



Establishing a regional interdisciplinary resilience center: a bottom-up approach

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Abstract

Both natural and manmade disasters have severely impacted the region of Southeast Texas over the past few decades, and this has negatively affected the socio-economic well-being of the region. The state of Texas has suffered 200–250 billion dollars in damages from natural and manmade disasters since 2010. Given the region's strategic importance to the nation's energy and security, developing resilience knowledge and multi-disaster resilience research focused on issues pertaining to the region is needed. This paper describes the structure and process of building a center for multi-disaster resilience at a regional public university. By utilizing a bottom-up approach, the Center's mission and design are broadly democratized through the participation of a variety of scholars and various stakeholders with whom they interact. Resilience needs specific to the Southeast Texas region are examined, as is the relationship between resilience and the academic disciplines of the stakeholders involved. The issues of resilience in the region are discussed as well as the future steps for the Center's continued growth and development for the study of resilience.

Keywords Resilience center · Regional resilience · Disaster resilience · Resilience indicators

1 Introduction

Due to the frequency of manmade and natural disasters in Southeast Texas (SETX), through the State of Texas congressional mandate, Lamar University (LU) established the Center for Resiliency, focused on multi-disaster resilience

beginning in late 2021. The Center for Resiliency's definition of resilience depends upon the discipline and application through which it is viewed. While a psychologist may focus on one's ability to deal with trauma or tragedy during a natural disaster, an engineer may examine a levee system and its capability to maintain functionality post-storm surge during a hurricane. Both instances involve the study of systems and the extent to which they can adapt or be adapted to adversity, but the researchers' methods of study and perspectives vary greatly. Often, the study of resilience is siloed, with most research centers focused on a particular aspect of resilience or the performance of certain systems in adverse conditions rather than examining resilience broadly across multiple disciplines. Here in we define multi-disaster resilience and its usefulness to planners and tell the story of the formation of a center designed to study it.

The Center's challenge was to bring together scholars from all five colleges at LU to develop research, educational opportunities, community outreach, and collaborations in multi-disaster resilience in the SETX region. According to Linkov and Trump (2019), resilience applies to many fields. However, holistic implementation requires considering two main challenges: (1) inconsistent standards, definitions, and

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interpretations and (2) contextualizing resilience within a system, network, or combined approach. With these challenges in mind, a group of faculty members from across all five colleges at LU- College of Arts and Sciences (COAS), College of Business (COB), College of Education and Human Development (COEHD), College of Engineering (COE), College of Fine Arts and Communication (COFAC) were invited to participate in the first Executive Committee for the Center and responded to the following questions about resilience:

1. What or who is involved in resilience in each discipline? What does resilience mean for these disciplines?
2. What are the issues of resilience?
3. What is needed for each discipline to enhance resilience?
4. How can the center unify or consider collective resilience for all disciplines in terms of resourcefulness, rapidity, robustness, and redundancy?

As a newly developed Center, we primarily focused answering questions 1 and 2 in the first year of the Center. After completion of more multi-disciplinary projects and collecting data on resilience, future investigations will be conducted on attempting to investigate the questions 3 and 4. (Please see further discussion in Sect. 5.2). When a university's colleges, departments, teaching, and research activities have traditionally been siloed, it is particularly difficult to break boundaries and bridge disciplines as is needed for comprehensive resilience research. This bottom-up approach was crucial to establishing a broad, cross-disciplinary examination of the study of resilience. Activities supporting the Center's development included examining the structure and goals of other resilience centers (Sect. 2), understanding the situation in SETX (Sect. 3), and gathering data and resilience indicators in its first year (Sect. 4). We provide a discussion and overview of the steps needed to move forward (Sect. 5). Furthermore, this paper lists some of the practices used to initiate a resilience center at this academic institution.

2 Developing a resilience-focused center

Over the past few years, resilience centers have been established across the U.S. to broaden the understanding of resilience and promote research on developing resilient systems and projects. In addition, the federal government had established national initiatives such as in 2014 when the National Academies of Sciences, Engineering, and Medicine (NASEM) initiated the "Resilient America Program" to improve the understanding of resilience and strengthen a community's resilience and adaptation and when in 2016 the U.S. Army Corps of Engineers established a resilience

roadmap to better support resilience efforts in the U. S. (U.S. Army Corps of Engineers 2016). In addition to the nationwide efforts, multiple regional centers have been established to improve resilience through dedicated centers. One example is the Colorado State University's Center for Risk-Based Community Resilience Planning, established by the U.S. Department of Commerce's National Institute of Standards and Technology (NIST). Table 1 summarizes these and other existing university-based resilience centers in the U.S. Most of these regional and university-based resilience centers focus on a particular facet of resilience.

The Gulf Coast region of the U.S. has recently experienced multiple natural and anthropogenic disasters that have impacted many peoples, communities, infrastructure, and natural systems in many ways. Given this recent, complex history of disasters, it is vital that any attempt to focus on learning and building resilience in this region must include a holistic approach to resilience rather than a narrower singular focal area. Thus, the concept of resilience and resilience research benefits from a more holistic, bottom-up approach. Developing a state-funded regional center on resilience requires a clear vision for catering to regional needs and creating an environment conducive to engagement and complementary activities. Therefore, building a regional multi-disaster resilience center for Gulf Coast in the SETX needs to incorporate the interdependencies and the interdisciplinary nature of the local communities and industries. Learning from the existing resilience-focused centers and past experiences with multiple recent disasters, LU aims to promote multi-disciplinary collaborations with an inter-professional approach to resilience research by leveraging a bottom-up approach.

The COVID era emphasized the collective understanding of issues and solutions (Trump and Linkov 2022). Policymakers and the public need a general idea of resilience to make informed, prompt decisions and policies. Because most centers focus on developing an in-depth understanding of resilience in particular domains, the current body of knowledge in resilience research is often fragmented. Therefore, our Center promises to build an environment to foster multi-disciplinary resilience research and, more importantly, develop a collective and interconnected resilience knowledge hub for decision-makers in future emergencies and disasters.

3 Resilience needs in Southeast Texas

One of the first challenges in developing the Center at LU was exploring the meaning of resilience for various disciplines. This effort can aid with the first challenge of establishing a center for resilience with more consistent standards, definitions, and interpretations by including inputs from the

Table 1 University-based Resilience Centers in the U.S

Center Name	Affiliation	Primary focal area
Environmental resilience institute	Indiana University	Climate change
Center for climate preparedness and community resilience	Antioch University	Climate justice and community resilience
Northeast center for coastal resilience	University of Massachusetts Amherst	Coastal resilience
Institute for coastal adaptation & resilience	Old Dominion University	Coastal resilience
Center for coastal & climate science & resilience	University of Hawaii	Coastal resilience
Coastal resilience and sustainability initiative	NC State University	Coastal resilience
Center for coastal resiliency	Louisiana State University	Coastal resilience
Center for resilient communities	University of Idaho	Community resilience
Center for risk-based community resilience planning	Colorado State University	Community resilience
Center for urban resilience	Loyola Marymount University	Community resilience
Resiliency center for families and children	Western Michigan University	Community resilience
The center for American Indian resilience	Northern Arizona University	Community resilience
Knowledge exchange for resilience	Arizona State University	Community resilience
Center for community resilience	George Washington University	Community resilience
Disaster research center	University of Delaware	Disaster research
University of Arkansas resiliency center	University of Arkansas	Food, water, and community systems
Center for global resilience and security	Norwich University	Human resilience
Indigenous resilience center	University of Arizona	Indigenous resilience
Center for disaster resilience	University of Maryland	Natural hazards
Coastal resilience center	University of North Carolina at Chapel Hill	Natural hazards (primarily coastal hazards)
Global resilience institute	Northwestern University	Overall resilience
Science and resilience institute	City University of New York	Resilient environment
Institute for resilient infrastructure systems	University of Georgia	Resilient infrastructure
Center for resilient infrastructures, systems, and processes	Purdue University	Resilient infrastructure

various disciplines in its definition. The following sections contain examples of previous research into resilience for multiple disciplines. These examples cover topics such as the economic resilience, the built environment, social or cultural factors, community and governmental perspectives, and resilience in the natural environment.

To address the second challenge of contextualizing resilience within a combined approach of many systems, if a system is more of a closed loop of processes, people and things, then identifying the networks amongst various systemic entities can help anticipate how changes in one system might impact others. Further research on this second challenge is planned but not included in this study due to the effort and space needed to address the multiple system challenge properly.

Each discipline’s interpretation or views of the impacts and resilience related to various types of disasters will emerge within the compilation of resilience issues brought forward by the many disciplines and will be evaluated as the Center grows. These compilations inform the criterion for quantifying resilience: “pre-established notions of resilience success and failure” (Linkov and Trump 2019). Adding the

criterion for multi-disaster resilience further complicates the future implementation of resilience in the Gulf Coast region. This section briefly outlines some of the disasters and their socio-economic impacts on the Gulf Coast for the last 20 years.

The SETX region (including Houston, Beaumont, Port Arthur, and Orange) significantly contributes to national energy and security: two of the nation’s top fifteen ports in tonnage and the key Sabine Neches Waterway, and Houston Ship Channel are within this region (U.S Army Corps of Engineers 2017). Twenty-nine refineries produce approximately 33% of the transportation energy demands of the U.S. located in SETX (U.S. Energy Information Administration 2016). The existence of refineries, ports, petrochemical companies, and other critical infrastructures creates a complex socio-technical system. Any disruption to them would greatly affect the regional and national economy, security, and well-being of U.S. society. The SETX region was hit by hurricanes Rita in 2005 and Ike in 2008 and then devastated by Hurricane Harvey in 2017, with massive flooding from the largest rainfall in a single storm ever recorded in the U.S. (Blake and Zelinsky 2018). In 2019, Tropical Storm Imelda

caused flooding in many of the same places impacted by Hurricane Harvey and new areas in the region (Latto and Berg 2020). In August 2020, while spared by the eye of Hurricane Laura (which featured category-four winds), the SETX region still felt the devastation of the high winds and moderate flooding. In October 2020, Hurricane Delta made landfall only slightly to the east of the region) and again caused wind damage to much of the area. These 2020 storms caused infrastructure damage at inland, and although they only produced minor storm surges, their intensities in the SETX region of the Gulf Coast point to a growing risk of significant storm surges in the future. In addition to storms with flooding and storm surge risk, Winter Storms Uri and Viola caused a catastrophic impact on Texas's critical infrastructures in 2021, and the estimated cost of these winter storms is around \$200–\$300 billion, along with the loss of 210 Texans (American Society of Civil Engineers 2022). Furthermore, the COVID-19 pandemic hit the SETX region hard, and the lockdown severely impacted the regional economy. The unemployment rates for both Jefferson and Orange Counties nearly doubled between March and April 2020. After the lift of restrictions in May 2020, the unemployment rates declined but remained far above the pre-pandemic levels.

The confluence of flooding, high winds, freezing temperatures, and pandemic impacts underscores the systemic vulnerability of the Golden Triangle and much of Texas as a whole. Furthermore, many of the minority and poor communities in the region may have been disproportionately impacted by recent floods. These same communities may have been among the hardest hit during the pandemic due to congested living environments, limited access to health-care facilities, and limited options for teleworking and social distancing. The issues in Texas and other areas of the U. S. during these disasters can stem from aging infrastructures and poor planning and investment decisions of infrastructures (Vajjhala 2021). Decisions related to infrastructure have lasting effects on the well-being of the communities (Linkov et al. 2022). Furthermore, underserved and underrepresented populations are frequently marginalized in areas with limited structure and resources (high-risk flooding areas, lack of access to safe food and water, lack of transportation, etc.). Investments may play a major role in overcoming the increasing nature of these extreme events, which is expected to be the new norm for Texas and many of the other parts of the U.S. Investments should be incorporated with better infrastructure-construction design, engineering, and planning (Vajjhala 2021). Infrastructure planning needs to include all federal, state, and local stakeholders, such as emergency managers and experts in resilience (Vajjhala 2021). Thus, due to the great need for resilience capacity in the SETX and neighboring Gulf Coast regions, Sect. 4 represents an overview of many of the steps forward in the

first ten months after the founding of the Center. Located in the heart of the Golden Triangle, the most eastern portion of SETX region, LU is uniquely situated to house a center for resilience to address the socio-economic and socio-technical issues of disasters.

4 Establishing a resilience center at Lamar university

The Center received final approval with the Governor of Texas' signature in July 2021, with funding allocated annually for the fiscal year (F.Y.) 22–23 biennium starting on September 1, 2021. A preliminary Center programmatic chart was developed by its inaugural director and approved by the LU executive leadership—this included a plan for a grouping of four categories of projects to be funded, which would focus on education, outreach, research, or a combination of any of the three. The four project categories are Springboard, Lamar, Flood Coordination Study, and Other, with the first three to be funded in FY22. In the wake of Tropical Storm Imelda, the Flood Coordination Study was initiated two years before and expanded when the Center was established in September 2021. The Springboard Project categories intend to allow the five academic Colleges at LU—COAS, COB, COEHD, COE, and COFAC—to build up their resilience research, educational offerings, and/or outreach within the various disciplines and focal areas of the individual faculty members, as a first step of the bottom-up approach. On the other hand, the Lamar Projects intend to develop interdisciplinary approaches for the Center or University-wide areas of resilience expertise.

4.1 Forming committees

The Deans of all five colleges at LU were invited to participate in the initial decision-making process for the Center as the first grouping of an ad-hoc expert panel for an interdisciplinary bottom-up approach. It was requested that each Dean appoint Team Leads from their respective college to serve on an Executive Committee to help foster Center-College relations and increase the diversity within the newly forming Executive Committee. Other Executive Committee members included representatives from other large centers on campus, such as the Center for Advances in Port Management, the Center for Midstream Management and Science, and the Center for Advances in Water and Air Quality. Each college was delegated one Team Lead except for the COAS, which was allocated three Team Leads due to its size and multiple focal areas. The Executive Committee is comprised of faculty across all five LU Colleges, all hailing from a variety of departments—Biology, Computer Science, Earth and Space Science, Political Science, Sociology/Social Work/Criminal

Justice, Accounting/Information systems, Chemical and Biomolecular Engineering, Civil/Environmental Engineering, Industrial and Systems Engineering, and Communications & Media.

The preliminary center programmatic chart also included establishing a resilience indicator committee for center-wide support of all things related to resilience. The initial Resilience Indicator Committee was chosen by the Center director for the FY22 based on the expertise of a person in environmental issues, and then interested Executive Committee members were invited to recommend the initial membership for the Resilience Committee. Based on the literature review as it applies to the focused research of the Center, and the expert knowledge of members of the Resilience Indicator Committee, a comprehensive definition of resilience was developed along with broad indicators for measuring resilience. The Center’s definition of resilience required the inclusion of the vast disciplines and systems that work within the field of resilience. As such, the Center’s definition addresses resilience at many levels and across many systems (Rosowsky 2020; Vella and Pai 2019). The approved definition of resilience adopted by the Center is “*The capacity of a complex system to adapt and maintain its function and support the well-being of the interdependent subsystems through adversity*”. Like the definition of resilience, the indicators needed to address the broad range of research funded by the Center. We anticipate that the Center’s approved definition for resilience will evolve in the future based on our needs and understanding in this field. As illustrated in Fig. 1, the resilience indicators are divided into five main categories to show possible dynamic interactions (Cutter et al. 2010). More specific indicators were then initially identified within

the broader categories by the members of the Resilience Indicator Committee (Table 2).

4.2 Center funding for projects

The Center funded 21 initial Springboard Projects in addition to the Flood Coordination Study in FY22. Initial Springboard project funding was intended for basic research, outreach, or education into or about resilience in social, economic, infrastructure, and ecological systems relative to disaster, and the Center funded 7 Lamar Projects in FY22. These Lamar Projects were meant to be more interdisciplinary, involving researchers from multiple fields of study across various colleges, as seen in several of the items in the rubric, as displayed in Table 3. The goal for Lamar Projects was to develop programs that would support the mission of the Center. The projects may include research, outreach, and education and should bring together researchers from amongst the colleges that were interested in similar topics of resilience. Members of the Executive Committee were invited to review the proposals, and the FY22 Lamar Projects were awarded in early March 2022. Initial funded projects included in building a resilience indicator database, developing a coastal wetland restoration working group, and a resilience education initiative for the community. After only seven months since the establishment of the Center, 77% of all academic departments across the five academic colleges were involved with the projects. More than 63 full-time faculty members participated as investigators, with an additional 8 investigators comprised of adjuncts, post-docs, staff, or outside personnel. Additional departments were invited to participate in the summer of 2022 by the Center. The Center embraced every academic discipline within its first year and increased faculty and student involvement. Such broad-based University-wide participation indicates a bottom-up approach to holistically developing a Center that embraces resilience.

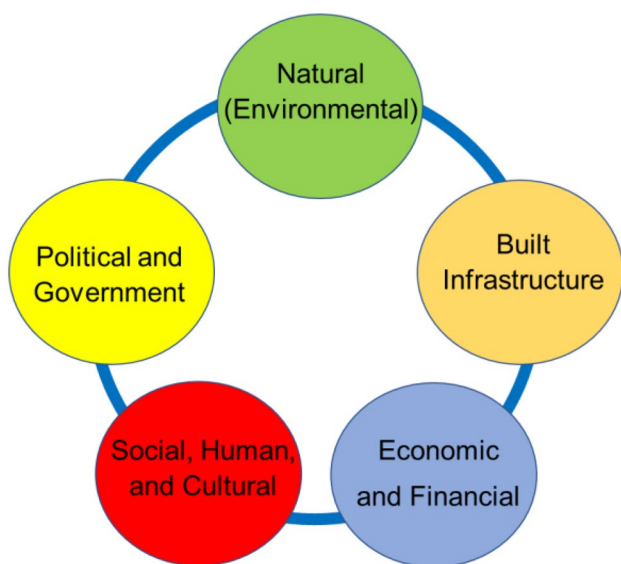


Fig. 1 Broad categories of resilience indicators

5 Discussion and steps forward

5.1 Democratization of the study of resilience

Scientists, engineers, community members, and planners must work together to build resilient communities and develop social, environmental, and economic policies (Linkov et al. 2021; National Academies of Science 2011). Ever-increasing risk and dynamic future conditions make this a challenging task. In fact, many approaches to resilience have failed because they are too prescriptive, only altering regulations and expecting compliance. Instead, resilience needs to be built by understanding and taking guidance from existing trends, structures, and the community’s needs

Table 2 Preliminary Indicator Checklist

Broad Categories	Indicators from resilience committee	P.I. Suggested indicators
Natural (environmental)	Water quality/quantity Air quality Soil quality Biodiversity Biomass (vegetation) Natural resources (other) Other	Water quality Water quantity Cyber physical security Flooding
Built infrastructure	Facilities (residential, commercial, and cultural) Lifelines (communications, healthcare) First response Food supply Utilities Transportation Other	Funding supplements
Economic & financial	Financial services Industry—employment services Other	
Social, human, & cultural	Healthcare access Special needs Health coverage Language competency Access to transportation Food availability/access Social capital—advocacy & services Spiritual connectedness Cultural support/marginalization Other	Community Communication
Political & Government	Fiscal capacity (i.e. G.D.P., Grants, etc.) Physical capacity (i.e. infrastructure, staffing, mutual aid agreements, etc.) Previous disaster experience Government fragmentation Diversity & inclusion in everyday policy Inclusive mitigation policy Inclusive disaster preparedness planning Active resilience policy Active sustainability policy Active community advisory boards Active community programs Active energy conservation programs Natural resources policy Intersectoral relations (non-profit and industry engagement) Perceptions of vulnerability Strategies to reach and meet the needs of vulnerable populations Other	

(National Academies of Science 2011). Such communities can be established by adopting more resilient behaviors—i.e., support, education, and adaptation at the regional level. one paradigm is that national-level resilience cannot be

achieved without first establishing regional resilience (Tokgoz and Gheorghe 2013). The Center at LU aims to increase the adoption of community resilience behaviors for the Gulf Coast Region through the Center's diverse multi-disciplinary

Table 3 Rubric Used to Evaluate FY22 Lamar Projects

	0	1	2	3
Project goals and outcomes/deliverables	No stated goals or research question, unclear outcomes, or deliverables	Vaguely stated goals or research question, somewhat unclear outcomes, or deliverables	Clearly stated goals or research question, clear outcomes, or deliverables	Outstanding goals statement or research question, clear, ambitious outcomes, or deliverables
Significance, value, benefit of the project to the center, the university, and the discipline; aligned to vision and mission of the center	No explanation of value, benefit, or significance; no relationship to vision/mission	Incomplete explanation of value, benefit, or significance OR only minimally aligned to vision/mission	Strong explanation of value, benefit, and significance and falls within stated vision/mission of the Center	Outstanding explanation transformative value, benefit, significance and clearly aligns with vision/mission
Feasibility/ability to deliver project goals within timeline	No indication of timeline	Vaguely stated timeline: neither appropriate for scope of project OR no linkages made	Clearly stated timeline; or appropriate for scope of project	Crystal clear timeline; clearly linked to scope of project; ambitious, yet feasible
Budget	Budget is not included or unclear to project	Vaguely stated budget with loose connection to project goals/outcomes	Clearly stated budget; appropriate for scope of project	Clear budget tied directly to project goals and vision/mission of the Center
Expected findings and plan for dissemination	No statement of expected findings; no dissemination plan	Vague or unclear statement on expected findings and/or dissemination plan; or plans not clearly linked to project	Clear statement of expected findings; dissemination plan goes beyond annual symposium	Outstanding statement on expected findings; dissemination plan goes beyond annual Symposium and includes peer-reviewed or juried possibilities in high-profile venues
Resilience indicators	No resilience indicators noted	Focus on resilience, but specific indicators not identified	Resilience indicators identified	Multiple indicators across domains identified
Interdisciplinary/interprofessional focus	No interdisciplinary or interprofessional focus	Opportunity for interdisciplinary focus, but not identified or outlined	Interdisciplinary or interprofessional focus identified	Clear and strong collaboration with other disciplines
Overall Impressions	Project is poorly suited to the Center	Vague proposal	Strong proposal	Excellent Proposal: project is clear, well-designed, and feasible with deliverables that align with the Center

projects. These projects cover many resilience activities—i.e., outreach, research, and education to improve the resilience of the communities. Projects funded by the Center include collaborative efforts from community leaders (county judges and other personnel, city employees, regional and state agencies, etc.), local agencies (non-profit, medical facilities, service providers), and various community members. Community leaders and local agencies collaborate on projects addressing the needs of the community, policies and efforts following disasters, and the infrastructure for responding to disasters. Community members engage regularly with the Center through the outreach efforts of the Annual Summit, monthly flood related meetings, and quarterly community education/outreach events. The Center is unique in its interdisciplinary and interprofessional approach to the study of resilience. By examining methods to enhance resilience from each individual discipline, it is the goal of the Center to develop a comprehensive model for enhancing resilience holistically. Results from projects completed during the inaugural year of the Center indicate that targeted efforts (i.e. specific community policies and programs, intentional evaluation of current structures, etc.) are addressing some specific needs of the community, such as providing continuing education forums for several disciplines in addition to communication avenues such as the monthly flood coordination meetings. In these early stages of research and development, we are gaining insight to the discipline specific needs for enhancing resilience and seeking to establish a comprehensive model for our community.

The Center is also unique in the funding of projects. Rather than funding projects through a prescriptive, top-down method (limiting the scope or method of study), the Center has democratized the process by committing to projects established from the bottom-up. This process gives agency to the researchers to approach the study of resilience through multiple lenses and focus on the endeavors most meaningful to them and SETX region while producing results generalizable or transferable (depending on the quantitative or qualitative nature of the work) enough to be implemented in other regions. Some of the practices used for and by the initial Executive Committee in starting the Center are as follows:

1. Populating the executive committee with team leaders from all Colleges at the University.
2. Including other established centers and support groups on the Executive Committee.
3. Using an expert panel approach with the executive committee and its ad-hoc members (all five academic college deans and upper administration) to establish the Center's Vision and Mission.
4. Allocating funding to all five colleges and using an interdisciplinary expert panel approach to establish the group

of initial Springboard Projects by letting the Deans and their Team Leads select these projects. This allows for input from all departments and facilitates a bottom-up approach.

5. Using an interdisciplinary expert panel approach for evaluating the proposals for the initial Lamar Projects and rewarding projects willing to break boundaries, bridge silos, and support the Center's Vision and Mission of regionality, accessibility, and inclusivity.
6. Expanding the science of resilience, both for evaluating the resilience that the Center offers and as a scientific resource.
7. Using an expert panel approach that invited any Executive Committee member or other member of the University to be on the Resilience Committee.
8. Using a survey of all projects to populate and expand a resilience checklist.

The Center's interdisciplinary approach and unique way of funding projects provides opportunities to evaluate resilience across multiple disciplines. Springboard and particularly Lamar projects were encouraged to be developed across disciplines and include research, education, and outreach components. These projects will allow the Center to measure and consider resilience metrics such as rapidity, resourcefulness, robustness, and redundancy across multiple disciplines simultaneously.

5.2 Current status and future steps

The first year of the Center has shown that the disciplines at a University like LU can readily represent many of the disciplines that are involved in a holistic, systematic view of resilience, providing an answer to half of Question 1, who and what are involved in resilience. The topical areas of the projects in the first year also provide a platform for collecting what resilience means to these disciplines. FY23 projects will aid in expanding these lists. In addition, the resilience indicators checklist also aids in tackling Question 2 and will provide initial ideas of what the issues are for resilience. However, further study is needed to help develop the resilience indicators checklist created by the Center. FY23 projects will participate with a revised version of the checklist used by FY22 projects. To increase the fidelity of the feedback, interviews with participating principal investigators would be valuable and lend better insight into why principal investigators chose the categories they did what they feel might be missing from the list. Also, as more projects engage with the indicator checklist over time, a longitudinal view of the data will emerge and may deliver additional insights. Tackling Questions 3 and 4 will be future challenges for the Center as the Center seeks answers to how resilience can be enhanced within each discipline or issue

and how these various ideas might intersect to provide resilience as a whole, over and within many systems.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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