

Graduate Certificate in Disaster Resilient Policy, Engineering and Design

Background

The costs associated with disasters in the United States and around the world are increasing at an exponential rate due to investments in known hazard areas, policies that incentivizes risky decision-making (including poor design and engineering practices) and the effects of a changing climate in locales that have been built to reflect a climate of the past. 2017 was the costliest year in the recorded history of the United States in terms of disaster losses (306 billion), due in large part to wildfires and hurricanes Harvey, Maria and Irma (NOAA 2018). The previous record of 215 billion dollars occurred in 2005, when hurricanes Katrina, Wilma and Rita hit the U.S. Gulf Coast. In North Carolina, Hurricanes Matthew (2016) and Florence (2018) represent the two costliest storms to ever strike the state.

Changes in the characteristics of natural hazards include more frequent flooding, droughts, extreme heat, wildfire, and hurricane-induced damages. Climate change impacts are also resulting in rising sea levels, increased coastal erosion, subsidence and loss of protective sea ice in arctic environments. The effects of a changing climate are particularly devastating to coastal communities, which comprise a disproportionate amount of the world's population. In the United States, more than 50% of the nation's population lives within 50 miles of the coast and are increasingly threatened by the growing intensity and duration of coastal storms, subsidence and sea level rise. Additional hazard threats are exacerbated by development in and adjacent to earthquake and landslide prone areas, the wildland urban interface and areas with inadequate water supplies to support human settlements.

Purpose of the Certificate

As we enter the Anthropocene, the need to create a cadre of student graduates that are aware of the latest knowledge about disaster resilient policy, engineering and design is of paramount importance. The imperative motivating the Graduate Certificate in Disaster Resilient Policy, Engineering and Design is to educate the next generation of practitioners and scholars to apply this knowledge to reduce the exponential rise in disaster losses and assist communities adapt to a changing climate. The aims of the certificate also reflect the NCSU vision of "Think and Do", to include using evidence-based information, assessing existing policy constraints and opportunities, and visually depicting examples of policy achieved through good planning, engineering and design. In order to be effective in today's jobs, as well as those that arise in the future, requires equipping students with the tools, technical knowledge and experience needed to address what represents one of the pressing challenges of the 21st century, which is to assist nations, states, local governments and others reduce future disaster-related losses, recover from extreme events when they occur and proactively adapt to the effects of climate change. Collectively, such actions will lead to greater resilience in North Carolina, the nation and across the globe.

Overview and Intent of Graduate Certificate Program

Technical knowledge to be obtained and applied by students in this graduate certificate program include: visualization of varied policy options; the critical assessment of existing and proposed natural hazards, disaster and climate change adaptation policies; the development of scenario-based governance strategies; interdisciplinary problem solving spanning architecture, building sciences, engineering, landscape architecture and land use planning; understanding hazard mitigation (risk reduction) disaster recovery and its connectivity to climate change adaptation; and applying policy, design and engineering concepts to these issues.

The certificate will combine theoretical and experiential knowledge, which will be learned in the classroom (to include lectures, seminars, speaker series and design studios) and applied in interdisciplinary field work undertaken in pre- and post-disaster settings. Examples include regularly scheduled field trips as part of classwork and creating special topics classes as opportunities arise, including in the aftermath of disasters. Some of these classes will involve working with a “client” to develop and apply data collection and analysis techniques and to formulate policy and design alternatives. Experiential knowledge will also be honed through intensive interdisciplinary seminars, class projects and studio-based coursework. Design studios and field-based experiences will be used to help students gain an appreciation for and skills required to collect data in pre- and post-disaster environments, the ability to work in interdisciplinary teams (to include learning technical skills from outside their discipline and collaborating across groups that use differing techniques, terminology and processes) and understanding the importance of conveying varied types of information to broad audiences, some of whom may be in the throes of disaster recovery.

Core Courses

The certificate will foster interdisciplinary thinking in core courses that are required of all students through classroom exercises, presentations, group projects, papers and field work as assigned. There are no prerequisites for any core course other than being a graduate student in good standing at NCSU. All core courses stress interdisciplinary thinking through classroom examples, case studies, readings, group projects and field trips where interdisciplinary actions have been undertaken (or the failure to do so has led to suboptimal outcomes). While the coordinator of the certificate program will lead the teaching of core classes, discipline-focused topics in core courses will be taught by multiple professors in Public Administration, Construction, Civil and Environmental Engineering; Landscape Architecture and Architecture in order to ensure that relevant content is taught by experts in each respective field.

Track-Based Coursework Electives

In addition to core courses, students will delve deeper into select topics that are germane to one of three tracks in which they are participating. For instance, students in the Design Track will take 6 hours of electives that may include one six-hour design studio course emphasizing disaster resilient design or two 3 credit hour classes in landscape architecture or architecture focused on design-related topics. Other elective options are possible given the approval of the design-track coordinator.

Policy Track students will be expected to take six hours of elective policy-related classes, some of which will be delivered by the Department of Public Administration and others with a knowledge of and/or experience in policy development, implementation and program evaluation.

Those participating in the Construction, Civil and Environmental Engineering Track will be required to take elective classes that apply engineering and construction principles to issues germane to natural hazards, disasters and climate change adaptation. Examples include geotechnical (earthquakes, subsidence, landslides, coastal erosion) and hydrologic (floods, storm surge) processes and their impacts on civil infrastructure such as roads, bridges, levees, seawalls and dams.

Students enrolled in disciplines other than Public Administration, Construction, Civil and Environmental Engineering and Landscape Architecture may apply for the certificate, subject to the approval of the certificate coordinator and the track coordinator in which the student plans to focus their efforts. Based on a consultation between the certificate coordinator, track coordinator and student, a tailored course of action will be developed for each applicant meeting this condition.

Participating Departments & Coordinators

This certificate involves the Department of Landscape Architecture, Department of Civil, Construction and Environmental Engineering and the Department of Public Administration.

Program Coordinator (and Design Track Coordinator):

Gavin Smith, PhD., AICP

Professor

Department of Landscape Architecture

North Carolina State University

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gavin_smith@ncsu.edu

Civil, Construction and Environmental Engineering Track Coordinator:

Sankar Arumugam, Ph.D.

Professor

Department of Civil, Construction and Environmental Engineering

North Carolina State University

919 515-6979

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Public Administration Track Coordinator:

Christopher Galik, PhD.

Associate Professor

Department of Public Administration

North Carolina State University

919 513-6011

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Faculty Participants

All courses will be taught by graduate-level faculty (to include tenure track, non-tenure track, and adjunct members with specialized expertise) in the College of Design (including Landscape Architecture and Architecture), Construction, Civil and Environmental Engineering, Public Administration, Meteorological Earth and Atmospheric Sciences, and others as identified. Each course instructor will meet the eligibility requirements of the Graduate School related to teaching. NCSU faculty will assist in teaching core courses, including those in each of the three tracks in order to expose students to principles and practices found in public policy, engineering and design.

Department of Landscape Architecture and Environmental Planning

Gavin Smith, Professor

Andy Fox, Professor

Kofi Boone, Professor

Fernando Magenelles, Associate Professor

Chuck Flink, Professor of Practice

Travis Klondike, Assistant Professor of Practice

Robby Layton, Teaching Assistant Professor

Celen Passalar, Assistant Dean for Research and Extension, Associate Professor

Gene Bressler, Emeritus Professor

Erin White, Instructor

School of Architecture

David Hill, Professor, Department Head

Bryan Bell, Associate Professor

George Elvin, Associate Professor

Kristen Schaffer, Professor

Hernan Marchant, Professor

Department of Civil, Construction and Environmental Engineering

Sankar Arumugam, Professor

Ranji Ranjithan, Professor, Department Head

Mohammed Gabr, Professor

Casey Dietrich, Associate Professor

John Baugh, Professor

Downy Brill, Professor

Ashly Cabas Mijares, Assistant Professor

Eleni Bardaka, Assistant Professor

Joseph DeCarolis, Associate Professor

Billy Edge, Professor

Fernando Garcia Menendez, Assistant Professor

Murthy Guddati, Professor

Abhinav Gupta, Professor

Ajaya Gupta, Professor

Angela Harris, Assistant Professor

Tasnim Hassan, Professor

Mervyn Kowalsky, Professor

Brina Montoya, Assistant Professor

Roberto Nunez, Lecturer and Senior Construction Extension Specialist

Alejandra Ortiz, Assistant Professor

Margery Overton, Vice Provost for Academic Strategy

Sami Rizkalla, Distinguished Professor Emeritus

Spencer Rogers, Interinstitutional Adjunct Faculty (NC Sea Grant)

Elizabeth Sciaudone, Research Assistant Professor

Rudolf (Rudi) Seracino, Professor and Associate Head for Undergraduate Programs

Public Administration

Christopher Galik, Associate Professor

Branda Nowell, Professor

Tom Birkland, Professor

Academic Requirements for Participants: Core and Track-Based Courses

The Disaster Resilient Policy, Engineering and Design Certificate is comprised of thirteen credits, including three core courses (two 3-credit hour and one 1-credit hour class) and one of three optional tracks (6 credit hours per track). Certificate tracks include: 1) Policy, 2) Design and 3) Construction, Civil and Environmental Engineering.

Electives are drawn from existing courses on campus (two 3-credit hour courses or a 6-credit hour design studio subject to the approval of the Certificate Director) as well as new courses created to address more in-depth topical areas for participants in each track. All elective courses are 500 level or higher.

All required and most elective courses will be delivered in a standard semester (fall and spring) format. Students will be able to complete the certificate by taking only courses delivered in a standard semester if they choose to do so. In some cases, summer courses will be delivered that can serve as an elective, to include, but not limited to international studios (at the European Center or other areas as identified), post-disaster field-based classes or lecture-based classes.

Core Courses

LAR 552	Survey of Natural Hazards and Disasters	3 credits
LAR 554	Disaster Resilient Policy, Engineering and Design	3 credits
LAR 607	Speaker Series: Natural Hazards, Disasters and Climate Change Adaptation	1 credit

Track-Based Electives (see electives listed below) **6 credits**

TOTAL REQUIRED COURSEWORK **13 credits**

Design Track Course Electives (Landscape Architecture & Architecture)

ARC 503/LAR 507 Coastal Dynamics Design Lab	6 Credits
(subject to topical area and approval by the Certificate Coordinator. Non-ARC/LAR students are subject to approval of studio instructors and these students may seek to take this class as a 3-credit hour course [focused on specific class sub-tasks that do not require design studio training/education]. ARCH students are subject to a lottery to get into studios).	

LAR 630/697 Capstone Independent Project Option	9 credits
(College of Design Students only. Requires the approval of Certificate Coordinator. A student may identify an idea/issue and focus on it for a full academic year. (9 total credits: LAR 630 = literature review, methods, background documentation + LAR 697 = 6-credit self-directed project. Requires a minimum of 3 faculty advisors).	
LAR 582.015 Planning for Natural Hazards and Climate Change Adaptation	3 credits
LAR 545 City Planning and Design	3 credits
LAR 546 The Landscape Imperative	3 credits
LAR 535 Environmental Social Equity and Design	3 credits
LAR Greenway Planning and Design	3 credits
LAR 520 Landscape and Culture Seminar	3 credits
LAR 582/ARCH 590 Design for Resilient Food Systems	3 credits
LAR 582 Special Topics in Landscape Architecture	1-6 credits
LAR 630 Independent Study	1-3 credits
Other LAR courses as identified – subject to approval of instructor and track coordinator.	
ARC 590: Resilient Thinking	3 credits
ARC 520: Sustainable Architecture	3 credits
ARC 548: Vernacular Architecture	3 credits
ARC 563: Public Interest Design Seminar: Case Studies and Current Issues	3 credits
ARC Resilient Coastal Design and Construction	3 credits

ARC 544 The City of New Orleans	3 credits
ARC 590 - Special Topics in Architecture	3 credits

Other ARC courses as identified – subject to approval of instructor and track coordinator.

Policy Track Course Electives

PA (Public Administration) 553 Disaster, Crisis and Emergency Management and Policy	3 credits
PA 507 The Public Policy Process	3 credits
PA 511 Public Policy Analysis	3 credits
PA 798 Collaborative Governance and Public Networks (Special Topics in Public Administration and Policy)	3 credits
PA 550 Environmental Policy	3 credits
PA 546 Seminar in Program Evaluation	3 credits
PA 514 Management Systems	3 credits

Other PA courses as identified (including special topics, field study-see, for instance, firechasers program (<https://research.cnr.ncsu.edu/blogs/firechasers/>)) – subject to approval of instructor and track coordinator.

Civil, Construction and Environmental Engineering Track Course Electives

CE 746 Soil Dynamics and Earthquake Engineering Prerequisite: CE 440, or CE 443 or CE 548	3 credits
CE 581 Fluid Mechanics in Natural Environments	3 credits
CE 596 Coastal Hydrodynamics	3 credits
CE 596 Coastal Modeling	3 credits
CE 567 Risk and Financial Management in Construction	3 Credits
CE 578 Energy and Climate	3 Credits
CE 583 Engineering Aspects of Coastal Processes	3 Credits
CE 725 Earthquake Structural Engineering	3 Credits

CE 786 Hydroclimatology	3 Credits
CE 790 Advanced Topics in Civil Engineering	1 – 3 Credits
Other CE courses as identified – subject to approval of instructor and track coordinator.	

General Electives (may fulfill track requirements based on concurrence with Certificate & Track Coordinators):

MEA 517 – Fundamentals of Climate Change Science	3 Credits
MEA 593 (MEA 501) – Fundamentals of Climate Change Science	3 Credits
MEA 593 (MEA 502) – Climate Risk Analysis for Adaptation	3 Credits
MEA 519 – Barriers to Climate Change Literacy	3 Credits
COM 538 – Risk Communication	3 Credits
COM 579 – Climate Change Communication	3 credits
COM 566 – Seminar in Crisis Communication	3 Credits

Educational Objectives

The following objectives of the Disaster Resilient Policy, Engineering and Design Certificate represent a series of interconnected elements that span education, research, and engagement. In each case, objectives serve to enrich the educational outcomes of participating students, to include the following:

- 1) Provide students with the interdisciplinary knowledge and research experience needed to actively contribute to the study and/or the practice of natural hazards and disaster resilience. More specifically, the certificate will help to produce well-trained researchers and practitioners who can help the public, non-profit and private sectors cope with natural hazards and disasters and adapt to the effects of a changing climate.
- 2) Provide students with a rich blend of theory, experiential learning, and applied work that makes them well suited to work as a practitioner or scholar in this highly applied, interdisciplinary field. Upon graduation students will possess a unique blend of policy, engineering and design thinking that differentiates them from other graduates at other colleges and universities.
- 3) Attract and teach the next generation of students that are more reflective of the general population. In the case of disaster resilience, for instance, the field is less diverse than the general population, while those who study and engage in the practice of climate change adaptation comprise a relatively new cohort that is in need of

additional scholars and policymakers. The certificate program will strive to be inclusive, as reflected by underrepresented minorities, women, and a mix of students with academic and practice-based career goals. This will enable students to interact with and contribute to the education of under-represented minorities and to embrace equitable design, engineering and policy.

- 4) Develop strong alliances with those who stand to employ graduates participating in the certificate program. This may include but is not limited to private sector consulting firms; federal, state and local government agencies; academic institutions; research-based organizations; non-profits and foundations; corporations; international aid organizations and others.
- 5) Use the certificate program to help coalesce the world class faculty at NCSU to address one of the most pressing issues of the 21st century, namely reducing the negative social, economic and environmental effects of natural hazards and disasters in an era of climate change and recovering following rapid and slow onset events in a way that enables individuals, communities and regions to return to a more equitable, safer and resilient condition. This will be achieved, in part, through a close association with the emerging NCSU program, sustainable and resilient coasts initiative, a campus-wide effort involving over 200 faculty and engagement experts.
- 6) Develop an “esprit de corps” among students enrolled in the certificate through the establishment of applied interdisciplinary group projects in the classroom and design studios, engagement in research with participating faculty and practitioners, partnering with the NCSU student association HazNerds, and exposure to leaders in the field through internships and mentoring programs, a certificate program lecture series, workshops and fieldwork.

Potential Audience – Industry Demand and Potential Student Market

The Certificate Program Coordinator, Dr. Gavin Smith maintains extensive contacts in the field of natural hazards risk management, disaster resilience, emergency management and climate change adaptation. These relationships, as evident in the speakers regularly brought to class, will be used to help students obtain internships and jobs in the field. There is a substantial and rapidly growing cadre of individuals working to address disaster resilience, including consulting firms; federal, state and local government agencies; universities and colleges in the U.S. and abroad; the construction industry; insurance and reinsurance firms; corporations; non-profits and foundations and international aid organizations. As disaster losses continue to grow exponentially in the United States and abroad, there is a critical need to train the next generation of both practitioners and scholars, to include placing an emphasis on diversifying those working in this space to better reflect the population characteristics of the United States.

As we enter an era of climate change, the International Panel on Climate Change and the US National Climate Assessment have described the devastating affects to communities, the environment, and the economy, which highlights the breadth of issues that need attention. The myriad challenges provide opportunities for students to apply their base of knowledge obtained in their respective degree program with the focused knowledge, training and experience gained by pursuing the graduate certificate. The combination of a degree and a focused certificate in the study of disaster resilience from NC State University serves to differentiate graduates from others who seek to go into this rapidly growing field.

Collaboration with Industry

Collaboration with industry is achieved through several avenues including a required speaker series course, student internships, an emerging International Learning Lab and a number of community engagement efforts delivered as part of required and elective courses. The speaker series, for instance, provides a venue for invited guests from the US and abroad to discuss their work and experiences and deliver important insights associated with the skills needed to prosper upon graduation. Speakers are also asked to share job and internship opportunities with students during their visits as part of a sustained commitment to place students in part-time and permanent positions. The coordinator of the Certificate Program as well as participating faculty will reach out to colleagues in the varied sectors to solicit their involvement. The International Learning Lab, described in more detail later in this document, is designed to foster partnerships with not only faculty and students, but also private sector experts to work in field-based settings. The studio coursework and other engagement opportunities allow students to work with identified industry representatives.

Learning Outcomes

Upon completion of the Graduate Certificate Program in Disaster Resilient Policy, Engineering and Design, students will be able to:

- Understand the opportunities and impediments associated with the development and implementation of disaster resilient policy, engineering and design solutions.
- Serve as leaders in this burgeoning field of natural hazards, disasters and climate change adaptation scholarship and practice.
- Understand and apply key concepts, such as governance, resilience, sustainable development, hazard mitigation, disaster recovery, social vulnerability, design-thinking, non-stationarity and climate change adaptation to current policy dilemmas as well as engineering and design challenges.
- Transfer knowledge gained in the classroom to tangible policy options and engineering and design-based solutions.
- Operate effectively in interdisciplinary teams, to include gaining a general understanding of topics found in non-specialization tracks and how they relate to the students chosen focus track.

- Educate and train the next generation of practitioners and scholars pursuing work and research in the natural hazards, disasters and climate change adaptation space.

Requirements for Admission to NC State and Application Process to the Certificate Program

All graduate students applying for admission must be in good standing at North Carolina State University. Students must have a Bachelor's degree from an accredited four-year college or university, and have an overall (or major) GPA of at least 3.0 on a 4-point scale for admission into the Graduate Certificate Program in Disaster Resilient Policy, Engineering and Design. An application for acceptance into the Graduate Certificate Program is required for all new students.

Students must complete the Graduate School application, found at <http://www.ncsu.edu/grad/applygrad.htm>. In the future, the Graduate Program Coordinator will explore allowing students from the University of North Carolina at Chapel Hill (UNCCH) and Duke University to pursue the certificate. UNCCH and Duke students will be allowed to take the classes regardless of whether they can be counted towards the certificate, unless their enrollment precludes a North Carolina State University Student due to class size restrictions. In that case, NCSU students will receive priority seating in any Core Certificate class.

Those applicants who are currently enrolled in an NC State graduate degree program need only provide the graduate student Certificate Plan Data Entry form, found at <https://grad.ncsu.edu/wp-content/uploads/2015/12/grad-cert-plan-data-entry.pdf>.

Applicants to the Graduate Certificate in Disaster Resilient Policy, Engineering and Design must complete an application form to be considered for the program (see Appendix E). New applications will be reviewed at the department/program level. Registration procedures, registration dates, and course availability for each semester can be found on the NCSU Registration and Records webpage at <http://www.ncsu.edu/registrar/>.¹

Academic Performance Requirements

Academic success in the Graduate Certificate Program in Disaster Resilient Policy, Engineering and Design might have a strong bearing on admission to a graduate degree program, and courses are designed to be transferable. However, completion of a graduate certificate program in no way guarantees entry into a graduate degree program, which must be done through a separate application process.

- To receive a Graduate Certificate, a student must maintain a minimum 3.00 grade point average (GPA) on all coursework taken at NCSU.
- All courses taken for certificate credit must be completed with a grade of "B-" or

¹ Based on numerous requests from practicing professionals in engineering, architecture and landscape architecture, the Graduate Program Coordinator will explore the potential development of an on-line program for practicing professionals at a later date.

better.

- Transfer credit from other institutions is not allowed. All coursework must be registered through NC State University.
- All Graduate Certificate requirements must be completed within four (4) calendar years, beginning with the date the student commences courses applicable to the Certificate Program. In addition, students must maintain continuous enrollment every semester until all coursework is completed. A leave of absence may be granted if the student is unable to enroll in a course due to extenuating circumstances. The leave-of-absence must be approved in writing by the Program Administrator before the start of the semester.
- Graduate certificate courses taken by students who are also enrolled in a graduate degree program may be double-counted with their degree.

Program Administration

The Disaster Resilient Policy, Engineering and Design Graduate Certificate Program will be led by Gavin Smith, Professor, as the Program Director and Coordinator from the Department of LAR. Dr. Smith will report directly to the Head of the Department of LAR.

Program Coordinator

The key responsibilities of the Program Coordinator are to:

- Develop policies on academic probation, warning and termination.
- Review of certificate applicants.
- Correspondence with prospective and current students.
- Review and approval of forms and paperwork (e.g., Plans of Work).
- Recruit and coordinate course instructors.
- Coordinate certificate program assessment.
- Review plans of work.
- Preparation of certificate forms and paperwork.
- Review and approve for graduate certificate completion.
- Serve as liaison with graduate school for the certificate program.

Track Coordinators

Each track will have an assigned coordinator. The Policy track will be coordinated by Christopher Galik in the Department of Public Administration. The Engineering track will be coordinated by Sankar Arumugam in the Department of Civil, Construction and Environmental Engineering. The Design track will be coordinated by Gavin Smith.

Tuition and Fees

Fees will be the same as those normally charged for Graduate Distance Education courses at NC State University. See current Graduate Distance Education tuition and fees at the following site: <https://cnr.ncsu.edu/prtm/online-masters-degree/tuition-and-fees/>

Outcomes Assessment Plan

In this certificate program, students will learn and apply concepts tied to the creation and implementation of disaster resilient policy, engineering and design, to include the important roles of good governance, interdisciplinary problem solving, hazard mitigation (risk reduction), disaster recovery, and climate change adaptation.

Objective 1 - The certificate program will provide course assignments and components to meet desired expectations of the graduate students who complete the program.

Outcome	Evidence to be Collected	Source of Evidence	Frequency of Collection
Understand the role of design, engineering and policy to advance disaster resilience and climate change adaptation.	Course assignments and associated grades, exams, presentations and portfolios. Interviews with students (annually, to include exit interviews upon completion of certificate).	Data provided by students and instructors ; Assembled by Prog. Coord. Assessed by Director and Track Coord's.	Data collected each semester and assessed annually.
Understand and apply key concepts including social vulnerability, hazard mitigation, disaster recovery, and climate change adaptation; governance; sustainable development; and resilience through class readings, case study assessments, plan quality review; studios, community engagement and other approaches as identified by the instructor and students.	Course assignments and associated grades, presentations and class papers; exams and community engagement debriefings. Interviews with students (annually, to include exit interviews upon completion of the certificate).	Data provided by students and instructors ; Assembled by Prog. Coord. Assessed by Director and Track Coord's.	Data collected each semester and assessed annually
Develop the skills needed to work effectively in	Course assignments, studio classes (where	Data provided	Data collected

interdisciplinary teams to tackle complex resilience-related challenges.	applicable) and faculty observations of community engagement. Interviews with students (annually, to include exit interviews upon completion of certificate).	by students and instructors ; Assembled by Prog. Coord. Assessed by Director and Track Coord's.	each semester and assessed annually
Gain general knowledge of varied design disciplines as they relate to disaster resilience, including architecture, building sciences, engineering, landscape architecture and land use planning.	Interdisciplinary course reading discussions, assignments and class projects, debriefing of field trips where this type of work is practiced, elective studio class assignments and exams. Interviews with students (annually, to include exit interview upon completion of certificate).	Data provided by students and instructors ; Assembled by Prog. Coord. Assessed by Director and Track Coord's.	Data collected each semester and assessed annually
Describe theories as related to disaster resilience and climate change adaptation	Course assignments, including class reading discussions, exams, class presentations, papers. Interviews with students (annually, to include exit interview upon completion of certificate).	Data provided by students and instructors ; Assembled by Prog Coord. Assessed by Director and Track Coord's.	Data collected each semester and assessed annually
Apply analytical	Course assignments	Data	Data

techniques and principles to assess the degree to which policy, plans engineering and design address natural hazards, disasters and climate change adaptation.	and projects, including exams, studios, class presentations and written papers. Interviews with students (annually, to include exit interview upon completion of certificate).	provided by students and instructors ; Assembled by Prog. Coord. Assessed by Director and Track Coord's.	collected each semester and assessed annually
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Identify theories that underline the study and practice of good governance, policy, engineering and design as it relates to disaster resilience.	Course assignments and associated grades, presentations and portfolios, community engagement projects and class debriefings of assigned work and interactions that require the use of theory to guide proposed solutions. Interviews with students (annually, to include exit interview upon completion of certificate).	Data provided by students and instructors ; Assembled by Prog. Coord. Assessed by Director and Track Coord's.	Data collected each semester and assessed annually
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Identify future trends and challenges in the management of natural hazards and how they can draw from best practices.	Course assignments and associated grades, presentations and portfolios, community engagement projects and class debriefings of assigned work. Interview with students (annually, to include exit interview upon completion of	Data provided by students and instructors ; Assembled by Prog. Cord. Assessed by Director	Data collected each semester and assessed annually
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	certificate).	and Track Coord's.	
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REFERENCES

National Oceanic and Atmospheric Administration. 2018.

Smith, Gavin, Mai Thi Nguyen, Colleen Durfee, Darien Williams, Ashton Rohmer. September, 2018. *Resilient Design Education in the United States*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Resilience Center of Excellence.

Appendix A. Drawing on Recent Research to Develop a Program Targeting Identified Educational Gaps

The proposed approach described in this proposal differentiates the Disaster Resilient Policy, Engineering and Design certificate program from other efforts currently underway in US Colleges and Universities as uncovered in the national report assessing the state of disaster resilient design curricula.² The lack of interdisciplinary thinking and experiential learning among US colleges and universities that purport to teach disaster resilience-related classes and certificates is failing students that seek to become practitioners or scholar in this field and the Disaster Resilient Policy, Engineering and Design certificate is designed to address these shortfalls.

NCSU graduate students will be exposed to classroom and field-based settings that instill in them a unique combination of “design thinking” with an understanding of the policymaking process and concepts drawn from civil engineering as it applies to creating more disaster resilient communities. Examples include the use of drawing, digital modeling and visualization to provide a graphic representation of varied policies tied to hazard mitigation (risk reduction), disaster recovery and climate change adaptation. Additional policy themes to be unpacked include the agenda setting process, policy drivers (incentives and disincentives) that influence the adoption of proactive versus reactive design strategies, the role of leadership in disasters, and the existing disaster management policy milieu in the United States, including how it differs from other nations and the potential for lesson-drawing across varied governance frameworks from around the globe.³ Engineering principles explored include how varied characteristics of natural hazards, including floodwaters, wind speed, storm surge, fire and ground motion differentially impact structures (e.g., housing, public facilities) and the vulnerability of interconnected infrastructure such as bridges, roads, water and electrical systems.

The term “design” is broadly defined to include landscape architecture, building sciences, engineering, architecture and land use planning. These disciplines are all taught at NCSU.

² The certificate program is informed by the findings of the report, *Resilient Design Education in the United States: Current and Emerging Curricula in Colleges and Universities led by Dr. Gavin Smith* (Smith, Nguyen, Durfee, Williams, Rohmer, Schwaller, 2018).

³ International lesson drawing will be addressed in core classes as well as electives, including courses taught overseas as part of an emerging International Learning Lab and the NCSU European Center described later in this proposal.

Landscape Architecture and Architecture degrees are housed in the NCSU College of Design. The Director of the Certificate, Dr. Gavin Smith (Professor in the Department of Landscape Architecture) has a PhD in land use planning. Building Sciences and Engineering are taught in the NCSU Department of Construction, Civil and Environmental Engineering and faculty from this department have agreed to teach courses and assign a faculty member to manage the engineering track.

Students are not required to have a “design background,” but rather should be willing to study and work with students and faculty from a range of disciplines in the classroom, through both core courses and in elective fieldwork or studios (the latter of which are intensive, 6-credit hour classes that tackle complex problems through the application of “design thinking”). Nor are students required to be enrolled in public policy or engineering programs. Good resilient design, engineering and public policy is fundamentally interdisciplinary in nature and students will benefit from the active involvement of varied disciplines including those pursuing a graduate degree in the social sciences, humanities, agriculture, natural and physical sciences.⁴

Important topical areas of convergence in the classroom and in the field include how to work with others possessing differing training and expertise and how to visualize / depict / and articulate (verbally and in writing) varied policies in a way that will resonate with broad audiences (i.e. homeowners, local, state and federal officials, and others). Additional design concepts explored include planning for uncertainty, alternative futures associated with changing landscapes, public interest design (i.e., how to design in a manner that recognizes vulnerable, less powerful populations) and the problems encountered in an era of climate change when applying the engineering concept of stationarity (i.e., using past hazard events to establish return periods of varied intensities for future climate-influenced extreme events) lead to inadequate solutions.

These topical areas point to a set of interrelated and fundamental challenges for society, which include what is an “appropriate” design standard in an era of climate change? How do new design standards reflect the needs and capabilities of vulnerable populations? How are standards adjusted over time based on an evolving understanding of risk? How do varied design standards influence the evolution of human settlements over time? Who decides how design standards are changed over time and who pays for it? What role does landscape architecture, architecture, building sciences, land use planning and engineering play in tackling these issues? What role does the protection and management of natural systems play in fostering more resilient communities? How can we create more resilient agricultural systems, including farming and ranching operations and the sustainable management of

⁴ It is important to note that some electives in varied tracks may require prerequisites, including for instance, design studio experience, policy coursework, calculus and physics, or general engineering knowledge. Students will work with their faculty advisor in partnership with the Certificate Program Manager and Track Coordinators to determine class eligibility requirements.

working lands as an alternative to further suburban sprawl into agriculturally productive areas that are also hazard-prone like floodplains?

Several of the certificate's aims are drawn from a US Department of Homeland Security-supported study assessing the state of disaster resilient design curricula at US colleges and universities (Smith et. al. 2018). The study, titled *Resilient Design Education in the United States: Current and Emerging Curricula in Colleges and Universities*, resulted in several goals, including:

- Improve Institutional Commitment
- Develop New Curricula Models and Organizational Structures
- Build Interdisciplinary Teams
- Emphasize Field and Studio-Based Projects
- Create Flexible and Responsive Curricula
- Meet and Exceed the Need of Stakeholders

Each of these goals will help to undergird the NCSU Graduate Certificate in Disaster Resilient Policy, Engineering and Design. The institutional commitment of NCSU to advancing a disaster-resilient curriculum is evident by the standing up of a sustainable and resilient coast program. In the Spring of 2019, Professor Gavin Smith and Angela Harris, an Assistant Professor in the Department of Civil, Construction and Environmental Engineering, have identified over 240 NC State employees working in this space, many of whom have committed to support the Disaster Resilient Policy, Engineering and Design Certificate Program.

The new curricula model will include a series of required classes and electives drawn from across a number of departments. In addition, the certificate will include faculty that are willing to develop elective courses on relatively short notice in response to identified needs, including those following disasters or as part of new and emerging disaster resilience policies, requests from prospective clients and other opportunities as identified. NCSU has significant experience in this process as several classes and design studios were developed in response to Hurricane Matthew and these lessons will inform future efforts.

Appendix B. Existing NCSU Faculty and Programs, including an Emerging University-Wide Program in Coastal Sustainability and Resilience

The certificate is intended to complement the emergence of a university-wide program in Coastal Sustainability and Resilience at North Carolina State University. The program is intended to bring together existing faculty, engagement experts and students from departments, labs and other organizations from across campus, to include the College of Design; the College of Engineering; North Carolina Sea Grant; the Climate Adaptation Science Center; Center for Geospatial Analytics; Coastal Studies Institute; Department of Meteorological, Earth and Atmospheric Sciences (including Climate Science & Society Degree Program) and others as identified.

The certificate has been developed in partnership with the departments noted above (and other interested parties) to ensure the new Disaster Resilient Policy, Engineering and Design coursework complements and draws from existing programs such as the Professional Science Master's degree program in Climate Change and Society and others that teach classes in areas aligned with the broad concept of disaster resilience. Additional partnerships will take advantage of experts in community engagement as noted below.

The breadth of partnerships in the emerging coastal sustainability and resilience program allows for faculty and students to address the three aims of NCSU's Land Grant University mission, which includes research, teaching and engagement. These aims will be a focus of the Disaster Resilient Policy, Engineering and Design Certificate as well. Examples of existing partnerships that reflect and provide potential course venues and vehicles to implement the broader goals of NCSU and the certificate include: 1) Coastal Dynamics Design Lab, 2) Climate Adaptation Science Center, 3) North Carolina Sea Grant, 4) Department of Construction, Civil and Environmental Engineering and 4) School of Public and International Affairs. Other partnerships will be developed over time as the Certificate and the coastal sustainability and resilience program evolve.

Coastal Dynamics Design Lab. Housed in the NCSU College of Design, "The mission of the Coastal Dynamics Design Lab (CDDL) is to organize and lead trans-disciplinary research and design teams to address critical ecological and community development challenges in vulnerable coastal regions, with a concentrated focus on the mid-Atlantic seaboard." For more information on the Coastal Dynamics Design Lab see: <https://www.coastaldynamicsdesignlab.com>. The CDDL, led by professors Andy Fox (Landscape Architecture and Environmental Planning) and David Hill (Architecture), provide an existing venue to deliver studio-based classes, field-based research, and community engagement addressing disaster resilience for students and faculty as noted in the Certificate course requirements. The 6-credit hour ARC 503/LAR 507: Coastal Dynamics Design Lab may, on occasion, be modified, for instance, to serve as part of elective certificate coursework. Established relationships fostered by Fox and Hill will allow for a range of possible educational, research, and engagement opportunities for students, including those found in pre- and post-disaster settings. The Coordinator of the Disaster Resilient Policy, Engineering and Design Certificate has worked with Fox and Hill extensively, including following Hurricane Matthew as described later in this document.

Southeast Climate Adaptation Science Center. The Southeast Climate Adaptation Science Center (SE CASC) provides an institutional venue to link disaster resilience and climate change adaptation through research, teaching, and engagement opportunities. For instance, the Coordinator of the Certificate Program is a SE CASC Faculty Affiliate, serving as one member of a larger network of partners across campus who are interested in research, teaching and engagement tied to climate change adaptation. SE CASC Faculty Affiliates can nominate students to apply for the Global Change Fellows program, which provides a one-year stipend

(\$24,000 - \$30,000) and an expenses-paid week-long summer field trip focused on climate adaptation challenges and strategies. This program will help to recruit prospective NCSU Graduate students interested in pursuing the Graduate Certificate in Disaster Resilient Policy, Engineering and Design. In addition, students may sign up for regularly scheduled for-credit seminars each semester, including the SE CASC Global Change Seminar Series and the Global Change Reading Group, thereby enriching their overall educational experience.

Meteorology, Earth and Atmospheric Sciences Department: Master's Degree in Climate Science and Society. The Climate Change and Society program is housed in NC State's Department of Marine, Earth and Atmospheric Sciences. The thirty-one credit master's program partners with the National Oceanic and Atmospheric Administration (NOAA), the NC State Climate Office, the Environmental Protection Agency (EPA), and NC Sea Grant, among others, to provide valuable hands-on experience for students in the program who want to work at the nexus of climate change and society. Specific courses that may serve as electives in the Disaster Resilient Policy, Engineering and Design Certificate include: MEA 593 (MEA 501) Fundamentals of Climate Change Science (3 Credits), MEA 593 (MEA 502) Climate Risk Analysis for Adaptation (3 Credits), and COMM 579 Climate Change Communication (3 credits) and others as approved by the Certificate Program Coordinator. Students pursuing the Master's degree in Climate Science and Society may choose to take Disaster Resilient Policy, Engineering and Design courses as electives in their program, subject to the approval of Dr. Roberto Mera, the Climate Change and Society Associate Program Coordinator.

North Carolina Sea Grant. North Carolina Sea Grant has a long history of engaging with coastal communities, including work tied to natural hazard risk reduction, disaster recovery activities and climate change adaptation. The strong community connections and trust developed by NC Sea Grant personnel will be used to help identify locations in which faculty, students, and Sea Grant extension experts can work together on identified problems, to include potential coursework that may serve as an elective in the certificate program. Additional opportunities include working with other Sea Grant Programs in the Southeast as well as the National Oceanic and Atmospheric Administration (which sponsors national Sea Grant programs) on varied grants focused on disaster resilience.

Department of Construction, Civil and Environmental Engineering. The North Carolina State University Department of Construction, Civil and Environmental Engineering lead a track in engineering and help teach courses in the certificate program that may serve as electives, such as Introduction to Coastal Modeling, and other courses as identified. Dr. Sankar Arumugam is the Track Coordinator for the Department of Construction, Civil and Environmental Engineering.

Dr. Mohammed Gabr and Dr. Casey Dietrich represent two key faculty among many in the Department of Construction, Civil and Environmental Engineering that will participate in the Graduate Certificate Program. Dr. Gabr will teach general and advanced courses addressing a

range of geotechnical engineering principles and processes as well as courses in resilient infrastructure. Dr. Gabr currently teaches a class titled Engineering Geology (CE 435) that include topics tied to geologic and hydrological hazards. This course is a precursor to a more advanced course tailored to engineering students interested in the engineering track.

Dr. Dietrich teaches classes tied to coastal storm surge modeling, to include their operational uses, drawing from his experiences working with the US Army Corps of Engineers, FEMA, and NOAA. Practice-based examples include the development and validation of high-resolution computational models of hurricane waves and storm surge along the Gulf coast. Dr. Dietrich has also applied these models in an operational framework to forecast storms including Hurricane Isaac (2012) as well as oil transport following the BP spill in 2010.

Engineering faculty also serve as regular guest lecturers and host students at the Constructed Facilities Laboratory (CFL) on Centennial Campus, which tests the performance of large-scale infrastructures submitted to various stressors such as those following earthquakes. The CFL also hosts the Paul Zia Distinguished Lecture Series, which provides a venue to co-host top engineering scholars and practitioners focused on disaster resilience in tandem with the Natural Hazards, Disasters and Climate Change Adaptation Speaker Series course.

An additional partnership exists between NCSU and the Civil Engineering Program at the University of Puerto Rico at Mayaguez in partnership with Dr. Ismael Pagan and Dr. Ricardo Lopez. Dr. Louis A. Martin-Vega, the dean of the NCSU College of Engineering, is a graduate of the University of Puerto Rico at Mayaguez and a colleague of Dr. Pagan. Dr. Pagan, the Department Head has worked with the Certificate Program Coordinator, Dr. Smith for several years, to include regularly speaking in one another's classes in Puerto Rico and in North Carolina. One avenue being explored is the development of a faculty/student exchange program addressing interdisciplinary policy and design issues like the relocation of flood-prone housing in Puerto Rico following Hurricane Maria and sharing lessons drawn from large-scale buyouts that have occurred in North Carolina following a number of major disasters. Another possible action includes recruiting promising Hispanic undergraduate engineers from the University of Puerto Rico at Mayaguez to pursue a graduate degree in engineering at NC State.⁵

School of Public and International Affairs. North Carolina State University's School of Public and International Affairs conducts research, teaches and participates in community engagement efforts that advance resilience. For instance, Dr. Thomas Birkland is an internationally-recognized expert in disaster policy learning, a former Director of the National Science Foundation's program that funds social science research in disasters and former coordinator of a cohort of senior faculty that mentored junior faculty interested in pursuing a career focused on natural hazards and disasters. Dr. Branda Nowell is an Associate Professor

⁵ The University of Puerto Rico at Mayaguez graduates the largest number of Hispanic civil engineers of any program in the United States.

who teaches courses tied to interorganizational collaboration, including that which is applied to emergency and disaster settings. She also leads the Firechasers program, which is focused on advancing the science of adaptive capacity toward more disaster resilient communities (<https://research.cnr.ncsu.edu/blogs/firechasers/>). Since 2008, this team has worked in collaboration with the US Forest Service on research aimed to improve inter-agency coordination and communication during large scale wildfire events. This combination of scholarship, teaching and community engagement will be drawn upon in the certificate, to include Dr Birkland and Dr. Nowell teaching classes in the policy track and exploring collaborative opportunities tied to community engagement and research. Dr. Christopher Galik, an Associate Professor in the department, who has agreed to serve as the Policy Track Coordinator, is exploring collaborative partnerships with Dr. Smith that are focused on policy lesson-drawing and the relocation of hazard-prone communities.

Appendix C. Existing Relationships with International, Federal, State, and Local Partners

The certificate will draw from strong connections with international, federal, state and local officials. Drawing lessons from other nations is sorely lacking in US disaster policy and in an era of climate change, the ability to learn and gain hands-on experiences while working in other countries is critically important. This will be achieved by partnering with existing and new programs like the NC State University European Center in Prague and an emerging International Learning Lab, which involves a partnership born from Hurricane Matthew, which struck North Carolina in 2016.

The European Center provides a rich learning environment with an established connection to the College of Design. The facility includes an existing studio space for up to 36 students, traditional classrooms and a library (<https://prague.ncsu.edu/about/facilities/>). Art Rice, a Professor of Landscape Architecture has a long-standing partnership with the European Center and will work with the Certificate Program Coordinator to help to foster the partnership between the European Center and students pursuing the Graduate Certificate in Disaster Resilient Policy, Engineering and Design. One example of collaboration may include teaching summer courses focused on disaster resilient design challenges in Europe that can serve as an elective in the graduate certificate program.

The Hurricane Matthew Disaster Recovery and Resilience Initiative is representative of a US-based node among a larger network of partnerships, including established relationships with state government and university officials as well as private sector consultants in Australia and New Zealand. Following Hurricane Matthew, the Governor's Office and the North Carolina Division of Emergency Management asked the Certificate Program Coordinator to build a team of faculty, students and practitioners to assist six hard-hit communities that had a modest capacity to recover. NCSU faculty from the College of Design created six documents titled Homeplace which provides guidance on possible replacement housing prototypes as well as options for communities to develop greenspaces in locations where flood-prone

homes were acquired and the land converted to open space (For more information on the Homeplace documents see [Homeplace](#)). This is the type of work that will be produced by multi-disciplinary teams of students and faculty in partnership with existing organizations on campus like the Coastal Dynamics Design Lab, local governments and other universities. Additional partnerships are being explored with Professor Hernan Marchant, Professor in the Department of Art and Design in the NCSU College of Architecture, who leads a summer program in Chile.

Additional partners include federal agency representatives from the Federal Emergency Management Agency (FEMA), US Department of Housing and Urban Development (HUD), National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), and the US Department of Agriculture (USDA). The certificate program coordinator has strong relationships with these and other partners and will draw on these connections to include involving federal, state and local personnel as lecturers, potential partners in joint research and engagement efforts, hosts of student interns and visiting faculty, providers of permanent positions for certificate graduates and future mentors once hired.

Graduate Certificate Application in Disaster Resilient Policy, Engineering and Design

The application form used to apply for the graduate certificate, which is attached on the following page can also be found in the College of Design's website in the section focused on graduate certificate programs.

Application for the Graduate Certificate in Disaster Resilient Policy, Engineering and Design
 College of Design
 NC State University

Name: _____ Student ID: _____

Address: _____

Phone(s): _____ Email: _____

Degree Program: (please circle) MLA MCE MPA Ph.D. (Design) PhD (CE) PhD (PA)

Other: _____

Please list the courses you propose to take to meet the Disaster Resilient Policy, Engineering and Design Certificate Requirements.

	Required Course (3)	Required Course (3)	Required Course (1)	Elective Course	Elective Course	Elective Course
Course No. & Title	Survey of Natural Hazards and Disasters	Disaster Resilient Policy, Engineering and Design	Speaker Series			
Semester						
No. Hours	3	3	1			
TOTAL HOURS	3	3	1			

Total Credit Hours Towards Graduate Certificate: _____

 Signature of Student Date

 Signature of Degree Coordinator Date

 Signature of Graduate Certificate Coordinator Date