Community resilience in the face of riverine flooding: applying lessons from resilient competitions to Pennsylvania's vulnerable communities

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ABSTRACT: Flooding as an adverse effect of climate change is becoming more pronounced each day, making communities vulnerable to its threats. There is an urgent need for resilience planning and well-coordinated, science-based design intervention. There is significant information on coastal flooding as evident from recent resilience competitions. The goal of this paper is to learn from this information what can be done to address the lack of coordination and communication related to flooding in Pennsylvania's riverine communities. Only 186 out of more than 2500 communities are safe from high water, making flooding the most frequent and damaging disaster in Pennsylvania according to PEMA (Pennsylvania Emergency Management Agency). A recent survey carried out by DVPRC shows that riverine flooding represents risks in the form of flooding of private properties and roadways and stress on aging water infrastructure like sewer lines and dikes. While the US government has led initiatives to plan for resilience, there is a lack of expertise, coordination and communication to guide the process. Reports on the winning projects in recent competitions are a source to address current short-fallings. By taking a step forward and leading the path towards resilience planning, they have provided resources that can be translated to inform other regions and risks. This research undergoes a case-study review of a couple of resilience competitions to learn about their resilience design process. Using this knowledge, it aims to close the gap in knowledge and address limitations of a traditional planning process across Pennsylvania's riverine communities. Findings focus on effective community-engagement strategies, need for and ways to adopt multi-disciplinary collaboration, institutional changes required to facilitate resilience planning and the overall resilience design process. The paper concludes that traditional planning approaches by local government bodies could largely benefit from adopting or locally adapting the proposed resilient strategies.

KEYWORDS: Community Engagement, Design, Flooding, Planning, Resilience

INTRODUCTION

Historically people have settled along rivers; However, living next to rivers poses risk. Riverine flooding caused by climatic events create major disruption worldwide. Within the United States, riverine communities face such struggles on a regular basis. Pennsylvania has more miles of rivers and streams than any other state with the exception of Alaska. Most of Pennsylvania's communities were settled along its 86,000 miles of waterways, during times when these areas were not identified as floodplains. Today, however, flooding has become an increasing burden on community vitality, with only 186 of Pennsylvania's more than 2,500 communities safe from high water. 2018 was the wettest year on record for the state, with flooding occurring more frequently and in areas that were previously unaffected. Pennsylvania Emergency Management Agency (PEMA) has identified flooding as the most frequent and damaging natural disaster occurring throughout the Commonwealth (PEMA n.d.). While there have been efforts to adapt to and mitigate coastal flooding, as evident from resiliency competitions held in United States in the past decade, the unique conditions of riverine flooding have received less attention. Recent survey findings from Pittsburgh, Pennsylvania suggest that people perceive local flood risks as having increased and are expected to increase further in the

future. The study concludes that, in order to communicate climate change adaptations effectively, it is important to target protection against the local flood risks (Bruin et al, 2014). Many regions in Pennsylvania are prone to flooding risks recurring annually. Snyder County, for example, is likely to flood every year according to data by the National Climatic Data Center (*Snyder County Hazard Mitigation* n.d.). While there are many existing plans for hazard 'preparedness' and mitigation, the current trend of designing for resilience takes a reactionary approach in which solutions are based on past events, presenting a 'lock-in scenario' (Laboy and Fannon 2016, 41). Aspiring to return to a 'status quo' represents a narrow understanding of resilience. Laboy and Fannon (2016) encourage adopting a social-ecological resilience approach that recognizes that buildings exist in a dynamic relationship between technology, human use and the natural environment. These authors recommend adapting to changing social and ecological context. Analysis of hazard preparedness plans for flood prone counties in Pennsylvania indicate a reactionary approach. In the interest of informing methods for enhanced collaboration and proactive planning, this research reviews some recent U.S. resilient competitions to learn about their resiliency strategies and execution structure to gain a better understanding of how resiliency can be achieved with a vision for the future. It goes on to address the gap in knowledge that exist in the traditional flood-adaptation plans delineated by local government bodies. Recommendations include and are focused on areas of community engagement and collaboration strategies.

1.0 LITERATURE REVIEW

1.1. Towards community resilience

The word resilience is derived from the Latin word 'resiliere' which means "to jump back" or "rebound" (Paton 2006, 7). One of the pioneers of this term, Holling (1973, 14) defines resilience from an ecological point of view as a

> measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables

Another widely cited author, Pimm (1991), describes resilience from an engineering perspective. His definition focuses on the return of structural and functional attributes of systems to pre-disturbance conditions following a disturbance. Contrary to Holling's earlier definition of resilience, Holling and Gunderson (2002) redefines resilience in a system as having the ability to absorb changes to reach a new stable state controlled by different variables and characterized by a different structure. This new definition was termed 'ecosystem resilience'. Further development by Walker et al. (2004, 5) define resilience as

> the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks

Resilience in planning and design is also informed by the thinking of other disciplines including medical fields and the social sciences. Adger's (2000) sociological version of resilience discusses the ability of groups or communities to cope with external stresses and disturbances. Defined by Magis (2010, 401) community resilience is the

> existence, development and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability and surprise

A community's resilience is often understood as the capacity of its social system to come together to work toward a communal objective. Butler (2007, 402) defines community resilience as

> good adaptation under extenuating circumstances; a recovery trajectory that returns to baseline functioning following a challenge

Paton (2006) describes it as the capability to bounce back and to use physical and economic resources effectively to aid recovery following exposure to hazards. Rockefeller Foundation president Judith Rodin (2014, 3) shares that resilience can be understood by the

> capacity of any entity—an individual, a community, an organism, or a natural system—to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from

disruptive experience

This addresses the pressing needs for planning ahead for resilience, especially in a world inundated with natural disasters due to adverse climate change.

In every aspect of its definition, the meaning of the term 'resilience' revolves around a central theme - identification of some sort of stress to a system and a focus on either adapting or coping with that stress and bouncing back to its pre-disturbance state or ideally, emerge in a stronger state than before. Recent resiliency competitions adopt this theme of communities 'bouncing back' and emerging stronger. Central to proposed solutions is a focus towards building adaptive capacity of vulnerable communities through equipping them with valuable knowledge and resilient infrastructure to fight the adversities of the climate change.

1.2. Community resilience and adaptive capacity

Berkes and Ross (2013) share that community resilience is rooted in two strands of literature - one strand comes from ecology and addresses the ecosystem while the other comes from the psychology of mental health and personal development. According to these authors, the overlaps and the complementary nature between these two strands makes community resilience of special interest. Magis (2010) explains that resilience is often understood as the capacity of a community's social system to come together to work towards a communal objective in order to fight against vulnerabilities. This 'fight back' attitude is possible in communities that possess 'adaptive capacity'. Adaptive capacity is defined as "the capacity of actors in the system to manage and influence resilience" (Walker et al. 2004). It is a pivotal concept that ties together vulnerability and resilience literature. The stronger the adaptive capacity of a community is, the better it can work towards reducing its vulnerabilities and enhancing its resilience. According to Chapter 18 of the third assessment report of The Intergovernmental Panel on Climate Change (IPCC), adaptive capacity is determined by a community's economic resources, technology, information and skills, infrastructure, institutions, and equity (Smit et al. 2001). Thus, it is concluded that, in order to improve community resilience, it is vital to increase adaptive capacity. This research is focused on boosting the adaptive capacity of community by providing access to information, ensuring equity and empowering communities to make decisions for themselves

2.0 PENNSYLVANIA FLOODING SCENARIO AND NEED FOR COMMUNITY RESILIENCE

2.1 Historic flooding-Pennsylvania

Three major watersheds (Delaware, Susquehanna, and Ohio) encompass most of the Commonwealth of Pennsylvania. As a result, Pennsylvania has experienced some of the worst flooding in the United States, leading to loss of lives and a huge economic loss of properties over the years (*Flooding in Pennsylvania* n.d., Jeffrey 2007, Hasco 2018). According to a 2000 United States Geological Survey (USGS), no other disaster has claimed as many lives and property damage as floods (Perry 2000). Predictive and proactive measures are needed and some efforts are underway in Pennsylvania's Delaware River Valley.

2.2 Contemporary flooding- Delaware River Valley, Pennsylvania

The earth has warmed by about one-degree Fahrenheit (°F) in the last century and, according to the Delaware Valley Regional Planning Commission (DVPRC), if todays' trend continues, Pennsylvania is predicted to warm by between 5.4 to 6°F (*Flooding in Bristol Township* n.d.) and consequentially experience higher sea level rise and more frequent heavy storms. Figure 1, by NOAA, of the Philadelphia Tide Gauge, represents flooding risks associated with the aforementioned climate change scenario in comparison with past climatic events. The figure shows the tide height measurements above high tide and portrays how a sea level rise scenario will exacerbate flooding conditions. Figure 2 shows likely flood inundation of areas in Bristol Township, Pennsylvania as a consequence of predicted sea level rise. According to DVPRC, coastal storms may produce any of the heights today, but sea level rise will cause all

of these predicted scenarios in the near future. Moreover, some areas under five (5) feet above sea level may be permanently inundated.

	Current (ft)	2030 (ft)	2050 (ft)	2100 (ft)
1%/100-year flood	4.13	4.93	5.53	7.53
Flood of April 2005 (~April 4, 2005)	3.06	3.86	4.46	6.46
Hurricane Irene (~August 28, 2011)	3.23	4.03	4.63	6.63
Hurricane Lee (~September 3, 2011)	1.65	2.45	3.05	5.05
Superstorm Sandy (~October 30, 2012)	3.94	4.74	5.34	7.34
10%/10-year flood	3.05	3.85	4.45	6.45
99%/1-year flood	1.12	1.92	2.52	4.52
Permanent inundation at high tide (mean higher high water)	0	0.8	1.4	3.4

Sources: NOAA, central estimate from Kopp et. al 2016.

Figure 1 (left): Flooding estimates at the Philadelphia Tide Gauge (Source: *Pennsylvania Coastal Resiliency* n.d.)

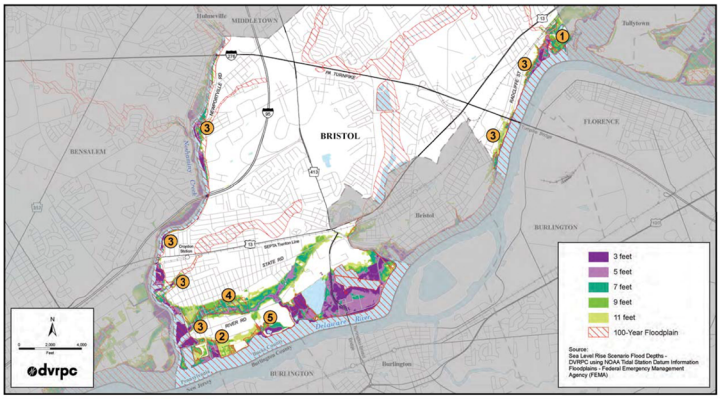

Figure 2: Flooding inundation due to sea level rise in Bristol Township, PA (Source: *Pennsylvania Coastal Resiliency* n.d.)

According to a survey carried out in 2017 in thirteen municipalities along the Delaware River Valley, the predicted sea level rise and future flooding conditions add concern in the following categories: 1. Flooding of private property (homes, cars, commercial buildings) 2. Flooding of residential basements. 3.Flooding of roadways. 4. Stress on aging flood mitigation and stormwater infrastructure (sewer lines, storm drains, inlets, dikes, levees). 5. Secondary effects of flooding: siltation, erosion, pollution. 6. Destruction of tidal wetland habitat. 7. Insufficient flood monitoring systems (*Pennsylvania Coastal Resiliency* n.d.). In light of the above concerns, it is clear that resilience planning - that engages diverse participants and is in line with local needs - is a salient measure that needs to be taken in these riverine communities.

2.3 Planning and community outreach recommendations by DVPRC

To address present and forthcoming flooding challenges in the Delaware river valley, DVPRC has developed a series of recommendations for plans, regulations, and ordinances. These include incorporating flood projections and depth caused by sea level rise in municipal plans

and ordinances; planning beyond the standard 20-25 year timeline through a community-wide planning process; creating a post-disaster redevelopment plan; protecting community assets from flooding using municipal zoning ordinances; re-designing or retrofitting infrastructure to increase survivability; updating flood elevation data to allow elevation of existing structures or new construction to respond accordingly; and, finally, acquiring certification in the National Flood Insurance Program (NFIP) Community Rating System (CRS).

Moreover, the DVPRC recognized the need for community engagement and responded with a series of community outreach recommendations. These include creating a program for public information to help organize the municipality's outreach practices on coastal hazards, organizing annual presentations for residents, business owners and other groups to spread awareness, packaging flood preparedness materials to residents in advance, creating a dedicated and easily accessible flood information page on the municipal website. Policy recommendations include a coastal hazard disclosure policy that is used by lenders and real estate agents when speaking with potential buyers. Other recommendations were to conduct regular educational sessions and outreach for flood preparations and disaster assistance to the residents living in vulnerable locations.

2.4 Need for enhanced community engagement in Pennsylvania Communities

A concerted effort is needed to break the cycle of loss of life, destruction of property and irreparable damages to people, property, infrastructure, environment and the historic fabric of Pennsylvania's riverine/waterfront communities. Organization and resulting recommendations and regulations are useful and necessary based on historical and projected flooding scenarios. However, the majority of Pennsylvania's historically significant communities do not have the resources, information or coordination to respond in kind (DCED, 2015). Moreover, the flooding in Pennsylvania's riverine communities are unique, requiring localized approaches and rigorous process. Solutions must be informed by local problems and the needs identified by community members - utilizing climate science research, planning and design capabilities, and facilitated understanding of law and ethical decision-making. The better able a community is to identify a suite of practical solutions to combat flooding and its effects, the more empowered it will be to successfully fund and implement change

3.0 IN SEARCH OF A RESILIENT WAY FORWARD

3.1 Competition case-study

In order to better understand methods for collaboration and myriad solutions to challenges in diverse locales, research was conducted on how resiliency is planned through a case-study review of winning projects of Rockefeller Foundation supported resilient competitions: *Rebuild by Design-Hurricane Sandy and Resilient by Design-Bay Area Challenge*. Important aspects of the design structure, significant collaborators in resiliency planning, community engagement strategies, and resilient planning process, are documented which led to learning about innovative strategies to approach design and engage community members in the process.

Rebuild by Design-Hurricane Sandy: Rebuild by Design was a competition that was designed in response to immense damage left in 13 states by Hurricane Sandy. This was organized by HUD (U.S. Department of Housing and Urban Development) in partnership with Municipal Art Society, Regional Plan Association, NYU's Institute for Public Knowledge, The Van Alen Institute and with support from the Rockefeller foundation and other philanthropic partners. What makes this competition unique is that it draws innovative, scientific knowledge from experts around the world and combines it with insights from local communities to devise solutions that are practical and implementable. The idea here is not just to 'rebuild' but rebuild in a way that prepares the affected region for storms worse than Hurricane Sandy. The competition yielded ten (10) winning projects by interdisciplinary teams, out of which 7 projects received federal approval and funding for implementation.

Resilient by Design-Bay Area: Inspired and modelled on the Rebuild by Design competition, Resilient by Design-Bay Area was designed to tackle the resilience issues of the vulnerable San Francisco Bay Area. While Rebuild by Design was created in response to a climatic event, this competition is designed to develop the Bay Area in a way that makes it resilient against rising sea level and future climatic threats. Interdisciplinary design teams (informed by specified criteria) were chosen through an open call and vulnerable sites were identified based on feedback from community members, government staff and regional experts. Much like the Rebuild by Design competition, ten (10) teams were chosen, who devised clever, implementable solutions after a thorough collaborative research and design phase.

3.2 Why adopt a design-oriented process in resilience

Both the Rebuild by Design and Resilient by Design competitions adopt a design-oriented approach towards devising resilience solutions. Henk Ovink, Principal of Rebuild by Design, explains that a design process generates holistic solutions due of its comprehensive nature. He goes on to inform how the 'innovative' elements in design can encourage people, including politicians, to engage and be a part of the new opportunities (Cohen, 2016). Resilience process is not only about devising solutions to existing problems but going beyond to perceive new opportunities in the solutions devised, to address the social and economic issues through layered strategies, and to be able to devise solutions for problems that are yet to materialize. A design-oriented process in resilience planning adopted in the resilience competitions reflects how multiple benefits can be achieved through a single, well-perceived intervention and should be considered in traditional planning. One such example is the proposal by The Big U, of designing berms with salt tolerant trees that also function as waterfront civic spaces for the communities (The Big U, n.d.). A design-driven resilience approach can lead to such innovations by maximizing utilization of resources. This is an especially crucial aspect to consider for small communities with limited capability for flood resilience initiatives

3.3 Collaborative process in *Rebuild by Design*

Phasing and partnership structures, as well as limitations on opportunities in the collaborative process, were identified using documentation available from *Rebuild by Design*. Four (4) phases comprised the competition:

Talent: In this phase, scholars and experts from around the world were sought to share their expertise. This was matched with local experts in the Superstorm Sandy affected region, who knew the specific and significant details about the area. This marriage between local and international expertise ensured that only the best recommendations were provided to build resiliency.
Research: This phase allowed for thorough research to gather a deep understanding of the region's vulnerabilities, risks and opportunities. In addition to acquiring scientific data about the climatic patterns, ecological and geographical conditions, the team members, assisted by experts, made site visits to the Sandy-affected areas in order to hear first-hand about the problems that the local residents prioritized.
Design: In this phase, informed by the interdisciplinary and collaborative research, the team members devised implementable solutions with support from local communities and government. Various workshops with community members were held throughout this process in order to make sure that local aspirations and values were reflected in the plans put forward.
Implementation: Finally, in the implementation phase, government and community stakeholders came together to work as a team to help build the projects.

Table 1 compares the traditional government planning process with the Resilient planning process: Lessons from the resiliency competitions were derived to understand how successful community outreach may be conducted.

The community outreach recommendations from the Rebuild by Design competition are not only innovative but they also shed light on the fact that the resilience planning process encompasses much more than the usual limited engagement with community stakeholders. Community residents were engaged at every step of the process throughout the research,

design and implementation phases. This ensured that their values were reflected and their aspirations accounted for. Moreover, this empowered them to make decisions that affected their regions, fostering a sense of belonging and ownership. The mechanisms applied in bringing community members together were innovative. Instead of the usual informative presentations alienating participants, facilitating workshops that included design explorations, such as model-making, allowed residents to participate in redesigning their communities to adjust to climate change. These fun interactive methods educate the community, catch the public attention, and effectively communicate complex science and related messages. Table 2 shares some of the successful community outreach techniques applied by the winning team members of Rebuild by Design competition.

Table 1: Comparison of traditional planning process with resilient process derived from resilient design competitions.

Traditional Process	Resilient Process
Limited scope for interdisciplinary collaboration	Significant Interdisciplinary collaboration
Lack of an organized structure	Organized into an orderly structure
Not enough scope for collaborative research	Significant time for research (with locals, academicians, local organizations, industry experts and state officials) before getting into the design of solutions
Not enough provisions for long term	Plans for short term problems with long term vision
Most recommendations are reaction-oriented	Recommendations are resilience-driven
Gender and economic issues not prioritized	Included advisory staff in gender and economic equity issues to ensure equitable planning.
Confined within the municipality	Inter-municipality collaboration to address flooding issues that affect several regions together.
Reliance on past storm data to predict future events	Planning for unforeseen projected climate trends.

Table 2: Tools used by the Rebuild by Design teams to facilitate collaboration (prepared by studying the finalists' report). Adapted from Rebuild by Design Competition book. Retrieved form http://www.rebuildbydesign.org/resources/book

Aspect of Research	Tools used in process
Understanding residents' perception of 'Resilience'	Hand-sketches made by community residents during drawing exercises
Understanding community residents' aspirations regarding the design solutions	Series of interactive Interchangeable models that community residents were encouraged to design
Gaining feedback from engaged stakeholders	Workshops, meetings, Research colloquium; Web-based surveys. Design charrettes
Getting the stakeholders involved	Public events with interactive installations, displays & research related activities
Waterfront design details.	"Build your own waterfront activity"-Foam models of berms, flood walls, and public amenities given to community residents to let them design
Identification of shared values of community	CrowdGauge Tool coupled with online game-like interface used to understand what aspects in their community residents value the most (e.g. clean air, safe roads, community parks, etc.)

3.4 Proposed collaboration model

Figure 3 shows a proposed collaboration structure adapted from the *Rebuild by Design Hurricane Sandy* competition. The important collaborators in each phase that crucially shaped the resilience design process are indicated. The diagram was derived by inferring from public resources made available by Rebuild by Design and the list of collaborators included are not

exclusive. Rather, the list gives an idea of the kind of experts that should be sought to enable a community-led resilience design process.

A similar structure for collaboration in Pennsylvania riverine communities may involve getting important stakeholders like PEMA, DEP, municipality staff, local experts and community members actively involved through collaborative research and design phases, in order to overcome the lack of coordination and communication in the system. Adopting the collaboration model from the resilience competition and engaging the relevant stakeholders can lead to practical and equitable solutions for the community.

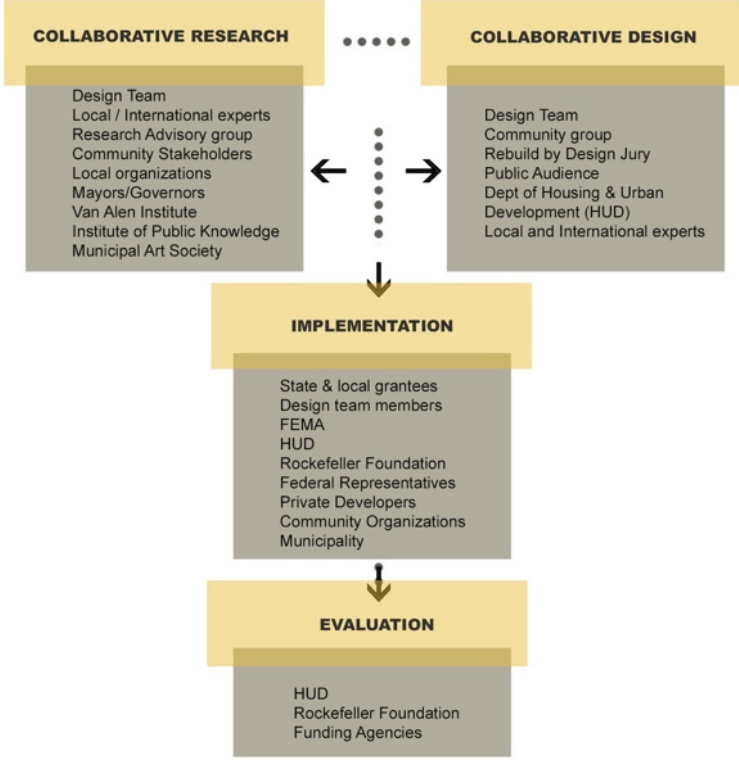

Figure 3: List of collaborators and collaboration structure in *Rebuild by Design Hurricane Sandy* competition

4.0 DISCUSSION AND FINDINGS

Using the knowledge derived from studying resilient competitions, recommendations are made to address a gap in the traditional planning processes in an attempt to add momentum to the resiliency of Pennsylvania's riverine communities. Research and experience indicate that the top-down traditional planning process is yet to achieve community resiliency. The process must address vital elements of effective community engagement, inter-disciplinary collaboration and well-perceived planning with provisions for unforeseen challenges.

Problems, addressing unique challenges and their solutions, must be locally defined. Communities in Central Pennsylvania suffer from three types of flooding. The large-scale sustained flooding that occurs along main river stems, such as the Delaware or Susquehanna, are certainly of significant concern. But equally, or perhaps more troubling, is the localized flash flooding that affects the upper reaches of the rivers and their tributaries. Many of these waterways have not been accurately mapped for flood risk, and some smaller tributaries are missing from the maps completely. These primary and secondary types of flooding are increasing in magnitude and frequency, and often cause major property destruction or

fatalities. Moreover, increases in precipitation is causing flooding from unexpected sources, such as the stormwater infrastructure that is intended to mitigate and protect, and recent recurring flooding has affected properties that never flooded previously. River communities are becoming increasingly more vulnerable due to overworked storm water systems, runoff pollution, rising flood insurance costs and damaged infrastructure.

While resilience competitions like Rebuild by Design and Resilient by Design are focused towards the large-scale impacts of coastal flooding, riverine flooding and flooding from tributaries and stormwater are not as comprehensively researched. Adopting the four-phase model of the resilience competitions would ensure that:
An interdisciplinary team of experts would be engaged to assist with identifying and addressing the resilience issues in Pennsylvania's riverine communities during the *Talent* phase.

1. A better understanding of region and values would guide the process through the *Collaborative Research* phase
2. Feedbacks from community members and relevant experts would lead to comprehensive and informed solutions through the *Collaborative Design* phase
3. Funding mechanism and sources would be identified early in the process through the *Implementation* phase.

4.1 Obstacles in adapting the 'resilience' way

Referring to the definitions of 'resilience' discussed previously, resilience can either mean adapting to a stress and bouncing back to its pre-disturbance state or emerge into a different, stronger state. This leaves a profound dilemma when faced with decision-making for riverine communities. There is a need for decision support to inform responsible outcomes. A problem arises due to the fact that different types of floods and stormwater control fall under different jurisdiction. Flooding from tributaries are managed by the Department of Environmental Protection (DEP) while FEMA manages larger-scale floods. This segregation in the system was an impediment in implementing the winning projects of the *Rebuild by Design* competitions. Pennsylvania communities face similar flood resilience obstacles. Learning from *Rebuild by Design,* active steps can be taken to assure that problems are addressed and feedback is heard by maintaining regular updates with local leaders and relevant authorities (Grannis, 2016). As evident from this case, siloed responsibilities an create a profound lack of coordination. Integrating the relevant systems into a coordinated whole would prevent superfluous solutions and enable maximum resource utilization.

Top-down traditional planning approaches are yet to achieve community resiliency because they do not address vital elements such as effective community engagement, interdisciplinary collaboration and a well-perceived planning process with provisions for unforeseen challenges. While coastal flooding receives much attention - giving rise to massive scale competitions like *Rebuild by Design* which are producing real-life projects that are getting implemented - riverine communities are yet to benefit from that momentum. It is vital to apply these resilient principles when planning in flood-prone riverine areas. Some of the recommendations suggested can be enacted if proactive action is taken; Others require changes at a policy-level. Regardless, it is crucial to equip the riverine communities with vital knowledge and access to information regarding flooding, to involve them in the planning process, and to encourage them to participate in community-driven and informed action. Following the 4-phase resiliency design process informed by the *Rebuild by Design* competition can help make progress in an ordered manner while the collaboration model can help guide towards the kind of engagement necessary to build resilience. It is expected that the traditional planning approach could largely benefit from these suggestions.

CONCLUSION

The study of publications documenting recent resilient design competitions, such as the Rebuild by Design winning projects, has led a path to planning for resilience during a time when the concept of resilience is still being debated. By providing insights and sharing experiences, the competition teams have pioneered what it takes to successfully plan for

coastal resilience. Riverine flooding, on the other hand, is not as largely researched. In recognition of this concern, the US government has led initiatives in the interest of hazard preparation, mitigation and adaptation. However, these initiatives are not always aligned with the resilience principles that scientists and experts around the world have recommended, including adequate local engagement. This research has been carried out in an attempt to bridge that gap; it aims to help lead the path to guide the vulnerable riverine communities of Pennsylvania towards a resilient future.

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