion. The half day meeting consisted of local government council members, community members, and engineers from a consulting firm hired to assess potential relocation sites for part of the community. The first author participated in a regional meeting concerning environmental, economic, and energy concerns in rural Alaska. The two day meeting took place in rural Alaska and included stakeholders from local communities, federal, state, regional, and community government organizations, non-governmental organizations, private industry, and academia. Small group break-out sessions provided opportunities for informal conversations to understand diverse perspectives concerning infrastructure adaptation. The international meeting took place in Washington DC with the intention of bringing together diverse stakeholders concerning climate change impacts and adaptation in the Arctic. This two day meeting provided opportunities to understand how the adaptation of infrastructure in Alaska was shaped by the internal adaptation research agenda and funding agencies based outside of Alaska. These three meetings improved the reliability of data collection by improving the researcher's ability to identify appropriate participants. Further, these meetings improved the researchers' knowledge of climate change adaptation processes in rural Alaska, thus improving the reliability of data analysis. Finally, member checks will be incorporated to improve reliability of data analysis. As a part of the member checks, all interview participants will be sent a draft of the final paper prior to publication and given an opportunity to provide feedback. Member checks ensure participant perspectives are accurately captured, thus improving the reliability of the data analysis (Thomas et al 2017).

KEY FINDINGS

In this paper, we found that participants identified five key drivers and five key barriers to infrastructure adaptation based on their respective experiences (Table 2).

***Table 2**: Drivers and barriers of infrastructure adaptation*

Dimension	**Driver (+)**	**Barrier (-)**
Socio-cultural	Active communication with community stakeholders	Community usability of scientific data

	Strong community leadership	Understanding socio-cultural dynamics within communities
Institutional	Community adaptation plan	High turnover in community staff
	Institutional support for community collaboration	Flexibility in project process and designs
Economic	Funding for a local coordinator	High cost of technology and infrastructure
	Flexibility in funding conditions	Access to and stipulations on funding
Physical	Local access to large equipment	Lack of local infrastructure to host stakeholders
	Airport to fly in equipment	Substandard living conditions
Environmental	Local access to natural resources	Lack of construction resource nearby
	Community access to land	Destabilized conditions for construction

Socio-cultural Drivers and Barriers

Participants described active communication with community stakeholders and strong community leadership as the primarily socio-cultural drivers to infrastructure adaptation. Both of these identified drivers were often discussed regarding the need for "a local champion", a person from the respective community who is pushing infrastructure adaptation agendas forward by providing consistent contact with external stakeholders and providing necessary information to fulfill infrastructure project development requirements, such as paperwork for grants. This is especially important as infrastructure adaptation projects are primarily grant-funded with strict reporting and timelines. Active communication with community stakeholders and strong community leadership support infrastructure adaptation projects by ensuring that projects remain compliant with requirements set by funding agencies and align with community expectations.

Despite strong relationships with some communities, participants identified a lack of understanding of socio-cultural factors within communities as a barrier. One participant from the Federal government described internal hierarchies within some communities based on family ties: "There are internal divisions – factions within villages that we must be aware of, where dominant families have more power than others…What I'm getting at is power dynamics." In addition to a lack of understanding of community structure, participants described a lack of understanding of cultural priorities, such as spiritual ties and evasions to the land, as a barrier to choosing appropriate sites and materials for infrastructure adaptation. Further, participants identified the limited use of scientific data by communities. A participant in academia explained: "It's like we have all this data but it's not being used. We have 10 communities of data and videos and…we're not doing enough with it [to support communities in understanding and addressing environmental

risks].” Scientific data is an essential tool for communities to apply for funding and communicate with external stakeholders. These examples of socio-cultural drivers and barriers highlight the limitations in understanding of external stakeholders and the importance of strong engagement with diverse community representatives.

Institutional Drivers and Barriers

Participants identified key institutional drivers including, the development of a community adaptation plan, and institutional support for community collaboration. The development of a community adaptation plan involves an assessment of climate change impacts and short term and long term planning to address these impacts. This is an important driver based on its potential to build community capacity to identify and communicate community priorities for the future. One participant from a non-profit described the development of an adaptation plan as an important process for creating a long term community vision, asking community representatives, “what do you want your community to look like in 20, 40, 60 years?” The “groundwork” of an adaptation plan and community vision provides a foundation from which communities can make decisions concerning infrastructure adaptation, such as where to relocate some buildings or what type of infrastructure to put into place. Similarly, institutional support for community collaboration was identified as another important driver by participants who felt they were well supported by their institutions to meet in person with community councils. One participant from the State government described the ability to travel to communities as an important driver in building rapport and improving communication, in turn improving community collaboration. Strong institutional support for community collaboration supports the mobilization of necessary resources for infrastructure adaptation including funding, scheduling, community participation.

While some institutions provide flexibility in mechanisms for community engagement, high turnover in community staff emerged as an institutional barrier for progressing through an infrastructure adaptation project. One participant from the Federal government described a situation where critical information for a grant application was not available due to turnover in staff and a lack of knowledge transfer between community employees. Similar situations involving lack of knowledge transfer were described across participants as barriers to meeting the needs of strict grant and project timelines for infrastructure adaptation projects. Further, additional flexibility in project planning and implementation were identified as an institutional barrier. This is best captured by a participant from the Federal government who explained, “There are no provisions to help address unique situations – there needs to be increased flexibility. Agents from Federal and State organizations want to help, but the change happens at congress level.” This participant was referring to the need for increased flexibility in the requirements needed to qualify for applying for and receiving State and Federal funding. In addition to flexibility concerning the funding application and awarding process, there is also a need for flexibility in project planning and implementation. Participants identified the need for more flexibility in conditions for initial approval of a project that may benefit from non-traditional approaches, including innovative engineering designs. This barrier has emerged out of the need for climate change adaptation policies and programs that are explicitly

intended to address climate change impacts to infrastructure. Based on current policies and programs, communities must work across many agencies to apply for funds not explicitly intended to address climate change impacts.

Economic Drivers and Barriers

In alignment with the identified socio-cultural drivers and barriers, participants identified the benefit of funding for a local coordinator and flexibility in funding stipulations, such as strict timelines. A local coordinator is someone from the local community hired to connect stakeholders locally, such as linking stakeholders with appropriate representatives and organizing local meetings. One participant in academia explained the value of available funding intended to pay for a local coordinator: "We had funds for quarter-time local coordinator…having somebody that is known by the community, who knows all those dynamics, who can help coordinate all of that was critical to the success of that planning effort." The participant recognized the limitations of his potential to understand and engage with the community and explained the importance of having access to funds for a local coordinator who could better support community engagement. Access to funding is critical for driving community engagement. Further, participants identified the benefit of flexibility in funding conditions to fit the specific needs of the community throughout the project process. While most participants identified a lack of flexibility in funding, many acknowledged the benefits of existing flexibility in the application of project funds, such as applying funds toward feasibility studies to be able to understand infrastructure adaptation priorities and future funding needs.

Similarly, participants identified stipulations on funding as a primary economic barrier. One participant from the Federal government explained that the current funding system is not conducive to the needs of infrastructure adaptation projects: "Funding is siloed by different components of infrastructure - sanitation, roads, housing and so on are all funded differently with their conditions. Impacts from erosion don't just affect one type of infrastructure, so this makes the upfront costs for starting the planning process the hardest." Communities often have to apply to grants across agencies, designated for different types of infrastructure. This siloed approach to funding does not support a holistic approach to address the impacts of climate change on infrastructure. Further, the grants communities receive for infrastructure adaptation projects often have strict criteria for qualifying to apply for the grant, strict timelines for use of the grant, and conditions on how the funds can be applied. This leaves communities with limited choices on which grants they can receive and how they can apply the funds and adapt.

Limited access to appropriate funding is exasperated by the high cost of technology and infrastructure in rural Alaska. Due to the rural nature of communities and limited transportation, the cost of collecting data for feasibility reports and implementing infrastructure adaptation projects is significantly higher than in other parts of the US. This is especially relevant since many Federal grants communities apply for are national and communities in Alaska are competing against communities in the lower 48, where costs are lower. These examples of economic drivers and barriers highlight that while

access to funding is key for supporting or limiting adaptation, the conditions on funding is equally important for mobilizing resources to effectively support adaptation.

Physical Drivers and Barriers

Participants identified local access to large equipment and the presence of a suitable airport for bringing in necessary supplies and equipment as important physical drivers. One participant with the Federal government identified discussed the importance of access to equipment and infrastructure due to the rural nature of most communities: "They have perhaps a local road of a mile or two or maybe a few miles of local roads, but it doesn't connect anything else and so they are accessible exclusively by air or by barge or water or snow machine in the wintertime, which is a challenge on its own these days as the ice is freezing up later and not as solidly and whatnot. So, working in a remote village is very challenging. And the remoteness is not just a function of its geography, it's also a function of what infrastructure is already there." This participant identified how the remote nature of communities creates unique physical barriers in infrastructure adaptation projects, emphasizing the importance of access to large equipment or diverse forms of transportation.

Similarly, the lack of local infrastructure to host stakeholders was identified as a physical barrier for long terms projects. Data collection for feasibility studies and implementation of infrastructure adaptation projects requires extended amounts of time in communities.

Further, substandard living conditions, such as overcrowding, poor sanitation, and compromised water sources, serve as a physical barrier for community engagement. As communities prioritize addressing daily needs, there is less capacity to engage in the long term infrastructure adaptation processes. These examples highlight the unique context of working in rural Alaska and additional considerations needed for extended timelines and high costs.

Environmental Drivers and Barriers

Participants identified community access to land and community access to local availability of natural resources as key environmental drivers. Access to land refers to community access to land suitable for relocation, based on both Federal funding standards and community priorities. Community access to natural resources necessary for infrastructure adaptation projects can increase the feasibility of a project. One participant from academia explained the role of natural resources for one community versus another: "So they have their own rock quarry. If you have your own rock, that makes you much more resilient to a lot of stuff. And so some communities, like Shishmaref, they've had to spend millions on rock. I mean the amount they've spent on rock is ten times more than the whole village and all the infrastructure's worth." Local access to rock can significantly reduce the cost and timeline of the infrastructure adaptation project, as rock would otherwise need to be barged into the community.

Similarly, the lack of natural resources near the project site is considered an environmental barrier. Further, destabilized conditions for construction due to thawing permafrost, erosion, and flooding was identified as an environmental barrier that is

especially important for the implementation of the planned infrastructure adaptation project. One participant from the Federal government described important considerations for construction in rural Alaska considering extreme and changing conditions: "Well, the limiting factor is the location of where you need to go and where you need to go to get materials to do construction, whereas where you want to do the building and the ability to use ice and snow is taking advantage of the natural environment to facilitate that. And again, as those windows become shorter with shorter winters and warmer winters, those advantages become smaller and it becomes more challenging." While this participant identified the potential of using the environment to support adaptation, the changing environmental conditions create an additional barrier. These examples highlight the contextual and increasingly unpredictable nature of adaptation in rural Alaska.

CONTRIBUTIONS AND CONCLUSION

This research responds to the critical need in adaptation literature to understand the drivers and barriers of infrastructure adaptation. These drivers and barriers emphasize the importance of adaptation processes that effectively accommodate the unique contexts of working across rural Alaska. There is a need for national adaptation funding and policy that encourages local decision-making power and supports the collaboration of Alaska based institutions and rural Alaska communities in adaptation.

This research facilitates actions taken by communities, governments, engineering firms, and organizations anticipating and responding to the impacts of climate change. By identifying multi-dimensional drivers and barriers across stakeholders, government agencies and organizations can use this research to inform institutional changes to better support communities undergoing adaptation. Specifically, the results indicate that stakeholders from across disciplines recognize the importance of all five dimensions of drivers and barriers and discuss them in reference to the need for adaptation processes that recognize the unique context of each project. While access to funding is essential for supporting infrastructure adaptation, institutional conditions on when and how funding is used can lead to maladaptation or create additional barriers to adaptation (Berrang-Ford et al. 2011). Further, conditions on initial approval of projects and the siloed nature of the existing funding systems create barriers throughout the adaptation process that hinder the capacity of communities to pursue funding for an adaptation project. The importance of increased institutional and economic flexibility throughout the adaptation project process was highlighted across participants. Despite strong recognition of the importance of community engagement throughout the project process, stakeholders recognized barriers to meaningful collaboration due to technical requirements and shortened timelines based on grant requirements. In this case, project success is based on both physical dimensions and socio-cultural dimensions. An increase in the flexibility in adaptation governance is important for supporting drivers and addressing barriers across all five dimensions of infrastructure adaptation.

Across all five dimensions of drivers and barriers discusses, results emphasize the contextual nature of adaptation, especially in the context of working in rural Alaska. The diverse cultural landscapes, extreme weather, rural locations, limited transportation, high costs, and changing conditions all highlight the need to reassess adaptation governance at

a Federal, State, and local level (Bronen 2011). Currently, communities applying to Federal grants for support for adaptation are directly compared to applicants from across the United States. Considering the high costs of working in rural Alaska and relatively low population count, the cost-benefit analysis performed in the decision-making process systematically disadvantages Alaska Native communities, who are primarily located in rural Alaska (Maldonado et al. 2013). Further, existing funding sources primarily utilized in Alaska are not intended to be used for climate change adaptation projects. Instead, community and external stakeholders are piecing together available funding for different aspects of a project to try to make the available funding work. Despite the concerns with this approach, without congressional action, there are limited alternatives for stakeholders.

In response to the lack of frameworks for adaptation governance, research initiatives have identified essential characteristics of frameworks for adaptation processes. One suggestion is the that utilizes existing government mechanisms for disaster response is to include "climate-induced ecological changes" in the definition of disaster in policy (Bronen and Chapin 2013; Marino 2012). In the context of Alaska, an adaptive governance framework that enables communities to determine when they need relocation support as an alternative to adaptation support for the current location is needed (Bronen and Chapin 2013). The need for self-determination within adaptation frameworks supports recognition of the sovereignty of Native communities by aiming to support the priorities of communities in adaptation (Huntington et al. 2017; Marino 2012). The primary concerns of communities vary and have significant implications in developing more effective responses. Results from this research provide specific examples of why policy and institutional frameworks must support contextual adaptation processes.

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