INTERNATIONAL URBAN RESILIENCE PROJECT

Workshop report & follow up

JR v1a

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CONTENTS

1) INTRODUCTION

This international urban resilience project is an *"international comparison study of hazard resilient cities: From risk evaluation to pathway development".*

This is a 'draft for discussion' report on the workshop at University of Manchester, 21-07-23

- The main section is a review of the case studies, in the form of summary notes and queries
- A section on next steps outlines the proposed '*Resilience 3.0 laboratory*'
- Case study templates are included here in the Annex
- Project information - www.manchester.ac.uk/synergistics/eco-wise-resilient-cities/
- Project materials - https://www.dropbox.com/sh/mlnc5f23rpyy9ej/AACblWUv33VOEFaRGCSGF39Ea?dl=0

Comments, queries, additions, further discussions are welcome.

Methodology

The general aims of the project include:

- compare hazards, risk assessments and resilience pathways, in a range of case studies around the world
- explore the deeper 'synergistic' levels of risk assessment and resilience pathways, with new methods and tools.

Broadly we aim here to explore critical questions on resilience – to what, for whom, where and when? For the international Sendai Framework, resilience is: 'The ability of a system, ***community or society*** exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the ***preservation and restoration*** of its essential basic structures and functions.' (UN 2015, Wenger 2017).

But what if the ***'community or society'*** here is based on inequality and exploitation – should we 'preserve and restore' the existing protection for the rich and insecurity for the poor? The implication is that risk and resilience is not only a direct technical issue, but raises *wider* questions of politics, and *deeper* questions of ethics. This highlights the difference between a technical approach, which by default screens out socio-political questions, and a ***synergistic*** approach, which builds them into a whole systems transformation agenda.

One example: after Chennai (India) suffered disastrous flooding in 2015, studies and plans were made. To make way for environmental improvements, over 100,000 shack-dwellers were then

evicted from the banks of rivers and water bodies, and moved to distant 'resettlement colonies', while the waterfront plots became a prime real estate windfall for the benefit of elite developers. Another example: the 2017 Grenfell Tower fire (UK) was widely seen as a result of systematic exclusion ('de-participation') of tenants from decision-making, privatization of regulation, hollowing and commercialization of public services by government policy for austerity.

WIDER & DEEPER CONCEPTS OF RESILIENCE

These and many other cases show critical implications for the concept of resilience, and the emerging debates on how such resilience concepts are increasingly problematic and politicized (e.g. Brown 2014). We can summarize the outlook:

- 'Resilience' is a useful concept only within its context: beyond the strictly functional and technical aspect, we have to include the deeper layers, the 'STEEP' combination of social, technical, environmental, political and cultural systems, each with varying degrees of vulnerability / resilience:
- Where the community or society is politicized, with structures of hierarchy, colonization, patriarchy, etc, then the concept of 'resilience' is likewise politicized, with the dynamics of expropriation or weaponization; (e.g. Harrison & Chiroro 2016).
- This is a multi-level agenda: the resilience of a household may differ from that of the local farming community, or the regional economy, or the global food system: but each level is inter-connected and inter-dependent.
- All this points to implications for resilience and/or 'transformative adaptation'. Firstly we can reframe the problem / solution of resilience as not only internal to the problem, but systemic. For example, for the resilience of peri-urban communities to climate change (typically a fragmented and conflicted agenda), we can explore systemic challenges and opportunities, in which peri-urban-climate resilience is a 'co-benefit' to other agendas.
- Second, we look for adaptative pathways not as one-off solutions, more as extended processes of collaboration for positive change and synergies: e.g. between urban design, real estate markets, landscape diversity, public health and community development.
- Thirdly, we recognize the multiplicity of 'resilience' concepts and conflicts in their socio-political STEEP context: e.g. if a farmer's resilience is in conflict with a community's resilience, or indeed the resilience of a multi-national corporation, then the only way forward is to recognize and work with such multiplicity.

Overall, such extended scope of the resilience concept can be framed as a *'collective resilience intelligence'*. In this sense we look for a wider community of interest, with deeper layers of value and systems logic, with further horizons of change and transformation. Such *'collective resilience intelligence'* is not so much an entity as a capacity, or process of mutual communication, learning, innovation and co-production.

This project is a small pilot which aims to test / demonstrate the synergistic approach to a ***'collective resilience intelligence'***, or ***'resilience 3.0'***. We put 5 case studies from around the world into a series of templates: this is then the start of a process of co-creative thinking where we explore the

synergistic risks, and synergistic pathways towards a transformative resilience. We don't expect any final solutions for Greater Manchester or Cape Town, but we can demonstrate some fundamental questions, which may then point to practical 'pathways' and strategic actions.

SUMMARY OF THE 'COLLECTIVE RESILIENCE INTELLIGENCE'

In summary such ***'collective resilience intelligence'***, can be mapped as multiple synergies / inter-connections:

- ***Wider*** community of stakeholders in communication & collaboration *(actor mapping);*
- ***Deeper*** layers of value & meaning, not only economic but 'triple bottom line' *(domain mapping);*
- ***Further*** chains of cause & effect, upstream & downstream *(factor mapping).*

This enhanced frame can then work on 2 main levels:

- ***Functional level:*** with a direct & technical approach to resilience *(problem-fix & 'bounce-back'):*
- ***Synergistic level:*** with an over-arching system & human-centred approach; *(transformative adaptation, 'BBB', 'bounce-forward', 'resilience-3.0', 'collective resilience intelligence').*

This provides a structure for the case study templates in the Annex.

- ***Risk / vulnerability Template A:*** explores the key problems (hazard / exposure / vulnerability), with 2 levels of systems analysis:
- ***'Resilience / pathway' Template B***: explores policies, programs, plans: other societal pathways (public, private, civic, grassroots etc): other ideas & innovations, both actual and proposed.

These templates provide a quick and practical way to compare information between case studies. They focus attention on the 'synergistic' issues (right hand column), which are often bypassed with the 'problem-fix' approach. The templates are based on a simple version of the 'synergistic approach' & 'pathways toolkit' (Ravetz 2020). They can be copied / renamed for further case studies, not as a 'result', but more as support for exploring useful questions, both direct and strategic.

SOURCES:

Brown, K, 2014: Global Environmental Change 1: a social turn for resilience*? Progress in Human Geography,* 38, 107-117

Harrison, E, & Chiroro, C, 2016: Differentiated legitimacy, differentiated resilience: beyond the natural in 'natural disasters'. *Journal of Peasant Studies*, 1022-1042. https://doi.org/10.1080/03066150.2016.1193011

Ran et al 2020 https://doi.org/10.1016/j.scitotenv.2019.134486

Ravetz 2020 https://doi.org/10.1080/00343404.2020.1813881

UN (2015) *Sendai Framework for Disaster Risk Reduction* 2015–2030, Geneva, UN.

Wenger, C. (2017) *Translating Resilience Theories Into Disaster Management Policies*, Report 251, Canberra, Australia National University, Bushfire and Natural Hazards CRC.

2) CASE STUDIES

Greater Manchester – 'city of revolution'

'GM' has experienced a series of medium level disaster events: mainly flooding, storm damage, wildfires on the surrounding hills, and the 2022 heatwave. There was one major terrorist attack in 2017. The pandemic was then a national emergency with massive impacts in GM as elsewhere: some of the most vulnerable populations were the hardest to reach, in terms of vaccination etc.

The GM Resilience Strategy has evolved from the previous 100RC program and various civil contingency programs. It appears to be a leader in the field, with its focus on the human & organizational side of DRR and urban resilience. The headings include – *Communities: Discovery: Leadership: Place: Responding*

Meanwhile the detail of the strategy is quite open about the structural challenges around and ahead – these were questioned and debated in the workshop. Here they are summarized by the above headings:

- ***Social / 'Communities'***: are the most vulnerable communities the hardest to reach & engage? Is national government policy creating a 'hostile environment' for those most in need? Is the rapid growth of food banks a sign of a society in breakdown??
- ***Environment / 'Discovery'***: what do we know about the most vulnerable communities & the highest risk locations? Could we do more to connect the different knowledges of policy/academia / civil society?
- ***Political / 'Leadership'***: while this seems to work at GM level, is it fair to say most people have near zero contact with local govt? should the civic society /3rd sector be the starting point for leadreship?
- ***Urban-rural / 'Place'***: many threats & hazards cross the GM boundaries, e.g. flooding of river catchments – are there realistic arrangements for whole integrated catchment management??
- ***Other / 'Responding'***: will future climate change bring new response challenges? E.g. the 2022 heatwave saw very little active response where most needed… Does the average person understand climate change & impacts?? How to counter mis-information and/or denial in mass media and social media?

General questions –

- if austerity & Covid have resulted in 500k avoidable deaths (UK) or 12500 GM pro-rata, is this relevant to the GM resilience strategy & priorities?
- Are there new forms of leadership / mobilization / participation which include the above??

Here is a summary matrix (details in the Annex)

	Direct / Functional	Systemic/synergistic
'Vulnerability'	• Flood risk • Storm, heat, wildfire • Critical infrastructure • Terrorist attack • Cyber attack	• Poverty & exclusion • Welfare system & hostile environment • Poor housing conditions & fragmented tenure system • Culture of denial & myopia
Resilience	• Strategic program for housing retrofit • Integrated environmental management of rivers, uplands, urban GI etc	• Transformation of welfare, housing & low-pay work situation • new forms of leadership / mobilization / participation

Changsha – 'city of flows'

Changsha is a rapidly growing modern / historic capital of Hunan Province. Its main direct hazards / risks are in flooding and related extreme weather events.

For many of the risks, and most of the resilience items, information is limited or near zero. So, most of this summary is a very rough interpretation of challenges, policy gaps, societal divisions & contradictions. This applies both to the risk side and especially the 'synergistic resilience', which highlights the system level transformations.

Questions for discussion:

- ***Social / community:*** is the apparent lack of social cohesion & social capital, in a rapidly expanding city, a structural problem for resilience, and what could be done to improve?
- ***Technology / infrastructure:*** can smart monitoring & data analytics manage the real-world complexity of land-use change and land management?
- ***Environment-climate:*** are there studies on the effects of 3 degrees of climate change: is there an connection between this and the national policy for more carbon-intensive (coal) energy sources?
- ***Economic / livelihood:*** is it significant there is no information on economic risks, costs or impacts on livelihoods etc?
- ***Political / governance:*** is the culture of information blocking and top-down governance, a structural problem for whole systems resilience, and how to change this?
- ***Cultural / worldviews:*** does the Chinese image of material success, have difficulty to recognize the vulnerability to growing natural hazards? Does the image of the 'hero to the rescue' work against preventative action?

Summary table:

	Direct / Functional	**Systemic/synergistic**
'Vulnerability'	• The city is in a wide valley surrounded by mountainous landscape, in sub-tropical climate, prone to extreme weather. • Rapid urbanization has changed water & soil systems, in peri-urban & rural areas. • The hazard applies both to low income areas in poor conditions, and high income in risky locations	• Upstream rural land-use, landuse change, agriculture & forestry • Policy gaps & fragmentation between departments & levels • No information on economic costs / benefits / impacts is available
'Resilience'	• Information systems can improve the integrated catchment management • Landuse & agriculture policy can improve the water retention & 'sponge' approach	• Culture of governance – shift from 'heroic' engineering, towards whole systems preventative • 'Stories' of successful resilience may help more than hard policies.

Beichuan – 'post-quake recovery'

An earthquake occurred in the province of Sichuan, China, on May 12, 2008.

- Ms 8.0, epicentre 50 miles NW of Chengdu, Sichuan Province
- Approx 80,000 dead, 400,000 injured, at least 5 million homeless
- Subsequent geohazards major issue - landslides, debris flows, "quake lakes"
- 200,000 such events recorded; responsible for 1/3 fatalities
- Wide criticism of sub-standard 'tofu building' due to corruption in construction industry.

For this case study -

- Broad question: what factors influence recovery from disaster?
- Motivated by literature on social vulnerability and resilience
- Data: census, satellite imagery, fieldwork
- Analysis focused on Wenchuan County (13 towns, approx 120 villages)
- Household income (over time) as outcome variable. Various topographic and socio-economic drivers explored.

Results:

- Clear effect of secondary hazards (landslides, **debris flows**) on household income at the village level. This effect is at times modest, but fairly consistent across towns, and seemingly leaves a medium-term signature rather than merely being a temporary shock.
- **Environmental justice hypothesis (I)**: poor towns will be concentrated in areas of high hazard. The towns in the heartlands of the landslide and debris flow activity - Yingxiu and Gingko - were wealthy to begin with. Although the prosperous hinterlands were far from the secondary hazards, so too were many poor towns, especially towards the South. **Evidence does not support.**
- **Environmental justice hypothesis (II):** living conditions and resource-dependent employment of the poor renders them uniquely vulnerable to environmental hazards. But the poorest towns aren't worst hit (no relationship between initial wealth and short-term resilience), there is a fair degree of resorting of income rankings over time (inverse relationship between initial wealth and long-term resilience), and inequality declines over time at village and town level. Little evidence of poverty traps - towns that suffered significant income shocks post-quake recovered substantially. **No reproduction of poverty.**

	Direct / Functional	**Systemic/synergistic**
'Vulnerability'	No evidence of 'social determinism': (damage & recovery is not dependent on income	Clear evidence of a "**hinterlands effect.**" Towns that are a) isolated from the main river and the County centre (geographically and likely politically isolated), b) not within the main landslide and debris flow area (so likely not a focus for recovery efforts), and c) that have rugged topography and so have limited prospects for commerce, industrialisation, or tourism, start wealthy yet fall into the poorest income categories
'Resilience'	Standard measures of **social vulnerability have little to no correlation with economic recovery** Some 'environmental determinism' (damage & recovery is not dependent on income	

Cape Town – 'zero city'

Cape Town has one of the highest inequality levels in the world: informal settlements, insecurity and unemployment. This case study focused on a single issue of water stress, a very challenging and divisive issue.

Overall the results seemed to show some success in engagement of wider society, including both low and high income groups, business and government. This was questioned and debated in the workshop -

- ***Social / community:*** is it realistic to say the 50 litres /p/day is successful? did it get support from low income groups as an equalizer? Did high income groups & businesses find ways around?
- ***Technology / infrastructure:*** is there scope for rethinking the water system from centralized to decentralized (e.g. UNESCO project);
- ***Environment-climate :*** If climate change is increasing what are the future prospects for water??
- ***Economic / livelihood:*** were any studies done on the impact of policy on/off for DRR / resilience?
- ***Political / governance:*** in a situation of distrust & division, how did government succeed in this?
- ***Cultural / worldviews:*** if SA public in general is not interested in climate change, could the zero-city change this?
- ***Urban-rural-spatial*** **-** should we include water sources in the wider region, in this debate?
-

	Direct / Functional	**Systemic/synergistic**
'Vulnerability'	Climatic (200 year drought) Infrastructural (Surface water dependent) Urbanisation trends…. Competing Water Uses (Minor) Social (Modest)	(Growing inequality) Institutional competencies Competing spending priorities Valuation/pricing of water Availability/cost of loan finance
'Resilience'	Governance 'capabilities' Demand management (in it together) Development of alternative supplies (private sources: busi, hsehld, key inf.) Maintain minimum levels of supply	Investing for more diverse water supplies (public sector and private individuals) New groundwater models/approaches (reclamation MAR, APZ, Aquifer Park) Institutional competencies/mandates and financial models……

Puerto Rico – 'aqueduct island'

(this section and its templates are contributed directly by Zorica Nedovic-Budic, who could not be at the workshop)

Introduction

Puerto Rico, an island nestled in the Caribbean and an unincorporated territory of the United States, faces a unique set of challenges when it comes to risk, vulnerability, and resilience in the face of natural disasters (Straub 2021). Located in the hurricane belt, the island is vulnerable to recurring hazards such as hurricanes, floods, and landslides. Those hazards threaten the island's infrastructure and the well-being of its residents. Central to Puerto Rico's disaster preparedness are its aqueduct projects, a network of pipelines, reservoirs, and treatment plants designed to provide safe and reliable drinking water. However, the path to sustainability and resilience is riddled with underlying challenges and questions that demand attention and action.

Sustainability across different infrastructures

Water Challenges

Puerto Rico's water systems have long been a concern (García-López 2018). Hurricanes Irma and Maria in 2017 exposed the fragility of the island's centralized drinking water system operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA). The damage left over 200,000 people without access to clean water for months. Ensuring water security is paramount, and this involves upgrading and diversifying water sources, improving water quality, and fortifying infrastructure against extreme weather events.

Energy Resilience

The energy sector in Puerto Rico faces significant challenges and it is a complex and often fragile system, primarily reliant on aging and centralized infrastructure (De Onís 2018). Historically dominated by fossil fuels, particularly oil and natural gas, the grid has suffered from inefficiencies, frequent power outages, and vulnerability to extreme weather events such as hurricanes (Laboy-Nieves 2014). Hurricane Maria's devastation left the island in the dark for an extended period, underscoring the urgent need for resilient energy infrastructure. There has been a growing push towards modernization and diversification of the grid, including investments in renewable energy sources like solar and wind, as well as the development of microgrids to enhance resilience and reduce dependence on imported fossil fuels while reducing the carbon footprint.

Transportation Infrastructure

The transportation system in Puerto Rico plays a vital role in the island's economy and disaster response. Vulnerabilities in this sector are exacerbated by a lack of maintenance and infrastructure investment. Addressing these issues requires strategic planning, resilient road networks, and integrated public transportation systems that can efficiently evacuate residents during disasters and facilitate economic growth in their aftermath (Benjamín Colucci Ríos 2018).

Waste Management and Sustainability

Waste management poses a unique challenge for Puerto Rico, with limited landfill space and inefficient recycling programs. Sustainability efforts should focus on reducing waste generation through public education and promoting recycling and composting. Developing sustainable waste-to-energy facilities can also help manage waste while contributing to the energy resilience of the island.

The Impact of Hurricanes Irma and Maria

The devastating Category 5 hurricanes, Irma and Maria, which struck Puerto Rico in September 2017, had a profound impact on the island's aqueduct systems (Brown et al. 2018). Prior to the hurricanes, Puerto Rico's water infrastructure was already substandard, with 70% of the island's water not meeting the standards of the 1974 Safe Drinking Water Act, according to the Natural Resources Defense Council (NRDC). As Maria approached, approximately 80,000 residents remained without power and clean water, highlighting pre-existing vulnerabilities.

Resilience Pathway

Puerto Rico's journey towards resilience and sustainability should be guided by several key principles:

- Diversifying energy sources and investing in renewable energy infrastructure, such as solar and wind, to reduce dependence on fossil fuels and enhance energy security.
- Upgrading critical infrastructure and modernizing water and transportation infrastructure to withstand natural disasters and adapt to changing climate conditions.
- Focusing on community engagement and empowering communities to participate actively in disaster preparedness and response efforts, fostering a sense of ownership and resilience.
- Investing in education and raise awareness about sustainability and disaster preparedness through public education and community outreach.
- Building local economies and developing resilient local economies to reduce reliance on external resources during recovery phases.

Aqueduct Projects as a Case Study

The aqueduct projects in Puerto Rico are not just a means to provide clean drinking water; they are a lifeline that bolsters the island's overall infrastructure and resilience against natural disasters. These projects have a rich history, with preparations for hazard mitigation dating back several decades. For example, the Carraizo Dam, constructed in 1953, was built to provide water for the San Juan metropolitan area and reduce the risk of flooding in the region. Another significant endeavor, the Dorado Ground Water Contamination Superfund Site, was established in the 1980s to combat groundwater contamination caused by industrial activities. A treatment plant was subsequently constructed to clean up the contaminated groundwater and ensure safe drinking water for the affected communities.

However, despite these efforts, Puerto Rico's aqueduct systems have faced significant challenges, particularly in the aftermath of catastrophic events like Hurricane Maria in 2017. Reports emerged that residents in some areas relied on wells from the Dorado Ground Water Contamination Plant for

clean drinking water more than three weeks after the hurricane's landfall. This incident exposed the fragility of the island's water infrastructure and the need for further improvements in resilience.

Puerto Rico boasts a diverse array of aqueduct systems, with 205 community aqueduct systems legally registered as franchises by the Department of Natural and Environmental Resources (DRNA). Additionally, there are informal aqueduct systems that operate outside the purview of the Puerto Rico Aqueduct and Sewer Authority (PRASA) because they do not meet established requirements.

The centralized drinking water system operated by PRASA suffered extensive damage, leaving over 200,000 people without access to clean water for months during the massive hurricanes. Despite these challenges, the aqueduct projects played a critical role in hazard mitigation. Most systems managed to sustain operations, with only 15% incapacitated during the initial weeks after the hurricanes. This resilience can be attributed in part to community involvement, a cornerstone of Puerto Rico's aqueduct projects.

This diversity presents both opportunities and challenges. On one hand, it underscores the importance of community-level resilience efforts. On the other hand, it complicates coordination and response efforts during and after natural disasters. Ensuring that all aqueduct systems meet appropriate standards and are integrated into disaster preparedness and recovery plans is a pressing concern.

Community involvement has been pivotal in strengthening Puerto Rico's resilience against natural hazards. The government actively engaged in public consultations, employed local labor, collaborated with community leaders, and conducted educational campaigns to promote community participation. These efforts helped communities prepare for and respond to disasters, making them more resilient in the face of adversity.

Critical Questions to Address

While community engagement is a crucial component of resilience (Delilah Roque et al. 2020), the accessibility of recovery funds remains a challenge. After Hurricanes Irma and Maria, recovery funds from the Federal Emergency Management Agency (FEMA) became available. However, accessing these funds has proven difficult for many community aqueducts. Limited publicity, bureaucratic paperwork requirements, and a lack of awareness among operators have hindered the effective use of these resources.

Other issues (Lugo 2018; Delilah Roque et al. 2020) might include topics such as resource allocation, policy and regulation, ways and mechanisms of community participation, and technological innovation. In particular, following the literature, pressing questions might be:

- How can Puerto Rico secure sufficient funding for infrastructure upgrades and disaster preparedness without burdening its economy?
- What specific climate adaptation strategies are needed to mitigate the impact of rising sea levels and increased storm intensity on coastal areas?
- How can the government enact and enforce policies that incentivize sustainability practices and resilience measures?

- How can community engagement be further improved to ensure that vulnerable populations have a voice in disaster preparedness and recovery efforts?
- What role can technology and innovation play in enhancing the island's resilience, particularly in the water, energy, and transportation sectors?
- Generally, how far is Puerto Rico the subject of systematic expropriation and disempowerment, by its far richer host country the USA?

Conclusion

Puerto Rico's journey towards sustainability, resilience, and disaster preparedness is fraught with challenges. The aqueduct projects, while critical, require continuous improvement and expansion to meet the island's growing needs and mitigate the impacts of natural disasters. Addressing the diverse array of aqueduct systems, microgrids, and other technological innovations, and ensuring their integration into disaster response plans is essential. Community involvement remains key to building resilience, but this must be complemented by streamlined access to recovery funds and enhanced public awareness. As Puerto Rico faces an uncertain future, addressing these issues will be critical in forging a path towards a more sustainable, resilient, and disaster-ready island. Collaboration between government agencies, communities, and stakeholders will be essential in navigating this challenging but vital journey.

References:

Benjamín Colucci Ríos, P. E. (2018). Lessons learned for Puerto Rico's transportation infrastructure after Hurricane María. Institute of Transportation Engineers. ITE Journal, 88(10), 38-43.

Brown, P., Vega, C. M. V., Murphy, C. B., Welton, M., Torres, H., Rosario, Z., ... & Meeker, J. D. (2018). Hurricanes and the environmental justice island: Irma and Maria in Puerto Rico. Environmental Justice, 11(4), 148-153.

De Onís, C. M. (2018). Energy colonialism powers the ongoing unnatural disaster in Puerto Rico. Frontiers in Communication, 3, 2.

Delilah Roque, A., Pijawka, D., & Wutich, A. (2020). The role of social capital in resiliency: Disaster recovery in Puerto Rico. Risk, Hazards & Crisis in Public Policy, 11(2), 204-235.

García-López, G. A. (2018). The multiple layers of environmental injustice in contexts of (un) natural disasters: The case of Puerto Rico post-Hurricane Maria. Environmental Justice, 11(3), 101-108.

Laboy-Nieves, E. N. (2014). Energy recovery from scrap tires: A Sustainable option for small islands like Puerto Rico. Sustainability, 6(5), 3105-3121.

Lugo, A. E. (2018). Social-ecological-technological effects of hurricane María on Puerto Rico: planning for resilience under extreme events. Springer.

Straub, A. M. (2021). Natural disasters don’t kill people, governments kill people:” hurricane Maria, Puerto Rico–recreancy, and ‘risk society. Natural hazards, 105(2), 1603-1621.

3) GENERAL QUESTIONS & CHALLENGES

These comments are drawn from the final workshop discussion on interconnections and insights, using the templates as a very rough structuring device.

Questions on risk & vulnerability

- ***Social / community:*** (global level) – overall less fatalities, but more economic loss from natural disasters. Will this change with increasing climate impacts? Maybe the secondary /systemic effects, in food /water systems, leading to social stress & conflict??
- ***Technology / infrastructure:*** (PRC) construction industry corruption: (UK) digital exclusion of older people
- ***Environment-climate:*** (UK) new adaptation plan is criticized by all including the govt CCC agency:
- ***Economic / livelihood:*** (SA) where businesses invest in boreholes, does this change the systemic urban resilience? (PRC) reliance on cost-benefit CBA & hard engineering, more difficult to do systemic change e.g. sponge city design.
- ***Political / governance:*** (PRC) govt prefers engineering & 'heroic actions' to systemic prevention. (UK) does privatized water system make integration more difficult? (e.g. 90% of rivers are polluted) (UK) does government action take agency & responsibility from others?
- ***Cultural / worldviews:*** (SA) was the water crisis linked with political party polarization? (UK) right-wing are making political capital from opposition to env-climate action.. (global) is there a general problem of 'silo' knowledge, and what can be done?
- ***Urban-rural-spatial:*** (PRC) govt controls all information, does this make learning & research more difficult? (SA) can we be always clear what is the problem – environmental = social / economic / political?

Questions on resilience & transformative adaptation

- ***Social / community:*** (UK) Manchester bomb 2017 – compensation was paid, but who is looking at long term effects of loss & trauma? Is there a view that *'adversity breeds individual resilience'* (maybe favoured by right-wing views)? Or, that *'collective adversity breeds collective resilience'* (maybe more left wing views)?
- ***Technology / infrastructure:*** (UK) Grenfell fire 2018 showed we don't understand potential of new social media for self-organization – now we have AI also – how to look & plan ahead??
- ***Environment-climate:*** (global) our work with tipping points shows massive crisis ahead, both direct & indirect, maybe only 10 years away – is anyone prepared or anticipating for this??? (UK) do we have a false sense of security??

- ***Economic / livelihood:*** (SA) was the 50 litre policy a great equalizer – does this point towards similar approach to other collective crises? (UK) are the many attempts at valuation of natural capital a way forward, or a great distraction from systems thinking?
- ***Political / governance:*** (PRC) is govt sending mixed signals on resilience.. while in practice promoting 'end of pipe' heroic solutions?
- ***Cultural / worldviews :*** (UK) is there a cycle of DRR activity? Should we increase the role of science in the long view? (big challenges from climate experience so far) – who could be the 'memory keepers' of the future?? (SA) is 'memory' here the learning from history, which can then help with transformative adaptation pathways?
- ***Urban-rural-spatial:*** **(**global) if we are talking about transformation of whole city systems… where are the plans which can even begin to envision that and work on it?

WAYS FORWARD

with the case studies on the table, further cross-cutting discussion could be very fruitful.

We could aim to explore further some of the more strategic challenges: -

- How to shift / adapt / transform the underlying cultures of governance, from the 'problem-fix' approach to 'whole systems' / synergistic approach ??
- How to mobilize local cohesion & social capital, against the power of global capital & hierarchical power??
- How to connect the practical detail of DRR, with the more strategic / 'whole systems' synergistic approach?
- This applies differently to each specific hazard, e.g. flood, storm, heat, drought, fire, sea-level rise etc, - each have different time horizons, risk profiles, social impacts etc.
- What kind of research & knowledge systems can best address such challenges? (i.e. most research institutions & cultures focus on specific packets of knowledge, not on whole systems).

4) NEXT STEPS

Overall, this workshop and its case studies have helped to move forward the 'state of the art' in resilience of whole systems, (not just the parts). As for next steps, in summary -

a) This pilot project completes in December with a final online workshop (tbc), following the Aug 22nd seminar in Hunan University;
b) 3 papers are in progress, following up or parallel to this theme;
c) A 'Res-Lab (*'collective resilience intelligence laboratory')* is emerging, based on these ideas. A follow up meeting is planned in January (hybrid tbc), to prepare for major EU funding proposal

Project seminar & final workshop

Seminar on urban resilience and the collective intelligence: 22nd August, Hunan University

This was a review of the multiple layers of resilience thinking, and the implications for resilience theory and practice. A range of examples includes:

- *PART A: 'SMART-WISE RESILIENCE 3.0'*
  1) Local placemaking – ***community resilience***
  2) Smart-wise cities – ***platform resilience***
  3) Well-health services – ***personal resilience***
  4) *'Collective urban intelligence'* & ***urban resilience 3.0***
- *PART B: 'ECO-RESILIENCE 3.0'*
  5) 'Rethinking Shrinking' – ***peri-urban resilience***
  6) Global socio-physical tipping points - ***climate resilience***
  7) 'how to survive the 21st century' – ***eco-urban resilience***
  8) *'Collective eco-intelligence'* & ***eco-resilience 3.0***
- (slides on https://www.dropbox.com/scl/fi/ky8zxsbfdhz1bmeqbl5eu/Hunan-seminar-Joe-Ravetz-22-08-23.pptx?rlkey=w6mwz9ly8z9yw5nmn445g6zpv&dl=0

Final project workshop December 2023 (online tbc) –
This will review results and decide ways forward -

PAPERS IN PROGRESS

1) Jing Ran with the urban resilience working group: *"International comparison study of hazard resilient cities: From risk evaluation to pathway development".* https://journal.hep.com.cn/laf/EN/2096-336X/home.shtml

(Abstract to follow)

2) Joe Ravetz & Jeremy Carter : *Exploring peri-urban climate risk and resilience : mapping and design for 'transformative adaptation' in situations of flux and uncertainty*. https://www.frontiersin.org/research-topics/57879/land-use-management-in-peri-urban-areas

> As the fastest growing land use around the world, peri-urban areas are on the front line of climate change hazard and risk: and as such they raise new challenges and insights for the ubiquitous concept of 'resilience'. This paper provides an overview of an emerging agenda, organised around a novel conceptual framework, and drawing on evidence and a typology of selected case studies.

3) Joe Ravetz with the Eco-War working group: *Does climate catastrophe mean human catastrophe? Exploring the geo-physical and societal tipping point interactions with the synergistic approach*. https://esd.copernicus.org/articles/special_issue1247.html

> This paper starts from a very topical and urgent question: how might climate change tipping points be a causal factor in societal tipping points into an escalating geo-political conflict (i.e. 'world war')? With the recent failure of the COP27 to agree a clear pathway for a 1.5 degree target, the likelihood of such tipping points, although hedged with uncertainty, can only increase. Meanwhile many of the conflicts in the 'hotspots' around the world are driven or amplified by competition over territory, resources, and migration, all entangled in some way with climate-induced impacts, disasters, and possible adaptation. To explore this the paper follows a combination of transition theory, complex systems, disaster management and resilience thinking. It uses the 'synergistic' method of mapping and design, in the context of *Foresight 3.0* and the *'collective anticipatory intelligence'* approach. The primary data comes from a series of online seminars / workshops 2022-23, involving a total of over 40 participants, within the general format of the *Laboratory for collective intelligence.*

Next steps: towards a 'Resilience 3.0 Laboratory' - ('Res3-lab')

There is a clear need and purpose to take this agenda forward.

The notion of a 'Resilience 3.0 Laboratory' - ('Res3-Lab') is taking shape, from the general platform of the ***Laboratory for collective intelligence.***

This then takes forward the 'Eco-wise' theme, as in www.manchester.ac.uk/synergistics/eco-urban-3-0-theme/. Here the 'Resilience 3.0' concept helps to make sense for a broad spread of themes -

- Climate change adaptation
- Net-zero and Green New Deal 3.0
- Peri-urban & new forms of territorial development
- Bio-regional, food-energy-water nexus & circular economy

The Res-Lab works along lines already established by the general platform –

Key themes and research agendas can then emerge, wherever there is capacity & commitment, which can mobilize in various ways:

- Funded research programs, local, national or international
- Thematic working groups
- Papers and briefings
- Networking & capacity building processes
- Common platform for dialogue and resources

For example - the Eco-war 3.0 project (www.manchester.ac.uk/synergistics/foresight-3-0-for-ww3-0 followed this model of a self-generated international working group: it is now about to publish a paper which feeds into the 'tipping point' report to the COP28.

To follow up, a meeting is planned in early 2024 (hybrid, tbc) -

- EU Funded research proposal
- Thematic working group(s) – post COP28
- Papers and briefings – following on the above

Interested forward thinkers and researchers are invited and welcome..

5) ANNEX: CASE STUDY TEMPLATES

GREATER MANCHESTER

Risk / Vulnerability Template A)

(focus on flooding and climate-related hazards)

RISK DOMAIN MAPPING:	***Scope***	***Functional level:*** ***(Direct technical risks)***	***Synergistic / cognitive level:*** ***(strategic societal risk-vulnerability)***
General risk		*Which are the key functional risks ('hazard x exposure x vulnerability')*	*Which are the key systemic risks, including multi-level multipliers*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	Low income households in high risk zones.	austerity policies for cutting public services add to social exclusion & vulnerability problems
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	Flood defences are designed for '100 year returns': but these now happen every 5-10 years	Climate adaptation is long term & uncertain, investment not simple
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	combined drought / heat / flooding events are increasing	Uncertainty of future climate change & impacts: long term adaptation policy more difficult
Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	UK flooding 2015-16 cost £1.6 billion. insurance does not cover all losses Maintenance of drainage & defences is under-funded	Economic pressures of inflation, cost of living etc, more difficult to invest Farming subsidies up to now have encouraged soil erosion. Many upland areas are in private ownership with few controls.
Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil society partnerships & community*	Most flood events cross admin boundaries, more difficult to coordinate. Water utilities are private firms, with first duty to shareholders, more difficult to coordinate	Government is not well coordinated for systemic cross-cutting risks, Full stakeholder participation may challenge existing structures. Political agenda for austerity & privatization - cuts vital services & increases vulnerability
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	Many gaps & barriers in public awareness & education	Widespread climate change ignorance, scepticism & denial
Urban-rural-spatial	• *Urban areas* • *Housing & construction* • *urban / rural fringe & linkage* • *landscapes & regions*	Some Pennine towns in narrow valleys are flooded every 2-3 years. House-building continues in many high flood risk areas.	Lack of 'integrated catchment management' between upstream & downstream:

Resilience / Pathway Template (B)

(for illustration: drawn from general background knowledge of the GM case)

RESILIENCE DOMAIN MAPPING	***Scope***	***Functional level: ('problem-fix resilience')***	***Synergistic / cognitive level: ('transformative resilience')***
General systems resilience		*Disaster recovery & 'bounce-back'*	*Transformative adaptation & societal 'bounce forward'*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	Priority for most vulnerable households in highest risk locations	Transformative & preventative public services (health, education, security etc)
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	Coordinated emergency communications for whole community Protection of critical infrastructure	Fully integrated smart systems & 'smart-wise' socio-technical systems Fully adaptive critical infrastructure with user participation
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	Direct responses & defences to climatic events	Transformative adaptation: eco-urban design, WSUD, sponge city, cool city
Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	Promote flood insurance & integration to resilience actions	Integrated climate-ecosystems finance with socio-ecological values & investment models
Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil society partnerships & community*	River catchment forums & partnerships, partially successful	Fully integrated governance based on *'collective resilience intelligence'*: with citizen-based forums, assemblies, mutual aid networks
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	Flood event response – mutual learning & management skills	Carbon & climate adaptation literacy programs: creative media
Urban-rural-spatial	• *Urban areas* • *Housing & construction ,* • *urban / rural fringe & linkage* • *landscapes & regions*	Agro-ecology policy for stormwater retention	Universal housing retrofit program for integrated climatic adaptation. Rural & landscape patterns for transformative adaptation & eco-livelihoods.

CHANGSHA

(focus on the flooding / climate related hazards)

Risk / Vulnerability Template A)

This is shown here with questions to be addressed. *(When I fill this form, I realised that some questions are not related to the evaluation of risk and vulnerability. So I added questions in red.)*

RISK DOMAIN MAPPING:	***Scope***	***Functional level: (Direct technical risks)***	***Synergistic / cognitive level: (strategic societal risk-vulnerability)***
General risk		*Which are the key functional risks ('hazard x exposure x vulnerability')*	*Which are the key systemic risks, including multi-level multipliers?*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	*Who is most exposed & vulnerable? (in which social types)* *Both low-income and high-income* *Low-income: travel with metro suffer underground flooding risk* *High-income: underground car parks at risk, expensive appartement with better river/lake view* *Jing: How to evaluate the social vulnerability?*	*Who are the key players in **socio-political** amplification of risk?* *Not enough information to answer* *Jing: What are the not measurable factors that may affect social vulnerability?* *Social cohesion and social capital*
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	*What are the technical issues in this risk / vulnerability?* *Design of drainage system* *Maintenance of infrastructure*	*What are the **socio**-technical issues in this risk / vulnerability?* *History and tradition of drainage design method*
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	*Which are the key ecological-climatic problems?* *Jing: What are the factors that may affect flood risk? (precipitation, rainfall pattern, soil moisture rate, vegetation rate)* *Climate change* *Increasing likelihood of intense rainfall across the catchment*	*Which are the key **socio**-ecological-climatic problems?*
Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	*What & how much are the first order economic risks?* *Not enough information to answer* *Jing: Should economic and livelihood be considered when evaluate the risk or vulnerability? What are the economic factors?*	*What & how much are the systemic economic risks / vulnerabilities?* *Not enough information to answer* *Jing: What is not considered in the economic/livelihood evaluation?* *(I personally think sometimes the cost-benefit analysis will draw back the resilience actions, because we may invest more money and human resources in prepare and mitigate the risk than the economic cost we protected. Also, it could be misleading that the rich area with more economic risk shall get more protection.)*

Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil partnerships & community*	*How is the government / policies part of the risk / vulnerability?* *Governance culture* *Policy implementation*	*How is the societal-governance system part of the risk / vulnerability?* *Leadership of the top decision makers in the government/departments*
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	*How are cultural perceptions & worldviews part of the problem?*	*How are cultural worldviews part of the societal risk-vulnerability?*
Urban-rural-spatial	• *Urban areas* • *Housing & construction ,* • *urban / rural fringe & linkage* • *landscapes & regions* •	*Land reclamation from wetlands* *Urban structure* *Land use planning* *Vertical design of the city*	*Where are the strategic locations for societal risk / vulnerability? (e.g. upstream & downstream)—Jing: This is a irrelevant/over simplified question* *Jing: What are the reasons prohibited the more resilient ways of urban-rural-spatial design and plans?* *The priority of other planning goals toward the urgency of flood mitigation* *Time and budget for making the spatial plan* *The coordination across boundaries and departments* *Planning tradition* *Market preference* *….*

Resilience / Pathway Template (B)

This is shown here with questions to be addressed.

RESILIENCE DOMAIN MAPPING	***Scope***	***Functional level: ('problem-fix resilience')***	***Synergistic / cognitive level: ('transformative resilience')***
General systems		*Disaster recovery & 'bounce-back'*	*Transformative adaptation & societal 'bounce forward'*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	*Who are the key actors in 'fixing the problem'?* *Everyone*	*Who are the key actors in 'transformative resilience'?*
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	*What are the key technical solutions to fix the problem?* *Risk information, Flood alert* *Upper stream water retainment*	*What are the most transformative **socio**-technical innovations?* *Awareness and education*
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	*Which ecological-climatic problems can be best fixed?* *real-time monitoring* *Low-carbon emission* *Climate adaptation*	*Which **socio**-ecological-climatic transformations are most effective?*
Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	*What / how much are the direct economic investments / benefits?*	*What / how much are the systemic economic investments / benefits?*
Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil society partnerships & community*	*How can the government / policies fix the direct risk / vulnerability?*	*How can societal-governance systems help transformative resilience?* *Change the way how performance of the government and research are evaluated. Give more credits on the real impacts, on the prevention rather than the hero in the rescue.*
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	*Community engagement*	*How can cultural worldviews help in transformative resilience?* *Stories successful and un-successful stories can help more than funding and new legislation*
Urban-rural-spatial	• *Urban areas* • *Housing & construction* • *urban / rural fringe & linkage* • *landscapes & regions* •	*Catchment approach is needed to design the city;* *Policy integration amongst spatial planning, hazard mitigation plan, and catchment plan* *LID design and planning method*	*Enhance Development control*

CAPE TOWN

(focus on the water stress / zero city crisis)

Risk / Vulnerability Template A)

This is shown here with questions to be addressed.

RISK DOMAIN MAPPING:	***Scope***	***Functional level:*** ***(Direct technical risks)***	***Synergistic / cognitive level:*** ***(strategic societal risk-vulnerability)***
General risk		*Which are the key functional risks ('hazard x exposure x vulnerability')*	*Which are the key systemic risks, including multi-level multipliers?*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	*Who is most exposed & vulnerable? (in which social types)* *All but in different ways. Elites can protect themselves. Poor are protected by state.*	*Who are the key players in **socio-political** amplification of risk?* *Multiple actors, (intra)acting in different ways.*
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	*What are the technical issues in this risk / vulnerability?* *Prior reliance on surface water storage*	*What are the **socio**-technical issues in this risk / vulnerability?* *Prior reliance on surface water storage*
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	*Which are the key ecological-climatic problems?* *Drought (meteorological, hydraulic and anthropogenic)*	*Which are the key **socio**-ecological-climatic problems?* *Water demand*
Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	*What & how much are the first order economic risks?* *Uncertain*	*What & how much are the systemic economic risks / vulnerabilities?* *Uncertain*
Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil partnerships & community*	*How is the government / policies part of the risk / vulnerability?* *Traditional approaches to water governance.* *Fragmentation across governance spheres and tiers*	*How is the societal-governance system part of the risk / vulnerability?* *Fragmentation across governance spheres and tiers* *Prevalence of individual responses (although this is also a marker of reducing system-level vulnerability)*
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	*How are cultural perceptions & worldviews part of the problem?* *?*	*How are cultural worldviews part of the societal risk-vulnerability?* *?*
Urban-rural-spatial	• *Urban areas* • *Housing & construction ,* • *urban / rural fringe & linkage* • *landscapes & regions* •	*Where are the key locations at most direct risk?* *Not readily discernable*	*Where are the strategic locations for societal risk / vulnerability? (e.g. upstream & downstream)* *Not readily discernable.*

Resilience / Pathway Template (B)

This is shown here with questions to be addressed.

RESILIENCE DOMAIN MAPPING	***Scope***	***Functional level: ('problem-fix resilience')***	***Synergistic / cognitive level: ('transformative resilience')***
General systems		*Disaster recovery & 'bounce-back'*	*Transformative adaptation & societal 'bounce forward'*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	*Who are the key actors in 'fixing the problem'?* *All, but question of engagement*	*Who are the key actors in 'transformative resilience'?* *All, but question of engagement*
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	*What are the key technical solutions to fix the problem?* *Multiple*	*What are the most transformative **socio**-technical innovations?* *??*
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	*Which ecological-climatic problems can be best fixed?* *??*	*Which **socio**-ecological-climatic transformations are most effective?* *??*
Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	*What / how much are the direct economic investments / benefits?* *??*	*What / how much are the systemic economic investments / benefits?* *??*
Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil society partnerships & community*	*How can the government / policies fix the direct risk / vulnerability?* *Too simplistic to take this view.*	*How can societal-governance systems help transformative resilience?* *Complex*
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	*How can cultural perceptions & worldviews help the problem?* *??*	*How can cultural worldviews help in transformative resilience?* *??*
Urban-rural-spatial	• *Urban areas* • *Housing & construction* • *urban / rural fringe & linkage* • *landscapes & regions* •	*Where are the key locations for direct response & recovery?* *??*	*Where are the strategic locations for societal transformative resilience?* *??*

PUERTO RICO

Risk / vulnerability template A)

RISK DOMAIN MAPPING:	***Scope***	***Functional level:*** ***(Direct technical risks)***	***Synergistic / cognitive level:*** ***(strategic societal risk-vulnerability)***
General risk		*Which are the key functional risks ('hazard x exposure x vulnerability')*	*Which are the key systemic risks, including multi-level multipliers?*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	*Who is most exposed & vulnerable? (in which social types)* *Low-income communities, particularly those living in informal settlements or substandard housing, who face heightened risks due to limited access to resources, inadequate infrastructure, and reduced capacity to cope with and recover from natural disasters and disruptions to the energy and water grids.*	*Who are the key players in **socio-political** amplification of risk?* *Marginalized and disenfranchised communities, often characterized by lower socio-economic status and limited access to political influence, as their concerns regarding environmental justice and resilience tend to be overshadowed by more privileged and politically powerful groups, resulting in uneven resource allocation and decision-making processes that exacerbate vulnerability.*
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	*What are the technical issues in this risk / vulnerability?* *Technical issues encompass the aging and vulnerable state of critical infrastructure, including power grids, water supply systems, transportation networks, and communication systems, all of which are prone to disruption during natural disasters, posing significant challenges to food, energy, and water systems and hampering effective disaster response and recovery efforts.*	*What are the **socio**-technical issues in this risk / vulnerability?* *Complex socio-technical issues that encompass the interplay of different types of critical infrastructure, particularly in terms of communication networks, their ownership and management. These challenges are compounded by inadequate disaster preparednesss and coordination mechanisms, which hinder effective responses to multifaceted crises.*
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	*Which are the key ecological-climatic problems?* *Extreme weather events like hurricanes and flooding, as well as indirect effects like temperature fluctuations, storm intensity, and sea level rise.*	*Which are the key **socio**-ecological-climatic problems?* *Heightened vulnerability due to social inequalities, inadequate disaster preparedness, and limited access to healthcare, emergency services, drinking water and electricity during the extreme events*

Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	*What & how much are the first order economic risks?* *Labor market stability, tax incentives, and infrastructure development (more information is needed and probably more in-depth economic analysis)*	*What & how much are the systemic economic risks / vulnerabilities?* *Government policies, public perception, and societal resilience (more information is needed and probably more in-depth economic analysis)*
Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil partnerships & community*	*How is the government / policies part of the risk / vulnerability?* *Ability to create decentralized solutions (water, energy).* *Potential delays in centralized policies due to the nature of central government.*	*How is the societal-governance system part of the risk / vulnerability?* *Coordination to effectively assess, mitigate, and respond to the unique environmental and socioeconomic risks and vulnerabilities facing the island, ultimately bolstering the resilience of its communities (main goal).*
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	*How are cultural perceptions & worldviews part of the problem?* *The island's unique blend of cultural influences, including Spanish, African, American, and Indigenous Taino traditions, has fostered a deep sense of resilience and self-reliance among its people. Some communities may view foreign technical interventions with scepticism, as they can clash with deeply rooted cultural values of self-sufficiency and community support.*	*How are cultural worldviews part of the societal risk-vulnerability?* *Cultural worldviews deeply intertwine with societal risk-vulnerability by affecting how communities perceive and prioritize environmental risks, such as hurricanes and rising sea levels. These perspectives influence decision-making processes and may hinder or facilitate collective efforts to develop strategic resilience measures. Bridging this gap between traditional worldviews and modern technological solutions is essential for effectively managing direct technical risks in Puerto Rico, as it requires a culturally sensitive and community-driven approach to build trust and ensure the successful implementation of resilience measures.*
Urban-rural-spatial	• *Urban areas* • *Housing & construction ,* • *urban / rural fringe & linkage* • *landscapes & regions* •	*Where are the key locations at most direct risk?* *Urban centers, such as San Juan and Ponce, face significant exposure to direct technical risks due to their dense populations and critical infrastructure. These urban hubs are often at the forefront of hazards like hurricanes, flooding, and seismic activity, making them key locations of immediate concern.* *However, rural areas, especially those in the central mountainous region, are not immune to these risks either. Limited access to resources, healthcare, and emergency services in remote rural areas can exacerbate the impact of disasters, underscoring the need for targeted actions.*	*Where are the strategic locations for societal risk / vulnerability? (e.g. upstream & downstream)* *Urban centers often concentrate critical infrastructure and high population densities, making them vulnerable to cascading societal risks. Additionally, the spatial distribution of these risks extends beyond the urban core, impacting both upstream rural areas that may lack access to essential services and downstream regions susceptible to the amplification of risk factors, highlighting the intricate cognitive mapping necessary for effective strategic risk mitigation across the island.*

Resilience / pathway template (B)

RESILIENCE DOMAIN MAPPING	***Scope***	***Functional level:*** ***('problem-fix resilience')***	***Synergistic / cognitive level:*** ***('transformative resilience')***
General systems		*Disaster recovery & 'bounce-back'*	*Transformative adaptation & societal 'bounce forward'*
Social / community	• *demographics* • *lifestyle & consumption* • *social inequality & vulnerability*	*Who are the key actors in 'fixing the problem'?* *Mostly grassroots organizations and local volunteers who address community challenges and promote resilience in the face of adversity.* *Also, government through programs, however, local organizations still operate as advocates in those programs.*	*Who are the key actors in 'transformative resilience'?* *Grassroots organizations, local government agencies, federal US agencies, educational institutions, and community leaders collaborating synergistically to foster cognitive shifts in disaster preparedness and recovery strategies.*
Technology / infrastructure	• *food energy water systems* • *critical infrastructure, communications*	*What are the key technical solutions to fix the problem?* *Implementation of advanced functional-level monitoring systems that can proactively detect and isolate network or infrastructure issues, enabling rapid problem resolution and minimizing service disruptions.* *Decentralized solutions: microgrids, local aqueducts.*	*What are the most transformative* ***socio****-technical innovations?* *Implementation of community operated and maintained smart systems for critical infrastructure, which leverage advanced artificial intelligence and human-machine collaboration to enhance the resilience and responsiveness of critical infrastructure in the face of natural disasters and other challenges.*
Environment-climate	• *temperature, precipitation, storm, sea level, wildfire, heatwave, drought, landslide:* • *indirect effects*	*Which ecological-climatic problems can be best fixed?* *Restoration and preservation of critical coastal ecosystems such as mangroves and coral reefs stands out as a key strategy to mitigate the impacts of rising sea levels and extreme weather events, while also safeguarding biodiversity*	*Which* ***socio****-ecological-climatic transformations are most effective?* *Prioritize building cognitive resilience through education and community engagement, enabling individuals and communities to adapt and innovate in the face of climate change challenge*
Economic / livelihood	• *Markets & production* • *Enterprise & firms* • *employment & livelihoods* • *investment & value chain*	*What / how much are the direct economic investments / benefits?* *?? – not clear. Maybe, it's possible to say that there are federal US money comes to Puerto Rico through the federal programs.*	*What / how much are the systemic economic investments / benefits?* *?? – again, not very clear, maybe increasing human capital development and adaptability within the workforce*

Political / governance	• *National govt* • *Local govt* • *Public services* • *Emergency services* • *Civil society partnerships & community*	*How can the government / policies fix the direct risk / vulnerability?* *Establishing dedicated government task forces that systematically assess and promptly address infrastructure deficiencies, bureaucratic inefficiencies, and regulatory obstacles, ensuring the island's ability to swiftly respond to crises.*	*How can societal-governance systems help transformative resilience?* *Complex; there are educational programs that empower citizens with the knowledge and skills needed to adapt and innovate.*
Cultural / worldviews	• *Education / communication* • *Attitudes & perceptions*	*How can cultural perceptions & worldviews help the problem?* *There is a strong sense of community, deep appreciation for the island's heritage and history, therefore, the best strategy will be community engagement and work with local leaders and groups with respect and honor or their traditions.*	*How can cultural worldviews help in transformative resilience?* *Nurturing a cognitive level of adaptability, where individuals and communities draw upon their rich cultural heritage and traditional knowledge.*
Urban-rural-spatial	• *Urban areas* • *Housing & construction* • *urban / rural fringe & linkage* • *landscapes & regions* •	*Where are the key locations for direct response & recovery?* *Focus on densely populated urban centers (primarily, San Juan and Ponce), remote rural communities, and critical infrastructure hubs.* *Strategic energy and water management.*	*Where are the strategic locations for societal transformative resilience?* *Community-driven hazard mitigation plans, public private partnerships related to the critical infrastructure.*