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Rural coastal community resilience: Assessing a framework in eastern North Carolina

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ABSTRACT

Rural coastal communities have unique vulnerabilities to the impacts caused by sea level rise and saltwater intrusion compared to coastal urban areas that have growing populations, increasing property values, and extensive infrastructure. In contrast, rural coastal communities are typically dependent on traditional natural resource livelihoods like farming, commercial fishing, forestry, and outdoor recreation opportunities. Saltwater intrusion, exacerbated by sea level rise, impacts rural livelihoods by limiting suitable agricultural land and development options, which compounds local economic difficulties. Higher rates of poverty, aging demographics, and out-migration already challenge the resilience of rural coastal communities. Informed by sociological research that addresses the local economic factors unique to rural communities and resilience research on coastal communities and natural hazards, we propose the Rural Coastal Community Resilience (RCCR) framework. We test the RCCR framework through a series of focus groups within the Albemarle Pamlico Peninsula of North Carolina (U.S.), a low-lying, rural region with nearly one-half of its land less than 1 m above sea level. Applying the RCCR framework revealed that local priorities include maintaining rural livelihoods, creating job opportunities, and addressing highly vulnerable populations. By including stakeholder voices to stimulate capacity building dialogue, the RCCR framework boosts rural coastal community resilience by focusing on locally perceived resilience needs as targets for capacity building workshops, management interventions, and climate action planning.

1. Introduction

Climate change and sea level rise (SLR) are threatening coastal cities, rural communities, ecosystems, and agricultural systems globally (Lane et al., 2013). The global environmental change caused by climate change will require coastal regions to develop adaptive responses to maintain resilience (Bostick et al., 2016; Sales, 2009; Adger, 2005). In the U.S., it is expected that 4.2 million coastal residents will be vulnerable to SLR by 2100 (Hauer et al., 2016). However, there are important differences in how SLR will affect urban and rural communities. Coastal urban areas have increasingly dense development and growing populations that place more people, infrastructure, and property at risk to storm surge damage and flooding; yet, urban areas frequently have more resources at their disposal for adaptation (Brown and Westaway, 2011; Morss et al., 2011; Tang, 2008). Coastal rural areas have natural resource dependent economies (e.g., farming, logging, fishing, and tourism) that are particularly vulnerable to saltwater intrusion, which alters coastal habitat for wildlife, leads to agricultural abandonment, and reduces suitable land and development options (Poulter et al., 2009; Moorhead and Brinson, 1995).

Research on resilience and adaptation to SLR has resulted in various frameworks for conceptualizing exposure and modeling potential impacts within coastal urban areas, beach tourism destinations, small island nations, and developing countries (e.g., Schwarz et al., 2011; Moreno and Becken, 2009; Sales, 2009). Much of this research has focused on disaster and hazard risk management in terms of population, flood insurance, and property value (e.g., Bostick et al., 2016; Nelson et al., 2007). Within environmental sociology, research has documented the unique vulnerabilities of rural areas, which include isolation from central planning agencies and out-migration following disaster, as well as high poverty levels, low average incomes, and limited insurance (Maru et al., 2014; Davies et al., 2009; Donner and Rodriguez, 2008). Yet, there is need to link resilience and environmental sociology literature to

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address rural coastal communities in a way that conceptualizes their unique and compounding vulnerabilities and enables capacity building dialogue (Davies et al., 2009; Vogel et al., 2007). This article presents a framework, the Rural Coastal Community Resilience (RCCR) framework, which considers physical exposures to SLR and saltwater intrusion, while placing rural social contexts on a series of spectrums anchored between vulnerability and resilience.

In the following sections, we provide an overview on coastal exposure to climate change impacts, resilience, and adaptive capacity, highlighting differences between urban and rural coastal areas. Then, we present the Rural Coastal Community Resilience (RCCR) framework and demonstrate how this framework can be applied within rural coastal communities to stimulate capacity building dialogue, using the Albemarle Pamlico Peninsula (APP) region of North Carolina (USA) as a case study. Following a description of the APP region, we present results from the application of the framework. We conclude with a discussion on possible improvements to the framework and the implications for spring boarding climate action planning and adaptive capacity building.

1.1. Coastal climate change impacts

Global mean sea level is expected to rise by .52 m–0.98 m under the high emissions scenario by 2100 (Church et al., 2013). Changes in the position of the shoreline caused by coastal erosion and subsidence can exacerbate SLR impacts, as can the presence of water control structures (e.g., dams) that reduce coastal sediment deposition and minimize accretion (Nicholls and Cazenave, 2010). Coastal flooding, caused by wind driven storm surge and heavy precipitation, has become a more common occurrence as a result of SLR and demands increased government spending on mitigation infrastructure, repair of highways, adaptation on properties, and planning (McNamara et al., 2015; Riggs et al., 2008; Moser, 2005).

Storms, and the associated heavy winds and flooding, cause extensive damage to buildings and infrastructure (FitzGerald et al., 2008; Donner and Rodriguez, 2008). For example, Hurricane Katrina, which made landfall in 2005 and became the costliest U.S. Hurricane, caused over $150 billion in damages (NOAA, 2017). Storm-related flooding also leads to salinization of groundwater tables and soils (Qi and Qiu, 2011). Salinization poses a threat to both the quantity and quality of drinking water supplies by intruding into aquifers in rural coastal regions where many residents rely on wells (Morss et al., 2011; FitzGerald et al., 2008). There are also substantial risks to agricultural production as salinization of groundwater tables leads to increased salinity levels in soils reducing suitable agricultural land and lowering plant productivity (Saleem Khan et al., 2012). Rural coastal community economies can then experience exacerbated out-migration (Bostick et al., 2016; Sales, 2009).

Kopp et al. (2015) demonstrate that North Carolina (NC) has averaged 2.5 mm/year of SLR during the 20th century and it is expected that it will experience between 42 and 132 cm SLR by 2100. Property loss in four coastal counties (Bertie, Dare, Carteret, and New Hanover) is estimated at $2.8 billion from SLR impacts alone (NCILT, 2012). North Carolina has also experienced more billion-dollar damage events due to storms and flooding than most other states in the U.S. (NCILT, 2012). Damages associated with Hurricanes have cost NC billions of dollars in damages (e.g., Matthew in 2016 ($10.1 B); Irene in 2011 ($14.6 B), Floyd in 1999 ($9.5 B) (NOAA, 2017). Flooding is also expected to increase in frequency; for example, Wilmington, NC is predicted to experience 30 separate 100-year floods between 2050 and 2100 (Kopp et al., 2015). Furthermore, the state has already experienced loss of timber and agricultural production within sea level rise zones due to salinization and subsequent abandonment (Poulter et al., 2009; Moorhead and Brinson, 1995).

1.2. Coastal resilience and adaptive capacity

Resilience theory, with its origin in ecological integrity assessment, has evolved into a field that addresses socio-ecological systems (SES) and their capacity to adapt or deliberately change in anticipation of stress (Nelson et al., 2007; Folke, 2006; Gunderson and Holling, 2002). The SES is a research paradigm that focuses on the interdependencies between human and environmental systems through links, synergies, and feedbacks (Cote and Nightingale, 2012; Turner, 2010; Ostrom, 2009). A resilient SES has the ability to anticipate, absorb, accommodate, or recover from the effects of a shock or disturbance in a timely and efficient manner while maintaining a similar structure and function (Nelson et al., 2007; Vogel et al., 2007; Berkes et al., 2000). Alternatively, vulnerability theory describes the degree to which a system is sensitive (i.e. the probability of a socio-ecological system being negatively affected), its exposure, and capacity to adapt to the adverse effects of climate variability and extremes (i.e. the ability or potential of a system to respond successfully) (Morss et al., 2011; Turner, 2010; Nelson et al., 2007). Risks are biological, environmental, or socioeconomic factors associated with an increased probability of a negative outcome contributing to greater overall vulnerability (Brown and Westaway, 2011; Van Aalst et al., 2008).

While coastal resilience work addresses SLR, there is significant focus on storm and extreme events (Bostick et al., 2016; Smit and Wandel, 2006), necessitating a focus on saltwater intrusion and long-term persistent impacts (Poulter et al., 2009). SLR and saltwater intrusion are slow and persistent stresses occurring on the order of decades compared to sporadic perturbations from natural hazards (storms or hurricanes) that can occur over the span of days or weeks (Gallopín, 2006). Adaptation to these persistent impacts may benefit from improving community dialogue (Olsson et al., 2004). A resilience framework that addresses the unique economic and demographic challenges facing rural coastal communities could facilitate this conversation.

Frameworks for assessing resilience are typically developed as top-down approaches that measure large scale economic and environmental factors designed for use by governments, policy makers, and planners (Yoo et al., 2011; Smit and Wandel, 2006). Attempts to develop widely applicable frameworks for assessing coastal resilience face issues of scale that make transferability to local scales difficult (Yoo et al., 2011). Additionally, frameworks have not accounted for differences in capacities for preparation and response between coastal urban and rural areas, particularly the ability of rural communities to access resources within local management structures for planning and land use decision-making (Davies et al., 2009). For example, the development of cities, communities, tourism, and industry within urban coastal areas increase the value of what is at risk to climate change but also the capacity to adapt with a stronger tax base (Frazier et al., 2010; Pielke et al., 2008; Adger, 2005). Subsequently, disaster planning and relief efforts (e.g., beach nourishment projects, coastal mitigation structures, and recovery aid) have favored property owners, tourism, and urban areas (Griffith et al., 2015; Morse, 2008).

Rural coastal communities are frequently at a disadvantage, as they typically do not have the same flow of tourism dollars, tax base from the high value properties, and strong industries found in cities and tourism-dependent beach communities (Davies et al., 2009). Moreover, Strobl (2011) documented how income disparities affect mobility post-disaster, explained as the ability for higher-income populations to relocate while low-income groups are often forced to stay and experience lowered economic growth rates. Given such differences, there is a need for tools to enhance resiliency that

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