

Overview of Governance Approaches for Pre- and Post-disasters in USA

State-of-the-Art Report

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Prepared by the Water Institute at the University of North Carolina at Chapel Hill

including

Felix Dodds, Elizabeth Christenson-Diver, Kristen Downs, Ranger Ruffins, Sarah Bates, Taylor Franklin, Cate Byrne, Julia Maron, and Hope Thomson

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UNITED STATES OF AMERICA

I. Introduction

The purpose of this summary report is to provide exploratory research regarding multi-level governance approaches for disaster risk reduction and resilience (DR3) and provide a summary of data sources for disaster occurrence, economic loss, and vulnerability indicators in the United States. This report summarizes governance approaches and budget allocation, policy measures and best practices, and the strategies used for equitable distribution of resources to vulnerable people for disaster planning and recovery across federal, state, and local contexts and across flood, heatwave, and drought disaster types. Additionally, this report identifies indicators for government disaster planning and recovery, and data sources for disaster occurrence and budget allocation.

Refer to work packages submitted December 2020 for full reports including state and local contexts. Stakeholder engagement is currently being conducted and is not included in this report. Refer to the IRB for work plan and methods regarding stakeholder engagement.

II. Legislation, Governance, and Funding Mechanisms

American disaster preparedness and response involves a wide range of actors in both the public and private sectors. Implementation of policy and decision-making is largely decentralized to the degree that it is difficult to identify any vertical leadership structure. Major federal agencies involved include the Federal Emergency Management Agency (FEMA), the Environmental Protection Agency (EPA), US Army Corps of Engineers, and National Oceanic and Atmospheric Administration (NOAA). Within the US Department of the Interior, the Bureau of Reclamation has emerged as a major voice for disaster resiliency, particularly in rural communities.

Narrowing scope, each set of climate-driven natural disasters has its own set of national actors. There are several financial bailout programs linked to the federal government and disaster recovery, however, pre-disaster resiliency lays mostly on the shoulders of state and local leaders with recommendations at the federal level. This is due to the varied and individual climates and populations which make up both states, and the risk associated with high-cost infrastructure and job creation for mitigation efforts. If a region does not suffer a natural disaster, the threat lessens, or funds are necessary elsewhere, the risk does not pay off. Decision-making and risk assessment at the federal level is predominantly associated with economic risk in the agriculture sector, property loss, as well as human health, though the latter is largely addressed through non-direct means (e.g., individual agency budgets, investment in safe water infrastructure). Additionally, the environmental justice sector of the U.S. EPA addresses concerns unique to vulnerable communities without the capital and infrastructure to properly prepare for natural disasters.

The Stafford Disaster Relief and Emergency Assistance Act is a 1988 federal law which allows the President to issue major disaster or emergency declarations at the request of the governor if a disaster overwhelms state and/or local resources (FEMA, *Stafford Act*, 2019). This law, alongside FEMA, is one of the only nationwide policies for disaster relief. Federal response otherwise is largely on a case-to-case basis supporting local and state leadership.

In 2000, Congress passed the Disaster Mitigation Act (DMA) which requires all local governments to develop a hazard mitigation plan and outline their jurisdiction's risks and vulnerabilities, develop actions to mitigate those risks, and create a strategy to implement mitigation activities. Following the DMA North Carolina passed Senate Bill 300 which requires all local governments to have an approved Hazard Mitigation Plan in order to receive state public assistance funds (effective for state declared disasters). According to the NC Division of Emergency Management, the minimum requirements for local governments include: enact and enforce building codes, zoning ordinances, and other measures to enhance their legal capability to protect life and property; make the public aware of hazards that present risks to people and property and measures they can take to reduce their risk and possible losses; and comply with Federal and other regulations that are designed to reduce disaster costs as well as preserve and protect natural, historical and cultural resources (Town of Morehead City 2017).

When it comes to disaster response, local governments are the first line of defense against emergencies and disasters. For example, North Carolina legislation requires each county in NC to provide an emergency management office under the North Carolina Emergency Management Act. The emergency management office is responsible for emergency management planning, administration, coordination, training, and support for the local governments within its jurisdiction (Carteret County 2019).

Flooding

Out of the three natural hazards, floods have the most direct, universal federal policy- the National Flood Insurance Program (NFIP). Created by Congress in 1968, NFIP is the primary program regarding flood resilience and aid (Interagency Task Force on Floodplain Management 1986). NFIP restricts development within floodplains and lessens the financial losses faced by businesses and residences damaged by flooding (FEMA, *The National Flood Insurance Program*). NFIP is a specialized program in contrast to other, larger-scope disaster assistance programs. Human health outcomes associated with flooding are addressed through infrastructure projects and industry standards, with federal regulations guiding allocations and standards. FEMA, the EPA, and the Bureau of Reclamation again play major roles in the form of recommendations and advocacy. In the sphere of non-governmental organizations, Team Rubicon and the American Red Cross has remained a large influence on flood disaster recovery.

Drought

No national drought policy exists at the moment. In 1998, the National Drought Policy Act was passed, creating the National Drought Policy Commission, which identified areas of risk and in need of policy reform, however, it was dissolved after the fact, largely providing frameworks for state and local leaders instead of federal policy (Motha, Raymond 2011). The areas and goals

included inclusion of mitigation strategies, improved collaboration between emergency managers and scientists, development of preparedness plans including insurance and other financial strategies, maintenance and development of emergency relief in the form of financial aid which prioritizes the environment and future mitigation, and effective, efficient coordination across all levels.

Following the 2012 drought, there was significant attention paid to agriculture losses, resulting in the 112th and 113th Congresses authorizing funding for the National Integrated Drought Information System to increase nationwide warning capabilities.

Despite the lack of federal drought policy, the National Drought Mitigation Center, National Drought Resilience Partnership, and Drought Risk Management Research Center have all been very central to resiliency efforts over the last decade. In California, a state highly affected by drought and wildfire, the California Water Action Collaborative has brought together actors from the private sector, individuals, and NGOs to address water scarcity in industrial and environmental contexts (Khalamayzer 2016). This collective is demonstrative of how national policy is frequently unable to address the unique challenges faced by the U.S.'s many climates, thereby necessitating innovation and collaboration at other, more localized, levels.

Heatwaves

Despite the high mortality rate associated with heat waves, little to no legislation exists to help communities mitigate the effects. Heat waves receive less specialized attention, but research has been conducted by the EPA, NOAA, and NASA as to future risk and occurrence of heat waves. The majority of risk assessment and policy for extreme heat occurs on the state and local levels. National Institutes of Health and the Centers for Disease Control and Prevention have collected mortality data on extreme heat, and all the above federal agencies have tips and procedures for civilians to access. For example, the EPA has created a series of recommendations for extreme heat adaptation. The urban heat island effect has made major cities most vulnerable, so recommended infrastructure changes include cool pavements, green roofs, and more heat resistant bridges and buildings (U.S. EPA 2019). In addition, it is recommended local officials establish early warning systems and urban cooling centers to aid vulnerable communities along with increasing awareness about the risks associated with extreme heat (U.S. EPA 2019).

Resource Distribution

Most financing from the federal government involving flooding, drought, and extreme heat addresses agricultural losses, a common metric for assessing economic fallout from natural disasters.

Federal disaster relief aid under the Stafford Act is primarily allocated when a community's resources are overwhelmed, the president declared a disaster in that area, or the state's governor requests aid from the federal government. The Stafford Act is funded by the Disaster Relief Fund (DRF), operated by FEMA, which addresses Individual Assistance, Public Assistance, the Hazard Mitigation Grant Program, distributing emergency response teams and equipment,

supplementing local and state responses to disaster, management of large-scale wildfires, and ongoing mitigation strategies (Congressional Research Service 2019). Federal loans and aid under the DRF, with some exceptions, require a 25 percent match from state or local government (FEMA, 2018).

While not actively sponsored by the federal government in most cases, buyouts for both home and business owners are identified by FEMA as an important financial tool which can mitigate the excess hardship low-income communities face as housing values in safe, non-affected areas surge post-disaster. The U.S. Small Business Administration is an example of a federal actor which provides financial assistance in the form of low-interest loans, available to help both businesses and residential homeowners recover financially after a declared natural disaster. In addition, the agriculture sector has been protected and bailed out by the federal government in numerous cases as a large stakeholder in natural disaster fallout. The Farm Services Agency gives aid to the agriculture sector, once proper criteria for a natural disaster have been met (ex. eight consecutive weeks of severe drought) (USDA Farm Service Agency Disaster Assistance Programs).

Strengths and Weaknesses

Despite increasing severity and frequency of natural disasters, federal policy has not radically improved in the last decade. This may be due to factors such as congressional deadlock, a change in administration, and the ongoing partisan struggle over climate change.

The federal government's policies surrounding natural disasters put a great deal of responsibility on state and local governments. Governors ask for federal assistance and disaster declaration as a means of supporting individual communities and the state as a whole when financial and/or physical resources are overwhelmed. This is a challenge as access to resources varies greatly not just between states, but between communities within a state, with vulnerable communities being likely low-income with less resources to begin with. Many factors play into these requests for assistance including general state economy, vulnerability to high-damage disasters, sustained or frequent natural hazards, and high levels of poverty. Alternatively, this decentralization can be seen as a strength as the U.S. climate is very different on a regional basis, so giving power to state and local governments, who have more experience and contact with their communities and the specific needs of the area, can be very beneficial so long as they have the ability to actually support the community through time, energy, and money. The International City/County Management Association published a paper on why and how local governments must manage natural disasters, emphasizing community care and learned experiences as necessary assets for mitigation and recovery (Becker 2009).

The clearest weakness for current drought policy is the lack of any comprehensive, national policy. There are many research groups, private sector entities, and committees devoted to addressing issues stemming from drought, but the decentralized approach has led to a largely financial-oriented approach to disaster resilience, leaving many vulnerable communities without aid. Due to the relatively hands-off role of the federal government, however, much of policies pertaining to droughts come directly from scientists with more experience and know-

how in the field. In addition, the United States has a lot of variability region-to-region regarding droughts, so more localized approaches to governance are more apt to address the specific needs of each community. In the future, increased oversight and assessment of drought response and recovery actors, namely the U.S. Army Corps of Engineers and the U.S. Bureau and Reclamation, may allow for better perspective on the flaws and successes of current policies and infrastructure.

Extreme heat and heatwaves are difficult to manage from a federal standpoint. Heatwaves are relatively unpredictable and do not necessarily always occur in the same regions. It is clear that the urban heat island effect puts cities at greater risk, but beyond recommendations for green infrastructure and local emergency teams, managing extreme heat on a localized basis is not under federal jurisdiction at this point in time.

The federal level's most wide-reaching and effective flood strategy is the NFIP, however, while universal in that it is a nationwide program, the NFIP has a large focus on recovery. A strength of the program is its restrictions on development on flood plains, but even with this strategy, repetitive loss properties and high-risk areas remain consistent economic and mortality risks. In addition, the example of 2019 Midwest flooding being largely ineligible for aid despite a large agriculture loss, illustrates lack of truly comprehensive federal flood management. Considering the predictions for more frequent and severe natural hazards, it appears necessary to continue directing attention to preparedness and mitigation. Currently, nearly all federal disaster assistance is allocated after a disaster is declared for a region, focused on short-term re-building with suggestions on how communities can strengthen their resilience on a local level long-term. Local communities still bear the greatest burden for both planning and recovery, with arguments opposing and supporting this norm.

III. Policy Ideas for DR3 Decision-making

Disaster Management

Disaster management is commonly broken into four parts: preparedness, response, recovery, and mitigation. Among academic works surveyed, there is a relative consensus that the 21st century requires a focus on mitigation and preparedness more so than recovery and response – a move from short-term reactions to long-term strategies. Hurricane Katrina strengthened this sentiment as the large-scale disaster made clear the many areas of improvement necessary within American disaster management and motivated the federal government to push for increased mitigation strategies. That being said, the federal government's responsibility in the current framework of shared governance is largely response and recovery oriented, with support and suggestion for the state and local levels. However, since Katrina, federal actors have dedicated over \$2 billion to training and preparation services for local actors, pre-written necessary paperwork and provisions in order to speed up response, helping to more than doubled the percentage of communities which reported confidence in local response plans. The major disaster management policy from the federal level is the

Stafford Act which allows for the president to make disaster declarations, opening up emergency funds in the Disaster Relief Fund for affected states/communities.

Mitigation

Federal mitigation strategies seek to lessen monetary losses through aid and economic restrictions, and human losses through regulations such as Hazard Mitigation Plans (HMPs) for local governments, response and recovery training, and high-level weather prediction technology. Vulnerability reduction is one such economy strategy and is accomplished by limiting the amount of development which can occur in disaster prone areas, such as limiting development on floodplains through the National Flood Insurance Program (NFIP), therefore reducing economic losses (Daniels et al. 2002). This would limit the loss of life and property on a local level, and save the federal government money which may have otherwise been used as emergency aid.

Since Hurricane Katrina, the federal government has taken steps to learn from their preparedness mistakes and created new mitigation techniques and tools. FEMA pushed to have military authorizations for disaster relief pre-written and approved to limit the amount of paperwork necessary for special operations troops to mobilize when another disaster struck (Phillips 2017). Overall, FEMA spent \$2 billion on training and preparing local responders between Katrina and Hurricane Harvey, doubling the percentage of communities which reported confidence in their local response plans (Phillips 2017).

Response

Federal aid is a bailout option for communities when local and state resources become overwhelmed, typically in the response and recovery stages of a disaster. Emergency funding from the federal government must be requested by the governor, usually after being requested by local government, and the president must declare the event in question a disaster under the Stafford Act (FEMA Individual Disaster Assistance). After going through these gatekeepers, FEMA then evaluates the request and distributes the necessary aid.

Response in the form of supplies has also become enhanced due to pre-positioned supplies such as food, water, and blankets being stored at designated shelters (Phillips 2017). Increasingly accurate prediction technology has made it easier for the federal government to foresee major disasters like Florence and Harvey, and once they are aware of an oncoming disaster, these supplies are moved into the at-risk cities.

Stakeholder Engagement

Stakeholders in disaster management include state and local governments, media, private sector entities from corporations to local businesses, non-profits like the American Red Cross, and citizens of affected communities, all of whom are engaged with in different mediums by the federal government. Decision makers on the federal level include Congress, the president, and agencies such as the United States Department of Agriculture (USDA) or the Department of the Interior, with FEMA as the central authority. As far as members of Congress, state governors, and the president, the most obvious relationship is between these politicians and

their constituents, particularly during disaster declarations under the Stafford Act. This connection emphasizes the public responsibility politicians have to those who elected them (Daniels et al. 2002), so in the case of a natural disaster, these politicians receive information from constituents through requests for aid and from information passed through local and state governments.

Outside the federal level, there are key stakeholders in state and local government. Shared governance necessitates efficient, effective information flows between all levels of government during disaster management, so the sharing of this information is a critical engagement function between these stakeholders (May and Walter 1986). Due to how emergency aid is allocated, it is critical for local, state, and federal decision makers to all be actively communicating the community's needs and approving appropriate measures of support, particularly high-risk populations.

Budget Allocation

Federal disaster funding used for mitigation, preparedness, and response or recovery to an event not declared a disaster is deemed non-emergency. There are several federal grants and other programs for non-emergency circumstances which require a set of actions from local and state decision makers. A strategy implemented by the Federal Emergency Management Agency (FEMA) required state, tribal, and local governments to create HMPs as a condition of being eligible for non-emergency disaster assistance, starting in 2004 (Jackman 2016). This requirement is implemented as a means to reduce non-emergency federal spending and strengthen local mitigation and planning.

Evidence for Effectiveness of Interventions

While broad federal disaster management has not been assessed for effectiveness beyond media critique and post-disaster lessons, specific interventions such as implementation of local hazard mitigation plans, federal aid programs, and vulnerability reduction through repetitive loss programs have been. Hazard mitigation plans, while helpful in limiting federal funding, have not been widely adopted. In a study conducted 3 years after the requirement from FEMA was implemented, it was shown that 67% of counties nationwide still lacked an approved HMP (Jackman 2016). Vulnerability reduction strategies and repetitive loss programs through FEMA have had mixed results, with the latter costing FEMA over \$3.5 billion since its inception (FEMA, Repetitive Loss Properties). The former, as previously mentioned, is largely accomplished in the form of limiting development in high-risk areas. Repetitive loss programs are directly tied to the National Flood Insurance Program, and have affected over 28,000 properties, however, due to the large deficit currently run by FEMA and the fact that this program largely ignores repetitive loss properties outside high-risk hazard areas (FEMA, Repetitive Loss Properties), many improvements still need to be made.

In a study analyzing disaster management under Presidents Ford and Carter, each president gave more monetary aid to communities represented by politicians of the opposite party, and Carter's administration in particular focused on increasing the diversity of communities served, whether that be geographically, racially, socioeconomic, etc. (Daniels et al 2002). However, in

both administrations the distribution of aid to communities requested appeared random, perhaps the result of bureaucratic structuring or time management (Daniels et al. 2002).

Strengths and Weaknesses

The federal, regulatory stance has encouraged more effective local planning through HMPs and limited development in areas where repetitive loss can occur (Daniels et al. 2002). These pre-emptive measures have allowed for prioritization of federal aid in an era of more frequent natural disasters by limiting the amount of federal dollars spent on preventable property losses. Weaknesses and areas of improvement are easier to identify as they have become apparent in past disasters. While positive in some regards, HMPs have much to improve on as they have been adopted at a low rate since the policy's inception. This could be due to factors such as cost and isolation – creating these plans may involve the creation of new positions, adoption of new technology, or the changing of social and development norms, all of which are costly. These costs can be mitigated through multi-jurisdictional plans, which have proven to be a supporting variable in completing HMPs (Jackman et al. 2016), however, large or isolated (geographically or socially) counties have a more difficult time creating such plans.

IV. Key Performance Indicators

Balanced Scorecard for Disaster Resilience and Risk Reduction (DR3)

After conducting a literature search for balanced scorecards, we reviewed 10 peer-reviewed articles, which focused on a balanced scorecard approach to humanitarian aid, crisis communication, education, and business. Four studies were related to disaster management. We present a balanced scorecard incorporating indicators from three of the four studies relating to community disaster resilience in Australia (Ramsey et al. 2016), a systematic review of indicators for post-disaster recovery in the United States (Horney et al. 2017), and a balanced scorecard approach for humanitarian logistics (Toklu 2017). We additionally review and include United Nations Development Programme (UNDP), Sustainable Development Goal (SDG) and Sendai Framework (UNISDR 2017) targets and indicators when related to DR3.

The balanced scorecard is not temporal by nature, but multi-dimensional. One study expanded the balanced scorecard so that one dimension had a temporal aspect (Toklu 2017). We go further so that each dimension in the balanced scorecard has a temporal dimension analogous to the stages of disaster response and mitigation (response-recovery-mitigation-preparedness). We present a balanced scorecard approach assessing four dimensions: finance, process, innovation and learning, and beneficiaries across four periods: response, recovery, mitigation, and preparedness. Activity periods are identified from Toklu 2017. Response occurs immediately after disaster (days to months) and activities are focused on saving lives and preventing further harm. The recovery period occurs while societies return to the state before the disaster (months to years). Mitigation activities (long term to continuous) increase community resistance to natural risks in order to reduce societal vulnerability to disasters. Preparedness activities (long term to continuous) include human resources, knowledge management, process management, and resources and community.

Overall, we identified 161 indicators across the balanced scorecard dimensions with 35 indicators in finance, 56 indicators in process, 19 indicators in learning and innovation, and 51 indicators in beneficiaries. Across time periods, there are 18 indicators in response, 44 in recovery, 53 in mitigation, and 47 in preparedness. The full list of indicators is summarized and color-coded in USA – WP3 – KPI Data.xlsx.

V. Disaster Data

We describe sources of federal data for disaster coverage at the national level. States may have disaster data specific to their states (see, e.g., North Carolina Hazard Mitigation Plan, which is federally mandated)

Heat wave

There is not a single standard definition of a heat wave due to differing opinions on threshold values, duration, and other variables (Smith et al., 2013). Hence, various terms describing prolonged, hot days range as defined above. The apparent lack of a unified definition can cause confusion when discussing patterns, trends, and impacts (Smith et al., 2013). Typically, weather forecasters in the US utilize the Heat Index when describing risks from hot weather (American Red Cross, 2020).

Heat wave data at the national level is less comprehensive. The NOAA National Centers for Environmental Information (NCEI) has data and documentation of heat stress events at major weather stations across the US. Gathered from the National Weather Service, the data is reported monthly since 1948 at point location level. Gaffen and Ross (1998) compiled apparent temperature climatology for first-order US weather stations and calculated the 85th percentiles of daily maximum, minimum, and average apparent temperatures which were used as threshold values for identifying extreme heat stress conditions (NOAA National Centers for Environmental Information, 2020). The data displayed shows the number of days per month that apparent average temperature exceeded the 85th percentile threshold, indicating an extreme heat event (NOAA National Centers for Environmental Information, 2020). The 85th percentile value has been shown by previous research to be closely correlated with weather related mortality statistics (Kalkstein & Davis, 1989). The US Environmental Protection Agency US Global Change Research Program (USGCRP) has compiled data for 50 large metropolitan cities in the US to show the change in heat wave frequency and length from the 1960s to 2010s.

Drought

Essentially an extended period of deficient rainfall, drought can be categorized in four different ways. Meteorological drought uses long-term precipitation data to measure present precipitation levels against departures from normal precipitation levels. Hydrological drought is defined by surface and subsurface water supply deficiencies based on stream flow, lake, reservoir, and ground water levels. Agricultural drought occurs when there is insufficient soil moisture to satisfy the water budget of a specific crop, leading to destroyed or underdeveloped crops with greatly depleted yields. Lastly, socioeconomic drought refers to the effects that

individuals feel when there is a physical water shortage (NOAA National Weather Service, 2015).

The US Drought Monitor is the best source for understanding which areas across the nation are currently experiencing drought conditions. The Drought Monitor team is comprised of three entities – the National Drought Mitigation Center at University of Nebraska-Lincoln, US Department of Agriculture (USDA), and the National Oceanic and Atmospheric Administration (NOAA). A map is released weekly with classifications portraying drought conditions across the US.

Flood

At the federal level, NWS defines flooding in two ways. A flash flood happens when heavily localized precipitation occurs in a short period of time at a given location. General flooding is an overflow of water onto normally dry land caused by rising water in an existing waterway lasting days or weeks (NOAA National Weather Service, 2015).

The United States Geological Survey (USGS) is the primary federal agency that collects flood data (USGS, 2020). USGS provides real-time and historic flood data through different online applications. For historical flooding events prior to 2011, there is documentation on the USGS Historical Flooding page (USGS, 2020) – most events captured were ‘historic’ or major events. Across the US, the Geological Survey has more than 10,000 stream gages deployed that gather and transmit point data water measurements every hour (USGS, 2020). Most data collected and displayed by USGS is done so in the form of interactive maps showing the extent of flooding. Additionally, the Federal Emergency Management Agency (FEMA) has the National Flood Hazard Layer geospatial database that contains current effective flood hazard data at the national level (FEMA, 2020). These federal data sets can be used to examine occurrences at the state and local levels as well.

From NOAA/National Weather Service, data has been compiled from media and other sources detailing fatalities specifically resulting from floods across the US and aggregated at the state level.

Data for Disaster Spending and Allocation Data (Financing)

In 1950 the Federal Disaster Relief Act authorized the president to provide federal assistance after disasters to supplement state and local funds. Over time the act evolved and provided The Stafford Act of 1988 which expands the power of the president to allocate federal funds and agencies toward disaster response. The Stafford Act codified cost-sharing requirements, mainly between federal and state governments (FEMA. Stafford Act). Today the federal government provides around 75% of disaster funding and non-federal agencies provide around 25% (this split may vary) (Federal Disaster Rebuilding Spending 2018). When a disaster occurs and local and state resources are overwhelmed a presidentially declared disaster enables supplemental federal funding and support to be accessed by states and allocated to areas in need.

The Federal Emergency Management Agency (FEMA) is the primary federal agency for funding assistance after a disaster (FEMA. State Profiles). Congress appropriates money annually into FEMA's Disaster Relief Fund (DRF) for public assistance, individual assistance, and hazard mitigation grant programs (Federal Disaster Rebuilding Spending 2018). Other funding agencies include the Department of Housing and Urban Development, Small Business Administration, U.S. Department of Agriculture, U.S. Army Corps of Engineers, and the national Flood Insurance Program

VI. Data for Mapping Vulnerability

Vulnerability Indicators

We identify whether available data correspond to three sets of vulnerability indicators: the UNDP, SDGs, and Sendai Framework. The five UNDP vulnerability indicator topics include discrimination, geography, governance, socio-economic status, and shocks/fragility. For SDGs, there were 9 indicators across three SDGs (i.e., SDG 1, SDG 11, SDG 13) relating to DR3 vulnerability. The Sendai Framework is comprised of 39 indicators across 7 target themes relating to disaster mortality, people affected by disasters, disaster economic loss, disaster damage to infrastructure and basic services, risk reduction strategies, international cooperation, and early warning system access.

In the United States, there are a multiple federal entities at the forefront of collecting and housing data on disasters including the Centers for Disease Control and Prevention (CDC), FEMA, USAID, and NOAA/NWS. Most data collected indicate fatalities number of disaster occurrences, and aggregated monetary damage caused by the disaster.

Vulnerability data

We summarize sources of publicly available data for measuring impacts and vulnerability due to disasters.

The Center for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI) uses US Census data to determine the social vulnerability of every tract within the US using a ranking system (Agency for Toxic Substances & Disease Registry, 2019). The SVI is particularly useful for understanding vulnerability at a local level, however it is not specific to disaster risk.

The FEMA National Risk Index is an online mapping application that identifies communities most at risk to 18 natural hazards including coastal and riverine flooding, drought, and heat wave (FEMA, The National Risk Index, 2020). The FEMA National Risk Index utilizes GIS mapping social vulnerability, community resilience, and expect annual loss at the census tract and county level for the US. The components of expected annual loss, hazard frequency, and historic loss are calculated for property value, population, and agriculture (FEMA, The National Risk Index, 2020). Like the CDC SVI, the National Risk Index is detailed to the census tract and county level for the US and the data for vulnerability is most related to the Sendai Framework Target C for direct disaster economic loss. However, the National Risk Index only details the potential economic loss, not actual data per disaster.

US Agency for International Development (USAID) works internationally to support disaster risk reduction specifically through the Office of US Foreign Disaster Assistance. The US government adopted the Sendai Framework for Disaster Risk Reduction 2015-2030 and is working to design its disaster risk reduction programs to fulfill the goals of the Framework (USAID, 2019)

The National Weather Service (NWS) provides statistical information on fatalities, injuries, and damages caused by weather related hazards (NOAA National Weather Service, 2020). These statistics are compiled by the Office of Services and the National Climatic Data Center and reports are provided annually for 9 weather events, including flood and extreme heat (NOAA National Weather Service, 2019). Within the report breakdown, fatalities are documented by state, gender (male/female), age group, and location (specifically mobile/trailer home or permanent home).

We found that there is a lack of easily found data for the individual number of people specifically affected by heat waves and drought. This could be attributed to the notion that these disasters indirectly affect individuals, whereas flooding has more of a direct affect. Direct economic losses specifically attributed to disasters do not seem to be readily shared data and may be held by private insurance companies. Most of what was found for economic loss was projected or aggregated and more often for flooding than heat wave or drought. The FEMA National Risk Index seemed to be the most comprehensive source for economic impact from disaster. Similarly, there is a lack of information about how disasters affect the livelihoods of individuals as well as any sort of further breakdown other than gender or age of individuals affected. Data regarding the number of destroyed facilities and number of disruptions to basic services from disasters was missing. Most information found in risk assessment plans indicated the number and kind of facilities in an area and planning for recovery of the facilities.

VII. Overview of Vulnerability to Disasters

Identification of Vulnerable Communities

Disaster risk reduction and resiliency is not accomplished through one-size-fits-all policies, as each community and geography require a different set of actors and plans to be effective. Evidence, put forth by the CDC, indicates those with low socioeconomic status, racial and ethnic minorities, children, the elderly, and disabled people are disproportionately, and similarly, at-risk to be affected by a natural hazard. The United States Geological Survey (USGS) uses a mix of geographical analysis, spatial modeling, and stakeholder surveys to understand and evaluate social vulnerability, and in 2011, the Federal Emergency Management Agency (FEMA) included parameters for mapping social vulnerability and risk. Despite these improvements, there is still a great deal more to be done at the federal level in order to adequately protect vulnerable communities. Federal support largely addresses vulnerability as an aggregate, by providing funding sources and guiding policies to protect civilians to state and local jurisdictions, however, this support typically neglects the inclusion of equity frameworks, perpetuating the elevated risks faced by low-resource communities. In comparing current US policies to the

UNDP, we see success in areas of infrastructure building, urban resiliency, and improved health and education services, however, the UNDP's goals of providing equity devoid of discrimination by geography and socio-economic status and the inclusion of shocks and fragility frameworks are not currently fulfilled. By addressing these gaps and integrating more local and state knowledge into federal resource allocation models, the United States can reduce natural hazard risks in vulnerable communities.

Evidence, put forth by the CDC, indicates those with low socioeconomic status, racial and ethnic minorities, children, the elderly, and disabled people are disproportionately, and similarly, at-risk to be affected by a natural hazard (Flanagan 2011). On the "Individuals and Communities" page of FEMA's website, the federal organization encourages specialized planning at the community-level, sharing resources for trainings, faith-based preparedness efforts, and children-focused emergency planning (FEMA, *Listing of Disaster Recovery Funding Resources*).

The USGS lays out the following variables which affect vulnerability and resilience: "(1) how communities choose to use hazard-prone land, (2) pre-existing socioeconomic conditions, (3) likely future patterns of land change, and (4) current efforts to reduce and manage risks" (USGS. Hazards Vulnerability Team). To assess community vulnerability and resilience, the USGS has used a mix of geographical analysis, spatial modeling, stakeholder surveys, and training to further their understanding of social vulnerability and enhance emergency management capabilities when aiding socially vulnerable populations (USGS. Hazards Vulnerability Team). FEMA's HAZUS-MH software, used to map hazard data for disaster management stakeholders, implemented features involving social vulnerability and risk in 2011, previously only showing infrastructure vulnerability and damages to estimate economic losses (Flanagan 2011).

Vulnerable communities, as identified on the federal level, appear to be frequently tied to the vulnerabilities identified in housing and other nearby infrastructure such as schools, hospitals, and transportation. This is due to infrastructure quality being tied to personal and community wealth (Flanagan 2011) and low quality being at higher risk for harm during natural disasters. This macro-level support is frequent in federal policy measures for vulnerable communities. Federal departments which play significant roles in DR3, as identified by Congress, are the U.S. Department of Housing and Urban Development, the Small Business Administration, Department of Agriculture, Army Corps of Engineers, and the Department of Health and Human Services (Congressional Research Service 2019) – only the last of which primarily addresses individual-level harm reduction.

In supporting individuals, most federal assistance is directed at those with low socioeconomic status or suffering unforeseen financial hardship following a natural disaster. This includes assistance programs for agriculture producers suffering low crop yield in the wake of drought, food support programs for low-income households facing food scarcity, the specifics of which we will explore more in depth below.

There are very few national or federal organizations specifically focused on supporting high-risk groups before, during, and after disasters, therefore it falls heavily on local and state

governments to bring awareness to these groups' unique needs. High-risk populations include people with disabilities, the elderly, those with low socioeconomic status, and non-white people. There has been some attention on how socioeconomic status and race play into the ability to prepare and respond to official disaster warnings and declarations (SAMHSA 2017). These groups are more likely to live in high-risk housing and have less access to warning technology (SAMHSA 2017). During Hurricane Katrina, data from New Orleans and surrounding areas was mixed, but some studies showed lower income households were more likely to not evacuate or leave at least one household member behind (SAMHSA 2017). Overall, these at-risk groups are frequently lumped together as just that, the "at-risk population", and served as such with little attention to individual needs or challenges, particularly on the federal level.

Comparison to International Guidelines

The UN Sustainable Development Goals, while not explicitly addressing disaster risk reduction and resilience in title of any goals, work to reduce risk for vulnerable communities by goals involving the building of resilient infrastructure, increasing urban resiliency, and improving education and health facilities (United Nations. Disaster Risk Reduction).

On a macro-level, the U.S. federal policy measures meet both these goals through their many infrastructure projects and grants, however, the UNDP framework of discrimination, geography, governance, socio-economic status, shocks and fragility is not wholly addressed on more micro-levels. Discrimination is the main aspect of the framework lacking from American federal disaster policy, as few programs exist to support racial and ethnic minorities, though there are some protections in place for Indigenous peoples through the Department of the Interior (FEMA, Listing of Disaster Recovery Funding Resources). The focus of federal assistance is on communities with low socioeconomic status, largely due to the fact that federal disaster assistance is primarily in monetary form. Most commonly, this assistance is given to local, state, and tribal governments, who then allocate funds to individuals, projects, and teams in need, as per the Stafford Act. Within this monetary assistance, there are specific programs in place to mitigate the different hazards rural and urban areas face, meeting the UNDP's emphasis on geography. Furthermore, there are programs in place to discourage infrastructure building in at-risk geographies such as floodplains, as laid out by the National Flood Insurance Program (NFIP). Shocks and fragility are addressed by the previously stated infrastructure planning and restrictions as well as several agricultural subsidies and restrictions.

We identify whether available data correspond to three sets of vulnerability indicators: the UNDP, SDGs, and Sendai Framework. Many of these indicators were not found in US-based data sources. We found data relating to three of five UNDP indicators. For SDGs, we found data relating to 5 SDG indicators from two SDGs (i.e., SDG 11 and SDG 13). For the Sendai Framework, we found data relating to 9 of these indicators from 5 target themes. See Work Package 5 for tables identifying indicators collected in the United States.

CASE STUDY: In North Carolina, sensitive populations are identified as those who are non-English speakers, older adults, members of rural communities, lower-income, communities of color, people with disabilities, members of racial or ethnic minorities, and of different

nationalities. However, the majority of mapping is based off of race and income at the census block level. The NC Department of Environmental Quality (NCDEQ) Environmental Justice Mapping Tool was used. In this tool and report, based on federal guidelines, “potentially underserved communities” based on racial composition and poverty rate. The NCDEQ also houses an Environmental Justice and Equity Advisory Board which has strict requirements for the racial diversity of its members. State policies place greater emphasis on the aspects of race and socioeconomic status as they contribute to disaster sensitivity and fail to mention gender, sexual orientation, religion, or governance. NC is often regarded as the birthplace of the environmental justice movement, a distinction which may contribute to this divide where environmental justice has historically been focused on differences in environmental exposures that fall along racial lines. However, the variety of ways communities can be more sensitive to disasters cannot be forgotten and further research is needed to understand the role of gender, sexual orientation, and religion in community resiliency. Of the recommendations for climate justice to come out of the *North Carolina Climate Risk Assessment and Resilience Plan*, a common theme was the improvement of community participation and diversity in governance. While goals were outlined, very little information is given on the baseline conditions or possible indicators of progress (NC Department of Agriculture and Consumer Services).

CASE STUDY: Morehead City’s local and regional hazard mitigation plans were reviewed to understand how vulnerable communities are identified in governance approaches and policy measures. The plans’ definition and guidance about how to define and assess vulnerability came from FEMA’s publication *Understanding Your Risks—Identifying Hazards and Estimating Losses*, which frames vulnerability in terms of physical and geographical exposure and economic losses in terms of property damage. Physical vulnerability dominates the analysis of Morehead City’s vulnerability indicators; however, the regional hazard mitigation plan identifies vulnerability using the CDC’s Social Vulnerability Index (SVI). While there is little focus on social vulnerability in the Town and Regional plans, geographic and physical vulnerability is assessed. Geographic vulnerability is evaluated in terms of flood zones, facility type, infrastructure, the number of residents located in an area with high exposure to a particular hazard, or the amount of monetary damage at risk in a given area (Town of Morehead City 2017; Pamlico County 2020). However, it was not clear from the mitigation plans how the governments connect their proposed activities to the social vulnerabilities identified within each plan. Many factors of social vulnerability can prevent the equitable allocation of resources. If social vulnerability is not thoroughly identified and addressed, entire communities may not receive the resources or investments necessary to mitigate the impacts of natural hazards. It is suggested that there be a deeper analysis of the social vulnerabilities within the jurisdiction, as well as specific mitigation plans that channel resources to initiatives that address the vulnerability indicators identified. Higher social vulnerability is an indicator that a community may be limited in its ability to respond to and recover from natural hazards. Additionally, many factors of social vulnerability can prevent the equitable allocation of resources (Thomas 2019). If social vulnerability is not thoroughly identified and addressed, entire communities may not receive the resources or investments necessary to mitigate the impacts of natural hazards. The Pamlico Sound Regional Hazard Mitigation Plan takes an important step in identifying vulnerability using the CDC’s SVI. This tool allowed plan developers to analyze social vulnerability for the counties within the

region and think about what role the social indicators play in hazard vulnerability. While this is an important first step, a deeper understanding of the region's social vulnerability characteristics would be beneficial. For example, the connection between vulnerability and housing type is discussed in the plan, but there is a gap in the discussion around the unique vulnerability associated with renters and the homeless. It is suggested that a combination of indicators used for the SVI tool as well as the SDGs would create a robust framework for evaluating vulnerability.

VIII. Equitable Resources Allocation

FEMA has compiled a full list of disaster recovery funding sources (CDC Social Vulnerability Index) several of which are geared towards supporting vulnerable communities outside solely socioeconomic dimensions. The U.S. Department of Health and Human Services in particular has created grants designed to specifically aid children and youth, older adults, and people with disabilities. The U.S. Department of the Interior has several programs to aid Indigenous groups with both economic and environmental losses.

That being said, the largest and more commonly used federal disaster relief program, the Disaster Relief Fund (DRF), is disseminated to state, tribal, territorial, and local governments through requests under the Stafford Act. These funds are then used to address more localized issues as the sub-national governments see fit. There is no protocol in place for DRF funds to address underrepresented demographics outside of those with low socioeconomic status. Federal disaster relief grants of this nature neglect to provide an equity framework for resource allocation, allowing for asymmetric information and dissemination that may continue to leave the most vulnerable populations without assistance.

Current resource allocation prioritizes the American economy and financial wellness as both communities and individuals. However, this focus on the economic losses which result from disaster fail to equitably address other demographics disproportionately affected by disasters. Disaster risk assessments for vulnerable communities have frequently been explained through the formula "Risk = Hazard * (Vulnerability – Resources)" (Town of Morehead City 2017) by academics, however, on the federal level, this mindset is lacking, as the responsibilities of recognizing and addressing vulnerabilities beyond economic is put on the state, tribal and local levels (Town of Morehead City 2017). This is a weakness as oversight is scarce, and these levels of governance have many less resources. In essence, there is a correlation in American policy between less resources and more responsibility when it comes to aiding vulnerable communities mitigate and recover from natural disasters.

The federal level's focus on addressing non-individual DR3 support in the form of infrastructure, agriculture, business, etc., all of which play larger roles in the U.S. economy, is much stronger. The DRF as well as NFIP, numerous USDA and Small Business Administration grants and protections all provide relief to the agricultural and business sectors of the U.S., allowing affected farmers and businesses to stay competitive with intent to mitigate harm done to the overall financial well-being of the region.

IX. Financing and Equity

There are significant equity issues embedded in disaster assistance. These programs still function in the same inequitable systems that exist in society today. For example, SBA loans are based on factors like credit score and income which systematically skew approval toward wealthier, whiter communities. Since 2001, SBA loans have been approved at a 52% rate in zip codes with 90% white populations, and at a 27% rate in majority-black zip codes (Disaster Loans Entrench Disparities in Black Communities). Similarly, FEMA and HUD funding are designed for middle-class homeowners. FEMA assistance, unlike for homeowners, is not available to landlords for repairs so they must rely on their own resources, insurance, or loans (Disaster Housing Recovery; NPR; PBS). HUD's CDBGs have historically been disproportionately allocated to programs serving homeowners rather than renters (Disaster Housing Recovery; NPR; PBS). While HUD and FEMA have some programs that support renters, available rental housing, post-disaster, is often scarce and makes households prone to long-term displacement or housing insecurity (Disaster Housing Recovery).

As discussed previously, outside of SBA loans, other federal support is not enough to restore or rebuild an entire home. Most people must rely on high-interest loans and insurance. Insurance, along with other aid programs, are typically based on how much people have lost, rather than what they need to get back on their feet (Disaster Housing Recovery; CNN Politics).

The most concerning findings come from a 2018 study by Howell and Elliot – Damages Done: The Longitudinal Impacts of Natural Hazards on Wealth Inequality in the United States (Howell 2019). Examining potential inequality within buyout programs (funded by HMGP, CDBG, and other federal programs) the study found that "households in high social vulnerability areas were less likely to obtain full financial compensation, and endured longer periods before receiving acquisition funds" (Howell 2019). Further, the study found that when controlling for local hazard damage, "the more FEMA aid areas receive, the more polarized wealth becomes across already unequal individuals" (Howell 2019). That is, as local FEMA aid increases, black, less-educated renters with very little household wealth, tend to have steadily declining wealth over time, however, the opposite is true for white, more-educated homeowner with \$100,000 in household wealth (Howell 2019). While these trends build on existing inequity in the United States, it also points to flaws within the disaster assistance allocation process.

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