PROGRAMME AND PROCEEDINGS

APRU

20TH APRU

MULTI-HAZARDS SYMPOSIUM AND CONFERENCE 2025 (APRU-MH20)

Resilience: Reviews and Projections

Multi-hazard Entanglements of Society, Environment and Technology in Space, Time and Place

UP Bonifacio Global City (UP-BGC) Campus,
Taguig City, PHILIPPINES
26-29 November 2025

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CONFERENCE OVERVIEW

While the Philippines is the number one country in the 2025 World Risk Index due to its location in the Asia Pacific Ring of Fire and Typhoon Belt, the country has been able to improve its performance across the various pillars of disaster risk reduction and management. The Sendai Framework 2023 Midterm Report however concludes that despite many gains in disaster risk reduction over the last 8 years, risk creation continues to outpace risk reduction. This symposium provides a venue for an urgent stocktake of how the country and the rest of the Asia-Pacific region can build upon existing gains and address persisting and emerging challenges through global cross-disciplinary exploration, research and collaboration.

The 20th Multi-hazards Symposium and Conference of the Association of Asia Pacific Rim Universities (APRU-MH20) provides a timely opportunity to assess these developments and explore ways for the Philippines and the broader Asia-Pacific region to consolidate gains, address persistent challenges, and respond to emerging risks through cross-disciplinary research and collaboration. Hosted by the University of the Philippines College of Architecture of Diliman, this landmark event APRU-MH20 took place at the University of the Philippines Bonifacio Global City Campus (UP-BGC) in Taguig, Metro Manila from November 26th to the 29th, 2025.

As we mark two decades of resilience work across the Asia-Pacific, we also look ahead to the challenges of the next twenty years. This event invites participants to help shape the future of resilience research, education, and practice.

As a network of leading universities linking the Americas, Asia, and Australasia, the Association of Pacific Rim Universities (APRU) brings together thought leaders, researchers, and policy-makers to exchange ideas and collaborate on practical solutions to the challenges of the 21st century.

APRU draws on the collective education and research strengths of its member universities to contribute to international public policy. In the post-pandemic era, its strategic priorities include:

1. providing a neutral platform for high-level policy dialogue;
2. exploring innovative solutions for a sustainable future; and
3. supporting diversity, inclusion, and minorities.

APRU's primary activities support these strategic priorities, focusing on critical areas such as disaster risk reduction, women in leadership, indigenous knowledge, virtual student exchange, e-sports, population aging, global health, sustainable cities, artificial intelligence, waste management, and more.

Visit the APRU-MH20 website for more details.

Message

I am honored to welcome you to the 20th APRU Multi-Hazards Symposium 2025 (APRU MH20), hosted by the College of Architecture and the College of Engineering at the University of the Philippines Diliman.

The APRU Multi-Hazards Program was initiated in 2013 as a trans-Pacific network of scientists, practitioners, and policymakers with the objective to address the complex challenges of natural disasters. It has harnessed the collective capabilities of APRU universities for cutting-edge research on climate-related hazards and disaster risk reduction. Over the past 12 years, this program has been outstandingly successful, and we are proud of our partnership and the impact it continues to have across the region.

This year's symposium theme, "Resilience Reviews and Projections: Multi- Hazard Entanglements of Society, Environment, and Technology in Space, Time and Place," invites us to reflect deeply on the evolving nature of risk and resilience. The interconnectedness of risks and the resulting complexity of disaster response and resilience across multiple sectors of society are a recurrent insight of recent disaster science. Disaster resilience strategies need to take a comprehensive, all-sector approach to natural hazards in the context of a changing climate and rapidly growing populations and economies.

International cooperation is essential in this endeavor. The APRU MH20 convenes leading voices from academia, government, civil society, and industry to exchange current scholarship and practice on multi-hazard response and disaster mitigation. It is through these cross-sector and cross-border engagements that we can co-create resilient systems and equitable solutions.

Universities and research institutions play a pivotal role in this process. As hubs of innovation and education, they are uniquely positioned to generate evidence-based insights, train future leaders, and engage communities in building preparedness and resilience.

We are deeply grateful to the University of the Philippines Diliman, especially Dr. Luis Maria Bo-ot (Dean, College of Architecture), Dr. Maria Antonia Tanchuling (Dean, College of Engineering), Dr. Carmen Bettina Bulaong, and Mr. Leonido Gines, Jr., for their dedication and vision in hosting this landmark event. I also extend my sincere thanks to APRU Multi-Hazards Program Director Prof. Izumi Takako from the International Research Institute of Disaster Science (IRIDeS) at Tohoku University, and the Advisory Group for their continued leadership and support.

I hope this symposium inspires new partnerships, bold ideas, and renewed commitment to building a safer and more resilient world for all.

Prof. Thomas Schneider, PhD
Chief Executive
Association of Pacific Rim Universities (APRU)

Message

Warm greetings to all participants, organizers, and partners of the 20th APRU Multi-Hazards Symposium and Conference 2025!

On behalf of the University of the Philippines, I welcome you to our Bonifacio Global City campus as we mark two decades of scholarship and action on disaster risk reduction and resilience across the Pacific Rim. UP Diliman is honored to serve as the Secretariat of this milestone gathering, which brings together researchers, practitioners, policy makers, and advocates from every corner of the Asia-Pacific and beyond.

The Philippines, situated along the Typhoon Belt and the Pacific Ring of Fire, is no stranger to complex disasters. We top the World Risk Index not by choice but by geography. Yet this very reality has strengthened our resolve to understand hazards, reduce risk, and share lessons with the world. The 2023 Midterm Review of the Sendai Framework reminds us that while we have made gains in disaster risk reduction, the creation of new risks still outpaces our capacity to reduce them. This symposium—with its 90 academic papers, 18 poster presentations, and countless conversations—offers an urgent venue for taking stock, learning from each other, and charting the next twenty years of multi-hazard collaboration.

Universities have a unique responsibility in this global effort. We hold vast troves of knowledge and generate new insights every day. But knowledge locked in libraries or behind paywalls cannot save lives.

At UP we have sought to break those walls: through our Resilience Institute, which works directly with local communities on multisectoral and anticipatory development planning; through open-data policies that share what we learn; and through transdisciplinary research that invites citizens, scientists, architects, engineers, and social advocates to stand on equal footing. We know we must get our feet wet and our hands dirty before our laboratories and libraries are themselves under water.

This work is inseparable from the broader struggle for climate justice. Disasters do not fall evenly; they magnify existing inequalities. A truly resilient future demands that the most vulnerable—whether indigenous peoples, coastal communities, or those whose livelihoods depend on fossil-fuel economies—are empowered to demand accountability and to shape a just transition. Our green transformation must create more jobs, better lives, and healthier ecosystems, ensuring that every element of the intricate web of biodiversity is protected.

The Association of Pacific Rim Universities provides an essential platform for this endeavor. By linking the Americas, Asia, and Australasia, APRU enables the exchange of ideas and the forging of solutions that no single nation or discipline could achieve alone. Your presence here affirms that while hazards may be local, resilience is a global project.

Let this 20th anniversary be more than a commemoration. May it be a shared commitment, a collective promise to act with wisdom, courage, and solidarity. Together, let us transform knowledge into action, and action into a safer, more just, and more sustainable world.

Welcome to Manila. Welcome to the University of the Philippines.
Welcome to the APRU-MH20.

Atty. Angelo A. Jimenez
President
University of the Philippines

Message

It is an honor for the University of the Philippines to host the 20th Association of Pacific Rim Universities (APRU) Multi-Hazard Symposium and Conference. I extend my appreciation to our distinguished partners and participants, including APRU CEO Dr. Thomas Schneider; Professor Takako Izumi, Program Leader of the APRU Multi-Hazards Program; representatives from the Department of Foreign Affairs; officials of the UP System and UP Diliman; and the leadership of the College of Architecture and College of Engineering. I likewise acknowledge our keynote speakers—Prof. Jeffrey Hou, Ms. Bea Tulagan, Hon. Alfredo Coro II, and Mr. Dominic Ligot—as well as colleagues from universities, government agencies, and organizations in the Philippines and abroad who have contributed to this year's gathering.

This symposium provides an important opportunity to reflect on the multi-hazard realities that increasingly define our shared future. The complexity of climate change, geopolitical realignments, socioeconomic disparities, emerging health risks, and the intensifying pressures on our natural environment demands both interdisciplinary approaches and transdisciplinary collaboration. The theme of MH20 captures this imperative and situates the discussions within the broader work of resilience-building across landscapes, communities, and institutions.

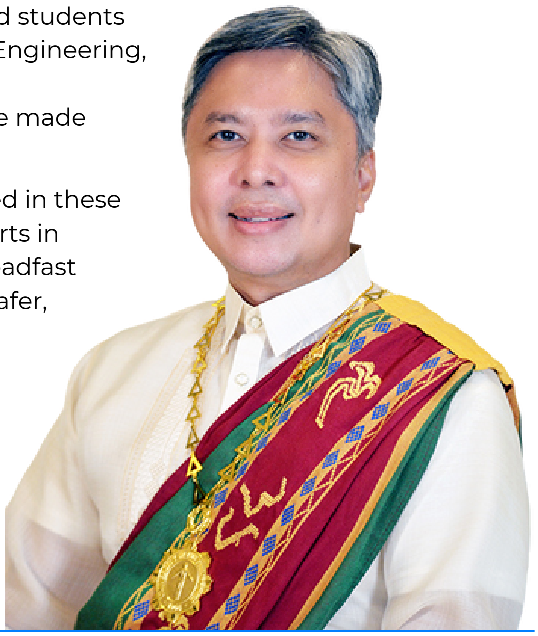
As the sole APRU member institution from the Philippines, the University of the Philippines remains committed to advancing the consortium's programs. Recent years have seen UP host the APRU Sustainable Cities and Landscapes Symposium, and in the coming year the University will serve as host of the APRU Presidents' Meeting. MH20 continues this trajectory, providing a platform for dialogue among scholars, researchers, practitioners, graduate students, advocates, and policymakers from across the Asia-Pacific. The conference also creates space for Filipino researchers to share their work and participate in global conversations on disaster risk reduction and resilience.

The Philippines' own multi-hazard context underscores the urgency of this work. In a span of a few months, the country has experienced destructive typhoons, earthquakes, and extreme rainfall events, alongside heightened public attention on corruption in flood control and engineering projects. While the nation has made significant progress—such as institutionalizing disaster risk reduction offices at the local level, strengthening preparedness efforts, and expanding hazard monitoring tools like the UP Resilience Institute's Project NOAH—major challenges remain. The recent drop in the Philippines' Climate Change Performance Index ranking highlights the scale of work ahead. Addressing governance failures, strengthening infrastructure systems, and reducing social and economic vulnerabilities are essential in safeguarding lives and ensuring long-term resilience.

This context makes the leadership of the UP College of Architecture and the College of Engineering particularly meaningful. Both units continue to integrate resilience thinking into the training of architects, landscape architects, engineers, and planners, and into research that bridges academic work with real-world applications. Their commitment to sustainable and nature-based solutions reflects a growing shift in professional practice—one necessary to meet the challenges of our rapidly changing risk landscape.

I extend my sincere appreciation to the faculty, staff, researchers, and students of the UP College of Architecture who, together with the College of Engineering, have worked diligently to organize this symposium and prepare this proceedings volume. Their dedicated efforts over many months have made MH20 possible.

It is my hope that the ideas, analyses, and collaborations documented in these proceedings will contribute meaningfully to regional and global efforts in multi-hazard resilience. The University of the Philippines remains steadfast in supporting scholarship, innovation, and collective action toward safer, more sustainable, and more equitable futures for all.



Atty. Edgardo Carlo L. Vistan II
Chancellor
University of the Philippines Diliman

Message

I would like to welcome all of you to the 20th APRU Multi-Hazards Annual Symposium, hosted by the University of the Philippines Diliman. First of all, I would like to express my sincere appreciation to the symposium organizing committee, especially Prof. Leonido M. Gines, Jr. and Dean Luis Maria T. Bo-ot, for their leadership, hard work, and extraordinary efforts in making this event possible. We could not have organized this vital event without their dedication and commitment.

I would also like to extend my heartfelt gratitude to all the participants and presenters. It is truly a privilege to listen to your presentations and to view the posters that showcase your significant research efforts and achievements.

This proceedings volume compiles the abstracts of papers presented at the symposium, which address essential topics and offer innovative ideas in Disaster Risk Reduction (DRR). We are constantly reminded—almost every day—of the increasing frequency and impact of various hazards: natural, technological, biological, human-induced, and environmental. The need for DRR research and practice is greater than ever, particularly in harnessing science, technology, big data, and AI to better understand and manage risks.

The academic community plays an indispensable role in deepening our understanding of risks, identifying effective mitigation measures, and advancing response and recovery strategies. The diversity and complexity of hazards confronting society continue to expand—extending beyond natural hazards to include technological, biological, and human-induced threats. Moreover, the growing prevalence of compound and cascading hazards poses new and formidable challenges for researchers and practitioners alike.

Confronting these multifaceted risks requires collective wisdom and shared action. It is therefore essential that we learn from one another, exchange knowledge and experiences, and promote collaborative research and partnerships across disciplines, sectors, and regions.

I sincerely hope that this symposium, together with the ongoing efforts of the APRU Multi-Hazards Program, will serve as a meaningful platform to strengthen our network, foster new collaborations, and further advance our shared goal of building resilient and sustainable societies for the future.

Prof. Takako Izumi, PhD
International Research Institute of Disaster Science (IRIDeS),
Tohoku University
Program Director, APRU Multi-Hazards Program

Message

As we speak, the world is challenged not only by political and economic divisions but by environmental phenomena manifesting themselves as personally life-threatening and felt by all the divisions implying impact to society way into the coming years. The 20th Association of Pacific Rim Universities Multi Hazard Symposium and Conference, or APRU-MH20, is equally necessary and timely to recollect on the visions and plans for disaster response and resilience as they were two decades ago, and to adjust accordingly to what are being experienced, being studied and being discussed. This is the spirit behind the APRU-MH20 theme of Resilience Review and Projections: Multi-hazard entanglements of society, environment and technology in space, time and place.

The main goal of organizing APRU-MH20 is to share and enhance the knowledge of every participant in disaster resilience, the anticipation and the preparation for the mitigation of the effects of disasters. We are given a good opportunity as those who have a keen interest in disaster resilience to share their ideas and practices to facilitate an update of ideas and practices, at the same time expose various novel ideas.

Through a cross-disciplinary weave of plenary speakers, paper presentations in parallel sessions, poster presentations, special topical sessions, and both formal and informal fora which include a side event involving Philippine professional organizations and an exhibit featuring artistic interpretations from real vulnerable members of the population as a response to their needs and thoughts when faced with disaster, APRU-MH20 provides a dynamic platform where recollection meet innovation, and the divisions transform into connections.

I thank the APRU-MH20 committees for extending their valuable time in organizing the program and to all the authors, reviewers, and other contributors for their efforts and their belief in APRU-MH20.

I welcome the participants and guests of APRU-MH20!

Mabuhay!

Prof. Luis Maria T. Bo-ot PhD
Convenor, APRU-MH20
Dean, UP Diliman College of Architecture

CONFERENCE PROGRAM

NOVEMBER 26, 2025 (WEDNESDAY)

8:00 - 9:00 AM	Registration for Resilience Advocacy Fair
9:00 - 9:20 AM	**Opening Program**
	National Anthem & UAP Credo Opening Remarks **Ar. Rachelle Lea Manuel** President, UAP Diliman Welcome Remarks **Asst. Prof. Richard Martin Rinen** Director, UP System Office of Design and Planning Initiatives (ODPI)
9:20 AM - 12:00 NN	**Advocacy Fair**
	Introduction of Participants Rights of Nature: Challenging the “human-nature” relationship **Yolanda Esguerra** National Coordinator, Philippine-Misereor Partnership Inc., *in collaboration with **Ar. Arlene Lusterio*** Ending the Age of Plastic **Marian Ledesma** Zero Waste Campaigner, Greenpeace Southeast Asia - Philippines Enhancing urban Resilience with High-Quality Walking & Cycling Infrastructure **Robert Siy PhD** Urban Planner, Transport Economist, and Co-Convenor of Move As One Yes to pasig River - No to PAREX Talk Back **Joven Jacolbia & Jayson Villeza** Ilog Pasiglahin Social Science Session **Dr. Pamela Cajilig, Dr. Recio & Dr. Chester Arcilla**
10:00 AM - 5:00 PM	Registration for APRU-MH20
12:00NN - 1:00 PM	Lunch
1:00 - 3:30 PM	**Debate - “Is sustainable development achievable when people are in survival mode?”**
	Discussants: **Mr. Alec Buenaventura, PMPI** **Ar. Ray Saulo, Sustainability Architect** **Atty. Grip Bueta, Environmental Lawyer** **Ar. Pablo Suarez, Sustainability Architect** **Ar./EnP. Dinky von Einsiedel PhD** **Ar./EnP. Armando Alli** Reactor: **Ar. Armin Sarthou** Rapporteur: **Asst. Prof. Marie Edraline Belga & UPCA Students**
1:00 - 4:30 PM	CAREscape Exhibition Viewing
3:30 - 3:40 PM	Break

CONFERENCE PROGRAM

NOVEMBER 26, 2025 (WEDNESDAY)

3:40 - 3:45 PM	**Reading of Manifesto on Designing and Advocating for Resilience of Communities to Multi-Hazards**
	Asst. Prof. Leonido Gines, Jr. Extension Program Director, UP Diliman College of Architecture
3:45 - 3:55 PM	**Signing of Manifesto by Speakers, Professional Organizations and Advocacy Groups and Presentation of Certificates of Appreciations**
3:55 - 4:00 PM	Closing Remarks
	LAr. Norman June Brito President, Philippine Association of Landscape Architects
5:00 - 8:00 PM	**APRU-MH20 Welcome Reception**
	Musical Call to Order UP Diliman College of Music Welcome Greetings **Asst. Prof. Diomari Centeno** Opening Remarks **Asst. Prof. Leonido Gines, Jr.** Program Committee Head, APRU-MH20 Message from CAREscapes Project Exhibit **Dr. Pamela Cajilig** CAREscapes Project Co-Leader Cultural Presentation UP Diliman College of Music Toast **Asst. Prof. Richard Martin Rinen** Project Leader, APRU-MH20 Closing Notes and Reminders **Asst. Prof. Diomari Centeno** APRU-MH20 Welcome Cocktails and Fellowship

CONFERENCE PROGRAM

NOVEMBER 27, 2025 (THURSDAY)

7:30 - 8:30 AM	Registration
8:30 - 9:15 AM	**Opening Program**
	Welcome Greetings **Asst. Prof. Jaclyn Alexandra Marie Brillantes-Bello** **Ar. Miguel Francisco Sebastian III** Philippine National Anthem Philippine Madrigal Singers Mark Anthony Carpio, Choirmaster Opening Remarks **Prof. Luis Maria Bo-ot, PhD** Dean, UP Diliman College of Architecture; Convenor, APRU-MH20 Video Message from APRU **Dr. Thomas Schneider** Chief Executive, APRU APRU Org Multi-Hazards Speech **Dr. Takako Izumi** Program Director, APRU Multi-Hazards Message from UP Diliman Chancellor **Atty. Edgardo Carlo L. Vistan II** Chancellor, University of the Philippines Diliman Festive Welcome Song Philippine Madrigal Singers Mark Anthony Carpio, Choirmaster
9:15 - 10:00 AM	Plenary Session 1
	Civic Resilience **Prof. Jeffrey Hou**
10:00 - 10:45 AM	Plenary Session 2
	Solidarity Ecologies: Regenerative Organizing, Solidarity Practices, and Community Resilience Amidst Social and Climate Shocks **Ms. Beatrice Tulagan**
10:45 - 11:00 AM	Wellness Break
11:00 AM - 12:15 PM	**Parallel Session 1**
	1A - Intersectionality 1B - Designing for Resilience 1C - Heritage Environments 1D - Policy and Governance
12:15 - 1:15 PM	Lunch
1:15 - 2:30 PM	**Parallel Session 2**
	2A - Intersectionality 2B - Designing for Resilience 2C - Heritage Environments 2D - Policy and Governance

CONFERENCE PROGRAM

NOVEMBER 27, 2025 (THURSDAY)

2:30 - 3:45 PM	**Parallel Session 3**
	3A - Intersectionality 3B - Designing for Resilience 3C - Heritage Environments & Climate Justice 3D - Policy and Governance
3:45 - 4:00 PM	Wellness Break
4:00 - 5:00 PM	Special Session
	Unraveling the Layers and Drivers of Community Resilience around Mayon Volcano **Dr. Lauriane Chardot, Katrina Jacinto, Felix Galistan** **Moderator: Dr. Pamela Cajilig**
5:00 - 7:00 PM	Poster Presentation
5:00 - 7:00 PM	Special Parallel Session
	Nature-based Solutions for Urban Resilience in the Anthropocene (NATURA) **Dr. Erich Wolff, Dr. Pamela Cajilig, Prof. Yeowon Kim, Annemie Rose Janssen**

NOVEMBER 28, 2025 (FRIDAY)

7:30 - 8:30 AM	Registration
8:30 - 8:35 AM	**Opening Program**
	Welcome Greetings **Asst. Prof. Maria Faith Varona PhD**
8:35 - 9:15 AM	Plenary Session 3
	Achieving Sustainable Development Goals in a Municipal Local Government: The Del Carmen Experience **Mayor Alfredo M. Coro II**
9:15 - 10:00 AM	Plenary Session 4
	AI in Climate and Disaster Resilience **Mr. Dominic Ligot**
10:00 - 10:15 AM	Wellness Break
10:15 - 11:15 AM	APRU Organization Session
11:15 AM - 12:30 PM	**Parallel Session 4**
	4A - Citizen Science 4B - Resilient Design & Technology 4C - Measurement of Resilience 4D - Resilient Design & Technology
12:30 - 1:30 PM	Lunch

CONFERENCE PROGRAM

NOVEMBER 28, 2025 (FRIDAY)

1:30 - 2:45 PM	**Parallel Session 5**
	5A - Citizen Science 5B - Resilient Design & Technology 5C - Complex Disasters 5D - Designing for Resilience
2:45 - 4:00 PM	**Special Parallel Session**
	ICOMOS International Scientific Committee on Risk Preparedness
2:45 - 4:00 PM	Poster Viewing
4:00 - 4:15 PM	Wellness Break
4:15 - 5:30 PM	Special Plenary Session
	From Interactions to Integrations: Innovations and Multi-Hazard Assessment and Management **Moderator: Dr. Alfredo Mahar Francisco Lagmay**
5:00 - 7:00 PM	Poster Presentation
5:30 - 6:00 PM	Travel to SPACE @ OneAyala
6:00 - 9:00 PM	**Closing Dinner**
	Opening Performance UP Diliman College of Music Welcome Greetings Asst. Prof. Norman June Brito Asst. Prof. Maria Vio Bianca Yumikura Opening Remarks **Prof. Maria Antonia Tanchuling PhD** Dean, UP Diliman College of Engineering; Co-convenor, APRU-MH20 Dinner Awards & Recognition **Assoc. Prof. Carmen Bettina Bulaong PhD** Scientific Committee Head, APRU-MH20 **Prof. Luis Maria Bo-ot PhD** Dean, UP Diliman College of Architecture; Convenor, APRU-MH20 **Prof. Maria Antonia Tanchuling PhD** Dean, UP Diliman College of Engineering; Co-convenor, APRU-MH20 **Prof. Benjamin Zhou** Program Manager, APRU Toast **Prof. Luis Maria T. Bo-ot PhD** Convenor, APRU-MH20 Closing Message **Asst. Prof. Leonido Gines, Jr.** Program Committee Head, APRU-MH20 Mini Concert UP Diliman College of Music Fellowship and Networking

CONFERENCE PROGRAM

NOVEMBER 29, 2025 (SATURDAY)

8:00 - 8:30 AM	Registration
8:30 - 10:00 AM	**Tour of Urban Flood Mitigation Systems**
	BGC Flood Control Tunnel, Burgos Circle
10:00 - 10:15 AM	**Guided Walk**
	BGC High Street Walk
10:15 - 11:30 AM	**Cultural and Architectural Immersion**
	Metropolitan Museum of Manila, MK Tan Centre 30th Street, BGC
11:30 AM - 12:30 NN	Travel to UP Diliman
12:30 NN - 1:30 PM	Lunch
	UP College of Architecture
1:30 - 3:30 PM	**Tour on Disaster Preparedness, Climate Adaptation, and Community Resilience Initiatives**
	UP Resilience Institute
3:30 - 4:30 PM	Travel back to UP BGC

PLENARY SPEAKERS

Civic Resilience

Prof. Jeffrey Hou

Provost's Chair
Department of Architecture
College of Design and Engineering
National University of Singapore

Jeff Hou, PhD, FASLA, is Provost's Chair Professor and Head of the Department of Architecture at the National University of Singapore. His work focuses on community design, civic engagement, public space for democracy, and empowerment of marginalized communities. In a career that spans the Pacific, Hou worked with indigenous tribes, farmers, fishers, and villagers in Asia and inner-city immigrant youths and elders in North America on projects ranging from wildlife conservation to bottom-up community placemaking. Before joining NUS, he was Professor of Landscape Architecture and director of the Urban Commons Lab at the University of Washington, Seattle.

Solidarity Ecologies: Regenerative Organizing, Solidarity Practices, and Community Resilience Amidst Social and Climate Shocks

Ms. Beatrice Tulagan

Co-Founder, Tala Storytelling Collective
Former Associate Director of Network Development 350.org

Beatrice Tulagan is a Filipina writer, poet, organizer & movement-building strategist with over a decade of experience organizing & storytelling with global climate justice non-profits. She is the co-founder of tala storytelling collective, a narratives studio guided by brave storytelling and joyful world-building. Tala supports mission-driven collectives with mapping narratives that uphold unjust power structures, imagining counter-narratives for justice, storytelling workshops, building skills on narrative analysis and strategy, intersectional campaign development, and leading creative interventions.

Beatrice has led the design and facilitation of various international trainings and convenings for more than a thousand activists, leaders and advocates from over 50 countries over the past decade. She has guest lectured at universities, Asian non-profit forums, United Nations side events, and other international summits on climate, gender, and social justice.

Beatrice holds an Executive Certificate in Nonprofit Leadership from the Harvard Kennedy School. She was also a former member of the Philippine National Delegation to the United Nations Framework Convention on Climate Change negotiations and was a UNDP Philippines Youth Advocate for Climate Change during COP 20. She was a fellow of Parabukas, FRIDA: The Young Feminist Fund, and Climate Tracker.

PLENARY SPEAKERS

Achieving Sustainable Development Goals in a Municipal Local Government: The Del Carmen Experience

Hon. Alfredo M. Coro II

Municipal Mayor
Municipality of Del Carmen
Siargao Islands, Philippines

Hon. Alfredo Matugas Coro II has dedicated much of his life to public service, serving a total of nine years as Municipal Mayor of Del Carmen in Siargao Islands, with an earlier three-year term as Vice Mayor, and currently serving once again as Mayor. Under his leadership, Del Carmen and the greater Siargao Islands have undergone a remarkable transformation through an environmentally balanced and community-based development approach, earning recognition from both national and international organizations. Beyond his public role, he considers himself a father first and a public servant second. His innovative governance has earned him numerous accolades, including the prestigious Galing Pook Award in 2023 and 2018 for public service innovation, the 2022 Most Impactful Island Innovation Ambassador award from the Island Innovation Awards, and recognition as one of the 50 Faces of Exchange by the U.S. Embassy in the Philippines in 2021. Additionally, the municipality has consistently received the Seal of Good Local Governance (2016–2018, 2022–2024) and was recognized by the Social Innovation for Health Initiative.

AI in Climate and Disaster Resilience

Mr. Dominic “Doc” Vincent Ligot

Founder
CirroLytix

Dominic “Doc” Ligot is one of the leading voices in artificial intelligence in the Philippines, known for his pioneering work in AI ethics, responsible AI adoption, and social impact through data. A technologist, data scientist, and entrepreneur with nearly three decades of experience, his work spans finance, public health, human rights, food security, and combating disinformation.

He is the founder of CirroLytix, an award winning social impact AI training and consulting company, and AI and Data Ethics PH, an advocacy community tackling the societal implications of data and AI. He also serves as Chair of AI Ethics and Safety at the Philippine AI Business Association.

Doc has been extensively cited in local and global media outlets including The Economist, South China Morning Post, Washington Post, and Agence France Presse for his expertise in AI and data governance. His award-winning work has been recognized and published by prestigious organizations such as NASA, Data.org, Digital Public Goods Alliance, the Group on Earth Observations (GEO), the United Nations Development Programme (UNDP), the World Health Organization (WHO), and UNICEF. He was also instrumental in leading Project SPARTA, a nationwide data science education initiative in the Philippines.

EXTENDED ABSTRACTS

PARALLEL SESSION 1A

INTERSECTIONALITY

Session Moderator: Maria F. Mangahas PhD

Disaster Risk, Institutional Trust, and Civic Engagement: Evidence from the Philippines

Lawrence Velasco
Lee Kuan Yew School of Public Policy, National University of Singapore

Disaster Risk, Institutional Trust, Fiscal Capacity and Civic Engagement: The Case of the Philippines

Lawrence Velasco[1]

I. INTRODUCTION

Climate-induced disasters are intensifying globally, with climate change projections suggesting an accelerating frequency and intensity of environmental shocks (IPCC, 2021). Between 2010 and 2019, 3,880 disaster events affected 1.7 billion people worldwide, a toll triple that of the 1980s (CRED, 2020). Yet a fundamental puzzle persists in disaster politics: identical environmental shocks often produce dramatically different political responses across affected communities. This inconsistency suggests that disaster effects on political engagement are highly contingent on contextual factors rather than universally mobilising or demobilising.

This study develops and tests a service substitution theory centred on institutional capacity: local government fiscal ability to deliver effective disaster response fundamentally shapes whether environmental shocks translate into political mobilisation. When local governments possess sufficient fiscal resources, they address grievances that would otherwise trigger political participation. Citizens whose needs are met through effective service delivery have less incentive to engage in costly political action. Conversely, when governments lack fiscal capacity, disasters create urgent unmet needs that trigger mobilisation as citizens demand action, organise mutual aid, or seek external intervention. Government capacity thus acts as a political buffer, either absorbing or amplifying the participatory consequences of environmental shocks.

II. METHODS AND DATA

We test this framework using data from the Philippines, a strategic case offering frequent typhoon exposure, decentralised governance making local fiscal capacity salient, dramatic variation in municipal fiscal resources, and conditions prevalent across much of the developing world where disaster risk is concentrated. The analysis employs multilevel regression on 1,196 respondents from the World Values Survey Wave 7 (Haerpfer et al., 2022) across 60 municipalities exposed to varying typhoon intensities between 2009 and 2018, linked to predetermined fiscal capacity measures from 2009-2012. We use log-transformed disaster exposure to account for diminishing marginal effects and examine three dimensions of civic engagement: institutionalised influence (voting, contacting officials), collective pressure (protests, petitions), and social engagement (organisational memberships).

III. KEY FINDINGS

The analysis yields four main findings that advance disaster politics theory. First, disasters significantly increase citizen action through institutionalised influence by 9% and collective pressure by 19%, while leaving social engagement unchanged—demonstrating selective mobilisation of instrumental political channels rather than general social disruption. Second, local fiscal capacity substantially moderates these effects: in fiscally weak municipalities, typhoon exposure associates with a 20% increase in mobilisation; in fiscally capable municipalities, the increase is muted to 8%—a 2.5-fold difference demonstrating that government capacity substitutes for political mobilisation. Third, compositional analysis reveals strategic channel selection: citizens shift toward formal politics when government is capable and toward contentious politics when government is weak, indicating purposive reallocation of

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civic effort based on institutional responsiveness. Fourth, heterogeneity analysis shows fiscal buffering concentrates among vulnerable populations while amplifying elite mobilisation, suggesting capacity serves dual functions—providing stability for the masses and enabling accountability for elites.

V. CONCLUSION

These findings advance understanding of disaster politics by demonstrating that institutional capacity fundamentally shapes how environmental shocks translate into political behaviour. The service substitution mechanism operates primarily among vulnerable populations dependent on government services, while producing the opposite effect among elites engaged in accountability politics when the government has the resources to monitor. This creates a fiscal capacity regime providing broad-based political stability while potentially increasing oversight pressure from affluent citizens—a progressive form of governance with important implications for democratic quality.

Keywords: natural hazards, civic engagement, fiscal capacity, state capacity, political mobilization, Philippines, disaster politics, climate change

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EXTENDED ABSTRACTS

PARALLEL SESSION 1B

DESIGNING FOR RESILIENCE

Session Moderator: Nappy L. Navarra D. Eng.

Fabulation and the Architecture of Survival: Speculative Fiction as Method in *Maynila in Manila.*

Harvey A. Vasquez
De La Salle-College of Saint Benilde

Characterization of Building Envelope Impacts of Climate Change on Thermal Performance of the In-City Resettlement Housing: The Case of Manggahan Residences, Pasig City

Patrick Nicolas Rodriguez, *John Arvin Manaloto*
College of Architecture, University of the Philippines-Diliman

Evidence-based Flood Response Desktop Drill with "Kiki-kuru: JMA's Real-time Risk Maps"

Kensuke Otsuyama[1], *Takuma Ota[2], Junji Hotta[3], Yasutaka Makihara[1], Kenichi Kuma[1], Hisashi Nakamura[1]*
[1] The University of Tokyo
[2] Meteorological Research Institute, Tsukuba, Japan
[3] Japan Meteorological Agency

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Fabulation and the Architecture of Survival: Speculative Fiction as Method in *Maynila in Manila.*

Harvey A. Vasquez[1]

ABSTRACT

This paper develops research-through-fabulation as an architectural method for designing with multispecies fragility, drawing on insights from Manila. Treating speculative fiction as an epistemic instrument rather than ornament, the presented case study research by the author —Maynila in Manila, a post-Rapture urban laboratory—translates narrative episodes into spatial rules through theoretical cross-reading to situate design claims beyond anthropocentric resilience. From Manila's vantage, the project advances accretive, situated resilience that refuses technocratic "bounce-back" logics by working with ruin, informality, vernacular memory, and spiritual cartographies. The contribution presents a replicable workflow that links speculative narrative to design guidelines, expanding the evidentiary repertoire of architectural research in the post-Anthropocene era and reframing survival as invention across human and more-than-human ecologies.

Keywords: speculative architecture; fabulation; post-Anthropocene; decolonial urbanism; diegetic prototypes.

I. INTRODUCTION

Earth now exceeds six of nine planetary boundaries (Richardson et al., 2023), shifting from stable to unstable regimes. In the Philippines, stacked hazards—heat, typhoons, sea-level rise, and biodiversity loss—converge on coastal and estuarine settlements. Conventional "bounce-back" architecture recenters human control, static objects, and universal solutions; it cannot engage more- than-human agency or layered temporalities.

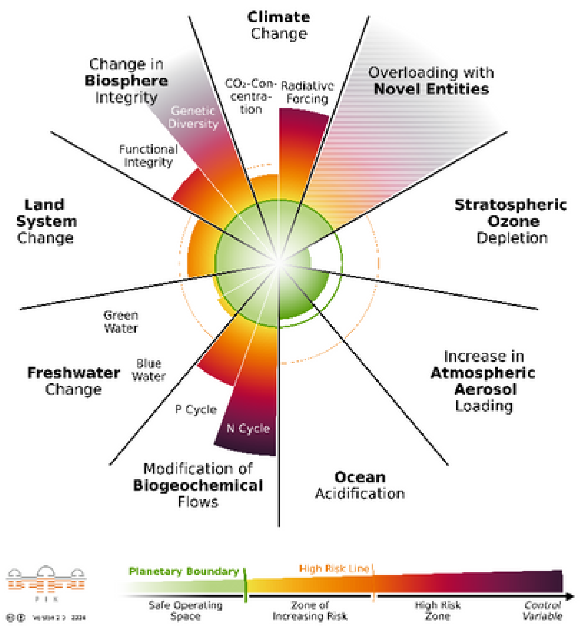

Figure 1. Planetary boundaries 2024 with legend.

Source: Potsdam Institute for Climate Impact Research(PIK), 2025; Wikimedia Commons; licensed CC BY 4.0.

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This paper advances a Manila-rooted alternative: speculative fiction as a method for post-Anthropocene architecture. Drawing on Deleuze via Colebrook and Haraway, using fabulation to assemble situated worlds and test protocols, not just images. The case study research, Maynila in Manila, treats narrative episodes as design experiments, translating them into closed-loop rules (loops, swap-times, easements) for heat, memory, and ritual. The goal is accretive resilience: small, measurable adaptations co-produced with local ecologies, yielding transferable guidelines without erasing context.

II. METHODOLOGY-HYBRID APPROACHES TO POST-ANTHROPOCENE ARCHITECTURE

The use of a practice-based, constructivist method that interweaves speculative fiction, architectural prototyping, and critical theory. **Research-through-fabulation** supplies the engine: based on the author's current novelette draft, the protagonist 1309 acts as a fabulator-relay through whom myth, memory, atmosphere, and ecological ritual coalesce into vignette-prototypes. These scenes are not décor; they are diegetic tests translated into rules. **Design fiction** then materializes the rules as modular habitats, biosynthetic skins, and multispecies care zones; drawings (axonometrics, time-sections, storyboarded plans) function as cognitive scaffolds for behavior and timing. **Theoretical cross-reading** (Deleuze/Colebrook, Haraway, Latour, Likavčan) keeps claims accountable. The hybrid method legitimizes **accretive world-making** as architectural knowledge, foregrounding the Global South, more-than-human resilience.

III. CASE STUDY: *MAYNILA IN MANILA.*

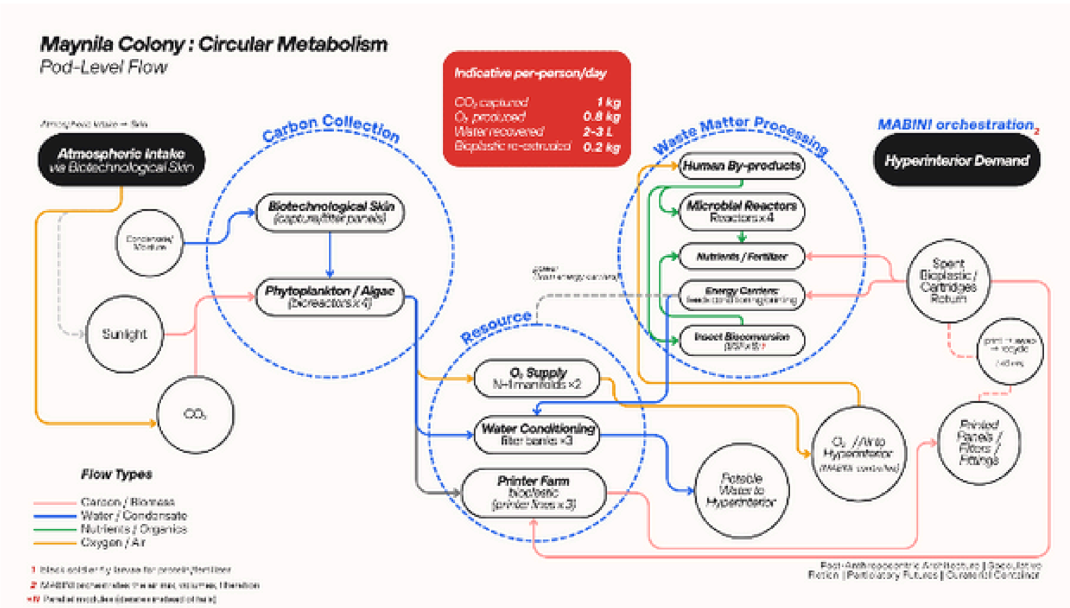

Figure 2. Maynila Colony—Circular Metabolism (pod-level flows)
Source: Author

Maynila in Manila is an experimental design laboratory where fabulation becomes evidence. World-building is translated into rules, material systems, and socio-technical protocols that answer Manila's stacked hazards. The integrated system couples a **three-pod loop** and **hyperinteriors** to keep life within safe thresholds while remaining repairable and distributable.

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Three-pod loop. A co-located metabolism—**Carbon Collection → Resource → Waste-Matter**—closes capture → convert → use → recycle cycles. Biotechnological skins and recon drones ingest carbon-rich air and condensate; micro-algal streams stabilize the atmosphere and feed printer farms that extrude cassettes, housings, and fixtures. Waste bioconversion returns nutrients and pellets, derating under stress rather than failing.

Hyperinteriors. Reconfigurable frames retune volume, air-mix, radiant membranes, and pressure skirts as **scene presets** (assemble, concentrate, rest). By orchestrating time rather than fixed rooms, interiors flatten peak HVAC/filtration loads and keep bodies from crossing dangerous thresholds during storms or toxic plumes.

Transferable protocols.

1. **Loop-first design:** treat cycles—not objects—as units.
2. **<10-minute swaps:** critical filters/cassettes serviceable by two people; log swap times.

Together, these moves deliver **accretive resilience**: small, measurable adaptations—loops closed, swaps fast, fleets composable, corridors provisioned—that cities can localize without erasing context.

IV. CONCLUSION

The paper attempts to reposition speculative fiction from ornament to method, delivering a fabulation → protocol pipeline where drawings operate as diagram-as-protocol. The integrated three-pod loop and hyperinteriors yield a testable standard loop-first design, <10-min swaps, grounded in Manila's hazard cultures and vernacular libraries.

Practically, the work offers replicable grammar for resilience that mainstream frameworks name but rarely operationalize.

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Characterization of Building Envelope Impacts of Climate Change on Thermal Performance of the In-City Resettlement Housing: The Case of Manggahan Residences, Pasig City

Patrick N. Rodriguez[1], John Arvin Manaloto[2]

ABSTRACT

The research addresses the urgent need for thermal resilience in low-income housing amid climate change and multi-hazard risks, with a focus on Manggahan Residences in Pasig City. This urban resettlement project was designed in collaboration with residents through the "People's Plan." The study utilizes on-site environmental measurements and thermal simulations of three five-story apartments within a 15-building complex, collecting data on air temperature and humidity over an eight-week period across six units on three different floors. By analyzing airflow patterns and thermal behavior, the research provides evidence-based insights for creating climate-responsive, thermally resilient housing strategies in tropical developing nations.

Keywords: thermal performance, building envelope, climate resilience, thermal simulation, in-city resettlement housing, indoor thermal monitoring

I. INTRODUCTION

As urban populations grow, multistory housing increasingly accommodates low-income residents in space-limited areas. This vertical resettlement approach improves living conditions through upward expansion, reducing hazard risks while providing affordable housing(Doberstein, 2019). However, thermal comfort concerns are significant in tropical regions, where heat and poor ventilation affect residents' well-being. The building envelope influences thermal performance, and poor design increases heat gain and cooling energy demand. The study examines thermal performance of building envelopes in Manggahan Residences, Pasig City, analyzing how materials, airflow, and solar exposure affect indoor comfort in resettlement housing to improve design efficiency.

II. LITERATURE REVIEW

Thermal performance in resettlement housing is vital for comfort and energy efficiency in tropical climates. This review examines building envelope components' effects on thermal comfort. About 83-87% of heat transfer occurs through envelope components (Iranfar & Al-Din, 2020), with roofs contributing 70.62%, followed by facades and windows (Mansouri & Leila, n.d.). Low-resistance concrete blocks increase indoor temperatures, while reflective materials reduce heat gain; reflective roofs can lower temperatures by 2.2°C (Al-Obaidi et al., 2014). Cool roofs with high solar reflectance reduce annual heat stress by up to 91% in tropical areas, achieving temperature reductions of 2.0°C to 7.0°C (Nutkiewicz et al., 2022).

Optimal thermal comfort requires compact design, moderate roof slope, southeast orientation, and high albedo (Lapisa et al., 2022).Singh Rajput & Thomas (2023)identified key variables including SHGC, window area, orientation, and U-value.

CFD analyzes airflow and thermal comfort, optimizing design and energy efficiency. Studies show cross-ventilation enhances comfort in low-cost housing (Rocha et al., 2023) and predicts wind speeds in warm climates (Tarkhan et al., 2022).

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[2] John Arvin Manaloto is an Associate Professor in the Architecture Program of the University of the Philippines Diliman.

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III. METHODOLOGY

A. Research Design

This study investigates the thermal dynamics of building envelopes in a resettlement housing complex using a quantitative approach. It includes four phases: site selection, data collection, data analysis, and recommendations (Figure 1).

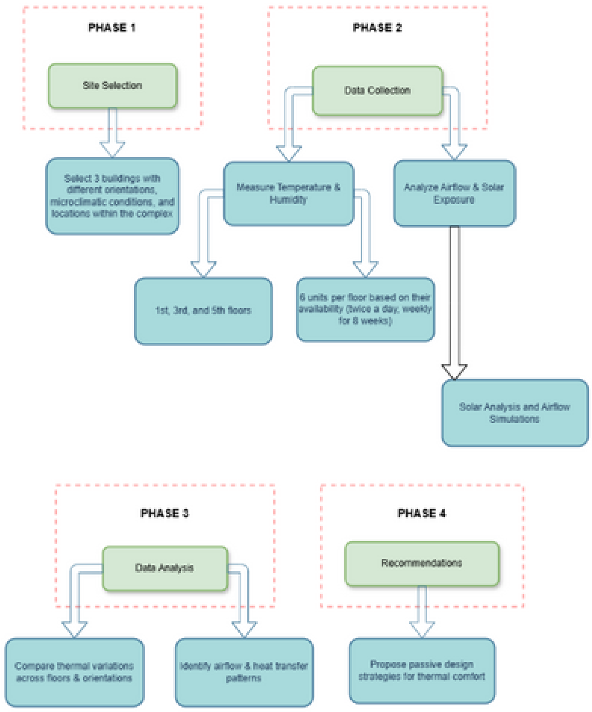

Figure 1. Research design for the case study.

Three buildings were selected for their diverse orientations to analyze thermal conditions related to solar radiation and airflow (Figure 2).

Figure 2. Research design for the case study.
Source: National Housing Authority-PMMDO Technical Unit; edited by the Author

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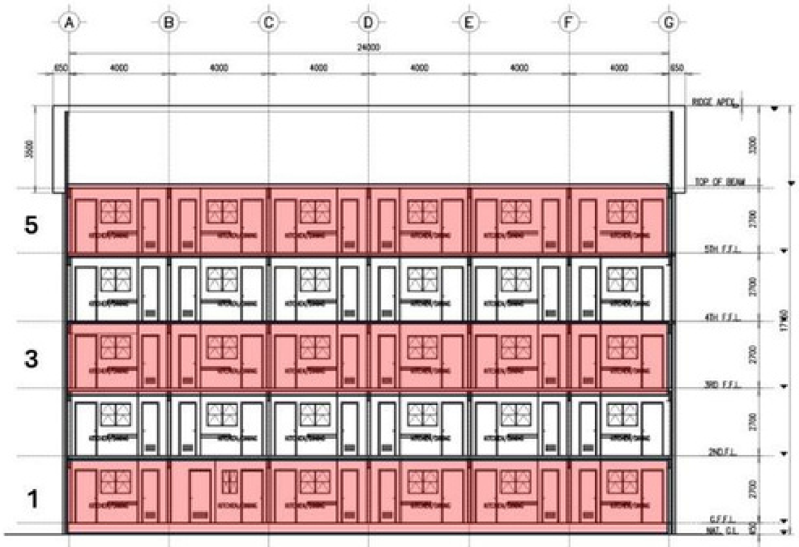

Figure 3. . Research design for the case study.
Source: National Housing Authority-PMMDO Technical Unit; edited by the Author

The 1st, 3rd, and 5th floors of a 5-story building differ in solar exposure, ventilation, and heat transfer due to their thermal envelopes (Figure 3).

Temperature and humidity were recorded twice daily (morning and afternoon) on the 1st, 3rd, and 5th floors over eight weeks to examine short-term variations (Figure 4).

Figure 4. Oria digital thermometer and hygrometer measurement tool.

Simulations of airflow and solar exposure analyzed heat transfer in resettlement housing, guiding passive design for enhanced comfort and energy efficiency.

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IV. DATA RESULTS AND ANALYSIS

A. Building Envelope Materials

The building envelope has poor thermal performance, with a roof U-value of 0.70 W/m²·K (ideal ≤0.11), wall U-values of 2.1 to 2.7 W/m²·K (ideal ≤0.18), and single-pane glass at 3.13 W/m²·K (ideal ≤1.6). High U-values in building materials lead to excessive heat gain and retention, resulting in discomfort for low-income households without access to cooling.

BUILDING ENVELOPE			
COMPONENTS	MATERIAL	U-VALUE (W/m²·K)	THERMAL PERFORMANCE NOTES
Roof	Gauge 26 Long-span metal sheet; pre-painted	0.70 *	Moderately low U-value for metal roofing; may offer some reflectivity but requires insulation to reduce heat gain.
Wall	Uninsulated 6" concrete hollow blocks	2.1-2.7 **	High U-value indicates poor insulation; concrete mass absorbs and re-emits heat, causing thermal lag.
Windows	Single pane of 6.0 mm thick clear glass	3.13 *	High U-value; poor thermal resistance leads to significant heat gain/loss.

* Polat & Yildirim, 2023
** Yu et al., 2024

Table 1. Tabulated summary of building envelope materials used for the project.

B. Temperature and Humidity Measurement

As shown in Figure 5, Building 5 (orange and yellow-orange colors) consistently exhibits high outdoor temperatures, rarely dropping below 33°C, while Building 1 (light and dark blue colors) demonstrates greater fluctuation and generally lower values compared to Buildings 5 and 10.

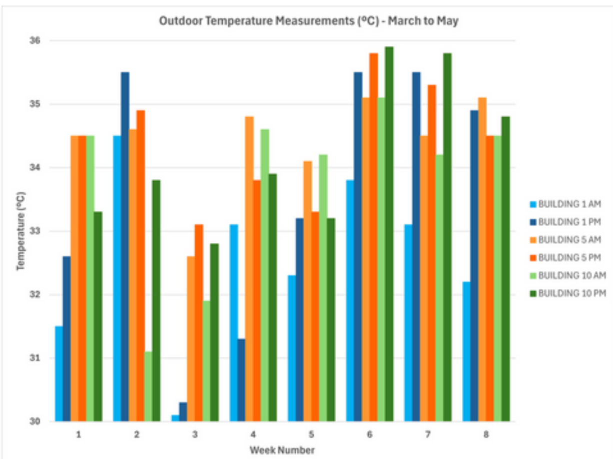

Figure 5. Chart for the outdoor temperature readings from March 7 to May 2, 2025.

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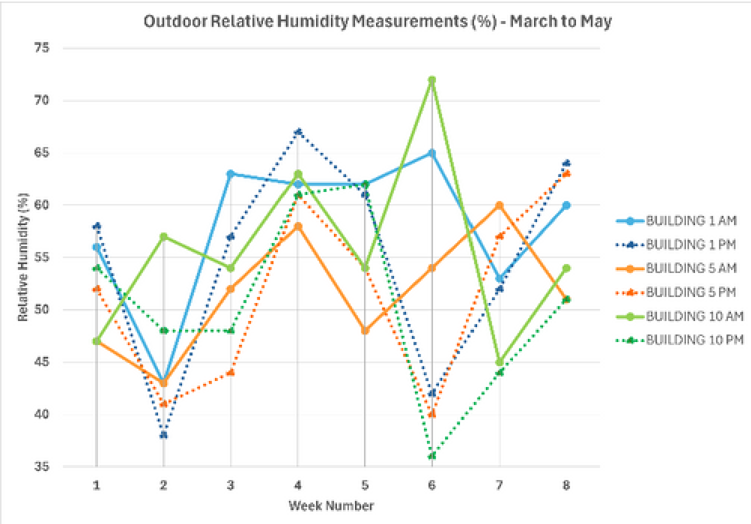

Figure 6. Chart for outdoor relative humidity readings from March 7 to May 2, 2025.

Figure 6 indicates that Building 10 experiences the highest outdoor relative humidity fluctuation in Week 6, with readings ranging from 72% in the morning to 36% in the afternoon, mostly below the tropical comfort range of 60% to 90%. Building 1 exhibits moderate levels (38%-67%), while Building 5 records lower humidity, peaking at 40% in the afternoon.

Figure 7 shows that the 1st floor had a low morning indoor temperature of 30.87 °C in Week 3, indicating strong cooling effects. Although temperatures stabilized later, afternoons remained hotter.

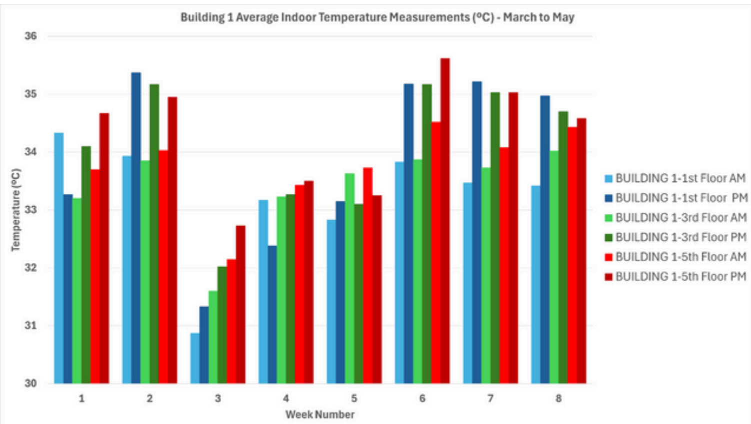

Figure 7. Chart for average indoor temperature readings of Building 1 from March 7 to May 2, 2025.

Figure 8 shows a stable temperature profile in Building 5, with minor fluctuations and consistent reading.

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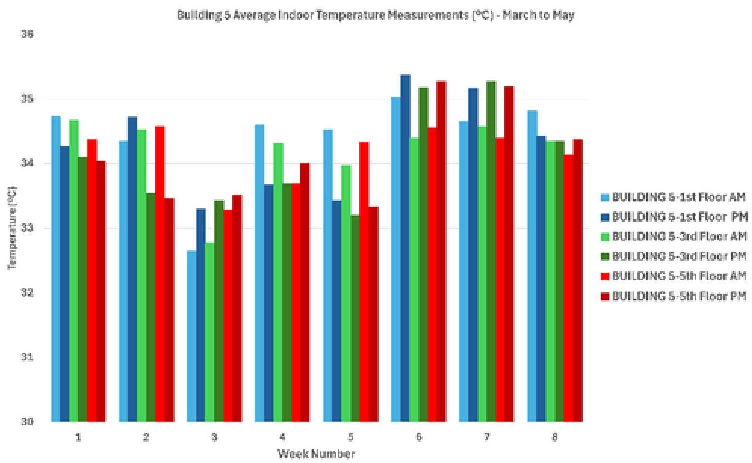

Figure 8. Chart for average indoor temperature readings of Building 5 from March 7 to May 2, 2025

In Figure 9, Building 10 consistently exhibits higher afternoon temperature peaks, particularly reaching 35.83°C on the 1st floor in Week 7, the highest across all datasets.

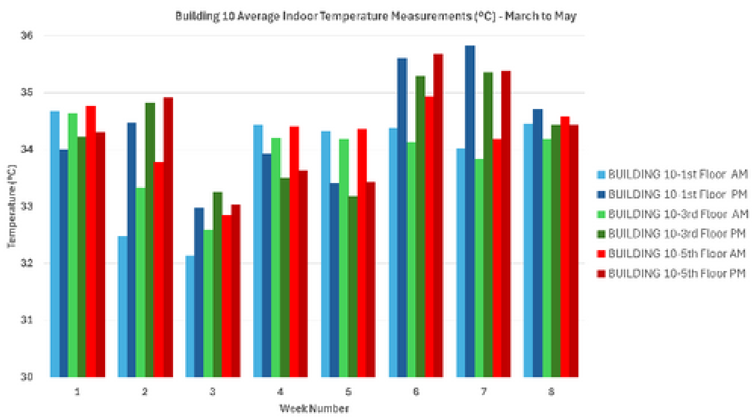

Figure 9. Chart for average indoor temperature readings of Building 10 from March 7 to May 2, 2025.

Building 1's indoor humidity: 1st floor stable at 49.50%-64%; 5th floor varied from 66% to 38.33%; 3rd floor ranged 46.33%-63.17%. Most variation was on the 5th floor (Figure 10).

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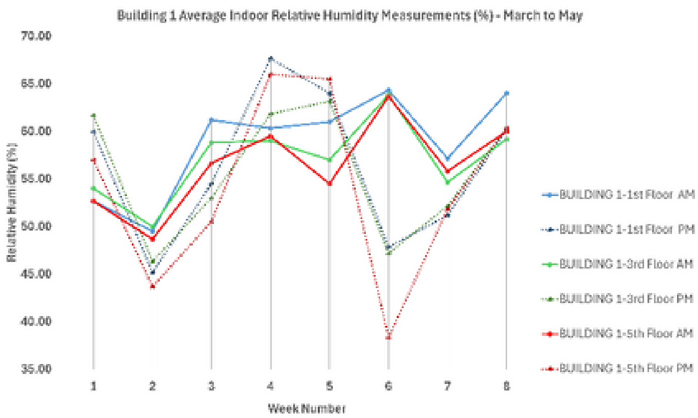

Figure 10. Chart for average indoor relative humidity readings of Building 1 from March 7 to May 2, 2025.

The chart in Figure 11 shows indoor humidity fluctuations at Building 5, ranging from 38.33% to 66%. Afternoon readings are more variable, especially in Weeks 4, 6, and 8, while morning readings remain stable.

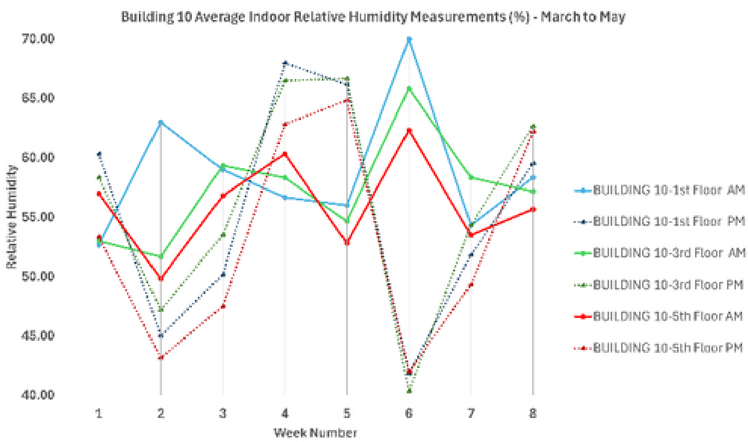

Figure 12. Chart for average indoor indoor relative humidity readings of Building 10 from March 7 to May 2, 2025.

Figure 12 shows humidity levels in Building 10 fluctuating between 40.33% and 70%, with significant peaks in Week 6. Afternoon measurements declined during this week, indicating possible environmental disruption. Discrepancies in humidity readings, especially on the 3rd and 5th floors, suggest variable time-of-day effects.

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C. Solar Analysis

C.1. Exterior Solar Analysis

Building 1 has morning solar exposure of 825 kWh (0.07 kWh/m²) and afternoon exposure of 293 kWh (0.02 kWh/m²). Building 5 has even higher morning exposure at 889 kWh (0.07 kWh/m²) and afternoon levels at 263 kWh (0.02 kWh/m²) (Figure 13).

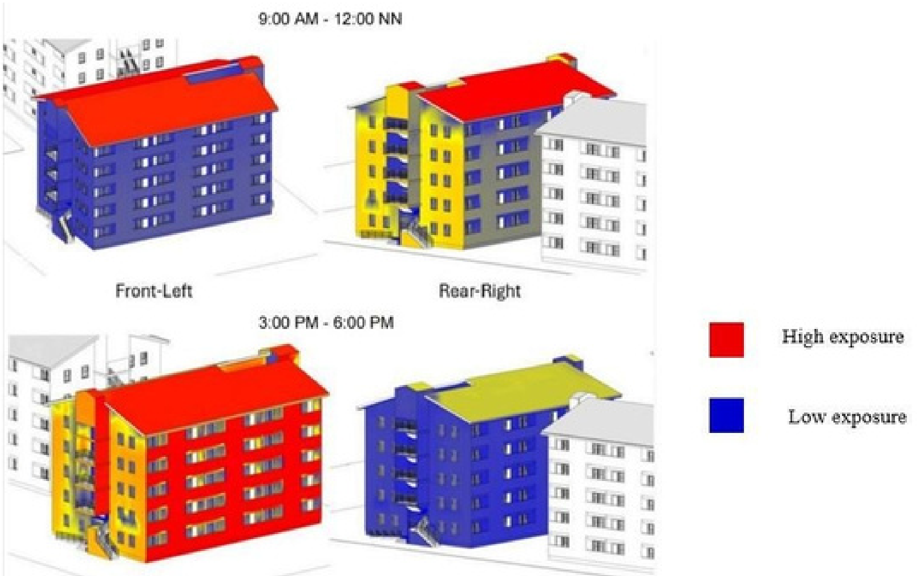

Figure 13. Simulated solar analysis of Building 1 for March 20, 2025 (Equinox).

Building 5 has the highest morning solar exposure at 0.07 kWh/m². While afternoon exposure decreases to 0.02 kWh/m² due to shadows, heat gained earlier remains due to the building's thermal properties (Figure 14).

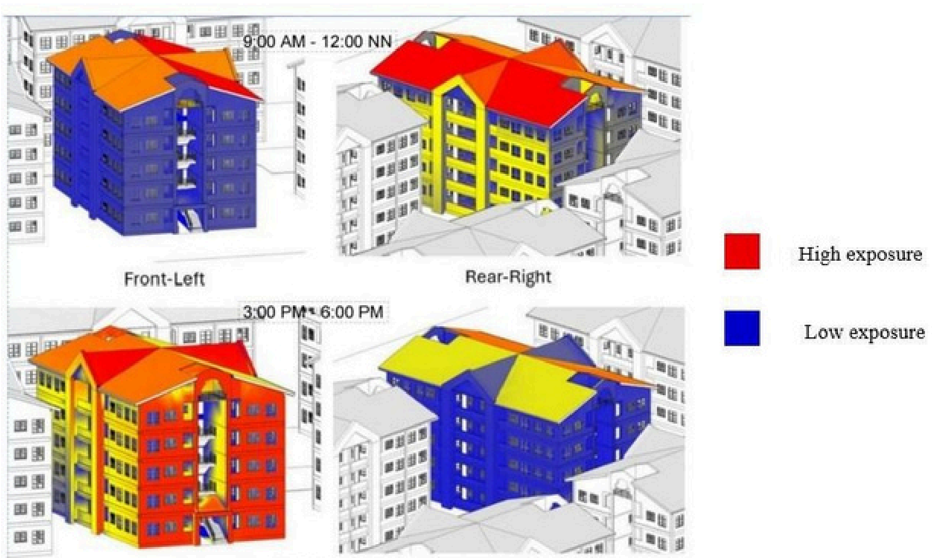

Figure 14. Simulated solar analysis of Building 5 for March 20, 2025 (Equinox).

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Building 10 receives 871 kWh of solar energy in the morning over 12,916 m², mainly on its façade and roof. Afternoon insolation drops to 273 kWh due to nearby shadows, but morning heat is retained by uninsulated walls and roof. While it benefits from some shading compared to Building 5, thermal control remains inadequate (Figure 15).

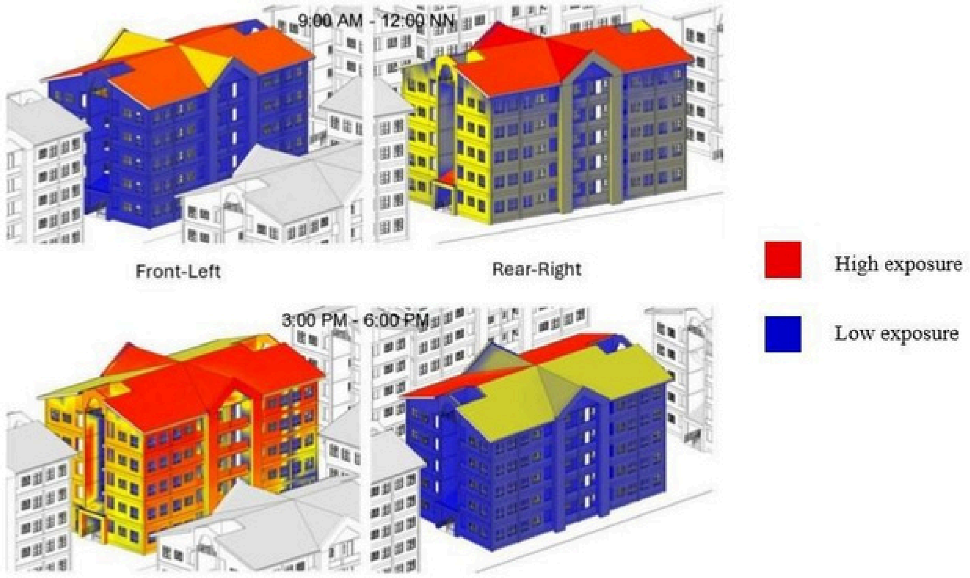

Figure 15. Simulated solar analysis of Building 10 for March 20, 2025 (Equinox).

C.2. Interior Solar Analysis

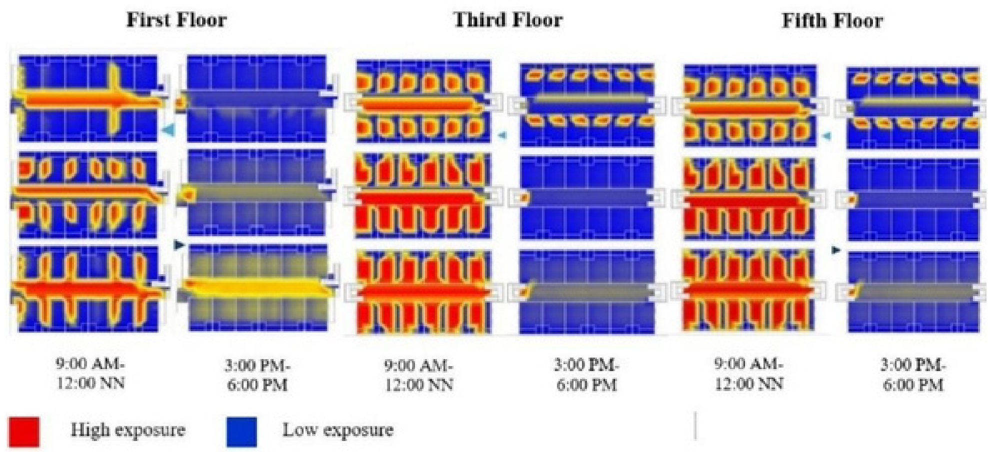

Figure 16. Simulated interior solar analysis of Building 1 per floor level.

Building 1's 3rd and 5th floors get 0.35 kWh/m² of solar exposure, while the 1st floor gets 0.15 kWh/m². In the afternoon, the 1st floor's energy consumption rises to 0.07 kWh/m² due to heat reflection (Figure 16).

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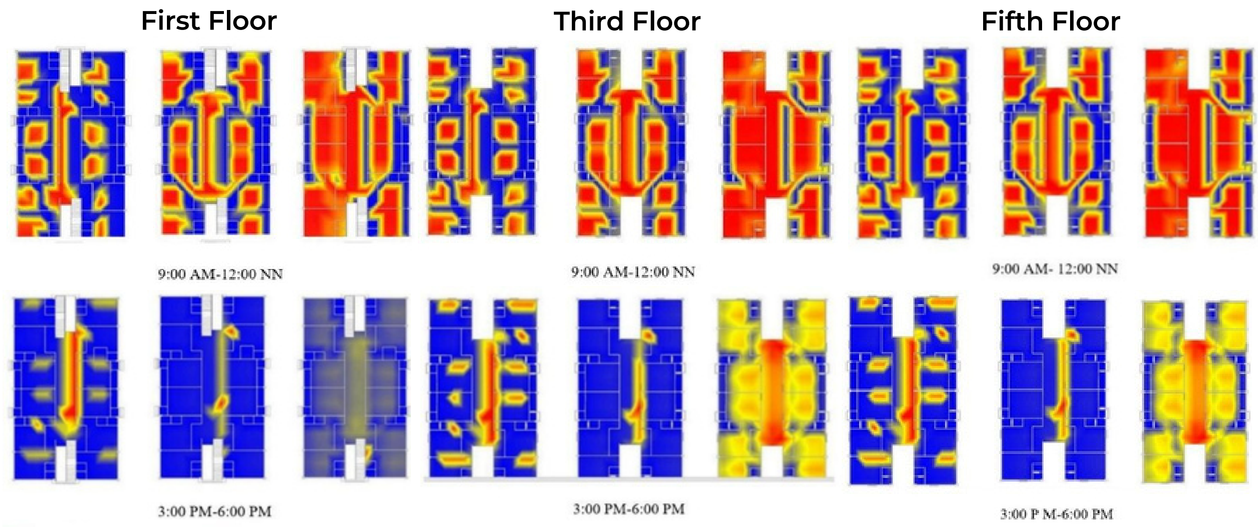

Figure 17. Simulated interior solar analysis of Building 5 per floor level.

Building 5 has significant solar exposure, with morning insolation peaking at 0.35 kWh/m² on the upper floors and 0.31 kWh/m² on the 1st. Afternoon levels drop to 0.07 kWh/m² on the 1st floor and 0.02 kWh/m² on upper floors due to shading (Figure 17).

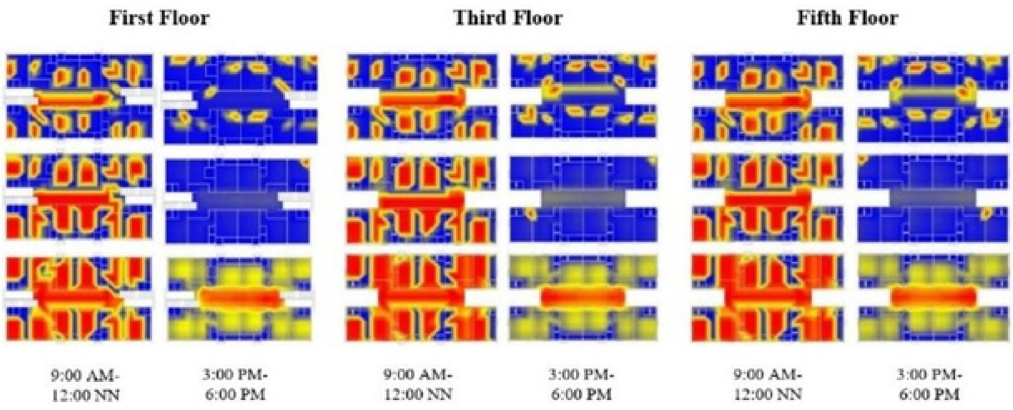

Figure 18. Simulated interior solar analysis of Building 10 per floor level.

Building 10 gets strong morning sunlight, especially on the 5th floor (0.35 kWh/m²), but minimal afternoon exposure (0.01-0.02 kWh/m²) due to shading. Poor thermal resistance causes heat gains and discomfort on upper floors (Figure 18).

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D. Airflow Analysis

Figure 19 shows that at 6.0 m/s, Buildings 1 and 10 have good airflow with Northeast winds, while Building 5 struggles. Southwest winds improve airflow for Building 5 but reduce it for Buildings 1 and 10.

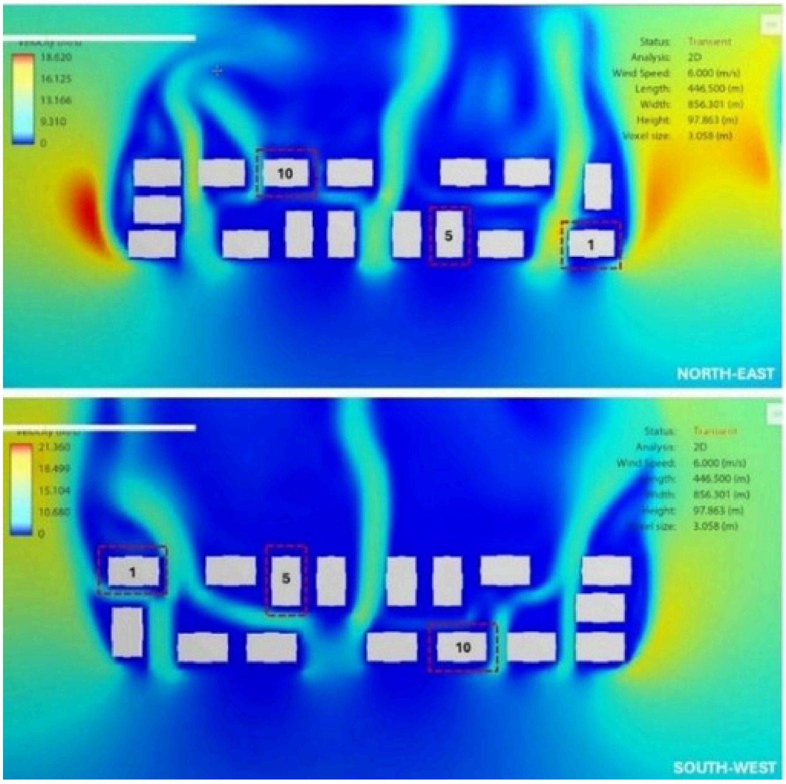

Figure 19. Preliminary airflow simulation showing wind exposure and patterns.

V. CONCLUSION AND RECOMMENDATIONS

This study analyzed thermal performance of housing in Manggahan Residences, Pasig City. Key findings show:

1. Poor materials (thin roofs, uninsulated walls, single-pane windows) cause heat buildup.
2. Building orientation and insulation affect overheating on upper floors.
3. Wind exposure and building alignment influence airflow and thermal comfort.
4. Upper units experience high temperatures due to poor thermal regulation and solar exposure.
5. Heat and humidity challenge comfort in buildings lacking insulation and passive design.

These findings highlight the need for improved building envelope design, orientation strategies, and passive cooling for thermal comfort in high-density resettlement housing.

Recommendations for the existing buildings to include reflective rooftop paint, shading, window films, ventilation, and plants for shade. Future developments should focus on cross-ventilation, insulated materials, and massing to minimize solar exposure while incorporating green spaces to reduce urban heat. Research should explore thermal comfort, affordable insulation, adaptive behaviors, and airflow to enhance housing policies in tropical urban areas.

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EXTENDED ABSTRACTS

Evidence-based Flood Response Desktop Drill with "Kiki-kuru: JMA's Real-time Risk Maps"

Kensuke Otsuyama[1], Takuma Ota[2], Junji Hotta[3], Kenichi Kuma[1], Hisashi Nakamura[1]

ABSTRACT

Timely issuance of early warnings for evacuation order remains a global challenge, including in Japan. Local governments in disaster-prone regions have introduced Flood Response Desktop Drill to strengthen the capacity of municipal officers, particularly in determining the appropriate timing of warning issuance. However, constructing realistic scenarios for such drills has posed significant challenges. To address this gap, the authors developed a novel, evidence-based scenario-building approach utilizing Radar/Rain Gauge Analyzed Precipitation (R/A) data and Kiki-kuru, the Japan Meteorological Agency's real-time risk mapping system launched in 2017. Kiki-kuru, provides nationwide, 1-km mesh risk levels for landslides, inundation, and floods, based on the statistical relationships between rainfall, topography, and approximately 30 years of disaster records. This study reports on three trials applying this approach to desktop drills in 10 municipalities in Japan, combined with a questionnaire survey of participants. Survey results indicated that participants perceived the scenarios as realistic and reflective of potential extreme weather conditions, although they also reported difficulty in appropriately issuing warnings due to rapidly evolving situation. These findings suggest that realistic hazard reproduction enhances officials' decision-making capacity, and the integration of such scenarios represents an advanced stage in drill design.

Keywords: climate change; desktop drill; real-time risk map; reanalysis

I. INTRODUCTION

Given the increasing likelihood of more frequent and severe disasters due to climate change, Disaster Management Office in Japan has been conducting blind-type heavy rainfall response drills since 2021. In these drills, scenarios are developed by retroactively calculating meteorological conditions under the assumption that a disaster has already occurred, which makes it difficult to eliminate arbitrariness in setting hypothetical rainfall events. To overcome these limitations, meteorological conditions scientifically grounded are necessary.

II. RESEARCH OBJECTIVES

The research team has jointly developed a new method for heavy rainfall response training, utilizing Radar/Rain Gauge Analyzed Precipitation (R/A) data and JMA's real-time hazard map "Kikikuru." Kikikuru not only calculates indices such as basin rainfall index but also establishes thresholds based on approximately 30 years of past disaster data, providing visualized risk maps for landslides, inundation, and flooding (Ota et al., 2023).

This study aims is to examine how participants in this new training method differ from those who participated in conventional exercises. While the similarity between prior research (E.g., Takenouchi et al., 2021), this approach holds significant potential for application in training because rainfall intensity in reanalysis data can theoretically be increased (e.g., by multiplying by 1.1–1.3).

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Evidence-based Flood Response Desktop Drill with "Kiki-kuru: JMA's Real-time Risk Maps"

Kensuke Otsuyama, Takuma Ota, Junji Hotta, Kenichi Kuma, Hisashi Nakamura

III. RESEARCH METHODOLOGY

The July 2017 Northern Kyushu heavy rainfall was shifted approximately 54 km southward and extended east–west to encompass the target municipalities. Based on these data, Kikikuru maps for landslide, inundation, and flood hazards were created.

In this study, three municipalities were designated as the intervention group, and the other three municipalities that conducted conventional training on the same days were designated as the control group. A questionnaire survey was administered, covering participant attributes and the perceived effects of the intervention.

Figure 1. Desktop Drill in Kumamoto Prefecture.

IV. RESULTS AND DISCUSSION

To compare differences from conventional training, analysis was limited to those with prior training experience, defined as participants who had joined at least twice (n = 53). In the intervention group, the responses "The content presented in the training could realistically occur" and "The locations where damage occurred were close to the damage assumptions" were significantly higher, whereas the item "The timing of evacuation information issuance during training was appropriate" was significantly higher in the control group.

V. CONCLUSION AND THE WAY FORWARD

The proposed new approach enabled risk visualization at locations closely aligned with realistic damage assumptions. As future challenges, it is necessary to expand beyond municipal-level tabletop exercises to include evacuation drills involving local residents, as well as to apply rainfall-scaling training—such as doubling rainfall intensity—in anticipation of the increasing severity of heavy rainfall under climate change.

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EXTENDED ABSTRACTS

PARALLEL SESSION 1C
HERITAGE ENVIRONMENTS
Session Moderator: Jocelyn A. Rivera-Lutap PhD

PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage
Jan Laren B. Bagonoc
Mapua University

Tide and Tenacity: Urban Disaster Resilience among the Bajau Communities in Coastal Southeast Asia
Juan Ramòn Jimenez Verdejo[1], *Jesus Alberto Pulido Arcas[2], Shu Yamane[3], Sanen Marshall[4]*
[1] The University of Shiga Prefecture, Japan
[2] Center for R&D of Higher Education,The University of Tokyo
[3] School of Architecture, Kwansie Gakuin University
[4] Centre for the Promotion of Knowledge and Language Learning, University of Malaysia Sabah

Poblacion Placemaking: An Integrated Spatial Analysis for Sustainable Urban Conservation of selected towns in Rizal, Philippines
Lawrence Ferreras Intalan
College of Architecture, University of the Philippines-Diliman

Batad Rice Terraces: Multi-Method Assessment of Geo-Hazard Risks Using Field Survey, GIS Mapping and Drone Photogrammetry
Marie Edraline B. Belga[1], *Avegail P. Casono[2], Trisha Leigh O. Lunas[3]*
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PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage

Jan Laren B. Bagonoc[1]

ABSTRACT

The paper revolves around an integrated waterway transit system in Metro Manila linking the cities of PaMaNa (Pasay, Malabon, Manila, and Navotas). In pursuit of honoring the vibrant waters of the urban sphere, the study regards them as the "Blue Heritage" that has pivotally rendered resources across different lines of generations.

Rooted in the significance of sustaining a transit network, it encompasses the humane language of visions, design strategies, and innovations through the following aspects: SDG 6 — Clean Water and Sanitation, SDG 9—Industry, Innovation, and Infrastructure, SDG 11—Sustainable Cities and Communities, and SDG 14—Life below Water. While the project was principally devised for the Navoteños who depend on neighboring cities for their educational, employment, and social needs, it will rise in the heart of Navotas Tourism Site Map with in-city, intercity, and interregional linkages to the rehabilitated satellite stations and existing ferry terminals and port in Metro Manila. Hence, the project has four (4) phases of development.

Through a mixed-method approach, the gathered data involve the perceptions and experiences of college-age and working-age intercity dependents of Navotas City, MMDA officers of the eleven (11) stations and docking yard of Pasig River Ferry Service, administrative and security officers of Esplanade Seaside Terminal, and WTA Architecture and Design Studio.

The findings reveal issues concerning passenger ferry ridership variables that affect the security and efficiency of transit processes. Hence, the study deductively imbibes Herron's Urban Design Framework, Asset-Based Community Development, Network Theory, and other sub-theories.

This approach permits strengthened connectivity between the facility, the users, and the Blue Heritage. In turn, this study mobilizes the umbrella of architecture and urban design in empathizing with intercity dependents.

Keywords: waterway transit system, blue heritage, linkages, urban sphere, intercity dependents

I. INTRODUCTION

In coherence with the urban development by which mobility is necessary, Transit-Oriented Development (TOD) addresses the gaps anticipated. The City Government of Navotas disclosed its plan in 2019 to promote an alternative, efficient transportation network through its proposed ferry complex, participating in the Tourism Sites Map published in 2015. The project is sought to primarily support the intercity dependence of Navotas City residents and mobilize its waterway assets as potential streams of transit solutions. In parallel to the limited land resources against vehicle and passenger volume, the coastal condition of Navotas City is an advantageous asset for administering waterway transit.

Discussing the details of the concern required an in-depth study of the areas involved. The dimension of the paper surrounded the nature of the following:

[1] Jan Laren B. Bagonoc is a former scholar of OWWA-EDSP Scholarship at Mapua University. Specializing in Urban Design, she is currently working as a Junior Architect of PDP+ Architecture - Master Planning Studio and as an ESL Teacher at Preply, Inc. She is the founder of Bristlebook Ph – a painting studio.

1. comparative analysis on the experiences and insights of intercity dependents between the traditional land-based transportation and waterway transit system,
2. exploration of the operations associated in sustaining the variables of passenger ferry ridership, and
3. evaluation on the architectural framework that will induce passenger demand.

In summary, the study revolved within the enlisted problems:

1. How can a waterway transit empathize with the experiences of intercity dependents?
2. How can spatial configuration sustain the variables of passenger ferry ridership?
3. What spatial elements will strengthen the relationship between the intercity dependents and the ferry complex?

II. METHODOLOGY

To address the research objectives, the researcher conducted the following:

1. Study on the statistical background of intercity dependent population of Navotas City
2. Online survey involving the college-age and working-age population of Navotas City
3. Onsite case study in the Pasig River Ferry Services Stations - (1) Escolta Ferry Station, (2) Lawton Ferry Station, (3) Quinta Station, (4) Sta. Ana Ferry Station, (5) Lambingan Ferry Station (6) Valenzuela Ferry Station, (7) Hulo Ferry Station, (8) Guadalupe Ferry Station, (9) San Joaquin Ferry Station, (10) Kalawaan Ferry Station, (11) Pinagbuhatan Ferry Station, (12) Napindan Hydraulic Structure – and in (13) Esplanade Seaside Terminal
4. Online case study about Brisbane Ferry Terminals: West-End and Queensland
5. Onsite Focus Group Discussion and online interview with WTA Architecture and Design Studio
6. Experiential case study on the comparative traffic data of transit networks

III. GATHERED DATA

The data gathered is discussed in relation to the respective methodologies above stated:

[1] The involvement of intercity dependents in this study is treated crucially. In consideration of the accuracy of the sample, the study conducted a statistical procedure involving datasets such as 2020 Census of Population and Housing (CPH) and 2023 Regional Social Economic Trends (RSET) acquired from the concerned bodies of the local and national governments. In this case, the study involved the participation of a statistician from the University of the Philippines Los Baños graduate. To provide concrete numerical data on the intercity population of Navotas, the statistician identified the contribution quotient of Navotas City concerning the college-age and working-age population of NCR. Hence, stratified sampling using disproportional allocation was employed accordingly. Lohr (2019) states that such a sampling technique allocates sampling units to strata with unequal sampling fractions nh/Nh. Thus, it induces the estimators' precision by considering that each stratum has its respective representative in the generated sample. This was the most credible strategy as the request to obtain the total population of intercity dependents in Navotas City was declined by the Philippine Statistics Authority and Commission on Higher Education due to violation of the Data Privacy Act of 2012. While this assumption is held reliable, Ganti (2024) emphasizes that the Central Limit Theorem (CLT) strengthens the role of assumptions in analyzing large data sets, thereby permitting statistical analysis and inference.

[2] While intercity living has become a primal, customary part of the daily experience of Navotas City residents, the data obtained from the JICA (2015) further reinforced the

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foundation of this study by providing statistical data about the population trends in the city in three (3) different years: 2014, 2025, 2035. While the baseline structure adheres with the discussed analytical 101 forecast, consequent data about the proposed transportation line development does not impose a connection with Navotas City. The quantitative data, divided into six (6) classifications, equated a favorable implication for the proposal: the demographic profile, travel time data, awareness and preference on the public transportation system, variables of passenger land-based ridership, variables of passenger ferry ridership, and data on the beneficiary footprint. Respondents are under the working-age and college-age population. The topmost neighboring cities visited are Manila, Caloocan City, Quezon City, Malabon city, and Pasay City, dominantly enduring 1-1.5 hours of traveling. In assessing the variables of passenger land-based ridership, the researcher found out that most respondents shared a neutral response, unlike their participation in the ferry ridership, which garnered positive claims. Most respondents agreed that the ferry station is the most accessible and sustainable transport modality to support their intercity living.

[3] Spatial division matters significantly in ferry complex – while the existing terminals reflect openness for flexible circulation, they also imbibe the variables of passenger ferry ridership. However, while some stations fully provide the users' necessities, some do not. Aside from the operational framework, the architectural aspect, conveyed through the building envelope, should be equipped with elements that foster a better relationship between the built and natural environment. Most ferry stations do not maximize the benefits of being a blue space: lack of cross 103 or stack ventilation, good landscaping, waterfront amenities, and public-centric activities. While these elements positively impact the users, many limitations require efficient addressing. The sufficiency of vessels and passenger-empathetic operational time frame should be further embodied.

[4] Commendably, the planning and systems used for the Brisbane Ferry Terminals make it triumphant over different competitions, with its problem-solving techniques catering to the principles of resiliency, accessibility, and elegance to win over environmental and social challenges. Notably, the design embarked on a sphere that gathered the public beyond being a conduit from the land to the river. The planning system provided holistic space efficiency amid the volume of activities. Notably, the surfaces of flexible and adaptable architecture are well-reflected.

[5] The FGD with the WTA Architecture and Design Studio was conducted comprehensively, integrating with the local community alongside its necessity for an intercity network. Adherence to the following elements is a must: (1) localized mass transit, (2) heritage and tourist spots, and (3) intermodal link between terminals, serving different groups of passengers. Additionally, the study should consider the following: (1) daily passenger volume, (2) daily trip schedule, (3) vessel passenger capacity, (4) walkability to location, (5) ridership factors, (6) population in the vicinity, and (7) co-existence of the built and natural environment. Touching the scale of urban planning, the experts revealed that a local loop should cater to the residents through the existing boarding areas of Tres Ferry Terminal, Quatro Ferry Terminal, and Singco Ferry Terminal. While these operations deliver passengers from Navotas City to Malabon City and vice versa, including it with the study will foster an innovative transportation system in the cities involved.

[6] The researcher conducted a minimal experiential data gathering that will further provide distinction between the existing land-based transit and waterway system that cohere with the intercity linkages of PaMaNa.

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The researcher conducted a minimal experiential data gathering that will further provide distinction between the existing land-based transit and waterway system that cohere with the intercity linkages of PaMaNa.

(6.1.) Navotas – Malabon: Arellano University (Jose Rizal Campus)

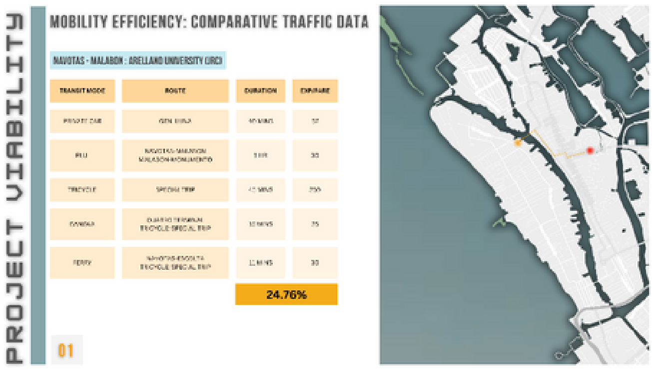

Figure 1. Mobility Efficiency from Navotas – Malabon: Arellano University (Jose Rizal Campus). (Image Generated).

Arellano University, Malabon, is a crucial institution that fulfills the educational needs of Navotas City's high school and college students. Hence, it is considered one of the important institutions honing the intercity network between Navotas and Malabon. For this route, four transit modes are available: private car, PUJ, tricycle, and bangkang de-sagwan. Respectively, the travel time takes 40 mins, 1 hour, 45 mins, and 15 mins, at the expense of 25.35 pesos, 30 pesos, 250 pesos, and 25 pesos. From such data, it can be analyzed that there is a significant gap between land-based transit modes and the ferry system in terms of duration and fares. Students Practically, Quatro Ferry Terminal will best render this route service along the rivers of Malabon and Navotas. That said, through the proposed ferry mode, passengers will only spend 11 minutes for 30 pesos (without government subsidy yet). In conclusion, the mobility efficiency compared to the existing land-based transit increased to 24.76%.

(6.2.) Navotas – Manila: Mapua University

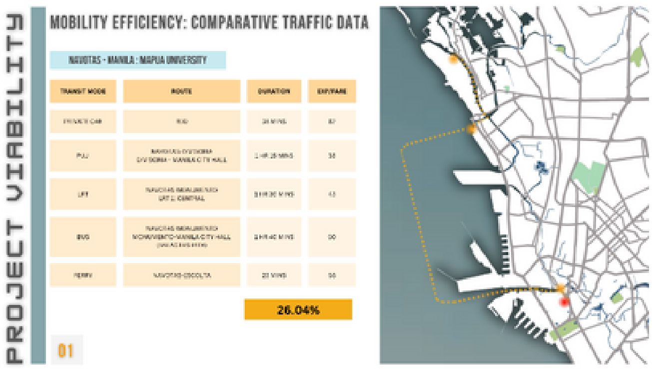

Figure 2. Mobility Efficiency from Navotas – Manila: Mapua University. (Image Generated)

Concerning the daily experience of the researcher, there are four routes available from Navotas City to Mapua University: (1) private car along Radial Road 10, (2) PUJ via Navotas-Divisoria and Divisoria-Baclaran (PUJ stop at Manila City Hall), (3) PUJ via NavotasMonumento and LRT 1 Yamaha Monumento to Central Station, and (4) PUJ via NavotasMonumento and PUB via Balagtas-PITX (Monumento to Manila City Hall). Correspondingly, the travel time and fare are as follows: (1) 38 mins at 83.20 pesos, (2) 1 hour and 15 mins at 33 pesos, (3) 1 hour and 30 mins at 43 pesos, and (4) 1 hour and 40 mins at 50 pesos. With the proposed direct link from PaMaNa Ferry Complex to Escolta Ferry Station, students from Navotas City will only consume 23 mins for 68 pesos – an efficient decrease in the commuting period from hours. This significant viability of transit convenience is sought to emphasize the empathetic façade of urban design for the students and employees. While the fare is relatively high compared to the traditional land-based transit expense, it should be noted that this proposal has no government subsidy yet from the concerned bodies such as DOTR-MARINA and LTFRB. With their intervention, the fare is expected to be more cost-efficient against the raw computations presented. The record claims a mobility efficiency of 26.04%.

(6.3.) Navotas – Pasay: SM Mall Of Asia

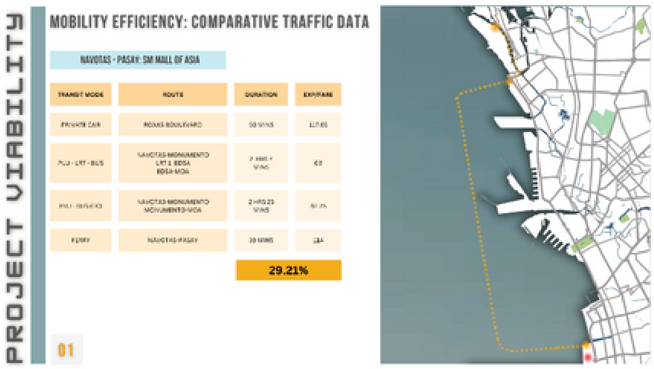

Figure 3. Mobility Efficiency from Navotas – Pasay: SM Mall Of Asia. (Image Generated)

For supplementary data, the researcher conducted a short data gathering with the dispatcher of Navotas Taxi Terminal on May 8, 2024. As he disclosed, the intercity dependents utilize 30 to 35 taxis from 6 to 8 AM and 40 to 45 taxis from 8 to 9 AM. Most routes served are heading to Intramuros, SM Mall Of Asia (MOA), and Double Dragon Plaza. This data further reinforced the link between Navotas and Pasay City. In the current scale, Navotas-Pasay is most accessible through 3 transit modes: private car, PUJ-LRT-PUB, and PUJ-PUB. Taking the private car leads the researcher for 50 minutes at the cost of 117.65 pesos. On the other hand, public transit takes more than 2 hours. In detail, PUJ-LRT-PUB through Navotas-Monumento, LRT 1 Yamaha Monumento – EDSA Station, and Bus via EDSA – MOA consumes 2 hours and 4 mins at 63 pesos. Another option is PUJ-PUB through Navotas-Monumento and EDSA Carousel via Monumento-MOA. However, it takes 2 hours and 23 mins for 82.25 pesos. Notably, the proposed transit system that will directly connect Navotas to Pasay City has a travel time of 39 minutes and a fare of 114 pesos. The calculated fare can be further reduced through government subsidy for passenger expense considerations. Mobility efficiency is quantified at 29.21%.

IV. RESULTS AND ANALYSIS

This study distinguishes the architectural needs of a ferry complex particularly focused on spatial analysis. Highly considering the variable of passenger ferry ridership, the paper abides by the aim of enhancing spatial division on ferry stations to foster a holistic experience for passengers and thus generate a higher volume of ridership as a means of providing an alternative transit route. Considering this aspect, the involvement of ferry operators is necessary. Their experiences, observations, and perceptions of the technical operation and passenger activities can contribute to formulating spatial configuration. Configuration of spaces for commerce, recreation, and tourism will boost the art of complex planning. Hence, the data gathered from interviews and focused group discussion was symmetrically aligned to cover the necessities of the occupants. In conclusion, the following procedures were conducted: (1) Outline and evaluate user needs, (2) Conduct spatial configuration, (3) Assess spatial considerations, (4) Integrate variables of passenger ferry ridership, and (5) Sustain the needs through elements of terminal planning.

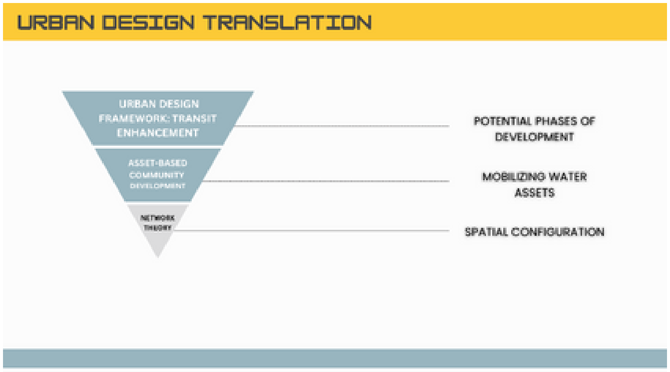

Figure 4. Urban Design Translation. (Image Generated)

The principles applied to the project under the field of urban design are as follows: (1) Herron's Urban Design Framework – transit enhancement and (2) Asset-Based Community Development Approach. On the other hand, the principles concerned with the field of architecture are the following: (1) Network Theory integrated with Defensible Space Theory and (2) scientific principles from the Second Law of Thermodynamics, Biophilia Hypothesis, green roof, retention pond, rainwater harvesting system, and wastewater recycling chamber.

For the umbrella of urban design, Herron's Urban Design Framework – transit enhancement and Asset-Based Community Development Approach are applied.

The first phase of development provides a linkage between Pasay, Manila, Malabon, and Navotas, collectively known in this paper as PaMaNa. The allocation of ferry terminals is according to a population-based segmentation to cater to a reasonable market. The route covers the following stations: (1) PaMaNa Ferry Complex, (2) Escolta Ferry Station, and (3) Esplanade Seaside Terminal.

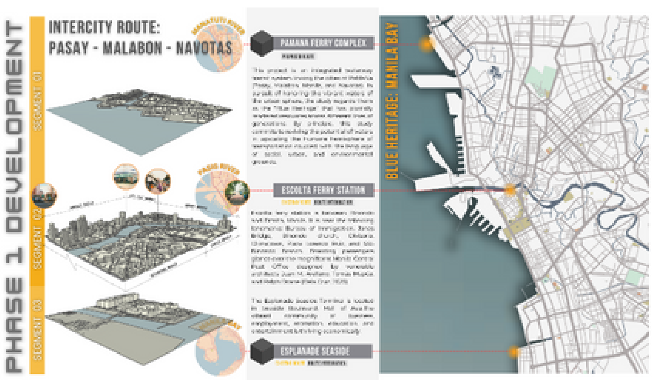

Figure 5. Phase 1 Development: Intercity Route - PaMaNa. (Image Generated)

PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage

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Figure 6. Phase 2 Development: In-City Route - Navotas – Malabon. (Image Generated)

With respect to the substantial suggestion from WTA Architecture and Design Studio, the local loop is applied under the phase 2 development. This includes rehabilitation of the existing ferry terminals that are known for servicing passengers through bangkang de-sagwan.

While the priority is to cater to an in-city network, it also aims to gather additional passengers from Malabon City. Importantly integrated with PaMaNa Ferry Complex, this phase encourages a more accessible transit system by providing the intercity dependents with a walkable, alternative mode of transportation. Instead of riding a PUV to head to their desired in-city or intercity destinations, the local community may save time by simply riding the ferries in Tres, Quatro, and Singco that are respectively located in Barangay San Jose, San Roque, and Tangos. These stations are correspondingly mirrored to the stations of Malabon: Concepcion and New Horizon and station of Tanza, Navotas. While the traditional bangkang de-sagwan routes implement a linear route only between the mirrored stations, this project aims to materialize a crisscross route from the mirrored to the next station.

The route covers the following stations: (1) Singco Ferry Terminal, Navotas – Tanza Ferry Terminal, (2) Quatro Ferry Terminal, Navotas – New Horizon Ferry Terminal, and (3) Tres Ferry Terminal – Concepcion Ferry Terminal, all the way to (4) PaMaNa Ferry Complex.

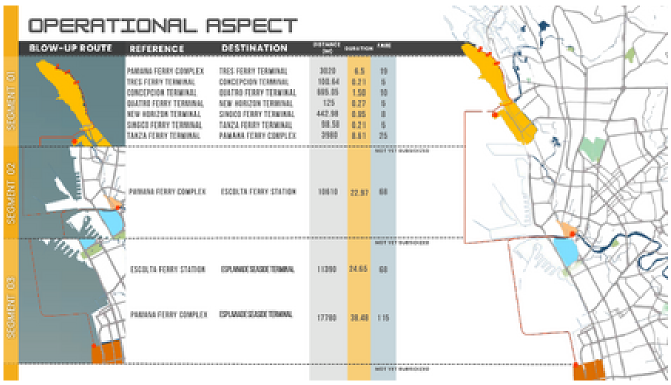

Figure 7. Phase 1-2 Development: Information on Operational Aspect. (Image Generated)

The operational aspect for phase 1 and 2 developments includes information on the blow-up route, reference, destination, distance, duration, and unsubsidized fare. Segment 1 covers data from in-city linkage concerning Malabon and Navotas, segment 2 covers linkage with Manila, and segment 3 covers linkage with Pasay City. In-city routes cover approximately 1-9 minutes of travel duration for 5 to 25 pesos. Notably, this project does not steal the edges of the traditional bangkang de-sagwan such as the standardized 3-peso-fare and 15-peso-special-trip

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that best serves the marginalized community.

The project is set to operate with 4 boats: 2 for in-city and 2 for intercity. By 6 AM, the facility operation begins. At 6:30 AM, boarding starts with a 50-seater boat from Navotas to Pasay and another one from Pasay to Navotas. Simultaneously, a 36-seater boat serves from Navotas to Malabon and another from Malabon to Navotas. Hence, 2 boats will dock at the PaMaNa Ferry Complex, 1 at Esplanade Seaside Terminal, and another 1 at Tanza Ferry Station. Through a 30-minute boarding – arrival interval until 6:30 PM, 900 in-city and 1,250 intercity passengers are benefited, summing up to a total of 2, 150 passengers served in a day. At such point, the terminal will be closed but the esplanade will be accessible 24/7. Moreover, 2 emergency vessels headed by the Philippine Coast Guard will be stationed at PaMaNa Ferry Complex to take over unwanted circumstances. Feasibility of the proposed routes was approved by PRFS, MMDA.

Phase 3 development embodies route integration with the complete line of PRFS. In the paper of Metro Manila Urban Transportation Integration Study (2024), plans on increasing the beneficiary footprint of ferry users were disclosed. Hence, additional ferry terminals will be built in the stretch of Pasig River: (1) Farola Station, (2) Fort Santiago Station, (3) Taguig Station, and (4) Muntinlupa Station. Hence, under the completion of this phase, an additional link from Navotas City will be directed to Farola Station, serving the opposing side of Escolta from phase 1.

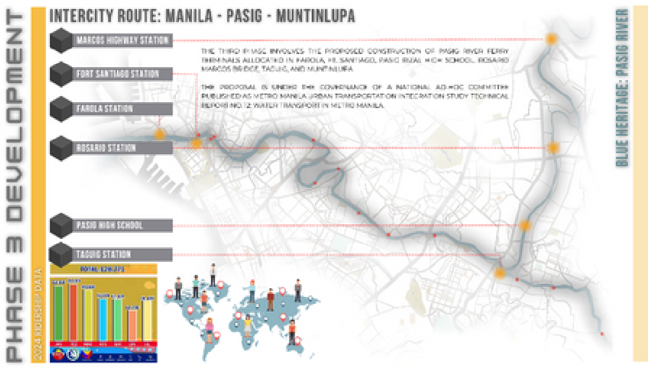

Figure 8. Phase 3 Development: Intercity Route Integration with PRFS Development. (Image Generated)

Alongside the operational stations, these proposed terminals are expected to benefit the western and eastern hemispheres of NCR. In fact, these even drew inspiration from the LRT 1-LRT 2 system as the proposal plans to establish stations in Marikina River namely: (1) Rosario Station, (2) Pasig High School Station, and (3) Marcos Highway Station.

This development is associated with the ferry ridership in 2024: 22, 568 in January; 23, 023 in February; 20, 688 in March; 17, 329 in April; 17, 021 in May; 12, 705 in June; and 16, 437 in July. The rising projection of numbers denotes a positive impact on the existing line and good implications for expansion plans. Above this, key measures for ridership increase are also considered by providing discounts to senior citizens and students and free or discounted transit service transfer.

PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage

Jan Laren B. Bagonoc

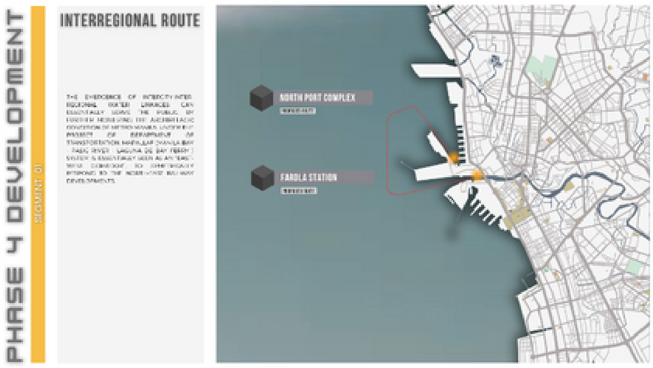

Figure 9. Phase 4 Development: Intercity Route Integration with MAPALLAF Development. (Image Generated)

Cordero (2024) states that the DOTR is eyeing the development of MAPALLAF (Manila Bay – Pasig River – Laguna Lake Ferry) System to provide access for the 4 sides of NCR. While the details of the stations and data involved are yet for public information, this project assumes the integration of interregional route from the phase 3 development's Farola station linkage with North Port Passenger Terminal Complex. This is envisioned to further revolutionize the archipelagic conditions of the country, easily connecting the urban core of NCR with the Northern and Southern regions.

The integration of principles from the Network theory and scientific concepts are fully elaborated in the sphere of architectural development. Information enclosed in this section are highly relevant to the transit needs of intercity dependents of Navotas, and additionally of Metro Manila. Functional in the enforcement of pedestrian-centric urban world, these phases of development reflect transit enhancement under Herron's Urban Design Framework. Significantly, Asset-Based Community Development Approach was applied by mobilizing the Blue Heritage of NCR: Manila Bay, MANATUTI River System, Pasig River, and Marikina River. The interconnection web between these waters is considered a transit-amplifying project for intercity dependents.

Moving forward to the scope of architecture, in conducting the site selection, detailed criteria are crucial. While objective evaluation should be embodied, this section abides by enlisting all factors for a comprehensive analysis. As the project is deeply inclined toward providing an alternative transportation network for Navotas City residents, site selection will feature the following aspects: (1) Factors of Coastal Site Evaluation, (2) Factors of Integrated Transport System Terminal, and (3) PESTEL Framework. Moreover, such site is the official location for the project as disclosed by the Local Government of Navotas.

Under Phase 1, this project, which delves into the integration of "heritage," utilizes the design concept of a Balangay—a traditional wooden boat used by Filipinos in transportation and trading. Indeed, such a vehicle has a historical commitment to the Blue Heritage the study aims to sustain. On the other hand, under Phase 2, the architecture resembles the humility and resilience of the users in harmony with the site – a service to the low-to-middle-income families who provide societal stability, permitting progressive mobility.

EXTENDED ABSTRACTS

PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage

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Figure 10. PaMaNa Ferry Complex, Phase 1 Exterior Perspective. (Image Generated)

Figure 11. PaMaNa Ferry Complex, Phase 1 Social Zone. (Image Generated)

PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage

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Figure 12. PaMaNa Ferry Complex, Phase 1 Passenger Critical Areas 1. (Image Generated)

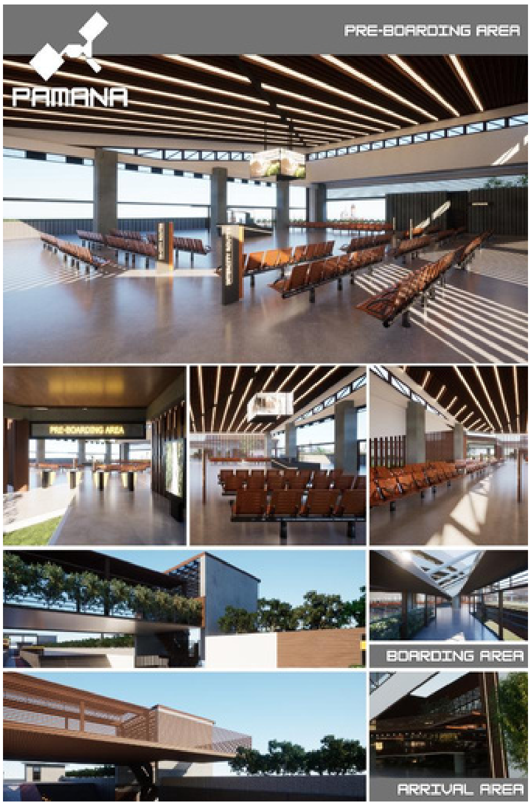

Figure 13. PaMaNa Ferry Complex, Phase 1 Passenger Critical Areas 2. (Image Generated)

PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage

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Figure 14. PaMaNa Ferry Complex, Phase 1 Public Conveniences Zone. (Image Generated)

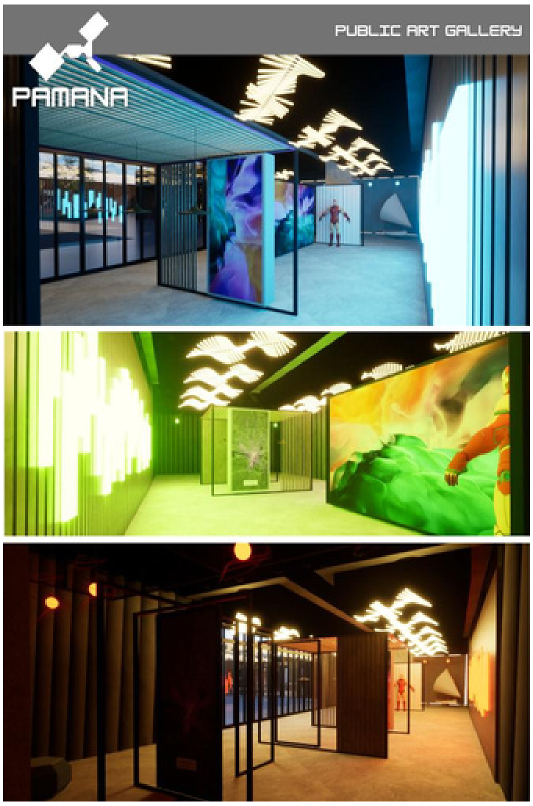

Figure 15. PaMaNa Ferry Complex, Phase 1 Public Conveniences Zone. (Image Generated)

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PaMaNa Ferry Complex: Sustaining a Transit Network along the Blue Heritage

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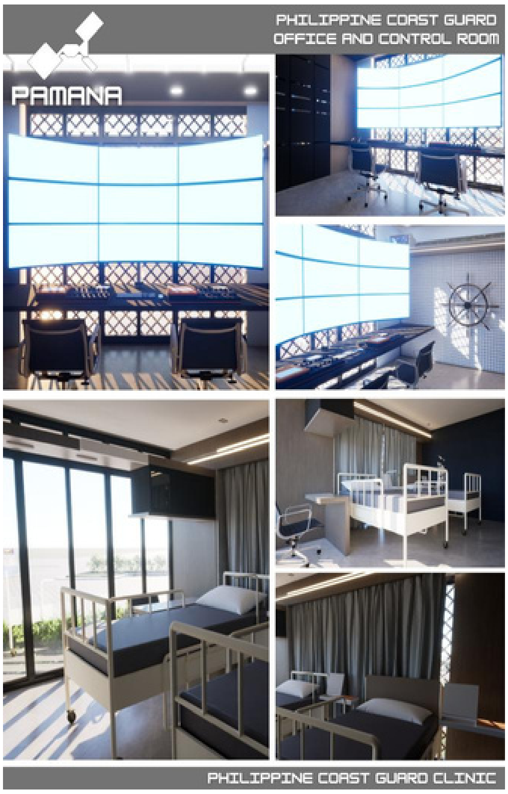

Figure 16. PaMaNa Ferry Complex, Phase 1 Private Zone. (Image Generated)

Figure 17. PaMaNa Ferry Complex, Phase 2 Satellite Stations. (Image Generated)

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Figure 18. PaMaNa Ferry Complex, Presentation Board. (Image Generated)

V. CONCLUSION AND RECOMMENDATIONS

In observance of uniformity to the issues studied, the researcher listed the following recommendations respective to SOP 1, 2, and 3:

1. The researcher recommends a lower margin of error to cover a higher confidence level for the statistical analysis. In this way, a larger group of samples will be studied across a variety of age groups. This will further assess the impacts of the in-city and intercity development for the said dependents.
2. The researcher recommends applying a modular system in planning a ferry complex.
3. The researcher recommends a more in-depth study to maximize the beneficiary footprint by involving more cities from the Northern and Southern parts of NCR.

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EXTENDED ABSTRACTS

Tide and Tenacity: Urban Disaster Resilience among the Bajau Communities in Coastal Southeast Asia

Juan Ramòn Jimenez Verdejo, Jesus Alberto Pulido Arcas, Shu Yamane, Sanen Marshall

ABSTRACT

This study explores the urban disaster resilience of the Sama-Bajau, a historically maritime and nomadic people of the Sulu and Celebes Seas who have been displaced from southern Mindanao to northern regions of the Philippines due to decades of armed conflict and social marginalization. Once sea-dwelling communities living on houseboats, many Sama-Bajau have transitioned to permanent settlements in Palawan, the Visayas, and Luzon, facing new forms of vulnerability in coastal and peri-urban environments. Through fieldwork conducted between 2022 and 2024—including spatial mapping, interviews, and site observations—eleven settlements were analyzed to understand adaptation patterns, exposure to environmental hazards, and community resilience strategies. The findings reveal three dominant spatial forms (linear, grid, and sprawl), each reflecting different responses to relocation, flooding, and urban redevelopment pressures. Despite limited land tenure and weak institutional support, Sama-Bajau communities demonstrate strong collective resilience through social cooperation, adaptive housing practices, and the maintenance of maritime livelihoods even in land-based contexts. Resilience among the Sama-Bajau is characterized less by formal disaster governance and more by improvisation, kinship networks, and cultural persistence. Their capacity to adapt to new urban ecologies—while sustaining symbolic and economic ties to the sea—illustrates a hybrid model of coastal resilience. The study argues that recognizing these informal systems is vital for inclusive urban planning and for understanding how displaced maritime populations negotiate survival, identity, and belonging within the changing tides of Southeast Asia's coastal cities.

Keywords: Sama-Bajau, sedentary process, Philippines

I. INTRODUCTION

The Sulu Islands, situated between the Zamboanga Peninsula and northern Borneo, are part of a maritime zone rich in marine resources and historical trade activity. This area, including the Sulu and Celebes Seas, has long been home to sea-oriented communities, including the Sama-Bajau, one of the three major ethnic groups in the region along with the Tausug and Vashau. Traditionally nomadic, the Sama-Bajau lived on houseboats and relied on fishing and marine trade.

Political instability in southern Mindanao since the 1970s, particularly armed conflict between Muslim groups and the Philippine government, has pushed many Sama-Bajau northward in search of safety and economic stability. Events like the 2013 Zamboanga siege further displaced thousands, intensifying this migration. As a result, many Sama-Bajau have settled in northern areas such as the Visayas and Palawan, transitioning from a seafaring to a land-based life.

This study investigates their resettlement patterns, aiming to understand how this nomadic group is adapting to permanent land-based communities.

II. METHODS

The research combined fieldwork, historical and satellite map analysis, and interviews. Three fieldwork campaigns were conducted between December 2022 and March 2024. Interview data from local authorities helped identify settlement locations, which were later verified using

Google Earth imagery. Semi-structured interviews with Sama-Bajau residents offered insight into their living conditions and challenges.

III. SAMA-BAJAU SETTLEMENTS IN NORTHERN VISAYAS AND PALAWAN

Five settlements were identified across Palawan, Cebu, Panglao, and Leyte. Two have been relocated over time: Bagong Silang (to Tagburos) and Isabel Marvel (to Isabel Monte Alegre). These communities vary in size, structure, and integration into local society.

A. Bagong Silang and Tagburos (Puerto Princesa, Palawan)

Originally located on the coast, Bagong Silang had 170 stilt houses before a fire in 2017 destroyed the settlement. Survivors were relocated inland to Tagburos, 8 km from the town center. The new site, disconnected from the sea, follows a grid layout with uniform housing blocks and limited infrastructure.

B. Dauis (Bohol)

Located near Tagbilaran and Panglao Island, this stilt-house community enjoys proximity to transport and trade. Despite poor road access, sea access allows residents to reach markets quickly. The community includes about 120 houses and basic services like small shops, a daycare, and a church.

C. Mambaling (Cebu City)

The largest community identified, with around 400 houses, was originally built with direct sea access. Urban redevelopment projects (expressways and artificial islands) have blocked access to the sea, causing environmental degradation and solid waste accumulation. Despite integration with local Visayans, the settlement now faces infrastructure and pollution challenges.

D. Bato (Leyte)

This small riverside community of around 100 stilt houses is located half a kilometer from the town center. The community enjoys good relations with local Filipinos and is mostly Christian. Tidal patterns influence daily life, as homes are used differently at high and low tides.

E. Isabel Marvel and Isabel Monte Alegre (Leyte)

The Sama-Bajau first settled in Barangay Marvel near the town center. They were relocated twice, first to the coast, then to a remote inland area to make room for port expansion. Access to the current site is difficult, involving footpaths, suspension bridges, and bamboo walkways. The 64 houses are arranged linearly on stilts and maintain traditional sea-oriented life patterns.

F. Batangas

Located near Batangas City, this Sama-Bajau community occupies a coastal strip beside a river delta. The settlement is semi-organized, with houses on stilts forming linear clusters along tidal flats. Residents continue to engage in fishing, though increasing coastal development threatens their access to the sea. Road access is limited, and there is little support from local authorities. The community faces environmental challenges such as flooding and waste accumulation.

G. Balayan

The Balayan settlement is situated in a shallow bay area, where houses are built on stilts over mangrove-covered tidal flats. It is a small community, with residents relying on shellfish gathering and small-scale fishing. Access to basic services is limited, and the pathway connecting the settlement to the town is in poor condition. Despite its long presence in the area, the community remains socially and politically marginalized.

H. Barra (Lucena)
In the coastal district of Barra in Lucena City, the Sama-Bajau community is settled on stilts above shallow waters, forming a linear strip between mangroves and reclaimed land. The community is moderately sized and relatively close to urban markets. However, regular flooding, lack of sanitation infrastructure, and poor waste management impact residents' health and well-being. Social inclusion is limited; while some children attend local schools, adults struggle with employment and legal documentation.

I. Dalahican (Lucena)
Close to Barra, the Dalahican settlement lies on the edge of a fish port complex. The houses are built directly above water and accessible only by narrow walkways. It is one of the smallest Sama-Bajau communities documented. Its proximity to fishing operations provides economic opportunities, but the area suffers from overcrowding and unsafe housing conditions..

J. Olongapo
The Sama-Bajau community in Olongapo is located on the urban fringe, where some families have settled on reclaimed coastal land and others in informal dwellings along riverbanks. Unlike other settlements, Olongapo's community has partial access to utilities such as electricity, schooling, and water, though living conditions remain precarious. Some residents have taken land-based jobs, reflecting a gradual cultural transition. However, tenure insecurity and social exclusion remain major concerns.

IV. SETTLEMENT PATTERNS AND OBSERVATIONS

Key criteria for choosing settlement locations are proximity to the city center and access to the sea. In smaller cities, like Bato and Dauis, both were achievable. In larger cities like Cebu, this was not possible due to land scarcity and development pressures. Relocations often push the Sama-Bajau to peripheral areas, indicating tension with local authorities and communities.

Three main spatial layouts were observed: linear, grid, and sprawling. Integration with local populations varies. Some communities, such as Bato, report strong ties, while others face exclusion and isolation. Environmental and infrastructure challenges are widespread, especially in settlements like Mambaling and Tagburos.

From our observations and interviews, a few patterns emerge:

- Settlement Criteria & Relocation Pressure: Across all regions, priorities include proximity to the sea (for livelihoods) and reasonable access to urban markets or centers. Where relocation occurs, authorities often push these communities into marginal zones, indicating friction and marginalization by host municipalities.
- Spatial Patterns: The three layouts (linear, grid, sprawl) remain observable in newer settlements, but the Luzon communities show more hybridity — blending stilt homes with partial land-based houses.

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Tide and Tenacity: Urban Disaster Resilience among the Bajau Communities in Coastal Southeast Asia

Juan Ramòn Jimenez Verdejo, Jesus Alberto Pulido Arcas, Shu Yamane, Sanen Marshall

Table 1. Analysis of the Status of All Sama-Bajau Settlements.

Settlement	Houses (approx.)	On-water / On-land	Layout	Distance to Center	Reallocated?	Predominant Religion
Bagong Silang	~170	On water	Linear	~1 km	Yes (to Tagburos)	Muslim
Tagburos	~170	On land	Grid	~8 km	No	Muslim
Dauis	~120	On water	Sprawl	~1 km	No	Christian
Mambaling	~400	On land	Sprawl	~2.5 km	No	Muslim
Bato	~100	On water/land	Linear	~0.5 km	No	Christian
Isabel Marvel / MA	~64	On water / On land	Linear	0.4 → 1.3 km	Yes	–
Batangas	small	On water	Linear / scattered	moderate	No	Muslim / mixed
Balayan	small	Over tidal flats	Linear	moderate	No	Muslim / mixed
Barra (Lucena)	small to medium	On water	Linear	moderate	No	Muslim / mixed
Dalahica (Lucena)	very small	Over flats	Sparse	moderate	No	Muslim / mixed
Olongapo	small to medium	Mixed (stilt + shore)	Linear / cluster	urban fringe	No	Muslim / mixed

- Integration & Challenges: Luzon-based groups, such as Olongapo, report better access to public services compared to more remote settlements. Still, all communities face issues in tenure, legal recognition, education, employment, and environmental hazards (pollution, flooding, waste). Social inclusion is uneven: while some groups have managed amicable coexistence with local townsfolk, others remain excluded or viewed as outsiders.
- Cultural Persistence vs Adaptation: Even as many Sama-Bajau settle on land, many maintain afloat cultural practices. Fisheries, shell gathering, and boat transport remain vital. Simultaneously, some groups adopt land-based livelihoods when possible, illustrating a hybrid adaptation.

V. CONCLUSION

The Sama-Bajau are undergoing a significant cultural transition from maritime nomadism to permanent land-based living. This study identified and analyzed five settlements in the Northern Visayas and Palawan, revealing different patterns of adaptation, urban integration, and environmental impact.

Despite internal social cohesion rooted in familial bonds, integration with host communities remains uneven. Challenges such as poor access to education, unemployment, and environmental degradation were common concerns among interviewees.

There is a need for continued research and inclusive urban planning strategies to better support these communities in their transition, while respecting their cultural heritage and ongoing connection to the sea.

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EXTENDED ABSTRACTS

Poblacion Placemaking: An Integrated Spatial Analysis for Sustainable Urban Conservation of selected towns in Rizal, Philippines

Lawrence F. Intalan[1]

ABSTRACT

This paper proposes a new placemaking strategy for the historic poblacion street networks of selected towns in Rizal, Philippines, which are under intense pressure from overdevelopment and urban sprawl. Aligned with Sustainable Development Goals (SDG), this study employs an integrated spatial analysis to understand the complex interplay between a town's physical form, environmental challenges, and its vital intangible cultural heritage (ICH). This research offers a replicable model for sustainable urban development by demonstrating how small-scale targeted NBS can enhance pedestrian experience, restore walkability, connectivity, and the cultural vitality of these streets. It advocates for a synergistic approach to urban conservation and placemaking that champions the physical and cultural sustainability of Rizal towns, ensuring their unique identity endures in the face of rapid urbanization.

Keywords: nature-based solutions, placemaking, space syntax analysis, isochrones, intangible cultural heritage, sustainable urban conservation

I. INTRODUCTION

This research presents a spatially grounded placemaking strategy for the historic poblacion street networks of selected towns in Rizal, Philippines. These urban cores face increasing stress from overdevelopment and sprawl, leading to the decline of walkability, social interaction, and cultural continuity. The study aims to establish a framework that integrates spatial analysis and small-scale Nature-Based Solutions (NBS) to enhance environmental resilience and support intangible cultural heritage (ICH) within these constrained urban environments. The research aligns with Sustainable Development Goals (SDG) 11 on sustainable cities and SDG 13 on climate action.

II. METHODOLOGY

The study employs a three-tiered spatial methodology that combines Space Syntax Analysis, the 10-Minute Pedestrian Isochrone Map, and Geographic Information Systems (GIS) vulnerability mapping. Together, these methods examine the interaction between urban morphology, environmental risk, and socio-cultural activity.

Space Syntax Analysis quantifies the socio-spatial logic of the poblacion using three key metrics: Integration, Choice, and Connectivity. Integration identifies streets with high accessibility and pedestrian attraction, forming the main arteries of everyday cultural life such as markets and community interaction. Choice measures through-movement potential, pinpointing routes essential for periodic ICH activities like processions and town fiestas. Connectivity assesses the density of local linkages, revealing small clusters that sustain neighborhood-level traditions. Declining values in these metrics, often due to fragmentation and bypass roads, indicate loss of social resilience and weakening cultural networks.

The 10-Minute Pedestrian Isochrone Map adds a human-scale layer by identifying the walkable cultural core centered on the historic church. The 10-minute walking threshold defines the practical extent of daily cultural interaction. This spatial data is validated using Project NOAH,

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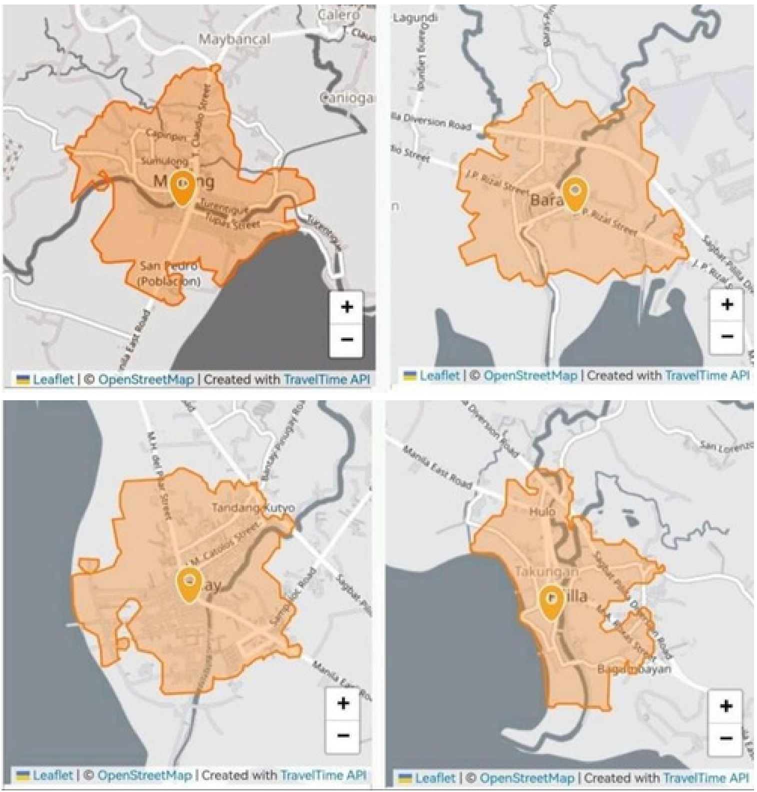
a GIS-based climate vulnerability map that identifies flood hazard zones. Overlaying these datasets reveals where environmental hazards intersect with culturally significant routes and spaces, such as procession paths vulnerable to flooding. This synthesis supports prioritization of interventions where environmental and cultural priorities converge.



Figures 1 to 4. Walkable Cultural Cores (10-Minute Isochrones) of Morong, Baras, Tanay, and Pililla. Maps illustrate the accessible street network from the central old churches, serving as a key metric for placemaking strategy and urban conservation.
Source: Author.

III. FINDINGS

The analytical results establish a clear spatial relationship between network configuration, environmental exposure, and cultural function. Highly integrated streets coincide with key cultural and commercial activity zones but are also the most vulnerable to climate impacts. These intersections form critical points where environmental adaptation can strengthen both ecological resilience and the continuity of ICH.

Within the narrow, high-density poblacion streets (typically 4 to 5 meters wide) the study introduces decentralized, small-scale NBS as a design response. Rather than replacing existing structures, the strategy activates façades, curblines, and pavement surfaces as ecological infrastructure. The interventions focus on environmental performance, spatial adaptability, and cultural compatibility.

Vertical Greening and Green Façades transform building envelopes into cooling systems that mitigate heat through shading and evapotranspiration without limiting pedestrian flow. Modular and Integrated Planters at high-integration nodes create micro-parks that provide greenery and seating. Their mobility allows streets to remain adaptable for festivals and processions.

To address multi-hazard risks, the framework applies Targeted Canopy Enhancement using native trees at intersections to reduce pavement temperatures and improve air quality.

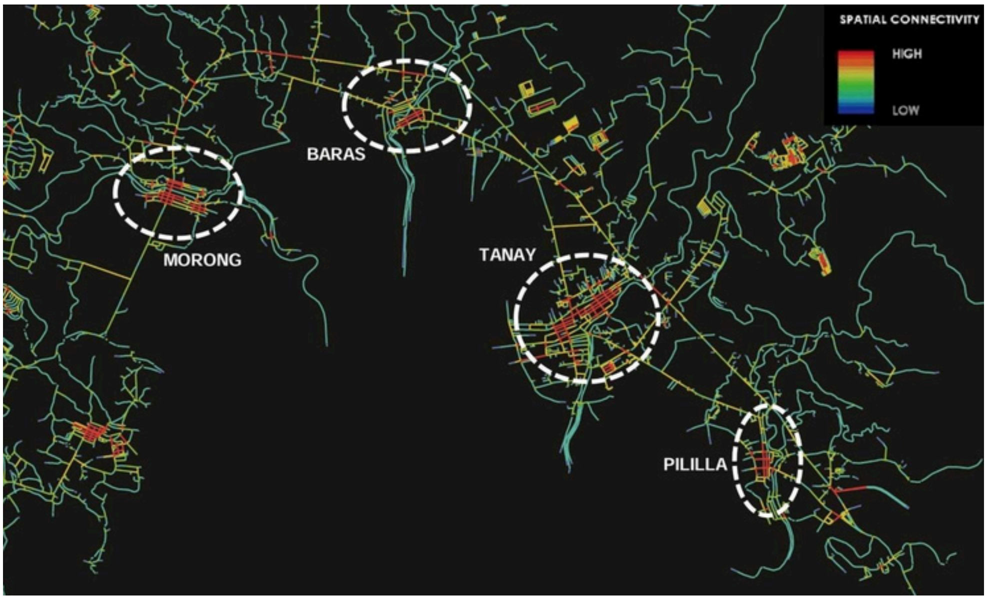


Figure 5. Axial map of Morong, Baras, Tanay, and Pililla street networkcolor-coded by Integration. Segments highlighted in Red indicate the highest spatial accessibility, defining the walkable cultural core and critical arteries for daily pedestrian flow and Intangible Cultural Heritage (ICH) activities.
Source: Author.

Figure 6 to 7. Reimagined poblacion streets with permeable pavement, vertical garden, and rain gardens along curblines.
Source: Author.

Permeable Pavement Systems replace impervious surfaces to promote infiltration, reducing surface runoff and flooding. Micro-Rain Gardens and Linear Bioswales along curblines capture and filter stormwater at source, enhancing drainage and introducing localized biodiversity.

These combined interventions could improve thermal comfort, restore walkability, and sustain public use of streets under variable climatic conditions. The approach demonstrates how environmental systems can reinforce, rather than displace, the socio-cultural functions of the poblacion core.

Poblacion Placemaking: An Integrated Spatial Analysis for Sustainable Urban Conservation of selected towns in Rizal, Philippines

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IV. CONCLUSION

The findings confirm that integrating spatial analytics with environmental design allows for data-driven prioritization of interventions, ensuring that environmental adaptation supports cultural continuity. The framework provides a replicable model for municipalities seeking to reconcile heritage conservation with climate resilience.

Small-scale, site-specific NBS can generate measurable environmental and social benefits in spatially constrained urban settings.By treating façades, pavements, and curblines as ecological interfaces, the strategy expands the definition of public space in the poblacion. It repositions everyday streets as multifunctional systems for drainage, cooling, and social exchange. This integrated approach advances a form of sustainable urban conservation that strengthens local identity while addressing the realities of rapid urbanization and climate stress.

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EXTENDED ABSTRACTS

Batad Rice Terraces: Multi-Method Assessment of Geo-Hazard Risks Using Field Survey, GIS Mapping and Drone Photogrammetry

Marie Edraline B. Belga[1], Avegail P. Casono[2], Trisha Leigh O. Lunas[3]

ABSTRACT

Batad Rice Terraces is one of the most recognizable and enduring living cultural landscapes in the Philippines. Along with Bangaan, Kiangan, Mayoyao, and Hungduan, it forms part of the five Ifugao Rice Terraces (IRT) clusters designated as both UNESCO World Heritage Sites (WHS) and Globally Important Agricultural Heritage Sites (GIAHS). A testament to the resilience of Ifugao culture, this elaborate man-made agro-ecological marvel has thrived for centuries, and continues to be actively cultivated today.

Despite its longevity, Batad Rice Terraces is faced with different challenges threatening its continuity. This study specifically investigates the geo-hazard risks confronting the Batad Rice Terraces. Its outputs ultimately inform the development of strategic recommendations and mitigating measures to reduce the geo-hazard vulnerability of identified critical areas within Batad Rice Terraces. The study employed mixed-method modes of data gathering and analysis which included field surveys, GIS-based mapping, and photogrammetry. The study's main output is a GIS-processed geo-hazard risk level map. This map classifies zones from low to high risk, as well identifies areas needing targeted site interventions such as improved drainage, stormwater interception, landscape cultivation, and slope protection. Supplementary outputs that correlate with the findings of the geo-hazard risk level map include an ortho-photo map, digital surface model, a 3D point cloud model, and a photo-documentation with field notes about the areas of concern. The analysis of the study is further contextualized by examining additional hazard drivers such as geography, geomorphology, hydrology, hydrometeorological trends, and anthropic activities.

Keywords: Batad Rice Terraces, Heritage Environments, Geo-Hazards, Risk Assessment, GIS Mapping, Photogrammetry

I. INTRODUCTION

Batad Rice Terraces is one of the most recognizable and enduring living cultural landscapes in the Philippines. Along with Bangaan, Kiangan, Mayoyao, and Hungduan, it forms part of the five Ifugao Rice Terraces (IRT) clusters designated as both UNESCO World Heritage Sites (WHS) and Globally Important Agricultural Heritage Sites (GIAHS). As the ancestral domain of the Ayangan Ifugao ethno-linguistic group, this man-made agro-ecological landscape continues to be used and cultivated today and stands as a solid testament to the enduring resilience of Ifugao culture.

II. LANDMARKS, POINTS OF INTEREST, AND COMMUNITY FACILITIES

Aside from the well-known rice terraces, there are quite a number of other notable landscape assets that can be seen in Batad. These include: a) their distinctive traditional no-nail houses-on-stilts called 'bale(s),' b) the natural springs in Sitio Higib, c) a towering tree associated with

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[3] Trisha Leigh O. Lunas: Graduate Student, Department of Geodetic Engineering, College of Engineering, University of the Philippines – Diliman Campus.

Batad Rice Terraces: Multi-Method Assessment of Geo-Hazard Risks Using Field Survey, GIS Mapping and Drone Photogrammetry

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mystic local folklore named "Acholeng," c) the "Mother Pay-aw" which is the the first paddy to be ceremoniously planted with rice during each planting season, e) the Tappiyah Waterfalls, f) the Awa View Deck, g) the traditional burial grounds in Sitio Ti-id, and h) finally, its forests atop the rice terraces that accommodate the "ala" (communal forest), the "muyong" (private woodlots), and the "uma" (swidden fields). On the other hand, local community facilities present in Batad include: 1) its barangay hall, 2) a health center, 3) a public elementary school, 4) a teacher's lodge, 5) a tourist information center, 6) a Presbyterian Church, 7) a Catholic Church, and 8) a Protestant Church.

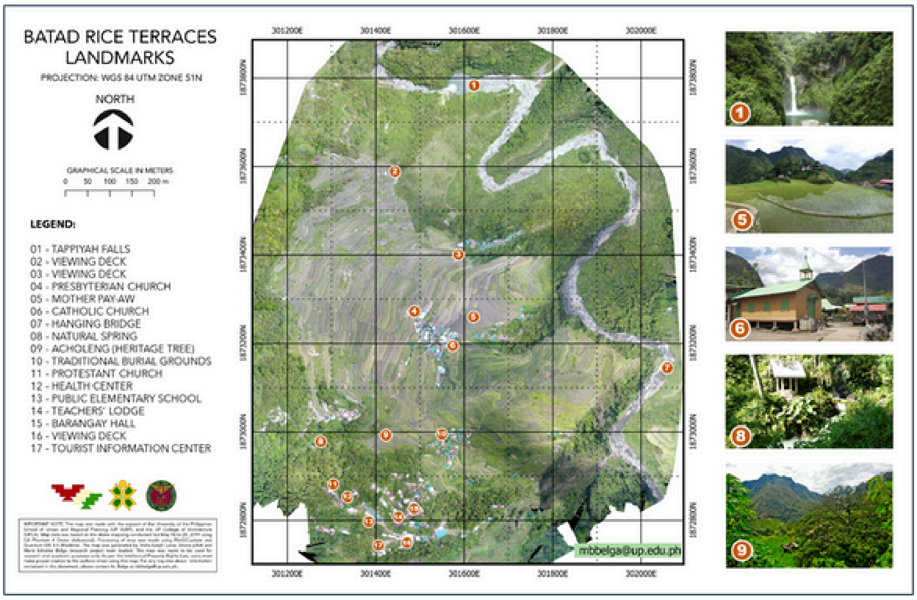

Figure 1. Landmarks and Points of Interest in Batad.
Map created and processed by ME Belga (2019).

III. MULTI-HAZARDS

Geological Hazards. Despite its longevity, Batad is faced with different challenges threatening its sustainability. Of primary concern would be its inherent susceptibility to geological hazards as landslides and soil erosion. Batad is uniquely found within a very steep, rugged, mountain terrain. Based on first-hand drone mapping data collected and processed by the researchers, elevations within Batad range from six hundred eighty meters to one thousand one hundred meters (680m – 1100m) above sea level, while eighty eight percent (88%) of its area have slopes higher than thirty percent (30%) (Bantayan et al. 2009).

Hydrometeorological Hazards. Another factor that exacerbates landslide and erosion sensitivity would be Batad's exposure to hydrometeorological hazards, further worsened by recent growing impacts of climate change. In a recent climate vulnerability assessment report released by the International Council on Monuments and Sites (ICOMOS) in 2024, Ifugao communities observe a significant increase in the intensity of typhoons, heavier rainfall, interspersed with prolonged periods of drought.

These converging geological and hydrometeorological hazards contribute to increased susceptibility to sudden landslides, creeping soil erosion, and reduced structural integrity of Batad's rice terraces.

Batad Rice Terraces: Multi-Method Assessment of Geo-Hazard Risks Using Field Survey, GIS Mapping and Drone Photogrammetry

Marie Edraline B. Belga, Avegail P. Casono, Trisha Leigh O. Lunas

IV. ANTHROPOGENIC RISK FACTORS

Aside from the topographical, geological, and hydrometeorological hazards that threaten the landscape of Batad, there are also anthropogenic factors that exacerbate the hazard risk. Among those identified include: a) frequent and intense hiking activities that erode trails and terrace walls, b) introduction of modernized or modified stonewalling techniques that usually involve cementitious mortar, c) concreting and narrowing of canals and waterways, d) land use conversion and introduction of new construction, e) disrepair of the canals and terraces, and f) the deterioration of the "badchang" tradition which contributes to the slow repair and lack of maintenance of the terraces.

V. DATA GATHERING AND RESEARCH OUTPUTS

This study specifically focused its investigation of the geo-hazard risks confronted by the Batad Rice Terraces. Its outputs ultimately inform the development of strategic recommendations and mitigating measures to reduce the geo-hazard vulnerability of identified critical areas within Batad Rice Terraces. The study employed mixed-method modes of data gathering and analysis which included field surveys, GIS-based mapping, and photogrammetry. The study's main outputs are multiple processed maps using QGIS and GRASS that contribute to the identification of critically-at-risk areas and potential patterns of geological hazards. These maps would help to classify zones from low to high risk, as well identify areas needing targeted site interventions such as improved drainage, stormwater interception, landscape cultivation, and slope protection. Basic map outputs that correlate with the findings of the geo-hazard risk levels include an ortho-photo map, digital surface model, digital terrain model, a 3D point cloud model, and a photo-documentation with field notes about the areas of concern. The analysis of the study is further contextualized by examining anthropogenic factors as additional drivers of risk.

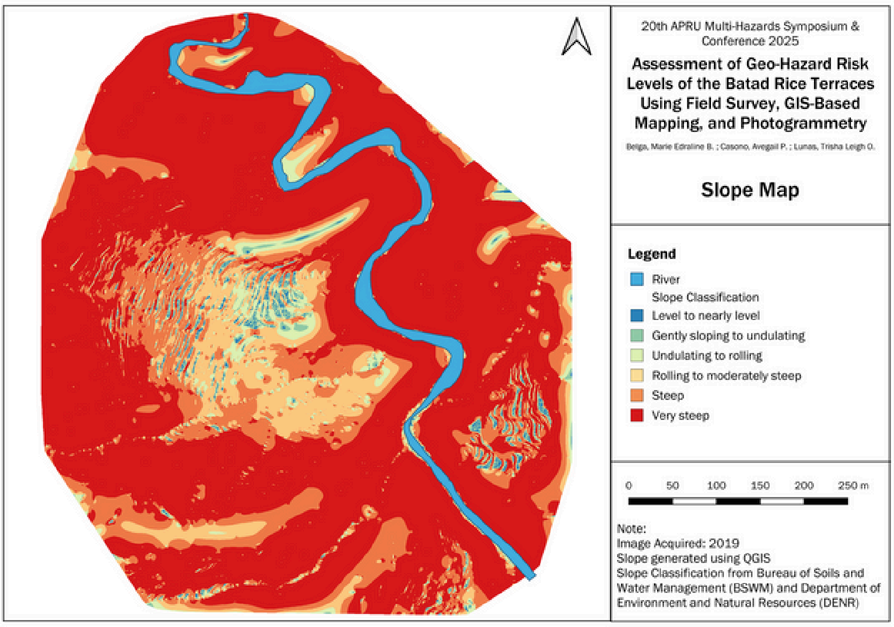

Figure 2. Slope Classification Map of Batad Rice Terraces.
Map created and processed by Trisha Leigh O. Lunas (2025).

EXTENDED ABSTRACTS

Assessment of Geo-Hazard Risk Levels of the Batad Rice Terraces Using Field Survey, GIS-Based Mapping, and Photogrammetry

Marie Edraline B. Belga, Avegail P. Casono, Trisha Leigh O. Lunas

Figure 3. An image of a landslide along a terrace in Sitio Higib. Photo by AP Casono (July 2019).

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EXTENDED ABSTRACTS

PARALLEL SESSION 1D

POLICY & GOVERNANCE

Session Moderators: Maria Benita O. Regala
and Jose Antonio P. Bimbao PhD

The Impact of Relocation for Disaster Recovery on Agriculture

***Miwa Abe*[1]**, *Yuri Nakagawa*[2], *Tadashi Uchiyama*[1]

[1] School of Humanity and Sciences, Tokai University

[2] Takasaki University of Commerce

Multihazard Framework Combining Quantitative and Qualitative Analyses of Hydrological Disasters Due to Heavy Rainfall

***Nilo Lemuel Junio Dolojan*[1]**, *Takayuji Takahashi*[1], *Masakazu Hashimoto*[2], *Akihiro Shibayama*[1], *Reika Nomura*[1], *Kenjiro Terada*[3], *Shuji Moriguchi*[1]

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[2] Faculty of Environmental and Urban Engineering, Kansai University

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Development of Community Level Flood Evacuation Plan: Case Study of Taman Sri Muda, Malaysia

***Bor Tsong Teh*[1]**, *Yong Adilah Shamsul Harumain*[1], *Nik Elyna Nik Mat*[2], *Michihiko Shinozaki*[3]

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Local Knowledge, Collective Experience, and Community-based Flood Resilience in Barangay Tumana, Marikina City, Philippines

Patricia Blanco Reyes

UP Resilience Institute; Meiji University Graduate School of Governance Studies

The Impact of Relocation for Disaster Recovery on Agriculture

Miwa Abe[1]**,** Yuri Nakagawa[2], Tadashi Uchiyama[1]

ABSTRACT

In Japan, over the past 50 years alone, more than 30,000 people have been collectively relocated within the country due to natural hazards. Research on residential relocation often mentions the economic and social impacts of relocation, but few studies focus on the primary industry (agriculture) that is affected by environmental changes. Securing farmland and agricultural workers in disaster-stricken areas is closely related to food security in those areas, but this issue has not been discussed in conjunction with disaster mitigation policies to date.

In this study, we conducted an online survey of 1,500 people in Japan to examine differences and effects of perceptions of relocation between urban and rural areas. We also compared relocation policies and examined post-relocation land use in the Tohoku region, which was affected by the Great East Japan Earthquake (2011).

As a result, in the disaster-stricken areas of Tohoku where large-scale residential relocation was implemented, it was possible to convert farmland into large-scale fields, but the number of households engaged in agriculture decreased. In addition, it was found that there are areas where many people are considering relocating their residences despite having no previous experience of disasters.

Japanese agriculture is often characterized by small-scale, family-run farms located close to residential areas. This study examines reconstruction policies, including residential relocation, for rural communities.

Keywords: disaster recovery, relocation and resettlement, agriculture, place attachment

I. INTRODUCTION

Supporters such as the World Bank posit that mass relocation accompanying disaster recovery can mitigate future vulnerability to disaster risks. Conversely, existing research treats resettlement support as a rare event [1][2], highlighting challenges including impacts on livelihoods and the social and psychological burdens associated with community formation [3]. Consequently, some view relocation as the worst-case option [4]. Although the need for cultural and social considerations in relocation has been indicated, resettlement policies have not been discussed based on long-term evaluations of their impact on survivors' livelihoods. However, recent changes in weather patterns have altered rainfall distribution, leading to frequent flooding in areas previously unaffected. While relocation to safer land after disasters requires discussion as a climate change adaptation measure, resettlement policies for both urban and rural areas—which differ in both living and social environments—are not uniform. Effective resettlement policies considering industry-specific regional characteristics have yet to be developed. Within resettlement policies focused on “rebuilding livelihoods,” there has been no explicit consideration of distinct regional characteristics or industrial structures. Therefore, this study aims to examine the differences in perceptions of residential relocation and its impacts between urban and rural areas.

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The Impact of Relocation for Disaster Recovery on Agriculture

Miwa Abe, Yuri Nakagawa, Tadashi Uchiyama

II. METHODOLOGY

To clarify attitudes toward domestic relocation after disasters and the factors influencing residential mobility, an online survey was conducted via the internet, collecting survey data from 1,500 samples nationwide among individuals aged 18 and older. The study targeted regions that experienced disasters within the past 20 years starting from 2024, as well as regions with high future disaster risk (regions without major disaster experience in the past 20 years). To examine not only disaster experience but also regional differences between urban and rural areas, participants were selected by clearly dividing them by population size.

III. SURVEY RESULTS

Results comparing disaster migration intentions by region (analysis of variance) showed significant differences between regions ($F(8, 1491) = 1.91$, $p < .10$), with Shikoku exhibiting a higher tendency toward disaster migration intentions than Kansai (Table 1).

Table 1. Analysis of Residential Relocation Due to Disasters.

	N	Mean	SD
Hokkaido	55	1.91	0.776
Tohoku	149	2.05	0.82
Kanto	474	2.01	0.854
Shinetsu-hokuriku	104	1.86	0.841
Tokai	168	1.98	0.826
Kansai	232	1.87	0.753
Chugoku	93	2.04	0.82
Shikoku	51	2.25	0.956
Kyushu	174	2	0.853
TOTAL	1500	1.98	0.832

A comparison of relocation status based on future disaster concerns among individuals with disaster relocation experience (N=77) by region (analysis of variance) revealed regional differences ($F(8,68)=1.85$, $p<.10$). A tendency was observed for individuals in the Kanto region to have experienced changes in their workplace location more frequently than those in the Kansai region (Table 2). In contrast, in the Tohoku region, which suffered significant damage from the Great East Japan Earthquake, no significant differences in relocation due to disaster concerns were observed compared to other regions.

Table 2. Changes in Work Location Due to Disaster Concerns.

	N	Mean	SD
Hokkaido	2	1.5	0.707
Tohoku	14	1.71	0.726
Kanto	18	2.67	1.237
Shinetsu-hokuriku	4	1.75	0.957
Tokai	2	2.5	0.707
Kansai	18	1.56	0.922
Chugoku	8	2	1.069
Shikoku	3	1.33	0.577
Kyushu	8	2.13	1.246
TOTAL	77	1.97	1.063

The Impact of Relocation for Disaster Recovery on Agriculture

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The results of a t-test comparing the intention to relocate following a disaster by gender showed that women (Mean 2.03) tended to have a higher intention than men (Mean 1.94) ($t(1498) = 1.96$, $p < .10$).

Table 3. Gender Differences in Residence Relocation.

	N	Mean	SD
Male	751	1.94	0.823
Female	749	2.03	0.84

To examine the determinants of relocation intentions due to disasters, a multiple regression analysis was conducted with the following explanatory variables: experiencing one or more disasters, housing status, sex, marital status, having children, income, and experiencing an earthquake of magnitude 5 or higher at home. The dependent variable was "relocation intention due to disasters." The F-value was significant at the 0.1% level (Table 4). The following factors significantly influenced the intention to relocate due to disaster: experiencing one or more disasters, being female, having no children, low income, and experiencing an earthquake of magnitude 5 or higher at home. However, the adjusted R2 was low at 0.026, indicating these variables alone cannot fully explain the phenomenon. Therefore, incorporating other determining factors into future research is necessary.

Table 4. Determinants of Relocation Intentions Due to Disasters.

Variable	β	
Experienced one or more disasters	0.116	***
Housing Status	-0.018	
Sex	0.052	*
Marrige	-0.041	
Child	0.097	**
Income	-0.045	†
Earthquakes of magnitude 5 or greater while at home	0.053	*
N	1500	
R^2	0.03	
Adjusted R^2	0.026	
F	6.641	***

p<.05*， p<.01**， p<.001***， p<.10†
Housing Status (1=Living with others, 2=Living alone), Sex (Male=1, Female=2), Marital Status (1=Married, 2=Unmarried), Children (1=Present, 2=Absent)

IV. CONCLUSION

Differences emerged between regions regarding changes in work location driven by intentions to relocate due to disasters or concerns about disasters. Shikoku showed a higher tendency toward disaster-related relocation intentions than Kansai, while Kanto exhibited a greater tendency toward changes in work location than Kansai. This is thought to be due to the impact of the Great East Japan Earthquake and memories of that time. On the other hand, no significant differences were observed between the Tohoku region, which was heavily affected by the earthquake, and other regions.

The Impact of Relocation for Disaster Recovery on Agriculture

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Furthermore, regarding relocation triggered by disasters, women were more likely than men to consider moving. It was also found that individuals who experienced damage at least once, experienced seismic intensity 5 at home, were female, had no children, and had lower household income were more likely to consider disaster-related relocation.

This study confirmed that attitudes toward relocation are influenced not only by disaster experience but also by regional differences in awareness and gender differences. However, conventional resettlement policies have not considered regional characteristics or industrial structures. Therefore, through ongoing surveys, we will organize data with a greater focus on local industrial structures.

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Multihazard Framework Combining Quantitative and Qualitative analyses of Hydrological Disasters due to Heavy Rainfall

Nilo Lemuel J. Dolojan[1,2], Takayuki Takahashi[2], Masakazu Hashimoto[2], Akihiro Shibayama[2], Reika Nomura[2], Kenjiro Terada[2], Shuji Moriguchi[2]

ABSTRACT

This study presents an integrated multihazard analysis of the hydrological disasters triggered by typhoons and heavy rainfall. The impacts of flooding, landslides, and debris flows triggered by extreme rainfall are evaluated using a combination of traditional field surveys, qualitative geomorphologic landform analyses, and quantitative numerical simulations. A case study is conducted to assess the impacts of Typhoon Yun-Yeung on Iwaki City, Fukushima, Japan in 2023. The landform analysis identifies a strong correlation between the typhoon-induced damages and the geomorphically-delineated vulnerable and high-risk landforms. The numerical analysis, on the other hand, provides quantitative spatial and temporal distributions of flood depths, slope stability, and debris flow runout in response to the typhoon. The combined approach performs the assessment from multiple perspectives, demonstrating the complementary strengths of evidence-based heuristic techniques and physics-based computational models in informing the decisions of policymakers and stakeholders. This research contributes to advancing multihazard frameworks in disaster risk reduction, offering actionable strategies for mitigating risks in typhoon-prone regions.

Keywords: multihazard analysis, rainfall-induced hazards, flooding, landslides

I. INTRODUCTION

Extreme rainfall events are becoming more frequent, causing significant hydrological disasters like floods and landslides. International frameworks, such as the Sendai Framework, call for integrated, multihazard approaches to disaster risk reduction. However, research in this area remains limited relative to single-hazard analyses, with theoretical and practical implementation facing challenges in unifying diverse physical and mathematical principles. This study addresses this gap by applying an integrated framework that combines qualitative geomorphologic analysis with quantitative numerical modeling bridging the abstract idealizations to concrete implementations. Recreating the damages of the 2023 Typhoon Yun-Yeung in Iwaki City, Fukushima (Figure 1), this research aims to assess the multihazard impacts of the event, evaluate the complementary strengths of different analytical methods, and provide actionable strategies for mitigating risks in typhoon-prone regions (Dolojan et al., 2025).

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[2] Researchers from Tohoku University and Kansai University, conduct interdisciplinary disaster science focused on natural hazards, risk reduction, and post-disaster recovery. Their work aims to develop resilient societies, advance hazard modeling, and support global collaboration in disaster preparedness, response, and reconstruction.

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Multihazard Framework Combining Quantitative and Qualitative analyses of Hydrological Disasters due to Heavy Rainfall

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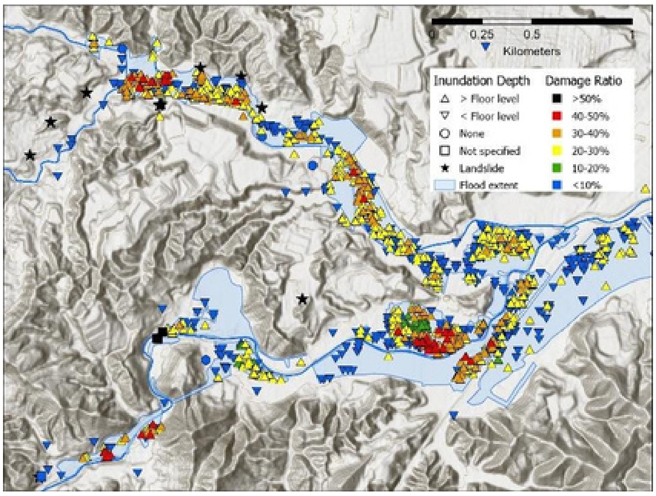

Figure 1. Damage map showing the distribution of landslides, flood extent, and damaged buildings.

II. METHODOLOGY

This study employs an integrated, multi-scale methodology to analyze the impacts of typhoons or heavy rainfall events. It employs a sequential, complementary methodology that combines both evidence-based heuristic techniques and physics-based simulations. A qualitative geomorphologic analysis is first conducted, utilizing aerial imagery and historical data to classify landforms and identify hazard-prone areas based on geologic and geomorphologic history. This is followed by a detailed quantitative assessment consisting of a two-part, multi-scale numerical simulation. First, a coarse-resolution catchment-scale model (Sayama et al, 2012) simulated the overall hydrologic response to provide upstream boundary conditions. This is followed by a high-resolution hydrologic-geotechnical model (Dolojan et al., 2023) to simulate infiltration, flooding, slope stability, and debris flow runout.

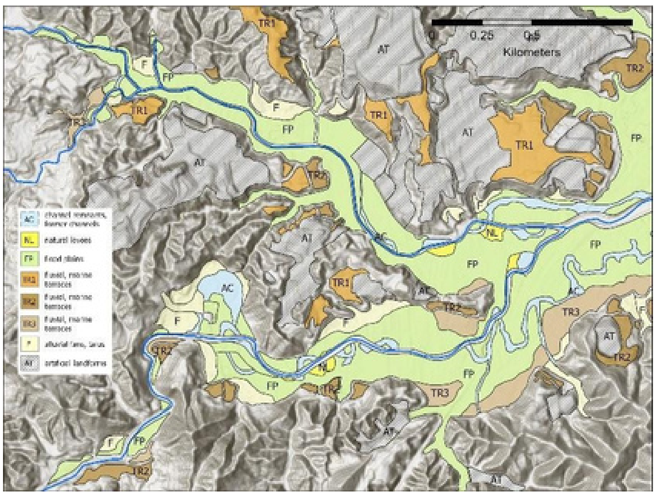

Figure 2. Landform classification map of the study area.

Multihazard Framework Combining Quantitative and Qualitative analyses of Hydrological Disasters due to Heavy Rainfall

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III. RESULTS

The geomorphological analysis (Figure 2) reveals a strong correlation between landform types and the actual damage distribution observed during the 2023 Typhoon Yun-Yeung. Inundated areas were predominantly located on low-lying floodplains and in topographic depressions corresponding to geomorphologically-delineated active and abandoned river channels and flood plains. Conversely, the documented landslides occurred almost exclusively on the steep slopes of elevated terraces, often at the base of alluvial fan deposits. These results highlight the predisposition of hazards and their recurrence according to their geomorphological context and geologic history.

The urban-scale simulation (Figure 3) successfully reproduces the observed hazard patterns. Simulated flood extents and depths showed strong qualitative agreement with post-disaster survey maps and damage reports. A quantitative comparison, using building damage ratios as a proxy for inundation depth, demonstrates a clear positive correlation: areas with higher simulated flood depths corresponded to higher damage classifications (Figure 4). The model also correctly identified the locations of observed landslides as unstable areas with a slope factor of safety values near or below 1.0.

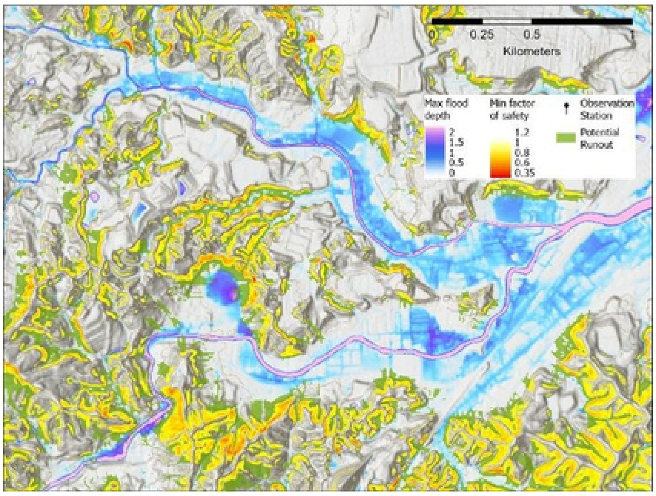

Figure 3. Maximum and minimum values for the flow depth and slope factor of safety.

IV. CONCLUSION

This study successfully demonstrates an integrated framework combining qualitative geomorphologic analysis with quantitative numerical modeling offering a comprehensive approach to multihazard assessment. The qualitative analysis contextualizes risk by highlighting historical vulnerabilities embedded in the landscape, while the quantitative modeling provided dynamic, physics-based predictions of hazard evolution during a specific event. The findings for Iwaki City can directly inform land-use zoning, the development of targeted, area-specific evacuation warnings, and future infrastructure planning. The methodology is highly transferable and particularly valuable for assessing risks in other typhoon-prone regions.

EXTENDED ABSTRACTS

Multihazard Framework Combining Quantitative and Qualitative analyses of Hydrological Disasters due to Heavy Rainfall

Nilo Lemuel J. Dolojan, Takayuki Takahashi, Masakazu Hashimoto, Akihiro Shibayama, Reika Nomura, Kenjiro Terada, Shuji Moriguchi

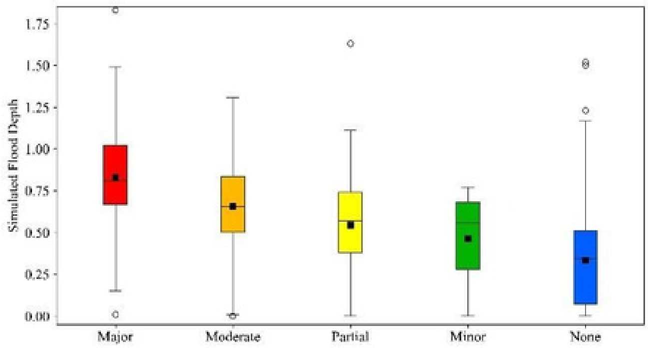

Figure 4. Boxplot showing the density distribution of the simulated flood depths for each damage class.

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EXTENDED ABSTRACTS

Development of Community Level Flood Evacuation Plan Using Open Data: Case Study of Taman Sri Muda, Malaysia

Bor Tsong Teh[1], Yong Adilah Shamsul Harumain[2], Nik Elyna Nik Mat[3], Michihiko Shinozaki[4]

ABSTRACT

Flooding is one of the common major climate-related disasters in Malaysia. Towards reducing the flood risk and building community resilience, the implementation of the flood disaster management plan by the Malaysian government can be noticed mainly restricted to the coordination and communication among the institutional agencies at the national and subnational level. However, much concerned context specific flood evacuation plan at the community level in providing direct beneficial guides to assist the residents safely escape during flood disaster is still rarely discussed. This study aims to discuss the development of community level flood evacuation plan supported by the open data. Taman Sri Muda, a flood-prone community in Kuala Lumpur, is served as the case for this study. Based on the Taman Sri Muda flood evacuation plan, the study found that the open data can provide detailed scientific and technical information for risk and vulnerability assessment particularly land use, facilities, infrastructure and built form. However, data relating to the elevation, slope, hydrology, inundation, demographic and socioeconomic data at the smaller geographic unit areas within the community itself is challenging. It is interesting to note that the open data is capable in supporting most parts of the evacuation route planning as well as shelter identification. This study concludes that the formulation of the community level flood evacuation plan using open data has a few limitations, but it remains helpful for the development of preliminary plan that is an important foundation to initiate the community participation and future improvement into the final complete plan.

Keywords: flood evacuation plan, open data, Taman Sri Muda, Malaysia

I. INTRODUCTION

The community level flood evacuation plan plays an important role towards enhancing community resilience. In the event of flood, the community level flood evacuation plan helps the community to escape timely, safely and in an organise way. A well-developed flood evacuation plan is data driven, as it requires a comprehensive set of information. By relying on the primary data that is collected directly from the community it would be time consuming, costly and labour intensive. This can be challenging for cities in the developing countries like Malaysia often limited in financial budget and human resources to develop the flood evacuation plan for flood prone communities. To address this challenge, this study aims to explore the alternative open data from the governments and institutions that are freely available for anyone to use, modify and share to develop the community level flood evacuation plan.

[1] Bor Tsong Teh is a senior lecturer at the Department of Urban and Regional Planning, Faculty of Built Environment, Universiti Malaya. He obtained his Ph.D. in Regional Environment Systems from the Shibaura Institute of Technology, Japan. He specialised in low carbon and climate resilient development for sustainable urban planning.
[2] Yong Adilah Shamsul Harumain is a senior lecturer at the Department of Urban and Regional Planning, Faculty of Built Environment, Universiti Malaya. She is an expert in transportation planning, mobility and urban design.
[3] Nik Elyna Nik Mat Yong is a senior lecturer at the Department of Building Surveying, Faculty of Built Environment, Universiti Malaya. She holds a PhD in Facilities Management from University College London. She is an expert in facilities management.
[4] Michihiko Shinozaki is a Professor Emeritus at the School of Architecture, Shibaura Institute of Technology. He holds a PhD in Urban Engineering from University of Tokyo. He is an expert in urban planning and design.

Development of Community Level Flood Evacuation Plan Using Open Data: Case Study of Taman Sri Muda, Malaysia

Bor Tsong Teh, Yong Adilah Shamsul Harumain, Nik Elyna Nik Mat, Michihiko Shinozaki

II. METHODOLOGY

Taman Sri Muda is a flood prone community (Figure 1) located in the Greater Kuala Lumpur, Malaysia is selected as the case study for this research. Five (5) key aspects of the flood evacuation plan namely: flood hazard and risk assessment; population and demography; critical infrastructure and facilities; transportation and evacuation routes; as well as safe zone and evacuation centers are discussed in this study. The related information of the open data platform provided by the Malaysian government agencies and international institution are applied to the development of Taman Sri Muda flood evacuation plan. To examine the suitability of the open data, this study focused on the three (3) dimensions that are relevance, accuracy and completeness. Relevance measures how useful the information serves for its intended purpose. Accuracy refers to the fact that information reflects the real-world entities. Completeness values whether all required information is present. Each dimension of the information quality is rated on three (3) level – low, moderate and high.

Figure 1. Major Flooding of Taman Sri Muda in 2021.
Source: Photo c/o Sadiq Asraf.

III. RESULTS AND DISCUSSION

Table 1 shows the results of the application of information from the open data sources for the development of Taman Sri Muda evacuation plan. The open data relating to the information of drainage networks, topography, flood inundation areas, flood depth, hydrology and history flood records for the technical analysis of flood hazard and risk assessment are relatively low in terms of relevance. It mainly offers crude information for broad regional context. The suitability of the open data for the population and demographic aspect of the flood evacuation plan varies. The information related to population, gender, age group and ethnicity is simple and generic in the wider geography areas. Meanwhile, information for residential land use and built form from open data can provide detail street level information in terms of housing typology, building height and construction material. It helps to identify the vulnerable community distribution within the Taman Sri Muda. In terms of critical infrastructure and facilities, the open data able to deliver the information of schools, mosque, temple and power substations of Taman Sri Muda in detail manner. For the transportation and evacuation routes, open data offers meaningful information on road networks and traffic data helps to identify safe and timely evacuation routes for Taman Sri Muda community. Lastly, for safer zones and evacuation centres, the information from open data can pinpoint the evacuation centres around the Taman Sri Muda.

EXTENDED ABSTRACTS

Development of Community Level Flood Evacuation Plan Using Open Data: Case Study of Taman Sri Muda, Malaysia

Bor Tsong Teh, Yong Adilah Shamsul Harumain, Nik Elyna Nik Mat, Michihiko Shinozaki

Table 1. The rating results of information from open data utilise in the development of Taman Sri Muda flood evacuation plan.

Key Aspect of Flood Evacuation Plan	Open Data: Department of Statistic Malaysia	Open Data: Department of Town and Country Planning Malaysia	Open Data: Department of Irrigation and Drainage Malaysia	Open Data: Department of Social Welfare Malaysia	Open Data: Google
Flood Hazard and Risk Assessment	Not Applicable	**Related Information** Water Bodies **Information Quality** Relevance: Low Accuracy: Moderate Completeness: Moderate	**Related Information** Flood Zone, Flood Depth, Historical Flood Records **Information Quality** Relevance: Low Accuracy: Moderate Completeness: Moderate	Not Applicable	**Related Information** Topography **Information Quality** Relevance: Low Accuracy: Moderate Completeness: Moderate
Population and Demography	**Related Information** Population, Gender Age Group, Ethnicity **Information Quality** Relevance: Low Accuracy: Moderate Completeness: Low	**Related Information** Residential **Information Quality** Relevance: High Accuracy: High Completeness: High	Not Applicable	Not Applicable	**Related Information** Residential Built Form **Information Quality** Relevance: High Accuracy: High Completeness: High
Critical Infrastructure and Facilities	Not Applicable	**Related Information** School, Mosque, Temple, Power Substation **Information Quality** Relevance: High Accuracy: High Completeness: Moderate	Not Applicable	Not Applicable	**Related Information** School, Mosque, Temple, Power Substation **Information Quality** Relevance: High Accuracy: High Completeness: High
Transportation and Evacuation Routes	Not Applicable	**Related Information** Road Networks **Information Quality** Relevance: High Accuracy: Moderate Completeness: Moderate	Not Applicable	Not Applicable	**Related Information** Road Networks, Traffic Data **Information Quality** Relevance: High Accuracy: Moderate Completeness: Moderate
Safer Zones and Evacuation Centers	Not Applicable	Not Applicable	Not Applicable	**Related Information** Evacuation Centre **Information Quality** Relevance: High Accuracy: High Completeness: Moderate	**Related Information** Topography **Information Quality** Relevance: Low Accuracy: Moderate Completeness: Moderate

IV. CONCLUSION

Based on the case study of Taman Sri Muda in Malaysia, the study noticed that information from the open data is meaningful for the three (3) out of the five (5) key aspects of flood evacuation including critical infrastructure and facilities; transportation and evacuation routes; and safer zone and evacuation centers. To a certain extent, the open data is also helpful for the population and demography. The study found that the open data remains helpful for the preliminary stage of flood evacuation plan development. Instead of starting from scratch with absence of information, the open data is useful to initiate important first step in the entire flood evacuation plan formulation stage.

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Local Knowledge, Collective Experience, and Flood Resilience in Barangay Tumana, Marikina City, Philippines

Patricia B. Reyes[1]

ABSTRACT

The study explores how local knowledge and experience shape protective behavior against flooding and how these can be integrated into flood resilience policies through participatory governance. It asks the central question: "How can local knowledge and collective experience inform protective behavior and formal policies against flooding?". This study employed a qualitative design with key informant interviews (KIIs), focus group discussions (FGDs), and field observations. Transcripts were analyzed using Braun & Clarke's (2013) thematic process guided by the Protective Action Decision-Making (PADM) model and the Whole-of-Society (WoS) approach. In Barangay Tumana, protective behaviors and decision-making during floods are shaped by local knowledge and unique experiences of flooding. Positive ones encourage evacuation to camps, while traumatic or unsatisfactory experiences lead residents towards more alternative and improvised strategies grounded in social ties. These protective actions, guided by lived experiences, were foundational inputs to developing and legitimizing localized, responsive, and appropriate solutions for community-based flood resilience. While previous studies explored flood resilience and behavioral responses separately, often using quantitative approaches, this work is the first to integrate these areas using an interdisciplinary dual-lens framework. This study's novelty lies in its incorporation of behavioral insights with policy analysis to demonstrate how local perspectives shape both protective behaviors and refine formal institutional strategies for flood resilience. The study focused on local knowledge and is limited by self-reported, anecdotal evidence, lack of disaggregated data, and access constraints. While triangulation and secondary sources helped mitigate these, variations in protective behavior across demographic groups remain underexplored.

Keywords: flood resilience, protective behavior, local knowledge, Protective Action Decision-Making model, Whole-of-Society

I. INTRODUCTION

The concept of disaster resilience has evolved from assessing tangible factors such as economic capacities, physical infrastructure, and technological advancements to incorporating more intangible factors such as lived experiences, culture, and local knowledge. Particularly for disaster-prone developing countries like the Philippines, where a big chunk of the population is significantly below the poverty line, these informal and undocumented assets play a significant role in shaping risk perception and protective behaviors against disasters like flooding. These perceptions are influenced by cultural, historical, socio-economic, and experiential factors that, in turn, can motivate or hinder adherence to recommended protective behaviors in the face of flooding.

II. METHODOLOGY

This study aimed to understand how local knowledge and collective experience can influence the protective behavior of low-income residents living in a low-lying, flood-prone barangay in

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Patricia B. Reyes

Marikina City, Philippines, to supplement local disaster resilience policies and protocols. This study employed a qualitative research design using key-informant interviews, focus group discussions, and field observations with the local community of Tumana to capture in-depth insights on local knowledge and collective experience of flooding, as well as protective behaviors and practices to cope with this persistent and recurring threat. This work utilizes an integrated approach that links behavioral insights with a policy critique using both the Protective Action Decision-Making (PADM) model (Lindell & Perry, 2004 & 2012) and the Whole-of-Society (WoS) approach (Kjellén, et al., 2023).

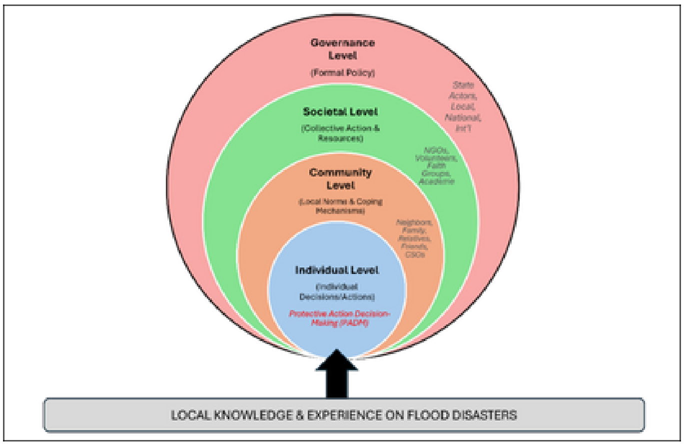

Figure 1. Analytical Framework Linking the PADM and WoS Approach.
Source: Illustrated by the author

III. SUMMARY OF FINDINGS

First, local knowledge (LK) and collective experience (CE) influence the protective action decision-making process of Tumanians in that their decision to enact recommended (i.e., evacuation) or improvised protective actions before (i.e., preparedness), during (i.e., response/coping), and after (i.e., adaptation) are built upon their LK and CE in flooding. Second, their improvisations are rooted in locally established knowledge on flooding and social networks, which are essential for vulnerable sectors of society who have little to no access to basic services. Third, this study provides evidence on how LK and CE shaped and became foundational inputs in the development of local flood resilience policies and protocols through the operationalization of participatory governance approaches, such as the WoS approach, and are now utilized across the city through Marikina's Flood Protocol. Finally, different communities share different histories, cultures, and customs, and socio-economic conditions. Paying attention to how these factors affect the effectiveness of formal measures is essential in sustainable community-based flood resilience, where resource sharing and social networks are vital for survival.

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Local Knowledge, Collective Experience, and Flood Resilience in Barangay Tumana, Marikina City, Philippines

Patricia B. Reyes

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EXTENDED ABSTRACTS

PARALLEL SESSION 2A
INTERSECTIONALITIES
Session Moderator: Maria Antonia Tanchuling PhD

Diversifying Livelihood Opportunities in Tabaco City, Albay for the Conservation of Mount Mayon Natural Park (MMNP)
Althea Beatrice G. Ylade, *Maria Vio Bianca F. Yukimura*
College of Architecture, University of the Philippines-Diliman

Relational disaster resilience for an “urgent future”
Shelley Tuazon Guyton
National University of Singapore and NUS College

Diversifying Livelihood Opportunities in Tabaco City, Albay for the Conservation of Mount Mayon Natural Park (MMNP)

Althea Beatrice G. Ylade[1], Maria Vio Bianca F. Yukimura[2]

ABSTRACT

The Philippines features numerous volcanoes and experiences frequent earthquakes which poses a risk for vulnerable areas. Mayon Volcano is the most active volcano in the Philippines, with Mount Mayon Natural Park (MMNP) as a protected area under the E-NIPAS Act of 2018. Although protected by the law, there remains reports of human activity in said areas. 39,192 individuals in Albay rely on agriculture due to environmental conditions favorable for cultivation. However, with evacuation and displacement due to volcanic events— lasting an average of three months, income source is put on pause. Agricultural lands have spread into the designated buffer zone, leading to potential encroachment into the protected area. This study explores livelihood diversification as a strategy to minimize the reliance on agriculture as the people's main livelihood. Planning scenarios are created to explore the most appropriate livelihood sector to develop. Its suitability was quantified using the principles of biodiversity-friendly enterprises outlined by DENR AO No. 2021-13 as the main criteria, while scoring is supported by literature review, interviews, and site visits. Results have shown that off-farm agriculture opportunities are the most suitable livelihood options. With income diversification through the (1) provision of land and resources, (2) permutations of livelihood opportunities, (3) livelihood calendar, and (4) income productivity, both environmental and economic strategies are identified. These relieve the pressure on agriculture while addressing threats of encroachment in MMNP. Furthermore, they provide local communities with economic opportunities to stabilize their primary livelihoods.

Keywords: protected areas, conservation, agriculture, livelihood diversification

I. INTRODUCTION

Being in Albay, Mayon Volcano is located right at the center of Bicol Region. The Mount Mayon Natural Park (MMNP) covers 5,327.15 hectares of land with a total altitude of 2,462 meters (PASU, 2024). The slopes of the Mayon Volcano are designated for agricultural use. The province of Albay gets its main source of economic activity from the agriculture, forestry, and fisheries (AFF) sector. In 2023, Albay's Gross Regional Domestic Product (GRDP) decreased by 3.4% after the agricultural sector was disturbed by the sudden Mayon eruption (NEDA, 2023). This can be attributed to the seasonality of income opportunities that are aligned with the lifestyle and conditions of living in the local community (PASU, 2024).

II. METHODOLOGY

The study is done through data gathering, data synthesis, scenario development. A preliminary research and literature review was conducted to identify the problems and the study proceeds with the data gathering phase from primary and secondary sources. Data is compiled to create site maps, summary of stakeholder preferences and perceptions, and general site information. These are synthesized and analyzed to understand the relationship between different

[1] Althea Ylade is a graduate of B Landscape Architecture from University of the Philippines Diliman. Her work mostly focuses on sustainability for the environment and its users. She aspires to channel her passion into designs to serve the local communities, especially the marginalized.
[2] Bianca Yumikura is a landscape architect and academic with multiple master's degrees: MS in Environmental Science from Ateneo de Manila University, MS in Sustainable Tropical Forestry from University of Copenhagen, and MS in Sustainable Tropical Forestry from AgroParis Tech.

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elements. Data shows that a significant portion of the habitable land is within vulnerable areas (Figure 2), some of which are agricultural lands (Figure 1).

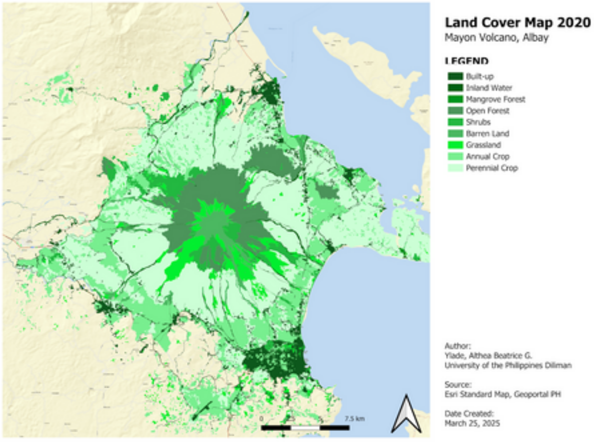

Figure 1. Land Cover Map.

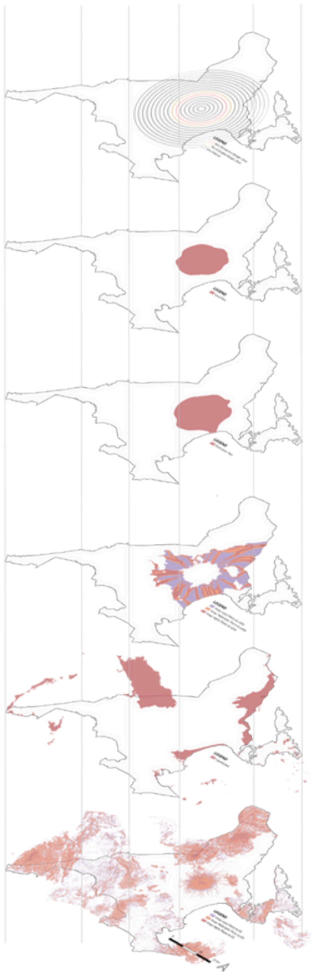

Figure 2. Hazard Mapping.

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III. RESULTS AND ANALYSIS

A. Planning Scenarios

The planning scenarios determine the most appropriate and effective approach to achieve the goal of livelihood diversification, as guided by DENR AO No 2021-13. From the said document, the planning scenarios developed are focused on on-farm agriculture, off-farm agriculture, fisheries, and ecotourism, wherein off-farm agriculture was chosen as the most suitable (Figure 3).

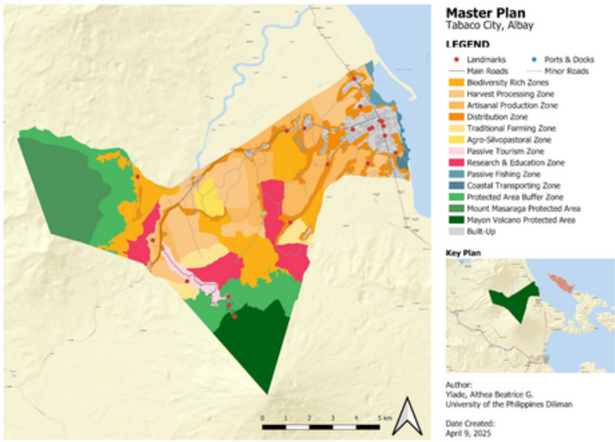

Figure 3. Masterplan Anchored on Off-Farm Agriculture.

B. Livelihood Calendar

The livelihood calendar describes the different activities that can be pursued in the proposed landscape development (Figure 7). The interventions are created to ensure year-round income generation for the local communities. This will help optimize operations and community opportunities without compromising environmental conditions.

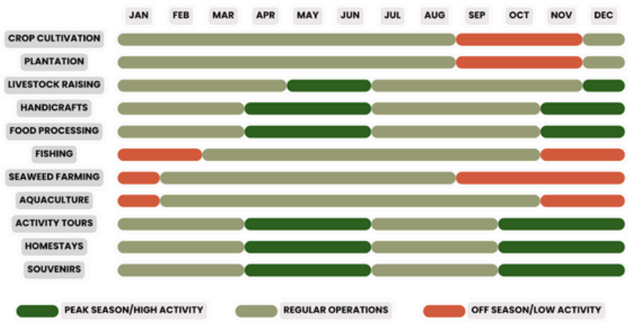

Figure 4. Sample Livelihood Calendar.

IV. CONCLUSION

The study examined the effectiveness of the different diversification scenarios. These scenarios factor in the impacts of disaster risk and vulnerability to natural hazards, specifically volcanic activities. Permutations of livelihood opportunities are integrated into the planning scenarios to support the sustainability of livelihood strategies considering external factors. Diversification of livelihood shows great promise in tackling economic resilience through improvement in operations of livelihood opportunities.

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Diversifying Livelihood Opportunities in Tabaco City, Albay for the Conservation of Mount Mayon Natural Park (MMNP)

Althea Beatrice G. Ylade, Maria Vio Bianca F. Yukimura

Utilization of land is not simply an issue caused by personal needs and demand for ownership. There lies complex reasoning influencing people's actions and motivations that is a result of social, political, financial, and ecological factors weaved together. By promoting resilient and community-driven livelihoods, the people of Albay can reimagine a more secure and stable future.

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Relational disaster resilience for an "urgent future"

Shelley Tuazon Guyton[1]

ABSTRACT

In the Philippines, hegemonic knowledge of environmental disaster and its management is rooted in a centuries-long history of colonial science and continuing orientation toward adopting external frames of thought and practice (social and technical) for dealing with disaster, often flowing not only from different cultural contexts but also along the lines of former colonial relations (United States) and hierarchical knowledge relations between Global North and Global South. This includes the international concept of "resilience," which has been implemented in local disaster mitigation practices. Taking a decolonial lens and drawing from long-term ethnographic study (participant-observation, interviews, document and media analysis, etc.) in post-Typhoon Yolanda Tacloban City Leyte, this paper analyzes scenarios in which encounters between survivors, relief workers, and government workers in the Philippines formed organic acts of relational care and resilience that responded to the immediate needs of people, and did not necessarily conform to the intentions and expectations of disaster science and governance.

We may think of a "coloniality of disaster" in which structures and enduring legacies of colonialism set the stage for disaster impact and its aftermath in post-colonial states and "survivance" of postcolonial communities (including diasporic members) (Bonilla and LeBrón 2019; Gonzalez 2022). "Decoloniality" asks us to acknowledge, question and disrupt colonial, "ongoing relations and patterns of power established by external and internal colonialism," and "make visible, open up, and advance radically distinct perspectives and positionalities that displace Western rationality as the only framework and possibility of existence, analysis and thought" (Mignolo & Walsh, 2018: 16-17). Decoloniality further challenge us to consider the potential and prospects for the "decolonial for"—why, how and for whom we imagine and put into praxis "decolonial otherwise" ways of being and doing in the world. Decolonial approaches to disaster similarly critique Western hegemony of knowledge and support indigenization of disaster knowledge (Cadag 2022). Moving away from "resilience" as a hegemonic frame for understanding lived experiences of disaster, we might move instead toward considering social ontologies of relationality which help us think "otherwise" about how disaster works in postcolonial and Global South contexts (Meriläinen et al. 2021).

Extending a decolonial qualification to questions of disaster as a socio-environmental phenomenon, I believe it is meaningful to ask: How might we recognize and analyze "decolonial otherwise" in practice on the ground in disaster situations? In answering, I turn to analyzing key moments of relational knowledge-making by disaster-affected people and those responding to disaster. I found that residents of urban poor coastal communities relied much more on informal infrastructures of survival they built themselves with practices of knowledge-sharing across kinship, friendship and locality-based networks than on formal disaster risk reduction infrastructures put in place by the local and national governments. In my neighborhood (purok) of focus, for example, fisher folk shared observations about weather-related sea conditions, middle-aged parents shared insights from local radio, young adult children used Facebook to reach out to the City Disaster Risk Reduction and Management Office for location-specific updates, and more. These family and neighborhood networks produced a unique relation-based knowledge specific to the purok's environmental

[1] Lecturer in Global Studies, National University of Singapore and NUS College. Working from an anthropological and Southeast Asian Studies perspectives, I ethnographically analyze how typhoon-affected people in the Philippines navigate disaster media infrastructures to survive annual typhoons. I am an educator on topics of disaster, infrastructure, media, and postcolonialism.

Relational disaster resilience for an "urgent future"

Shelley Tuazon Guyton[1]

and socio-economic context, which the residents primarily relied on to prepare for and survive annual typhoons. I argue that while a technocratic "resilience" was applied as a disaster mitigation strategy by governing agencies, survivors themselves produced a relational disaster resilience based on social networks of caring, and communal knowledge sharing that was attuned to the first-hand experiences and various expertise of disaster-affected people in their community (sometimes necessarily contradicting hegemonic disaster knowledge for survival). Furthermore, I propose that relational disaster resilience emerged non-linearly in both the acute need to respond to what I name as the "urgent future" of immediate typhoon survival needs, and the protracted, attritional future of typhoons in years to come. Relational disaster resilience was characterized by responsive moments, as opposed to the planned approaches packaged under resilience in organized relief and disaster risk reduction projects. A consideration of relational forms of disaster resilience on the ground contributes to ongoing research and practices of disaster resilience that can benefit by recognizing existing relational ontologies of survival in practice.

Keywords: disaster, resilience, relationality, decoloniality

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EXTENDED ABSTRACTS

PARALLEL SESSION 2B

DESIGNING FOR RESILIENCE

Session Moderator: Kristina Cordero - Bailey PhD

Managed Retreat or In-situ Adaptation? Empirical Metrics of Coastal Withdrawal and Substitute Adaptations after the 2011 Great East Japan Earthquake and Tsunami

Sosuke Tani, *U Hiroi, Kensuke Otsuyama, Saki Yotsui, Kaori Isawa*
The University of Tokyo

TAALalay: Landscape Approaches for Developing Scenario-Based Guidelines for Designing Evacuation Spaces for Taal Volcano Eruption

Moira Samantha Ysabel O. Estanislao, *Maria Vio Bianca F. Yukimura*
College of Architecture, University of the Philippines-Diliman

AguaVerde: A Case Study on the Ecological Revitalization of Selected Inland Water Channels of the Marikina River through Blue-Green Infrastructure

Diomari DG. Centeno, *Jose Dan V. Villa Juan, Jacklyn Alexandra Marie B. Bello*
College of Architecture, University of the Philippines-Diliman

An Integrated Ecological Approach to Urban Riparian Development: Valuation of the the Ecosystem ServicesNational River Park Corridor of New Clark City

Vic Dul-loog
University of the Philippines-Diliman

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Managed Retreat or In-situ Adaptation? Empirical Metrics of Coastal Withdrawal and Substitute Adaptations after the 2011 Great East Japan Earthquake and Tsunami

Sosuke Tani[1], U Hiroi[2], Kensuke Otsuyama[2], Saki Yotsui[2], Kaori Isawa[2]

ABSTRACT

Managed retreat has become crucial in disaster-risk reduction, while quantitative analyses are rare amid retreat strategies usually combine relocation with other interventions. Previous studies noted social resistance and fairness issues as possible barriers to managed retreat, but they rarely measured how much retreat was achieved or what substitutes were utilized. Using Japan's post-2011 recovery context of detailed hazard mapping and institutional relocation programs, this study quantifies spatial changes in residential tsunami exposure, examines geographic constraints on retreat, and identifies alternative adaptation portfolios. We combine 250-meter census grids for 2010 and 2020 with tsunami inundation data and residential building polygons to evaluate population exposure within inundated areas. Exposure change is assessed by comparing observed 2020 exposure to a counterfactual "no-disaster" scenario. Results show significant heterogeneity: some municipalities retained many high-exposure cells in severe hazard zones, while others achieved extensive retreat. These contrasts align with geography—ria coasts with limited flat land show persistence, whereas coastal plains exhibit greater relocation. Aggregated outcomes reveal differing local portfolios, ranging from inland relocations supported by hazard-zone prohibitions to adaptive on-site rebuilding with seawalls and elevated floors. The evidence from Japan serves as a transferable benchmark for crafting suitable adaptation strategies.

Keywords: tsunami, managed retreat, land use, GEJET

I. INTRODUCTION

Managed retreat—the intentional reduction of residential use in hazard-prone areas through regulation, incentives, or buyout—has gained prominence as climate risks intensify and structural protection or in-place adaptation may be insufficient (Siders, 2019). While classic work emphasized relocation's harms and governance challenges, recent studies assess program performance, equity, costs, and land outcomes (Mach et al., 2019). However, empirical evidence remains limited regarding both the achievements and limitations of retreat, as well as the adoption of alternative risk-reduction measures. In contrast, Japan's 2011 Great East Japan Earthquake and Tsunami (GEJET) implemented diverse institutional programs for large-scale urban restructuring and relocation from hazard-prone zones, providing a suitable case for examination. Accordingly, this study addresses how far retreat advanced in tsunami-affected areas, how topographic conditions influenced its progress, and what alternative risk-reduction strategies were adopted.

II. METHODOLOGY

The analytical process has three steps: (1) assemble geospatial inputs; (2) compute exposure for actual and counterfactual 2020; (3) evaluate exposure change against tsunami inundation depth in a matrix. Study units are municipalities in Miyagi and Iwate whose inundation area of GEJET Tsunami intersects at least ten 250-m census grid cells (Figure 1). First, we integrate

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Managed Retreat or In-situ Adaptation? Empirical Metrics of Coastal Withdrawal and Substitute Adaptations after the 2011 Great East Japan Earthquake and Tsunami

Sosuke Tani, U Hiroi, Kensuke Otsuyama, Saki Yotsui, Kaori Isawa

Figure 1. Locations of the target municipalities.

250-m census grid populations for 2010 and 2020, residential building polygons provided by Zmap-TOWN II (Zenrin Co.), and GEJET tsunami inundation extent/depth to delineate exposed cells and residents. Second, the counterfactual scenario multiplies 2010 mesh populations by pre-GEJET (2008) projected population change rates, excluding tsunami-related fatalities to isolate retreat effects. Third, we compute the outcome as the ratio of observed 2020 exposure to the counterfactual and classify each cell/municipality using a depth–exposure change matrix (Figure 2). This enables an empirical analysis of where population retreat has progressed and where it has not under tsunami hazards of comparable intensity.

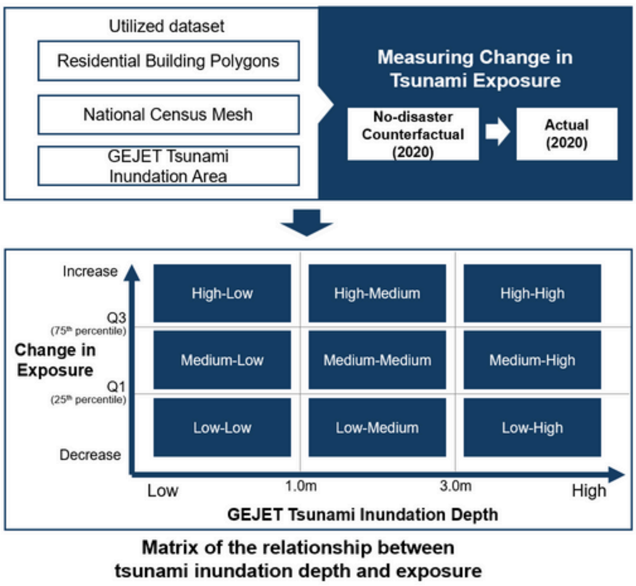

Figure 2. Analytical framework for estimating and classifying exposure change based on inundation depth.

Managed Retreat or In-situ Adaptation? Empirical Metrics of Coastal Withdrawal and Substitute Adaptations after the 2011 Great East Japan Earthquake and Tsunami

Sosuke Tani, U Hiroi, Kensuke Otsuyama, Saki Yotsui, Kaori Isawa

III. RESULTS AND DISCUSSION

Across the evaluated grids, even in areas severely inundated by the tsunami, the degree of population retreat differed widely. Some municipalities showed persistent residential exposure in deep inundation zones, while others achieved substantial withdrawal. Focusing on grids with inundation depth of three meters or more, municipalities with higher shares of limited-retreat cells are concentrated along ria coasts, while lower shares appear on coastal plains. Ria coast areas feature indented shorelines, scarce flat land, and heightened tsunami impacts, which constrain the availability of safe, developable sites and help explain the persistence of residence in high-risk areas (Kondo and Lizarralde, 2021). In contrast, coastal plains offer relatively abundant inland land, facilitating retreat away from high-hazard zones.

Even among ria coast municipalities, Rikuzentakata and Minamisanriku advanced retreat most decisively through the Group Relocation Program and other city planning tools, relocating urban functions to newly developed inland sites and designating former sites as disaster risk areas that prohibit new housing construction. Conversely, in Ofunato and Kamaishi, retreat was partial: within disaster risk areas, zones with lower inundation depth or areas protected by seawalls permitted conditional rebuilding, such as elevated living floors, thereby promoting adaptive in-place recovery (Araki and Hokugo, 2018). These contrasts indicate that under strict geographic and tsunami constraints, strategic choices between relocation and adaptive on-site recovery diverged across municipalities, and these choices are closely reflected in post-disaster exposure outcomes.

IV. CONCLUSION

This study estimates change in tsunami exposure across GEJET-affected areas, then classified mesh level retreat outcomes and aggregated them to municipalities. Results showed marked heterogeneity: ria coast municipalities retained high risk residence more often, while coastal plains more readily enabled retreat. Practice should align portfolios of relocation, disaster risk area regulation, and adaptive on-site measures with geographic constraints.

ACKNOWLEDGEMENTS

This research was the result of the joint research with CSIS, the University of Tokyo (No. 1412) and used Zmap TOWN II data provided by ZENRIN CO. of Japan.

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EXTENDED ABSTRACTS

TAALalay: Landscape Approaches for Developing Scenario-Based Guidelines for Designing Evacuation Spaces for Taal Volcano Eruption

Moira Samantha Ysabel O. Estanislao[1], Maria Vio Bianca F. Yumikura[2]

ABSTRACT

Volcanic crisis evacuations differ from others due to their uncertainties. The timing of evacuations ordered is critical as it can save tons of lives, but consequences also await if orders are too early or too late. With Agoncillo, Batangas' proximity to the volcano and its inclusion within both the 7-kilometer and 14-kilometer danger zones delineated by the Philippine Institute of Volcanology and Seismology (PHIVOLCS), the municipality is identified as a high-risk area requiring prioritized evacuation planning. Only few investigate and examine ways in which landscape architecture can play a meaningful role in reducing disaster risk management, moreover, volcanic events. This study looks at how landscape approaches be effectively integrated into evacuation plans for Taal Volcano eruptions by the use of scenario-building methodology that integrates PHIVOLCS' Alert Level system (ranging from Level 1 to Level 5) with simulations of ashfall dispersion. Findings indicate that as the Alert Level escalates, the number of affected barangays and displaced populations increases significantly, necessitating scalable and adaptable evacuation strategies. This study explored three evacuation planning scenarios and found Scenario 3 to be the most holistic and sustainable, as it not only provides shelter and basic needs but also includes livelihood support and community care, helping both evacuees and the host community recover and build resilience. When plans are effectively implemented in collaboration with governing officials, collaborators, and various sectors during a disaster, then it will ensure better-coordinated evacuation efforts, enhancing the safety, efficiency, and overall well-being of people affected by the eruption.

Keywords: volcanic eruptions, evacuation site, landscape approach, ashfall simulation, planning scenario

I. INTRODUCTION

The Philippines has moved toward proactive disaster management emphasizing preparedness and resilience. However, the 2020 eruption exposed poor evacuation facilities. Alejandria et al. found that 60.8% of 17,042 centers—mostly schools—remain hazard-prone and lack adequate amenities for evacuees.

Agoncillo's proximity to Taal Volcano makes it highly vulnerable to hazards. PHIVOLCS maps show several barangays within the 7 km Permanent Danger Zone and the entire municipality within the 14 km danger zone, requiring evacuation at Alert Levels 4 or 5. Thus, Agoncillo is prioritized for hazard assessment and disaster planning.

[1] Moira Samantha Ysabel Estanislao, a Bachelor of Landscape Architecture graduate from the University of the Philippines Diliman, developed a deep interest in how natural events shape environments. Witnessing the 2020 Taal Volcano eruption inspired her to study landscape changes and promote resilient, well-planned designs for communities in disaster-prone areas.

[2] Maria Vio Bianca F. Yumikura is a landscape architect and academic with multiple master's degrees: MS in Environmental Science from Ateneo de Manila University; MS in Sustainable Tropical Forestry from the University of Copenhagen; and MS in Sustainable Tropical Forestry from AgroParisTech.

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TAALalay: Landscape Approaches for Developing Scenario-Based Guidelines for Designing Evacuation Spaces for Taal Volcano Eruption

Moira Samantha Ysabel O. Estanislao, Maria Vio Bianca F. Yumikura

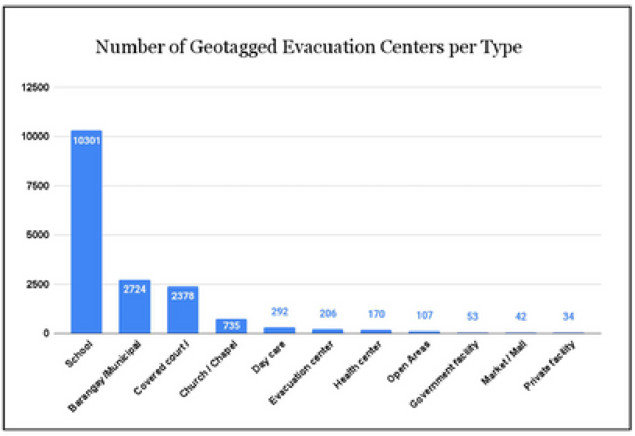

Figure 1. Number of evacuation centers for each category.
Source: Alejandria et al., n.d

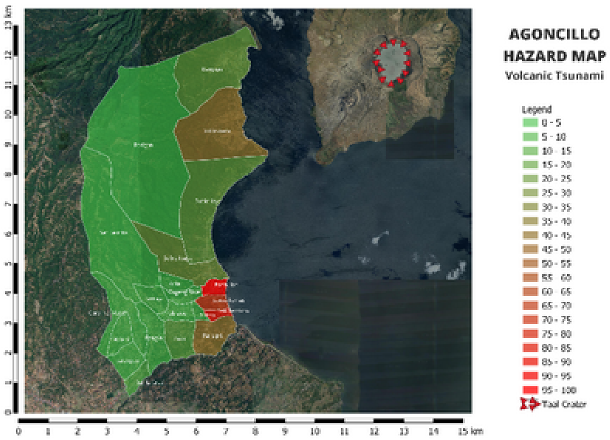

Figure 2. Affected Barangays in Agoncillo by Volcanic Tsunami.
Adapted from: PHIVOLCS, 2020

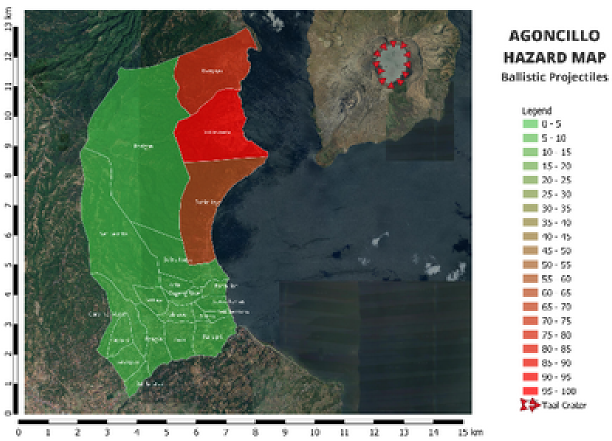

Figure 3. Affected Barangays in Agoncillo by Ballistic Projectiles.
Adapted from: PHIVOLCS, 2020

EXTENDED ABSTRACTS

TAALalay: Landscape Approaches for Developing Scenario-Based Guidelines for Designing Evacuation Spaces for Taal Volcano Eruption

Moira Samantha Ysabel O. Estanislao, Maria Vio Bianca F. Yumikura

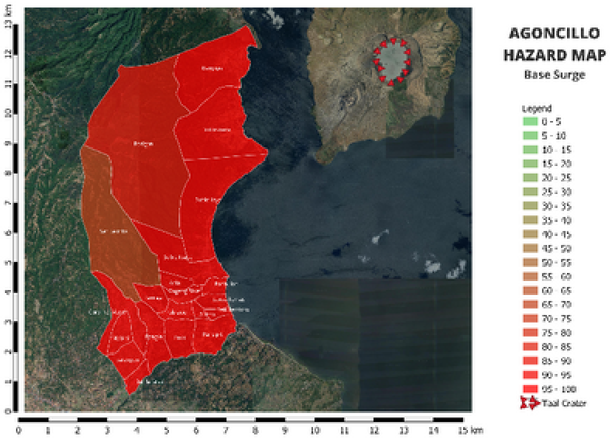

Figure 4. Affected Barangays in Agoncillo by Base Surge.
Source: Alejandria et al., n.d

With the numerous natural disasters the Philippines has experienced, including volcanic eruptions, raises the question of whether we are truly prepared to respond to such events effectively.

II. STATEMENT OF THE PROBLEM

How can landscape approaches be effectively integrated to improve evacuation plans for the town of Agoncillo during a Taal Volcano eruption?

III. OBJECTIVES

This study aims to determine optimal evacuation site locations, and analyze hazard maps for planning. It also evaluates existing evacuation schemes, integrates landscape approaches to space design, applies scenario building for Agoncillo's residents, and develops a guidebook for improved disaster preparedness.

TAALalay: Landscape Approaches for Developing Scenario-Based Guidelines for Designing Evacuation Spaces for Taal Volcano Eruption

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IV. METHODOLOGY

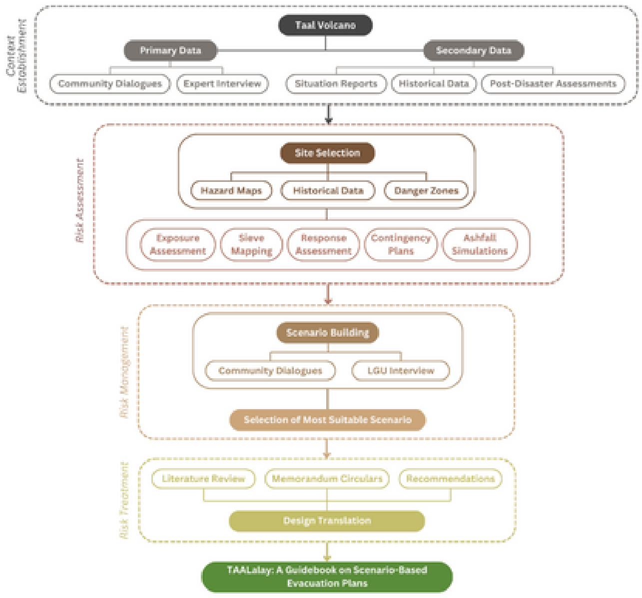

Figure 5. Methodological Framework.

V. RESULTS AND ANALYSIS

A. Safe Zone

The site in Calaca, Batangas, located in Poblacion, is accessible through major roads and close to key facilities like healthcare and supply hubs. Its open spaces can serve as a multi-purpose park and evacuation center.

B. Scenario Development

B.1 Scenario 1

It reflects the current setup, with designated pick-up and drop-off points for evacuation in Agoncillo, Batangas.

AGONCILLO BATANGAS

PICK UP POINTS

PP1. Bangin Brgy Hall
- Bangin

PP2. Coran na Munti NHS/ES
- Balangon, Coral na Munti, Mabini

PP3. Plaza Elena, Poblacion
- Adia, Bagong Sikat, Guitna, Pamiga
- Poblacio, San Teodoro

PP4. Sta Cruz Open Area
- Pansipit

PP5. Pook Elementary School
- Pook

PP6. Panhulan Elem School
- Sto Tomas

PP7. Pansipit Softball Field
- Pansipit

PP8. Subic Elem School
- Subic Ibaba and Ilava

PP9. Banyaga Brgy Hall/ Chapel Open Area
- Banyaga

PP10. Bilibinwang Brgy Hall
- Bilibinwang

DROP OFF POINTS

DP1.San Luis Municipal Hall
from: PP1 and PP2

DP2.Balayan Municipal Hall
from: PP3,PP4,PP5

DP3.Provincial Sports Complex
from: PP2,PP3,PP6,PP7,PP12

DP4.Calatagan Municipal Hall
from: PP8,PP9,PP10,

DP5: Mendez, Cavite
From: PP9,PP10

DP6.Tagaytay, Cavite
from: PP9,PP10,PP11

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ROUTES:

R1 : PP1 to DP1
Via: Lemery -Agoncillo Rd
D: 9.9 Km T: 23 Min
R2: PP2 to DP3
Via: Palico-balayan-batangas Rd-batangas Rd./P Burgos
D: 29.3 KM T: 52 MINS
R3: PP3 to DP2
Via: Palico-balayan-batangas Rde
D: 29.2 Km T: 59 Mins
R4:PP4 to DP3
Via: Lemery-agoncillo Rd. Palico Balayan -Batangas
D: 26.2KM T: 40 MIN
R5:PP5 to DP2
Via: Lemery-agoncillo Rd. Palico -Balayan -Batangas Rd
Distance: 23.8 Km Time: 36 Mins
R6: PP6 to DP3
Via: Lemery-agoncillo Rd-brgy. Sto Tomas Rd.- Calaca -Lemery Hwy/ Illustre Ave /Nh17/Palico-balayan -Batangas Rd
Distance: 38km Time: 1 Hr 5 Min
R7: PP7 to DP3
Via: Agoncillo-san Nicolas Rd-taal-sta Teresita-palico-balayan Rd/P Burgos
Distance: 30.3km Time: 58min
Distance: 38km Time: 1 Hr 5 Min
R8: PP8 to DP4
Via: Palico-balayan -Batangas Rd
Distance: 51.3km Time:1hr 9 Min
R9: PP9 to DP4
Via: Palico-balayan-batangas Rd
Distance: 59.7 Km Time: 1 Hr 26 Min
R10: PP9 to DP5
Via: Agoncillo-laurel Rd
Distance: 26.4 Km Time:56 Mins
R11: PP9 to DP6
Via:agoncillo-laurel Rd
Distance: 50.4 Km Time: 25 Mins
R12: PP10 to DP4
Via: Lemery-calaca-balayan Rd-batangas
Distance:57.6kn Time:1 Hr 23 Min
R12: PP10 to DP5
Via: Agoncillo-laurel Rd
Distance: 28.5 Km Time: 1hr
R13: PP10 to DP6
Via: Agoncillo-laurel Rd
Distance: 27.2km Time: 58mins
R14: PP11 to DP6
Via: Agoncillo-laurel Rd
Distance: 26.7km Time: 1Hr 3mins
R15: PP12 to DP3
Via: Palico-balayan-batangas Rd
Distance: 30.7Km Time: 57Min

Figure 6. Scenario 1 or Existing Scenario.
Source: Batangas PDRRMO, 2021

B.2 Scenario 2

The Calaca site will primarily serve residents of high-risk Barangays Bilibinwang and Banyaga. Scenario 2 offers flexibility, functioning as both an income source in normal times and an evacuation center during disasters.

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Figure 7. Scenario 2 (No Evacuees).

Figure 8. Scenario 2 (With Evacuees).

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B.3 Scenario 3

Scenario 3 presents a forward-thinking approach, addressing gaps in earlier models with a long-term plan that supports evacuees' shelter, livelihood, and well-being. Through livelihood training, community engagement, and cultural spaces, it aids recovery while serving as both an economic hub and evacuation center when needed.

Figure 9. Scenario 3 (No Evacuees).

Figure 10. Scenario 3 (With Evacuees).

EXTENDED ABSTRACTS

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Figure 11. Outdoor Amphitheater (No Evacuees).

Figure 12. Terraced Gardens (With Evacuees).

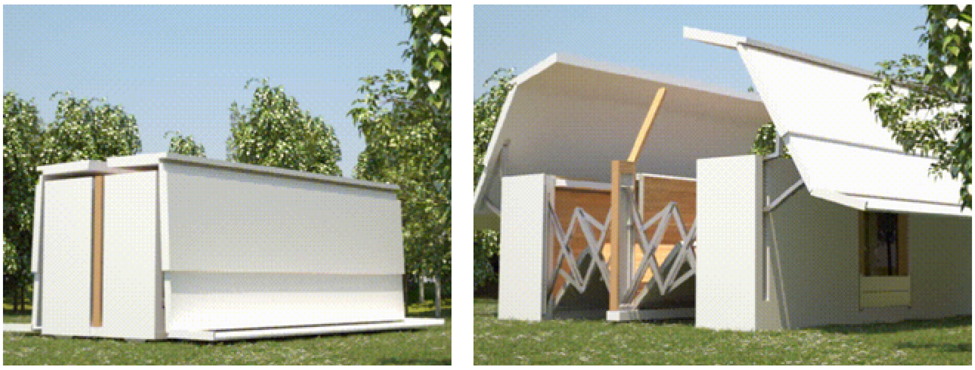

Figure 13. Mobile Structure by Tenfold Engineering.
Source: Tenfold, 2020

VI. CONCLUSION AND RECOMMENDATIONS

Scenario-driven analysis facilitated the development of evacuation strategies that corresponds to various eruption intensities, providing guidance for residents and local authorities.

Integrating adaptable design and space planning improved evacuation spaces to meet diverse emergency needs. Collaboration with officials ensures coordinated, safe evacuations, highlighting the value of a multidisciplinary approach that can guide other volcano-prone communities.

TAALalay: Landscape Approaches for Developing Scenario-Based Guidelines for Designing Evacuation Spaces for Taal Volcano Eruption

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Local governments should adopt landscape-based evacuation planning, conduct regular risk assessments, and develop adaptable sites. Community drills, collaboration, and continuous monitoring will ensure coordinated and resilient disaster preparedness.

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AguaVerde: A Case Study on the Ecological Revitalization of Selected Inland Water Channels of the Marikina River through Blue-Green Infrastructure

Diomari DG. Centeno[1], Jose Dan V. Villa Juan[2], Jaclyn Alexandra Marie B. Bello[2]

ABSTRACT

This case study investigates nature-based solutions for enhancing the resilience of six inland water channels within the Marikina River system in Metro Manila, Philippines. Through qualitative research incorporating digital mapping and remote sensing, participatory observation, and content analysis, the study identified six selected inland water channels: Nangka River, De Gloria Creek, Tumana Creek, Tanong Creek, Libis Creek, and Ugong Norte Creek. The study analyzes their site-specific conditions in terms of cross-section profile and adjacent land use and were categorized into four site conditions: loose vegetation, paved accessways, terraces with vegetation, and covered channels. Guided by Blue-Green Infrastructure (BGI) principles, the study proposes four design typologies: slope protections and stabilization, terracing, introduction of public amenities, and water purification basins. These strategies emphasize phytoremediation, enhanced infiltration, and riparian habitat restoration – nature-based interventions that support hydrological balance, mitigate urban flood risks, and contribute to long-term climate and disaster resilience. This study demonstrates that Blue-Green Infrastructure provides adaptable, nature-based strategies that can enhance ecological resilience, biodiversity, and social value in the inland water channels of the Marikina River. However, rather than definitive solutions, these interventions offer scalable frameworks that can be locally implemented and regionally adapted, contributing to the broader discourse on resilient urban riverine systems and advancing a landscape-based approach to disaster risk reduction in the Asia-Pacific context.

Keywords: urban river revitalization, blue-green infrastructure, Marikina River

I. INTRODUCTION

The Marikina River Basin forms one of Metro Manila's most significant watersheds, serving as a vital floodplain and drainage network for surrounding urban areas. However, rapid urbanization has severely degraded its inland water channels, leading to sedimentation, poor water quality, and loss of ecological and social function. These conditions have increased flood vulnerability and weakened the resilience of nearby communities.

To address these issues, nature-based solutions (NbS) rooted in Blue-Green Infrastructure (BGI) principles provide an alternative to purely engineered interventions. BGI integrates water-sensitive design (blue systems) with vegetated and permeable spaces (green systems), emphasizing multifunctionality and ecosystem services (Ghofrani et al, 2017). This approach not only improves hydrological performance but also restores biodiversity, enhances landscape character, and promotes social well-being (Lamond & Everett, 2019).

This study explores how BGI principles can be localized to revitalize the inland water channels of the Marikina River system. The research aims to demonstrate that nature-based strategies can advance ecological restoration and climate resilience in urban riverine contexts.

[1] Centeno is a Filipino Landscape Architect and a graduate of Master in Tropical Landscape Architecture from the University of the Philippines College of Architecture (UPCA). He currently serves as an Assistant Professor in the same institution, under the Environmental Landscapes Studio Laboratory (ELSL).
[2] Villa Juan and Bello are Filipino Landscape Architects and Assistant Professors in the UPCA-ELSL.

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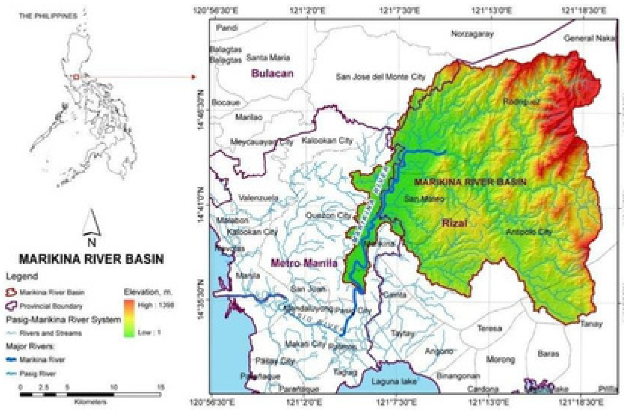

Figure 1. The Marikina River Basin (Santillan et al, 2013).

II. METHODOLOGY

The study adopted a qualitative case study framework, combining spatial analysis through digital mapping, field observation, and design-based inquiry.

A. Digital Mapping and Site Identification

The focus area was limited to the 19.85-kilometer length of the Marikina River running from San Mateo, Rizal in the north as it connects to the Pasig River in the south.

Figure 2. The Marikina River network and the study's scope of work.

The digital mapping covered a 25-square kilometer area, where layers of hydrology, communities, mobility, and green spaces were captured.

Figure 3. City-level sieve analysis of hydrology, communities, mobility, and green spaces.

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Six inland water channels were identified based on their hydrological connectivity to the Marikina River and their representative urban conditions, including Nangka River, De Gloria Creek, Tumana Creek, Tanong Creek, Libis Creek, and Ugong Norte Creek. Digital mapping and remote sensing data were used to delineate boundaries, drainage patterns, and adjacent land uses.

B. Site Observation and Condition Analysis

Participatory site visits documented physical characteristics, vegetation cover, and community interaction along each waterway. Cross-section sketches and photographic documentation were used to interpret spatial conditions. Four recurring site conditions were identified: (a) loose vegetation, (b) paved accessways, (c) terraces with vegetation, and (d) covered channels.

C. Design Framework and Typology Development

A content analysis of BGI literature, local environmental policies, and precedents informed the formulation of design typologies. Each typology was developed to respond to specific environmental challenges while integrating community-oriented and ecological functions.

III. RESULTS

The six inland water channels displayed varying levels of ecological degradation yet revealed distinct opportunities for restoration through BGI-based design strategies. Four design typologies were formulated to address the different existing site scenarios.

A. Typology 01: Slope Protection and Stabilization

The typology addresses slope protection, recommending slope stabilization plants for vegetation-friendly banks and geogrids for stronger soil stability on steeper slopes.

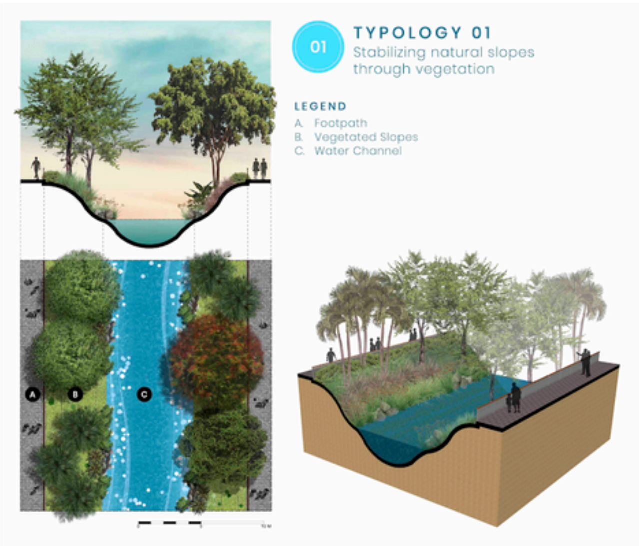

Figure 4. Typology 01: Typical plan, section, and perspective.

A. Typology 02: Terracing

The typology suggests a combination of slope protection and plant terracing, with potential for further improvement by reestablishing vegetation, incorporating plant terracing in narrow vegetation areas, and using permeable paving materials.

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B. Typology 02: Terracing

The typology suggests a combination of slope protection and plant terracing, with potential for further improvement by reestablishing vegetation, incorporating plant terracing in narrow vegetation areas, and using permeable paving materials.

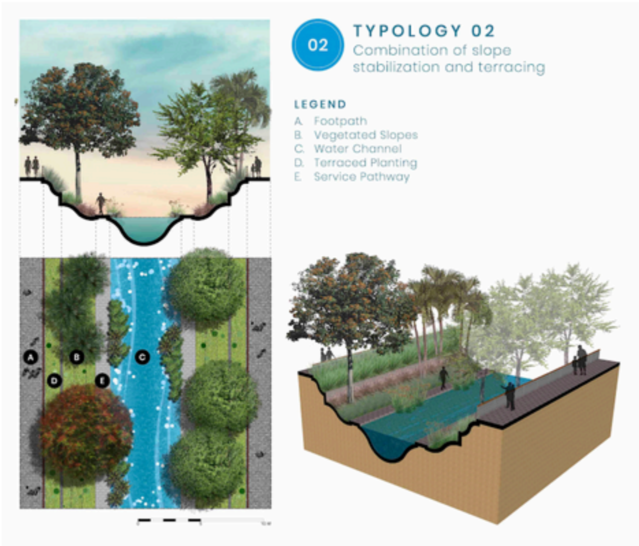

Figure 5. Typology 02: Typical plan, section, and perspective.

C. Typology 03: Introduction of Amenities

Viewing decks near higher walkways are recommended for pedestrians to experience riverine communities and view water channels. These decks can be made of wood agglomerates or sustainably-harvested wood. Informative signage about phytoremediation plants can increase public knowledge and understanding of river restoration in selected inland water channels.

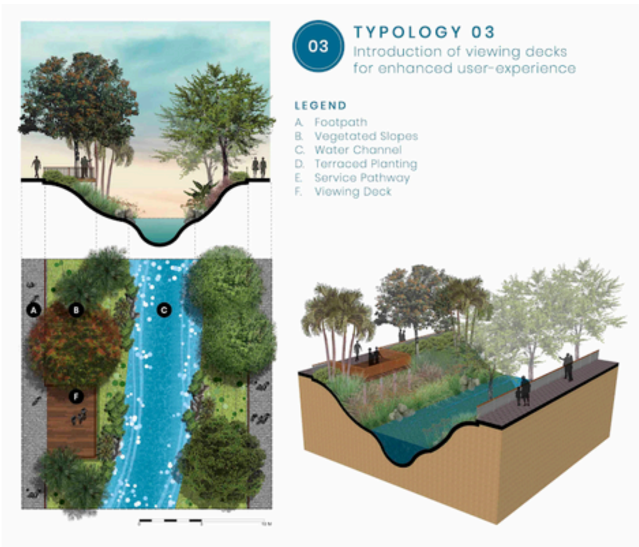

Figure 6. Typology 03: Typical plan, section, and perspective.

D. Typology 04: Terracing

In conditions of steep longitudinal slopes, small dykes or check dams are recommended for steep waterway slopes to slow water flow and create smaller basins for plant and animal life. Public-accessible water channels can benefit from bridging to improve pedestrian circulation and linking viewing decks.

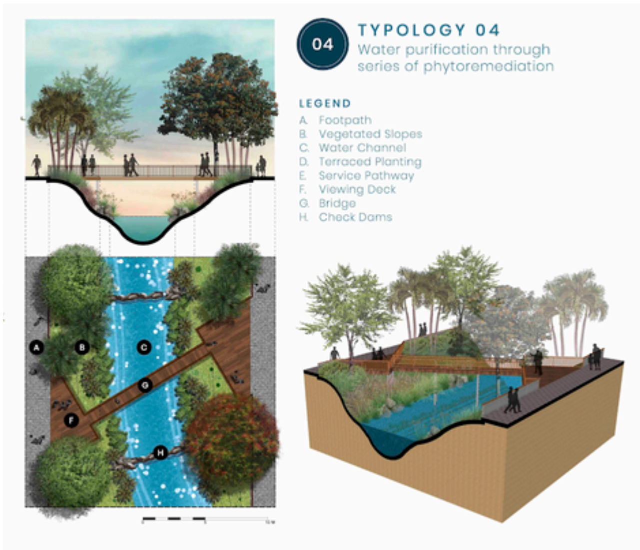

Figure 7. Typology 04: Typical plan, section, and perspective.

IV. CONCLUSION

This case study demonstrates the use of Blue-Green Infrastructure for ecological revitalization of inland water channels. The four proposed design typologies, including slope stabilization, terracing, public amenities, and purification basins, restore ecological function, enhance biodiversity, and reestablish community connection with waterways. These interventions highlight the coexistence of flood management and urban design through landscape-based solutions. The study highlights the role of landscape architects in creating resilient, inclusive, and regenerative cities.

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EXTENDED ABSTRACTS

An Integrated Ecological Approach to Urban Riparian Development: Valuation of the Ecosystem Services National River Park Corridor of New Clark City

Vic L. Dul-loog[1]

ABSTRACT

The National River Park Corridor is a 1.2-kilometre, 5-hectare linear park at the periphery of the National Government Administrative Center in New Clark City, Capas, Tarlac, Philippines. Conceived as both a social and ecological infrastructure, the project transforms a river-edge easement into a multifunctional landscape that serves athletes, visitors, employees, and local communities. Unlike conventional riprap-dominated riverbank treatments in the country, the park applies an integrated ecological framework that positions the river as the organizing element for biodiversity enhancement, climate resilience, and community identity.

The design employs a triad of ecological strategies: stormwater management through living swales; preservation and integration of local flora with native planting palettes; and riverbank stabilization using gabion-based bioengineering that supports vegetation growth. To evaluate performance, a systematic assessment was undertaken across critical environmental indicators, namely: (1) Flood Mitigation and Hydrological Assessment, which measured stormwater retention and peak flow attenuation; and (2) Ecosystem Services Assessment, which identified and valued benefits such as fauna habitat provision, heat mitigation, and recreational opportunities.

Findings demonstrate that the park contributes to flood risk reduction, strengthens ecological connectivity, and supports human well-being through recreation and cultural identity formation. Moreover, the valuation of ecosystem services highlights the tangible benefits of integrating nature-based solutions into urban design, providing evidence to inform planning, policy, and investment decisions.

The National River Park Corridor establishes a precedent for river-edge development in the Philippines, advancing beyond rigid engineering models to adaptive, multifunctional landscapes. It illustrates how riparian corridors can operate as living infrastructure, aligning with the Sustainable Development Goals by enhancing resilience, fostering biodiversity, and enriching the socio-ecological fabric of rapidly urbanizing communities.

Keywords: nature based solutions, riparian systems, ecosystem services, ecological approaches

EXTENDED ABSTRACT

The National River Park Corridor (NRPC) represents a pioneering and ambitious urban development project in the Philippines, one that challenges the conventional, engineering-centric models employed for river-edge treatment. Located at the periphery of the National Government Administrative Center in New Clark City, the NRPC is a 1.2-kilometer, 5-hectare linear park. This initiative was conceptualized as a critical piece of both social and ecological infrastructure. Its design aims to create a multifunctional landscape that serves the diverse needs of athletes, visitors, employees, and, crucially, the local communities and existing flora and fauna who share the riparian ecosystem.

[1] Vic Lopez Dul-loog is a Landscape Architect and Managing Partner of SGS Designs Landscape Architecture. He completed his undergraduate and master's studies at the University of the Philippines College of Architecture and is a senior lecturer. His work covers landscape design, master planning, and ecological landscape design.

An Integrated Ecological Approach to Urban Riparian Development: Valuation of the Ecosystem Services National River Park Corridor of New Clark City

Vic L. Dul-loog

Traditional approaches to riverbank treatment across the Philippines rely heavily on rigid, hard infrastructure, standardized concrete riprap. This method, while offering immediate structural stability, consistently and regrettably neglects the vital ecological functions a riparian zone (Cordova et al., 2019). This gray infrastructure effectively treats the river as a hazard to be contained and controlled, prioritizing engineering expediency over long-term environmental health. This severs the dynamic ecological connection between the land and the water, leading to habitat loss, reduced water quality, and diminished climate resilience.

In contrast, the NRPC employs an integrated ecological framework that positions the river as the central organizing element for the surrounding urban matrix. This shift in philosophy is specifically designed to move away from containment and towards integration, promoting comprehensive biodiversity enhancement, strengthening urban climate resilience, and fostering a distinct community identity. The study detailing this approach, titled An Integrated Ecological Approach to Urban Riparian Development: Valuation of the Ecosystem Services National River Park Corridor of New Clark City, provides a necessary and rigorous valuation of the tangible and intangible benefits derived from implementing Nature-Based Solutions (NBS) in rapidly urbanizing environments.

Body of the Research: Design Strategies and Integrated Ecological Approach

The core of the NRPC lies in its application of a Nature-Based Solution (NBS)-led landscape development employing a triad of synergistic ecological strategies.

Stormwater Management and Hydrological Integrity

A primary and essential component of the ecological design is the integration of swales for effective stormwater management. These vegetated drainage systems are a crucial form of blue-green infrastructure designed to naturally filter, treat, and significantly slow down the velocity of surface water runoff before it enters the river. The project's performance evaluation included a comprehensive Flood Mitigation and Hydrological Assessment, which quantified its effectiveness in achieving significant stormwater retention and peak flow attenuation. This strategic approach directly contributes to enhancing urban climate resilience and disaster risk reduction, demonstrating a successful, on-the-ground application of landscape ecology principles to practical urban planning (Francis et al., 2016).

Riverbank Stabilization through Bioengineering

Achieving durable riverbank stability is crucial for any urban riparian project, NRPC attains this through sustainable, adaptive means: gabion-based bioengineering. The eventual integration of mature vegetation within the structure ensures a more adaptive, living, and multifunctional landscape that improves in both stability and ecological value over time (Leblois et al., 2025).

Biodiversity and Ecological Connectivity

Finally, the park design prioritizes the preservation and integration of local flora through the deliberate use of native plants. This strategy is critical for strengthening ecological connectivity within the complex urban matrix (Forman & Godron, 1986), effectively transforming the riparian corridor from a neglected edge into a vital living infrastructure. This strategic planting contributes directly to the NRPC's essential role as an urban refuge and corridor for local wildlife, providing a vital green lifeline within a growing metropolitan area. The systematic assessment identified and rigorously valued the benefits specifically related to fauna habitat provision, demonstrating a quantifiable increase in ecological function.

To rigorously evaluate the success of this innovative development and provide actionable data for policy makers, a systematic assessment was conducted across critical environmental and social indicators. The Ecosystem Services Assessment (ESA) formed a central pillar of this evaluation, identifying and placing an economic and ecological value on the range of benefits provided by the restored natural system. This methodological step is crucial, as it moves beyond simple aesthetic or qualitative appraisal to highlight the quantifiable and tangible benefits of NBS integration (Costanza et al., 1997; Gómez-Baggethun & Maestre-Andrés, 2021). The valuation encompassed multiple categories of ecosystem services but will focus only on:

1. Regulating Services
2. Supporting Services

The findings decisively demonstrate that the National River Park Corridor contributes significantly to flood risk reduction, strengthens ecological connectivity. Moreover, the valuation of ecosystem services provides evidence-based information that underscores the necessity of moving beyond conventional cost-benefit analyses, which often fail to account for ecological capital.

The National River Park Corridor establishes a groundbreaking and readily replicable precedent for river-edge development in the Philippines and the wider Asia-Pacific region. By aligning development goals with the Sustainable Development Goals (SDGs), the project illustrates in practice how riparian corridors can effectively operate as genuine living infrastructure that enhances resilience, fosters biodiversity, and profoundly enriches the socio-ecological fabric of rapidly urbanizing communities. Its success validates the critical shift required in contemporary urban design: moving away from rigid, control-oriented engineering to adaptive, multifunctional, and nature-positive landscapes.

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EXTENDED ABSTRACTS

An Integrated Ecological Approach to Urban Riparian Development: Valuation of the Ecosystem Services National River Park Corridor of New Clark City

Vic L. Dul-loog

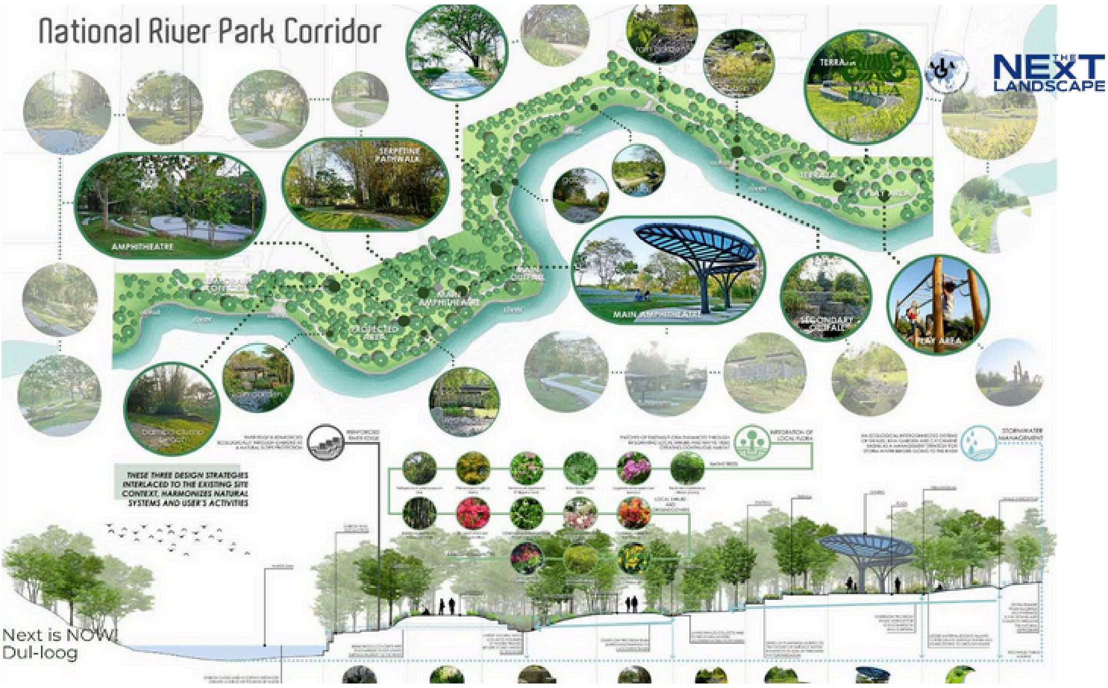

Figure 1. Masterplan of the National River Park Corridor.
Source: SGS Designs Landscape Architecture

Figure 2. River edge stabilization using gabions.

An Integrated Ecological Approach to Urban Riparian Development: Valuation of the Ecosystem Services National River Park Corridor of New Clark City

Vic L. Dul-loog

Figure 3. National Government Administrative Center Master Plan.
Source: SGS Designs Landscape Architecture

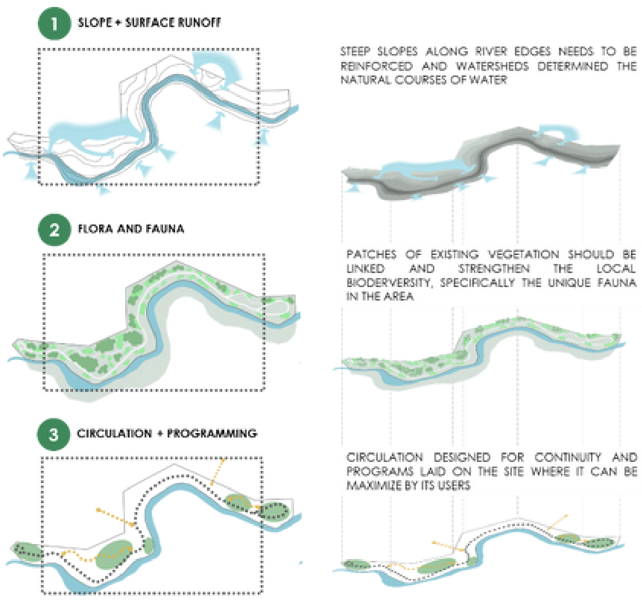

Figure 4. National River Park Corridor Analysis and Framework.
Source: SGS Designs Landscape Architecture

An Integrated Ecological Approach to Urban Riparian Development: Valuation of the Ecosystem Services National River Park Corridor of New Clark City

Vic L. Dul-loog

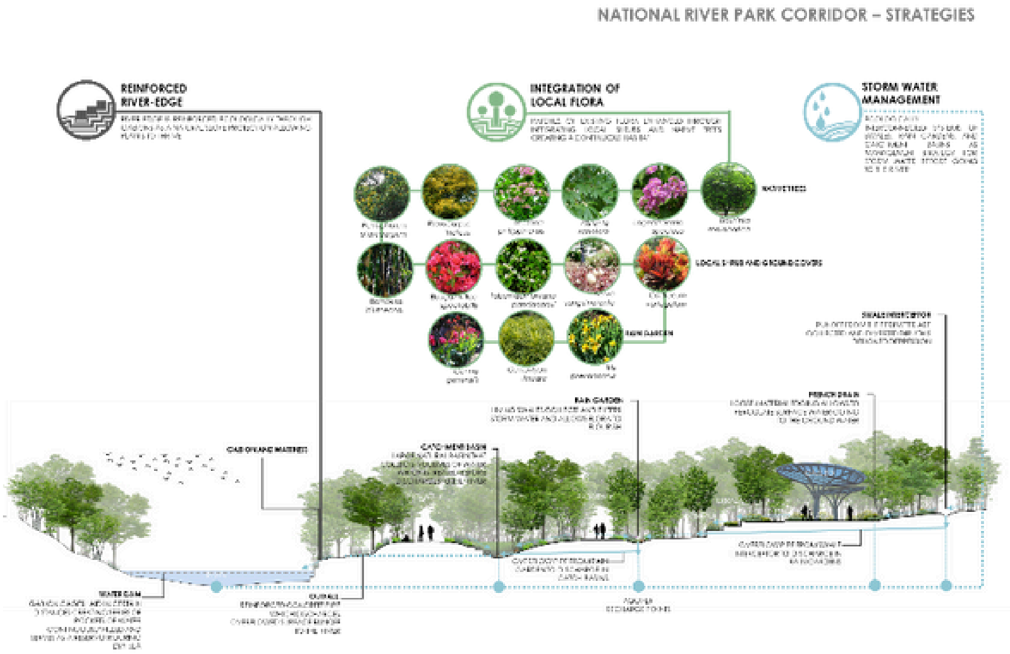

Figure 5. National River Park Corridor Analysis and Framework.
Source: SGS Designs Landscape Architecture

EXTENDED ABSTRACTS

PARALLEL SESSION 2C

HERITAGE ENVIRONMENTS

Session Moderators: Markel Cesar A. Luna
and Gerard Rey A. Lico PhD

Risk and Resilience of Spanish Colonial Heritage Brick Churches in Ilocos Norte: A Multi-Hazard Framework for Disaster Risk Reduction and Conservation

Emerson Valentino Bolibol, *Geraldene N. Acebedo, Jeric V. Casauran, Neil Meynard T. Doropan, Christian Dave E. Princesa*
Mariano Marcos State University

Casas Boholana: Lessons Learned from Observations on the Resiliency Features of Vintage Timber-Framed Houses in 2013 Post-Earthquake and Post-Yolanda Bohol

Marie Edraline B. Belga[1], *Jose Ricardo F. Rustia[2]*
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[2] Gusto Design Philippines

Heritage Resilience in Multi-Hazard Coastal Environments: Climate-Responsive Strategies from the Medieval City of Bagerhat, Bangladesh

Md. Reazul Hasan, *Mokbol Morshed Ahmad*
School of Environment, Resources and Development (SERD), Asian Institute of Technology, Thailand

Effects of Native Tree Cover Resiliency on the Thermal Comfort of Typhoon Affected Green Open Space

Patrick Andrew Espiritu Gozon
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Risk and Resilience of Spanish Colonial Heritage Brick Churches in Ilocos Norte: A Framework for Disaster Risk Reduction and Conservation

Emerson V. Bolibol[1], Geraldene N. Acebedo[2], Jeric V. Casauran[2], Neil Meynard T. Doropan[2], Christian Dave E. Princesa[2]

ABSTRACT

The Spanish colonial brick churches of Ilocos Norte are enduring cultural landmarks that represent the architectural and historical legacy of the Philippines. Constructed prior to modern building codes, these unreinforced masonry (URM) structures are increasingly at risk due to aging materials, lack of retrofitting, and continued exposure to environmental hazards. Located in a high seismicity zone and within the country's typhoon corridor, Ilocos Norte regularly experiences strong ground motion, high winds, and seasonal rainfall—placing significant stress on its heritage fabric. This study developed a multi-hazard assessment framework to evaluate the seismic vulnerability of eight Spanish-era churches. The methodology combined condition surveys, ocular inspections, Rapid Visual Screening (FEMA P-154 Levels 1 and 2), non-destructive testing (ultrasonic pulse velocity and X-ray fluorescence), limited core extraction, and finite element modeling. Among the eight sites, Sta. Monica Church in Sarrat and San Nicolas de Tolentino Church in San Nicolas were identified as the most structurally vulnerable. However, full technical investigation and simulation were only permitted in Sarrat. Modeling results for Sta. Monica revealed critical tensile and shear stress concentrations in the church walls, convent walls, and the bell tower, the latter of which features a composite structure of hollow concrete blocks over historic brick. Material testing confirmed advanced deterioration, low compressive strength, and high porosity. The lack of access in San Nicolas underscores recurring challenges in heritage risk governance. This study highlights the urgent need to integrate disaster risk reduction into heritage conservation through conservation management plans, values-based retrofitting, and inclusive stakeholder engagement.

Keywords: Unreinforced Masonry (URM), Seismic Vulnerability Assessment, Heritage Conservation, Disaster Risk Reduction (DRR), Finite Element Modeling (FEM), Spanish Colonial Churches

I. INTRODUCTION

Spanish colonial brick churches in Ilocos Norte stand as enduring cultural monuments that embody the Philippines' architectural, spiritual, and historical legacy. Constructed before the formulation of modern building codes, these unreinforced masonry (URM) structures face progressive deterioration and heightened exposure to environmental and seismic hazards. Ilocos Norte lies within Seismic Zone 4—the highest classification under the National Structural Code of the Philippines (NSCP 2015)—and is less than five kilometers from the active Ilocos Fault Zone. This geologic setting exposes centuries-old brick churches to repeated strong ground motions, high winds, and intense rainfall that threaten their long-term stability.

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[2] Geraldene N. Acebedo, Jeric V. Casauran, Neil Meynard T. Doropan, and Christian Dave E. Princesa are civil engineers who graduated from Mariano Marcos State University with a specialization in Structural Engineering. They assisted the author in conducting the technical aspects of the study.

EXTENDED ABSTRACTS

Risk and Resilience of Spanish Colonial Heritage Brick Churches in Ilocos Norte: A Framework for Disaster Risk Reduction and Conservation

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While their aesthetic and cultural value has long been acknowledged, systematic engineering-based vulnerability assessments remain scarce. Previous heritage studies have focused on documentation and architectural typology, with limited quantitative evaluation of structural integrity. Consequently, conservation interventions often proceed without the technical foundation necessary to ensure safety and authenticity. The study therefore advances a seismic risk assessment framework that integrates architectural conservation with structural engineering, employing both rapid field screening and laboratory-based diagnostics to establish a scientific basis for earthquake-resilient heritage preservation.

By combining Rapid Visual Screening (FEMA P-154), non-destructive and destructive material testing, and finite-element modeling (FEM), the research bridges the gap between cultural heritage management and structural risk assessment. The findings directly support Sustainable Development Goal 11.4 on safeguarding cultural and natural heritage, as well as the Sendai Framework for Disaster Risk Reduction (2015–2030). Ultimately, the study contributes to the formulation of evidence-based retrofitting and conservation management plans that harmonize structural safety, historical authenticity, and community resilience.

II. OBJECTIVES

The study aimed to determine the seismic vulnerability of selected Spanish colonial brick churches in Ilocos Norte and identify those requiring immediate structural intervention. Specifically, it sought to:

1. Conduct Rapid Visual Screening (RVS) of eight churches following FEMA P-154 (2015) procedures for URM structures.
2. Rank the relative vulnerability of each church based on computed RVS scores and site-specific parameters.
3. Identify the most at-risk structure for detailed material testing and finite-element modeling.
4. Perform non-destructive tests—Ultrasonic Pulse Velocity (UPV) and X-Ray Fluorescence (XRF)—and limited destructive core extraction to determine material strength and composition.
5. Develop and analyze finite-element models simulating seismic response, validating field and laboratory results.

III. METHODOLOGY

A mixed-method design combining qualitative documentation and quantitative analysis was adopted. Eight Spanish colonial churches—Sta. Monica (Sarrat), St. William's (Laoag), St. Anne (Piddig), St. Andrew (Bacarra), San Nicolas de Tolentino (San Nicolas), St. Joseph (Dingras), Immaculate Conception (Batac), and the Minor Basilica of St. John the Baptist (Badoc)—were surveyed under the Diocese of Laoag.

III.A. Phase 1 – Rapid Visual Screening

Field inspections followed FEMA P-154 Levels 1 and 2. Structural configurations, irregularities, materials, soil type, and seismic zoning were documented using PHIVOLCS spectral acceleration maps and municipal land-use data. RVS scores were computed to classify seismic risk.

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III.B. Phase 2 – Material Characterization

Between the two churches identified as the most vulnerable, only Sta. Monica Church underwent detailed testing. XRF analysis determined the elemental composition of its bricks and mortar at the MMSU-CIMEA laboratory (ASTM E1621-21), UPV testing (ASTM C597-19) measured internal density and uniformity, and limited core sampling (ASTM C42/C42M) established compressive strength.

III.C. Phase 3 – Finite Element Modeling

As-built surveys were converted into 3D models in SketchUp and analyzed in STAAD Pro CONNECT V22 using isotropic, linear-elastic assumptions. Seismic parameters (Zone 4, Z = 0.40, I = 1.0, R = 4.5, Site Class SD) followed NSCP 2015 and UBC 1997. Response spectrum analysis was applied in both X and Z directions. Stress contours and deformations were compared with allowable limits from UBC, UCBC, and ACI 530-88.

Ethical and heritage protocols limited interventions to non-invasive sampling, ensuring conservation integrity while achieving technical accuracy.

IV. RESULTS

IV.A. Rapid Visual Screening

All eight churches scored below the FEMA P-154 threshold (2.0), confirming seismic vulnerability. Sta. Monica (Sarrat) and San Nicolas (San Nicolas) obtained the lowest Level 2 scores (–0.2), signifying extreme risk due to plan irregularities, heavy roofing, and absence of seismic detailing. Sta. Monica was selected for full testing after site access limitations in San Nicolas.

Table 1. Final Level 1 scores of the Spanish Colonial Churches of Ilocos Norte using Rapid Visual Screening.

Church	Basic Score	Severe Vertical Irregularity	Moderate Vertical Irregularity	Plan Irregularity	Pre-Code	Post-Benchmark	Soil type A or B	Soil Type E (1-3)	Soil Type E (>3)	Final Level 1 Score	Remarks
Bacarra	0.9	-	-0.3	-0.3	-	-	-	-	-	0.3	For Level 2 Screening
Badoc	0.9	-	-	-0.3	-	-	-	-	-	0.6	No Further Screening
Batac	0.9	-	-	-0.3	-	-	-	-	-	0.6	No Further Screening
Dingras	0.9	-	-0.3	-0.3	-	-	-	-	-	0.3	For Level 2 Screening
Laoag	0.9	-	-	-0.3	-	-	-	-	-	0.6	No Further Screening
Piddig	0.9	-	-	-0.3	-	-	-	-	-	0.6	No Further Screening
San Nicolas	0.9	-	-0.3	-0.3	-	-	-	-	-	0.3	For Level 2 Screening
Sarrat	0.9	-	-0.3	-0.3	-	-	-	-	-	0.3	For Level 2 Screening

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Table 2. Final Level 2 scores of the Spanish Colonial Churches of Ilocos Norte using Rapid Visual Screening.

Church	Vertical Irregularity	Plan Irregularity	Redundancy	Pounding	S2 Building	C1 Building	PC1/ RM1 Building	URM	MH	Retrofit	Rank
	V_{L2}	P_{L2}					M				
Bacarra	-0.4	-0.7	-	-	-	-	-	-	-	+1.2	3
Dingras	-0.4	-0.7	-	-	-	-	-	-	-	+1.2	3
San Nicolas	-0.4	-0.7	-	-	-	-	-	-	-	-	1
Sarrat	-0.4	-0.7	-	-	-	-	-	-	-	-	1

IV.B. Material Tests

XRF results revealed deficient mineral composition—approximately 20–23 % SiO_2, 2 % CaO, and 7 % Al_2O_3—well below standard brick proportions, indicating weak binding and prolonged weathering. UPV tests recorded 978–1211 m/s in the church and bell tower (poor-quality range) but ≈ 2040 m/s in the convent (good-quality). Core compressive strengths measured 5.73 MPa (church), 4.91 MPa (convent), and 3.07 MPa (bell tower); the latter fell below acceptable URM standards, confirming severe deterioration.

Table 3. Chemical composition of Bricks (Church).
Source: https://civilsir.com/what-is-bricks-and-their-composition-and-properties/

PROPER TIES	%	STANDARD %	REMARKS
Lime (CaO)	2.29	10-12%	POOR
Silica (SiO)	20.48	50-60%	POOR
Ferric Oxide (Fe203)	7.45	<7%	EXCESS
Alumina (AI203)	7.16	20-30%	POOR
Manganes e Oxide (MnO)	0.14	<1%	GOOD
Organic Matter	-	<1%	-

Table 4. UPV of the Sta. Monica Church, Bell Tower, and Convent.

Standard UPV Source: Azam, R., Riaz, M. R., Haq, E. U., Shihata, A., & Zawam, M. (2022). Development of quality assessment criteria for burnt clay bricks of different ages based on ultrasonic pulse velocity test. MDPI

Sample Source	Pulse Velocity (m/s)	Average Pulse Velocity (m/s)	Standard UPV (m/s)	Remarks
Church	1308.17 1161.67 1163.33	1211.06	>3000 Excellent	POOR
Convent	2107.22 1860.00 2153.33	2040.19	2000 - 3000 Good	GOOD
Bell Tower	1041.67 1008.33 886.67	978.89	<2000 Poor	POOR

Table 5. Results of the Coring Test.

Source (compressive strength of church): Gonzales et al., 2022, Mechanical Characterization and Chemical Composition of Historic Masonry Building: A Case for Restoration and Retrofitting of the Sta. Monica Church in Sarrat, Ilocos Norte

Specimen	Maximum Load (kN)	MPa	Standard Compressive Strength	Remarks
Convent	9.63	4.905		PASSED
Bell Tower	6.03	3.071	4.3 to 6.9	FAILED
Church	10.355	5.725		PASSED

IV.C. Finite Element Modeling

Stress analyses showed shear and compressive stresses in the nave walls, façade, and bell tower exceeding allowable limits. The bell tower's upper and mid-levels experienced critical shear stress beyond UCBC and ACI provisions, while lower levels exhibited excessive axial compression, validating field observations of cracking and displacement. Sta. Monica's overall damage grade corresponded to D4–D5 (very high probability of collapse under Mw 7.0–8.4 events).

Table 6. Allowable shear and combined normal stresses by different codes for URM (MPa).

Source (compressive strength of church): Gonzales et al., 2022, Mechanical Characterization and Chemical Composition of Historic Masonry Building: A Case for Restoration and Retrofitting of the Sta. Monica Church in Sarrat, Ilocos Norte

	Allowable shear stresses				Normal stresses				
	UCBC (max)	UBC (ave)	ACI (max)	ABK* (max)	ACI 530-88		Both *	UBC	
					F_t	F_a	F_b	F_t	F_a
URM	0.10	0.14	0.38	0.56	0	2.30	3.00	0.25	1.83

*Ultimate shear strength criterion +ACI 530-88 and UBC.

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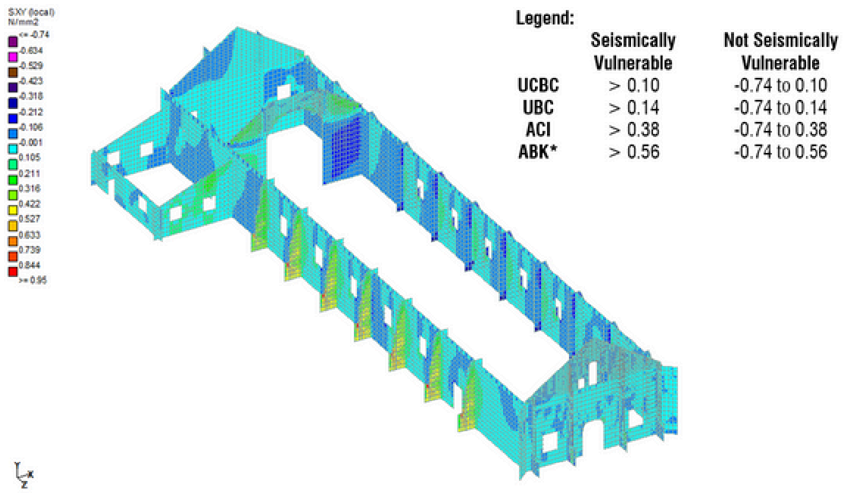

Figure 1. Shear stress in the local XY plane by service load combination $DL + \frac{Ez}{1.4}$

Table 7. Evident shear stresses experienced by Sta. Monica church URM wall.

LOAD TYPE	LOCATION	SHEAR STRESS (MPa)	Remarks
$DL + \frac{Ez}{1.4}$	Left Nave Wall	0.233	>UCBC and UBC
	Right Nave Wall	0.265	>UCBC and UBC
	Front Facade	0.191	>UCBC and UBC
	Rear Facade	0.134	>UCBC
	Arch	0.033	<Allowable
	Left Buttresses	0.081	<Allowable
	Right Buttresses	0.232	>UCBC and UBC
$DL + \frac{Ez}{1.4}$	Left Nave Wall	0.225	>UCBC and UBC
	Right Nave Wall	0.234	>UCBC and UBC
	Front Facade	0.272	>UCBC and UBC
	Rear Facade	0.140	>UCBC
	Arch	0.073	<Allowable
	Left Buttresses	0.075	<Allowable
	Right Buttresses	0.220	>UCBC and UBC

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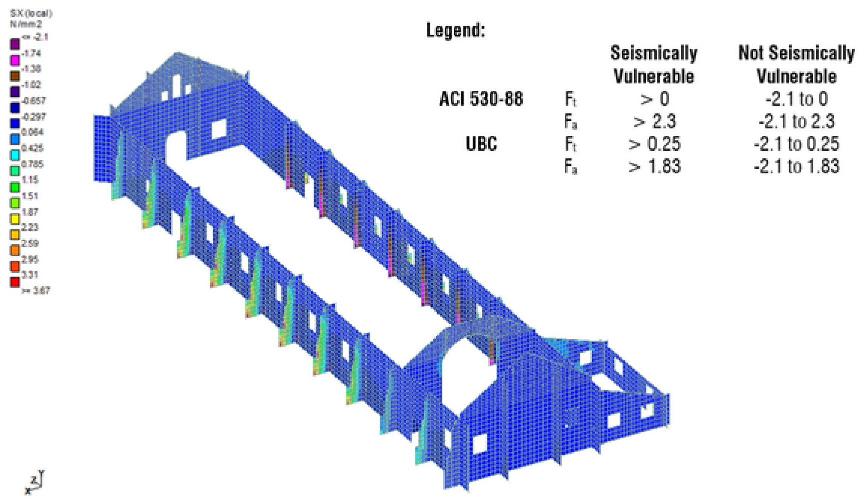

Figure 2. Axial stress in the local X plane by service load combination $DL + \frac{E_z}{1.4} DL + \frac{E_z}{1.4}$

Table 8. Critical portions of Sta. Monica church for tensile and compressive stresses of URM wall.

LOAD TYPE	LOCATION	AXIAL STRESS (MPa) -compression +tension	Remarks
$DL + \frac{Ez}{1.4}$ $DL + \frac{Ez}{1.4}$	Left Nave Wall	0.011	>ACI
	Right Nave Wall	-0.007	<Allowable
	Front Facade	0.038	>ACI
	Rear Facade	-0.001	<Allowable
	Arch	0.220	>ACI
	Left Buttresses	3.662	>ACI and UBC
	Right Buttresses	3.670	>ACI and UBC
$DL + \frac{Ez}{1.4}$ $DL + \frac{Ez}{1.4}$	Left Nave Wall	0.011	>ACI
	Right Nave Wall	-0.007	<Allowable
	Front Facade	0.024	>ACI
	Rear Facade	0.006	>ACI
	Arch	0.202	>ACI
	Left Buttresses	3.275	>ACI and UBC
	Right Buttresses	3.272	>ACI and UBC

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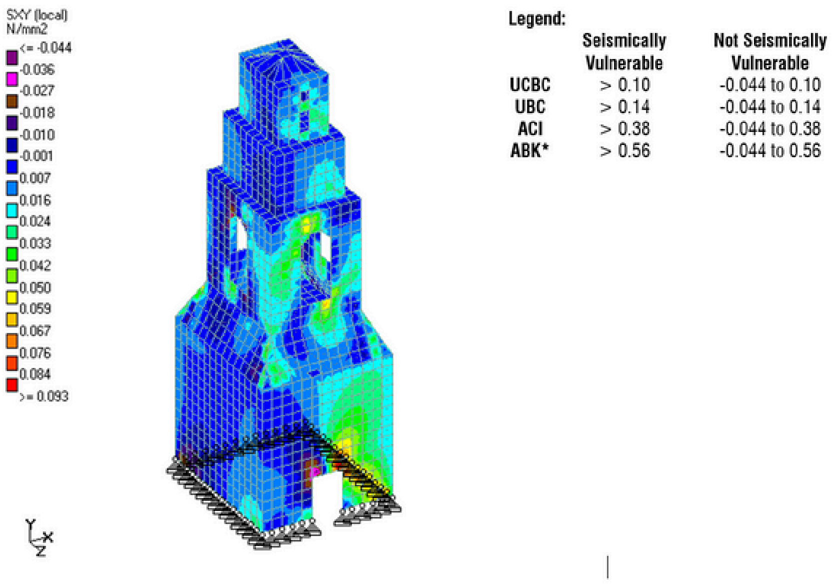

Figure 3. Shear stress in the local XY plane by service load combination $\boldsymbol{DL + 0.75\left(LL + \frac{Ez}{1.4}\right)}$

Table 9. Evident shear stresses experienced by Sta. Monica Bell Tower URM wall.

LOAD TYPE	LOCATION	SHEAR STRESS (MPa)	Remarks
	Dome	0.010	<Allowable
	Fourth Level	0.008	<Allowable
$DL + 0.75\left(LL + \frac{Ez}{1.4}\right)$ $DL + 0.75\left(LL + \frac{Ez}{1.4}\right)$	Third Level	0.158	>UCBC and UBC
	Second Level	0.512	>UCBC, UBC, and ACI
	First Level	0.086	<Allowable
	Dome	0.008	<Allowable
	Fourth Level	0.009	<Allowable
$DL + 0.75\left(LL + \frac{Ez}{1.4}\right)$ $DL + 0.75\left(LL + \frac{Ez}{1.4}\right)$	Third Level	0.139	>UCBC
	Second Level	0.495	>UCBC, UBC, and ACI
	First Level	0.083	<Allowable

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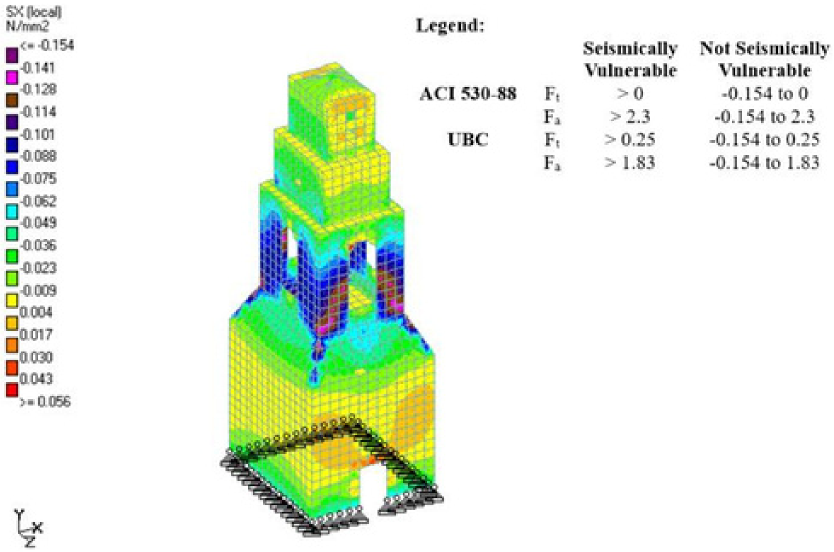

Figure 4. Axial stress in the local X plane by service load combination $DL + 0.75\left(LL + \frac{Ez}{1.4}\right)$

Table 10. Critical portions of Sta. Monica Bell Tower for tensile and compressive stresses of URM wall.

LOAD TYPE	LOCATION	AXIAL STRESS (MPa) - compression +tension	Remarks
$DL + 0.75\left(LL + \frac{Ez}{1.4}\right)$	Dome	-0.001	<Allowable
	Fourth Level	0.012	> ACI
	Third Level	0.021	> ACI
	Second Level	0.162	> ACI
	First Level	0.308	> ACI and UBC
$DL + 0.75\left(LL + \frac{Ez}{1.4}\right)$	Dome	-0.001	<Allowable
	Fourth Level	0.014	> ACI
	Third Level	0.028	> ACI
	Second Level	0.125	> ACI
	First Level	0.314	> ACI and UBC

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V. CONCLUSION

The Spanish colonial brick churches of Ilocos Norte exhibit high seismic vulnerability due to their unreinforced masonry system, material degradation, and lack of seismic detailing. All assessed structures scored below the FEMA P-154 criteria, with Sta. Monica Church in Sarrat emerging as one of the most structurally vulnerable. Laboratory analyses confirmed the poor chemical and mechanical quality of its masonry materials, while finite-element simulations revealed stress concentrations exceeding code-prescribed limits.

The study establishes a replicable, science-based framework for evaluating heritage structures in seismic-prone regions. Integrating Rapid Visual Screening, material diagnostics, and finite-element analysis provides a balanced methodology that upholds both engineering rigor and cultural authenticity. Immediate structural intervention for Sta. Monica Church, alongside the formulation of conservation management plans incorporating disaster-risk reduction measures, is therefore imperative.

Preserving Ilocos Norte's Spanish colonial churches requires a coordinated and interdisciplinary effort—uniting architects, engineers, and heritage custodians—to ensure that these monuments of faith and identity endure the challenges of both time and nature.

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Casas Boholana: Lessons Learned from Observations on the Resiliency Features of Vintage Timber-Framed Houses in 2013 Post-Earthquake and Post-Yolanda Bohol

Marie Edraline B. Belga[1], Jose Ricardo F. Rustia[2]

ABSTRACT

The island of Bohol in the Philippines uniquely experienced two consecutive natural disasters in 2013. It was shaken by a strong earthquake with a magnitude of 7.2 in the Richter scale on October 15, 2013. In the following month, a category 5 super typhoon - Yolanda (Haiyan) swept through the island that was still reeling from the shocks of the previous earthquake. While it was widely observed that the buildings severely damaged by the earthquake and typhoon were mostly modern masonry and concrete-framed structures, the vernacular timber-framed houses exhibited apparent resistance as evidenced by their continued structural integrity despite the two consecutive natural disasters.

This study intends to support the case of not only conserving timber-framed structures but also for integrating their techniques and principles in contemporary design and construction. The timber-framed houses featured in the study are taken from the listing of the book - "Casa Boholona: Vintage Houses of Bohol by Saloma and Akpedonu." The houses were surveyed in a 2014 field survey funded by the DOST-Build Back Better Program. The coverage of the researchers' assessment of the timber-framed houses include location, site development, building configuration or form, and construction methods and techniques.

The main output of the study is a characterization and documentation of the design and construction features that increase the earthquake- and typhoon-resistance of Bohol's vernacular timber-framed houses. A discussion of the advantages and disadvantages of utilizing traditional timber-framed construction in earthquake-prone and typhoon-prone areas is also presented in the study

Keywords: Bohol, Earthquake, Typhoon, Vernacular Houses, Timber-Framed Houses, Resilient Design, Heritage Environments

I. INTRODUCTION

In 2013, the island of Bohol in the Philippines uniquely experienced two consecutive natural disasters. First, it was shaken by a strong earthquake with a magnitude of 7.2 in the Richter scale on October 15, 2013. In the following month, a category 5 super typhoon - Yolanda (Haiyan) swept through the island that was still reeling from the shocks of the previous earthquake (UN WFP, 2013). Now in 2025, a similar wave of events occurred in nearby Cebu Island - a magnitude 6.9 earthquake first hit the island on September 30, 2025 (Lacuata & Perez, 2025) then Typhoon Tino swept Cebu with strong flash floods on November 04, 2025 (Clores, 2025). In both instances, the damage and the losses were widespread and catastrophic. Yet, these experiences have offered valuable lessons in resilience and opportunities for better rebuilding especially at the level of vernacular dwellings.

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II. VINTAGE TIMBER-FRAMED HOUSES OF BOHOL

Despite modernizing trends, traditional wooden or timber-framed post-and-lintel construction remains the most prevalent especially among the demographically-dominant low-income Filipino households. As such, one can say that such dwelling type can be considered as the vernacular form of housing most familiar to the average Filipino. Mass media often features these houses as among the most threatened and vulnerable during disaster events. Thus, rediscovering and re-learning the knowledge of rebuilding disaster-resilient vernacular timber-framed Filipino dwellings is very important if we want to reduce the risks posed by future calamities.

In early 2014, it was observed by the researchers that the buildings in Bohol that were severely damaged by the recent earthquake and super typhoon were mostly modern masonry and reinforced concrete-framed structures. On the other hand, the researchers were quite intrigued by the resilience of the vintage timber-framed houses, some already over a hundred years old, that maintained their structural integrity despite the two consecutive natural disasters. Such observation ran contrary to the prevalent notion that modern RC-framed masonry houses are more structurally sound compared to wooden or timber-framed houses. This highlighted the inherent importance of the vintage timber-framed houses of Bohol not only in the context of their historical value, but also of their educational value for architects, engineers, and constructors.

Figure 1. The Segundo House built in 1934 (Akpedonu & Saloma, 2011), beside the national road in Bgy. Bood, Maribojoc Town appears to stand after the earthquake undamaged.
Source: Photo taken by ME Belga.

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Figure 2. A few meters from the Segundo House, this RC-framed masonry house visibly incurred significant damage after the earthquake.
Source: Photo taken by ME Belga.

Figure 3. Built in the mid-1920's (Akpedonu & Saloma, 2011), the Raagas Ancestral Home in the población area of Maribojoc Town remains in-tact after the earthquake.
Source: Photo taken by ME Belga.

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Figure 4. Also in the poblacion area of Maribojoc Town, an RC-framed masonry house collapsed after the earthquake.
Source: Photo taken by ME Belga.

This study intends to support the case of not only conserving timber-framed structures but also for integrating their techniques and principles in contemporary design and construction. The timber-framed vintage houses featured and observed in the study are based from the listing of the book - "Casa Boholona: Vintage Houses of Bohol" by Akpedonu and Saloma (2011). The houses were studied in a 2014 field survey funded by the DOST's Build Back Better Program as part of the national government's efforts to improve guidelines and policies in disaster-resilient rebuilding. The coverage of the researchers' evaluation was mainly the rapid assessment of the timber-framed houses' building configuration or form, and construction methods or techniques. The said rapid assessment was primarily restricted to the exterior and ground floor only of the houses. More extensive assessment and inspection were possible only to houses with public access or those whose private access were granted by the owners or residents. Also included in the study are occasional comparisons with contemporary RC-framed and masonry construction that incurred significant observable structural damage especially after the earthquake.

III. STUDY AREA(S)

Areas that were chosen in the fieldwork include Loboc, Loay, Baclayon, Maribojoc, Loon, Tubigon, Carmen, and Tagbilaran City. Areas surveyed were reported to have a significant number of houses damaged by the earthquake, while at the same time having notable built heritage assets within their jurisdiction. The basis for choosing the fieldwork areas included the UN OCHA's report (2013) on the post-earthquake situation report of Bohol, aside from the Aside from the vintage houses listing in the Casa Boholana book.

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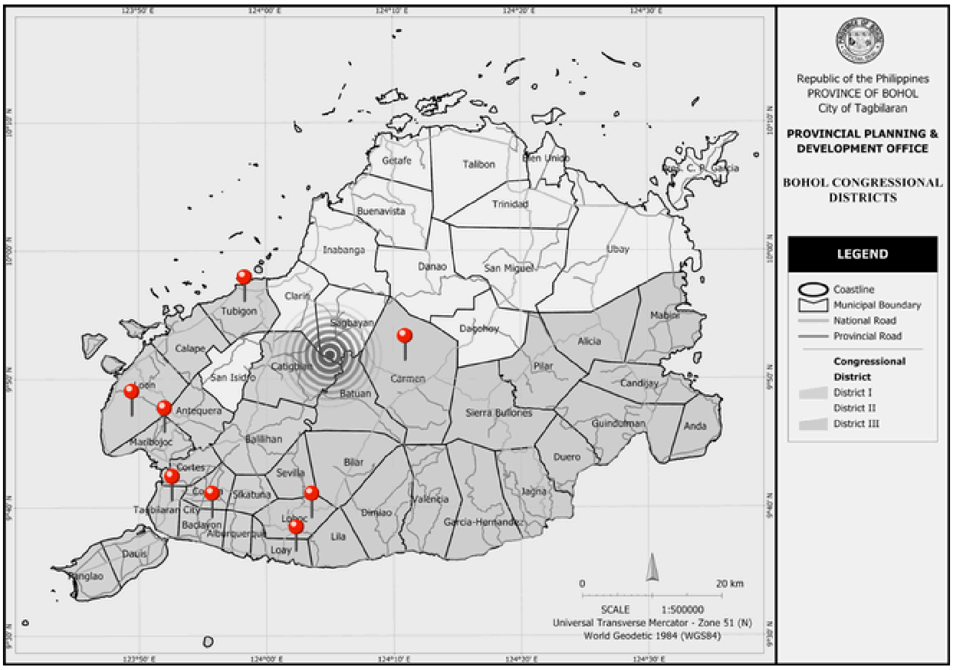

Figure 5. Map of Bohol's Municipalities | Districts.
Source: Bohol PPDO

IV. "BAHAY NA BATO" AND "BAHAY NA TABLA"

To provide context about the houses featured in the study, the paper will also first introduce and discuss the salient features of traditional Filipino "Bahay na Bato" (Stone House) and "Bahay na Tabla" (Timber House), and how they were made to evolve to be responsive to local environmental threats in the Philippines such as flooding, typhoons, and earthquakes.

V. RESEARCH OUTPUTS

For the main output of the study, it will present a characterization and documentation of the design and construction features that increase the earthquake- and typhoon-resistance of Bohol's vintage timber-framed houses. A discussion of the advantages and disadvantages of utilizing traditional timber-framed construction in earthquake-prone and typhoon-prone areas is further presented in the study. The study will also touch on construction issues observed in the contemporary reinforced concrete (RC) and masonry structures that were significantly damaged by the earthquake.

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EXTENDED ABSTRACTS

Heritage Resilience in Multi-Hazard Coastal Environments: Climate-Responsive Strategies from the Medieval City of Bagerhat, Bangladesh

Md.Reazul Hasan[1], Mokbul Morshed Ahmad[2]

ABSTRACT

Coastal heritage sites face increasing threats from the compounded impacts of climate change and environmental hazards. The medieval city of Bagerhat, a UNESCO World Heritage Site in the Ganges–Brahmaputra–Meghna delta, offers critical insights into climate-responsive vernacular architecture and community resilience. This study examines Bagerhat's adaptive heritage through the lens of multi-hazard entanglements, focusing on recurrent flooding, saline intrusion, and intensifying cyclonic storms. Using an interdisciplinary approach combining archival research, field surveys, spatial analysis, and stakeholder interviews, the research identifies historical design principles—such as elevated plinth level, water-adaptive landscape planning, and porous urban layouts—that mitigated hydrometeorological risks. Findings reveal that these indigenous strategies remain relevant in contemporary resilience planning, especially for low-lying, hazard-prone coastal cities. However, rapid urbanization, infrastructure development, and inadequate heritage-sensitive policies have eroded traditional adaptive capacities. The study proposes a hybrid framework integrating nature-based solutions, heritage conservation principles, and modern engineering innovations to address both tangible and intangible resilience dimensions. By situating the historic mosque city, Bagerhat within a broader regional discourse on climate justice and heritage protection, this research underscores the need for policy instruments that recognize cultural landscapes as active agents in disaster risk reduction. The insights contribute to emerging models that bridge architectural heritage, environmental adaptation, and socio-technical systems—aligning with the symposium's goal of advancing resilience across space, time, and place.

Keywords: heritage resilience; vernacular adaptation; climate-responsive design; hybrid framework; Bagerhat; coastal Bangladesh.

I. INTRODUCTION

The coastal heritage environments of South and Southeast Asia are among the most climate-vulnerable landscapes in the world. Located within the Ganges–Brahmaputra–Meghna delta, the medieval city of Bagerhat embodies both cultural heritage and environmental adaptation. Founded by Sufi saint Khan Jahan Ali in the 15th century, its spatial design—comprising hydraulic ponds (dighis), elevated mounds, and open water courtyards—illustrates early climate-responsive planning. This section introduces how Bagerhat's vernacular practices offer lessons for multi-hazard resilience under modern climate challenges.

II. METHODOLOGY

A. Archival and Historical Research

Analysis of historical maps, colonial surveys, and UNESCO nomination records reconstructed Bagerhat's hydrological morphology and heritage infrastructure.

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[2] Dr. Mokbul Morshed Ahmad is Professor and Head of the Department of Development and Sustainability (DDS), SERD, AIT, Thailand.

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B. Spatial and Field-Based Assessments

Field documentation and GIS mapping identified topographic depressions, drainage channels, and flood-prone areas to analyze how historic water systems mediated seasonal hydrology.

C. Stakeholder and Expert Engagement

Thirty heritage managers, planners, and community leaders were interviewed to evaluate adaptive practices and institutional responses. The findings informed a hybrid framework integrating traditional and modern resilience indicators.

III. GATHERED DATA

A. Vernacular Climate-Responsive Design

1. Elevated plinths and open-space networks minimized flood damage.
2. Dighis functioned as reservoirs, microclimatic regulators, and stormwater buffers.
3. Indigenous materials -Burnt brick and lime mortar improved material durability.
4. Community water stewardship ensured long-term maintenance.

B. Contemporary Vulnerabilities

1. Canal siltation and encroachment have disrupted natural drainage.
2. Groundwater extraction has weakened soil stability.
3. Policy fragmentation hampers integration between heritage management and disaster governance.

C. Comparative Insights

Comparisons with Ayutthaya (Thailand) and Venice (Italy) show that community-based hydrological design in Bagerhat achieved a balance between ecology and culture—whereas engineered flood barriers in Venice increased ecological costs and reduced flexibility.

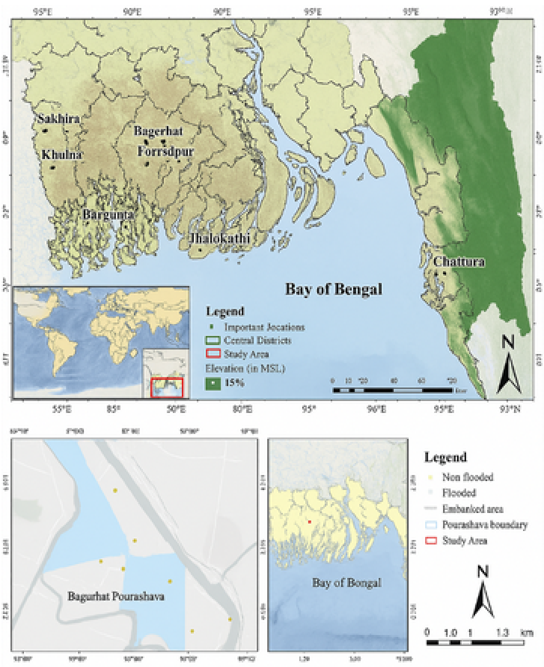

Figure 1. Location and hazard context of Bagerhat within the GBM delta and flood-prone zones.

Source: Adapted from Hasan and Rahman (2025), Water, 17(15), 2189. MDPI.

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Heritage Resilience in Multi-Hazard Coastal Environments: Climate-Responsive Strategies from the Medieval City of Bagerhat, Bangladesh

Md.Reazul Hasan[1], Mokbul Morshed Ahmad[2]

IV. RESULTS AND ANALYSIS

A. Indigenous Logic and Resilience

Bagerhat's vernacular hydrology reveals a low-carbon, regenerative urbanism where water, land, and built form interact dynamically. Its resilience derives from decentralized management and ecological feedback.

B. The Hybrid Resilience Framework

The framework integrates:

1. Nature-Based Restoration – Rehabilitating wetlands and heritage ponds.
2. Heritage-Sensitive Engineering – Using traditional materials and spatial configurations.
3. Community Co-Management – Engaging local custodians in implementation.
4. Policy Integration – Embedding heritage resilience into urban and national DRR policies.

C. Conceptual Implications

The framework redefines heritage as a living and adaptive infrastructure that supports both disaster risk reduction and cultural continuity. It links traditional ecological knowledge with modern adaptation strategies, where heritage systems function as dynamic socio-ecological networks. Through EII/SI evaluation, this model translates cultural values into measurable resilience, guiding policy and community action toward sustainable, climate-responsive heritage management.

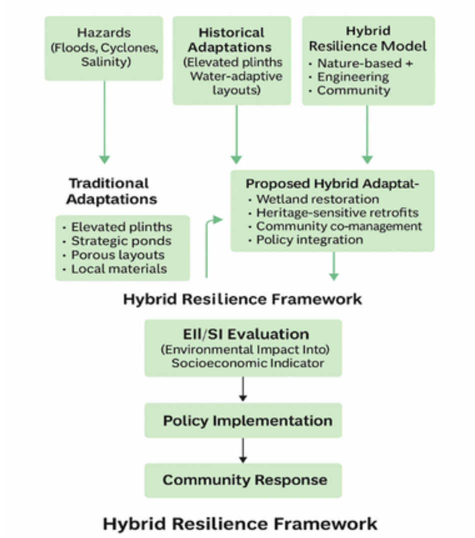

Figure 2. Hybrid Resilience Framework.

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Effects of Native Tree Cover Resiliency on the Thermal Comfort of Typhoon Affected Green Open Space

Patrick Andrew E. Gozon[1]

ABSTRACT

The presence of tree cover is deemed valuable in bringing down the high temperatures especially in summer at midday sun exposure. But since tree cover is seasonally threatened by damage during typhoons, the open spaces are always in threat of direct sun exposure. The study checked on how heat affects the acceptable levels of heat temperature for humans in using outdoor spaces. It attempted to measure the temperature of green open space at midday sun exposure with varying tree canopy cover. Research also qualified the damage sustained by trees in urban areas in several typhoon events to analyze how the damage affects the temperature/thermal comfort of the open space after the typhoon.

Keywords: green open space, native trees, typhoon resiliency

[1] Patrick Andrew E. Gozon took his Master in Tropical Landscape Architecture in U.P. Diliman. He is currently an Assistant Professor in the U.P. College of Architecture and is pursuing his PhD in the Designed and Built Environment in the same university.

I. INTRODUCTION

The Philippines is hit by several strong typhoons annually. On the other end of the spectrum, local urban outdoor spaces could experience temperatures exceeding 40 degrees Celsius, as high as 45 degrees during summer.

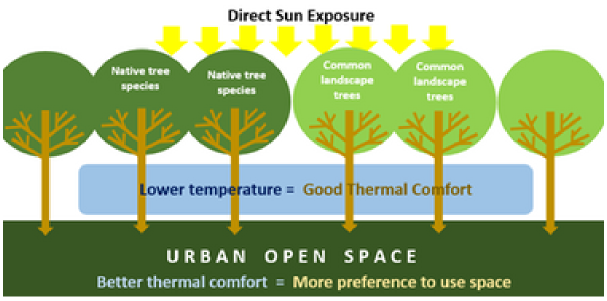

Figure 1. Urban open space model before the typhoon shock event.

The research looked into urban green space thermal comfort in the context of one of its factors which is air temperature. Temperature readings were obtained for outdoor space with a healthy full arbor cover. The study referenced if the temperature readings are comfortably acceptable for a tropical urban outdoor space.

The research takes note of the introduction of a super-typhoon event as a disruptor, It checks up on the typhoon damage on the tree arbor and how it affects green urban space coverage.

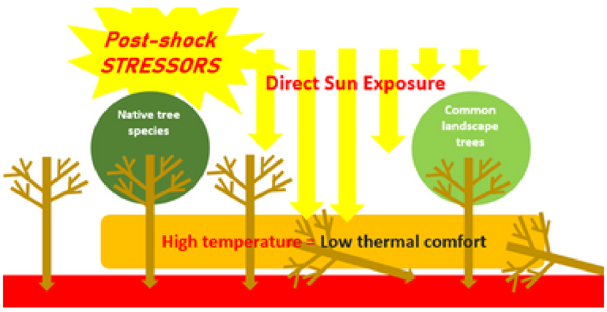

Figure 2. Urban open space model after the typhoon shock event.

Effects of Native Tree Cover Resiliency on the Thermal Comfort of Typhoon Affected Green Open Space

Patrick Andrew E. Gozon

Lastly tree canopy resilience is qualified for commonly used species of both native and non-native trees. The arbor's presence and resilience after the shock event was documented, compared and analyzed.

II. METHODOLOGY

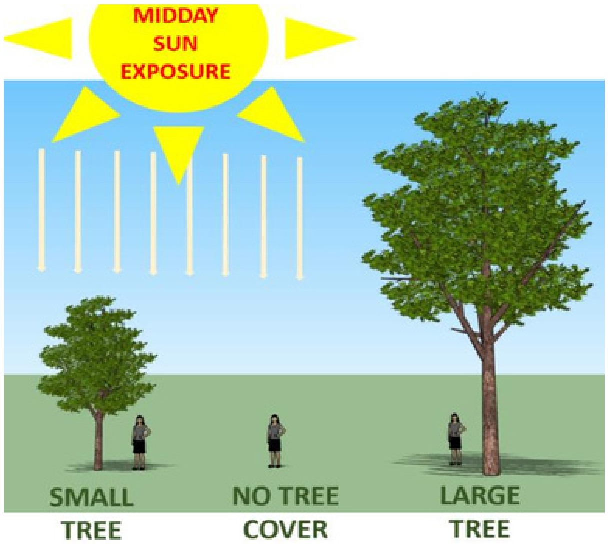

Figure 3. Research set up for the air temperature reading measurement.

The research compared temperatures in urban spaces, for both under tree cover and when it was directly exposed to the sun's heat at midday, receiving maximum sun exposure. Tree crown size was also factored in comparing small, medium and large diameters. Results were cross referenced with acceptable temperature levels in spaces for human use.

Date measured	Small Tree Shade	Diff. Deg. C	No Shade	Diff. Deg. C	Big Tree Shade
November 1, 2021	28 50%	19	47 30%	18	9 5%
November 2, 2021	30 45%	17	47 36%	18	9 1%
November 3, 2021	30 49%	11	41 34%	10	1 9%

Date measured	Small Tree Shade	Diff. Deg. C	No Shade	Diff. Deg. C	Big Tree Shade
April 2, 2022	36 30%	11	47 31%	14	33 31%
April 3, 2022	32 45%	6	38 31%	9	29 48%
April 4, 2022	32 38%	17	49 25%	16	33 29%

Figure 4. Dry bulb temperature reading results tabulation.

The study then compared data from typhoons Milenyo 2005, Glenda 2014 and Odette 2021. Cross referencing the sets of data shows that common native tree species fare better against the strong typhoon. This supports that planting native tree species contribute to a more resilient green cover securing better thermal comfort for urban open spaces.

Effects of Native Tree Cover Resiliency on the Thermal Comfort of Typhoon Affected Green Open Space

Patrick Andrew E. Gozon

Figure 5. Aerial image of property in Mandaue City before and after Odette. Picture courtesy of Dr. Mary Jeanne Oporto-Flordelis.

III. ANALYSIS

Site 1: Heritage Park, Taguig				Shock Event: Typhoon Milenyo, September 27, 2006 10-minute sustained: 155 km/h 1-minute sustained: 230 km/h			
Tree species	Local name	Nature	Number of trees in property	Damage sustained			
				Defoliated	Branch breakage	Leaned	Fell down
Albizia Saman	acacia	**introduced**	30	Partly defoliated	Some are partly debranched	2	**14**
Acacia auriculata	knife acacia	**introduced**	40	Damaged	Remaining heavily damaged	3	**32**
Pterocarpus indicus	narra	**native**	60	Partly defoliated	Partially damaged branches	None	**None**
Canarium ovatum	pili	**native**	15	Partly defoliated	Partially damaged branches	3 specimens	**None**
Eucalyptus deglupta	bagras	**native**	20	Partly defoliated	Heavily damaged branches	None	**None**
Vitex parviflora	molave or tugas	**native**	6	Partly defoliated	None	None	**None**
Roystonea elata	royal palm	**introduced**	25	None	None	None	**None**
Casuarina equisetifolia	agoho	**native**	18	None	None	None	**None**
Lagerstroemia speciosa	banaba	**native**	10	**Heavily defoliated**	Heavily damaged branches	None	**None**

Figure 6. Study sample data tabulation of trees after super typhoon.

Effects of Native Tree Cover Resiliency on the Thermal Comfort of Typhoon Affected Green Open Space

Patrick Andrew E. Gozon

PRE-SHOCK OBSERVATIONS

Tree shade could not achieve the acceptable thermal comfort levels comparable to indoor space but it will significantly bring down outdoor temperature close to acceptable levels.
Open space with no trees reaches as much as 50 degrees Celsius, way beyond healthy levels for humans. Tree shade will bring down temperature 10 to 20 deg. C. on a summer day

POST-SHOCK OBSERVATIONS

In study areas, no native trees observed toppled down during 230 kph typhoon winds. At 260 kph strong winds, a few native trees toppled down but mostly located as solitary plantings in open areas.

IV. CONCLUSION

The common native tree species would appear to be more resilient compared to the popular landscape exotic tree and would give better midday sun protection for urban green spaces translating to more acceptable thermal comfort.

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EXTENDED ABSTRACTS

PARALLEL SESSION 2D

POLICY & GOVERNANCE

Session Moderator: Francisco A. Magno PhD

Marine Carpenters of Southern Chile. Artisans on the Shoreline.

Jesus Alberto Pulido Arcas*[1]*, *Juan Ramon Jimenez Verdejo*[2]
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[2] School of Environmental Sciences, The University of Shiga Prefecture

Enhancing Climate Resilience Through Risk-Informed Development Plans: The Case of Calaca

Sheila Austero, *Jerico P. Negrite, Marlon Garcia, Ann Dominique Rodriguez, Evaristo Niño T. Cando, Edgar M. Reyes, Ryan Randle B. Rivera, Efraim D. Roxas*
College of Human Ecology, University of the Philippines-Los Banos

The Impact of Budget Efficiency on Disaster Management and Legal Protection in Indonesia

Naura Salma Taqiyya, *Adinda Riski Oktsari, Muhammad Ardy Ardan, Husni Mabarak*
University of Jember

The State of HADR in Southeast Asia 2024: Militaries

Keith Paolo Catibog Landicho, *Alistair D.B. Cook*
S. Rajaratnam School of International Studies

EXTENDED ABSTRACTS

Marine Carpenters of Southern Chile: Artisans on the Shoreline.

Jesus Alberto Pulido Arcas, Juan Ramon Jimenez Verdejo

I. COASTAL SETTLEMENTS ACROSS THE PACIFIC

Historically, marine cultures learned to coexist with the sea by establishing settlements in the intertidal zone. These settlements could be permanent, semi-permanent, or nomadic.

Notwithstanding the cultural and climatic differences, we have observed commonalities in the coastal settlements in locations as distant as Japan, the Philippines, Indonesia, Malaysia, and Chile (Figure 1). In Inecho (Japan), the funayas (舟屋, lit. boathouses) are home to a local community of fishermen and sea carpenters. The Sama-Bajau, once a sea-nomadic ethnic group, are now transitioning into a semi-sedentary way of life, establishing coastal settlements on stilt houses in Cebu, Kota Kinabalu, and Semporna. In the southern enclave of Chiloé (Chile), the sea carpenters remain the cornerstone of a rural society with strong connections to the inland and the sea (Núñez, 2020).. All of them have developed unique timber crafts that not only portray their culture, but also sustain the continuity of their settlements between land and sea.

In this contribution, we present the results of our research on the marine carpenters in Chiloé, conducted between 2022 and 2023. Through fieldwork and semi-structured interviews, we learned about their lives, hopes, and struggles, visited their workshops and homes, and saw the strong connection between their traditional timber craft and the sea. In parallel, drawing from our experience with the Sama-Bajau sea-nomads in East Asia, we argue that there are commonalities between these groups separated by geography but connected by their attachment to the sea. This contribution seeks to expand the body of knowledge on the sea-cultures along the Pacific rim with a peculiar case-study from South America, rarely documented from an Asian perspective.

II. ARTISANS AND RESILIENCE

The sea carpenters of Chiloé are artisans who build wooden boats and timber churches. Wooden boats are used for a local flourishing fishing industry; timber churches are the finest expression of Chilote carpentry—UNESCO designated sixteen of them as World Heritage in 2000. The sea carpentry of Chiloé embodies the process of cultural hybridization by which the European carpentry techniques imported by the Spanish in the 16th Century interweaved with elements from the sea-nomadic indigenous cultures of Chiloé. During the colonial period, the Spanish founded coastal settlements following a semi-nomadic system for evangelization: The circular missions.

As a result, this cultural hybridization also shapes the coastal settlements in Chiloé. The sea carpenters establish their workshops, and sometimes even their homes, in the intertidal zone. In Chiloé, this zone is called “bordemar”, a word unique to Chilean Spanish that describes the communal open urban space between the high and low tide lines. The bordemar carries a deeper meaning for the Chiloé people; it is a cherished natural resource, and the point for commercial and cultural exchange. Being respected artisans in their communities, the sea carpenters have the privilege to work in the bordemar and the responsibility to safeguard it.

For over 400 years, the sea carpenters have worked on the bordemar without land ownership rights, but with tacit approval from local communities. However, recent urban regulations based on zoning and property rights and the arrival of tourism have begun to threaten the bordemar and the future of marine carpenters. During our fieldwork and our interviews with the sea carpenters, we could observe that the shift in the legal and economic system has brought to the bordemar new activities alien to the traditional culture of Chiloé, such as cafes, boutiques, art galleries, and upscale hotels—Miller (2021) defines this process as “ruination”. Also, the interviews revealed that many carpenters feel that they are being forced out of their way of life, and no less are uncertain about the continuity of marine carpentry. If they disappear from the bordemar, will this space continue to exist, and who will preserve the UNESCO World Heritage churches and build boats for the local fishing industry?

Paradoxically, we have observed a similar process in the largest Sama-Bajau coastal settlement in Cebu, Alaska-Mambaling. A new development of artificial islands is encroaching on the settlement and blocking its access to the open sea. In both cases, the conflict between current urban policies and traditional uses of the intertidal zones underscores the necessity for a deeper understanding of marine cultures and a multifaceted approach to coastal urban development.

(a) (b) (c)

Figure 1. Coastal settlements in Kota Kinabalu (a), Inecho (b), and Chiloé (c).

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Enhancing Climate Resilience Through Risk-Informed Development Plans: Case of Calaca

Sheila B. Austero[1], Jerico P. Negrite[2], Marlon Garcia[2], Ann Dominique Rodriguez[2], Evaristo Niño T. Cando[1], Edgar M. Reyes[1], Ryan Randle B. Rivera[1], Efraim D. Roxas[1]

ABSTRACT

The Philippines has high climate and disaster risks due to its geographic location, making it susceptible to multiple natural hazards like typhoons, floods, and landslides. One of the cities prone to these hazards is Calaca, which is situated near Taal Volcano and the Lubang-Verde Passage Fault System in the Province of Batangas. Shifts in climate patterns have been linked to the rising frequency and intensity of climate-induced natural hazards in the city thus, this study aims to highlight the importance of the Climate and Disaster Risk Assessment (CDRA) in assessing the climate change vulnerability and disaster risk, and in identifying major decision areas in Calaca. CDRA includes Climate Change Vulnerability Assessment which considered climate data and climate change impacts via a ridge-to-reef approach, and the Disaster Risk Assessment which evaluated the exposure of five units: population, natural resource-based production areas, urban use areas, lifeline utilities, and critical point facilities. The results of the assessments aided in the identification and prioritization of major decision areas that required interventions. Out of 40 barangays, 17 have high susceptibility to flooding which is estimated to affect 13,352 individuals. Moreover, 57,584 individuals are in areas categorized under high and very high risk for rain-induced landslides while 69,688 individuals are in areas under moderate to high risk for earthquake-induced landslides. This shows that CDRA is a critical tool that must be incorporated in the creation of risk-informed development plans. It also promotes resilience by identifying priority areas for investment.

Keywords: multi-hazards, climate change, vulnerability, disaster risks, ridge-to-reef, Philippines

I. INTRODUCTION

According to the World Risk Report, the Philippines ranks first among 193 countries from 2022 until 2024 based on the World Risk Index computed in terms of exposure to natural hazards and vulnerability due to susceptibility, lack of coping capacities, and lack of adaptive capacities.

Calaca City of the province of Batangas is selected as the case study area because of its unique geographic characteristics. Firstly, it is situated approximately 12 km from Taal Volcano, which has been experiencing phreatic and phreatomagmatic eruptions from April 2024 until October 2025 (PHIVOLCS, 2025). Besides its proximity to an active volcano, it is also near the Lubang-Verde Passage Fault System making it vulnerable to earthquakes, ground shaking and earthquake-induced landslides.

Since the Philippines is along the Pacific Typhoon Belt, it is affected by the many typhoons that pass through the Philippine Area of Responsibility. The strong rains and winds brought by these typhoons resulted in floods and rain-induced landslides.

The goal of this paper is to emphasize the value of a comprehensive climate and disaster risk assessment in evaluating the climate change vulnerability and disaster risk, and in identifying major decision areas in Calaca.

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[1] These are the faculty members and planning specialists who are part of the project under the Technical Assistance Program on Human Settlements Planning (TAP-HSP) program of the Department of Community and Environmental Resource Planning (DCERP), College of Human Ecology (CHE), University of the Philippines Los Baños (UPLB). The team assists the LGU of Calaca, Batangas in formulating their government plans like the Comprehensive Land Use Plan (CLUP).

[2] These are the planning assistants hired under the TAP-HSP program of the same department, college, and university.

Enhancing Climate Resilience Through Risk-Informed Development Plans: Case of Calaca

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II. METHODOLOGY

Primary data was collected through surveys, key informant interviews, consultations, and workshops, which included participatory mapping, involving the 40 barangays of the municipality. Boundary shapefiles were shared by the local government unit (LGU) of Calaca. Datasets related to land use and road networks were retrieved from various offices, while hazard information was from the Mines and Geosciences Bureau (MGB) of the Department of Environment and Natural Resources (DENR), Philippine Institute of Volcanology and Seismology (PHIVOLCS), and National Mapping and Resource Information Authority (NAMRIA). Other relevant secondary data was gathered from city plans, profiles, and literature review. Geographic Information System (GIS) was used to process spatial data and ridge-to-reef analysis was done via transect mapping of the forest, agricultural, urban, and forest ecosystems.

III. RESULTS AND DISCUSSION

Climate projections showed a decrease in rainfall for March, April, May, and August, and an increase in rainfall for the rest of the months. Meanwhile, an increase in temperature is expected in all months. These changes will affect the forest, agricultural, urban, and coastal ecosystems like a chain where ecosystem conditions in higher elevations shall have impacts to the environmental health of ecosystems in lower elevations.

Based on historical data, disasters in the city were usually due to typhoons that resulted to flooding and rain-induced landslides. There were a few volcanic eruptions that led to casualties and damage to properties, while earthquakes producing disastrous high intensity ground shaking are rare.

Out of 40 barangays, 17 are found to have high susceptibility to flooding which is estimated to affect 13,352 individuals, 424.13 ha of natural resource-based production areas, 228.52 ha of urban use areas, and 15.09 km of roads. On the other hand, 10,970 ha are susceptible to ground shaking with 7,773 ha classified under the Philippine Earthquake Intensity Scale (PEIS) Intensity VII, and 3,197 ha under the PEIS Intensity VIII and above affecting all the 87,361 individuals of the city. Moreover, 65.91% of the population (57,584 individuals) are in areas categorized under high and very high risk for rain-induced landslides, while 79.77% of the population (69,688 individuals) are in areas categorized under moderate to high risk for earthquake-induced landslides.

IV. CONCLUSIONS AND RECOMMENDATIONS

The results of the CDRA showed flooding and rainfall-induced landslides as the most prominent hazards affecting the city based on historical accounts. Therefore, the programs, projects, and policies in the identified major decision areas should address these pressing concerns and must be included in the CLUP and CDP. These should also be prioritized in the Local Development Investment Program (LDIP). Although disastrous volcanic eruptions and earthquakes resulting in high intensity ground shaking are rare, appropriate initiatives must be in place to avoid or minimize casualties and damage to properties. It is also recommended that a multi-hazard risk score that consolidates all the hazards and their interactions be included in the CDRA. This way, the LGU, investors, and other stakeholders will have a way of checking if the overall risk in the city or municipality has decreased over time.

Enhancing Climate Resilience Through Risk-Informed Development Plans: Case of Calaca

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The authors would like to acknowledge the collaboration between UPLB DCERP TAP-HSP with the LGU of Calaca for the formulation of the city's CDRA.

EXTENDED ABSTRACTS

The Impact of Budget Efficiency on Disaster Management and Legal Protection in Indonesia

Naura Salma Taqiyya[1], Adinda Riski Oktasari[2], Muhammad Ardy Ardan[3], Husni Mubarak[4]

ABSTRACT

Indonesia is one of the countries with a high level of disaster vulnerability. However, the government's 33% budget efficiency policy imposed on the National Disaster Management Agency (BNPB) has had a paradoxical effect. This study aims to analyze how the BNPB budget efficiency policy affects the effectiveness of disaster management and the fulfillment of citizens' constitutional rights to self-protection. Using a mixed method, this study measures the effectiveness of efficiency policies through ex-ante Cost-Benefit Analysis (CBA) using the Net Present Value (NPV) approach, while also analyzing its impact on the fulfillment of citizens' constitutional rights to protection from disasters. The results show that budget efficiency causes a significant decrease in the allocation of long- term mitigation and preparedness due to a shift in priorities to reactive emergency response programs. As a result, several indicators have declined. Economic analysis shows a negative NPV of IDR 3,941 trillion, which means that every IDR 1 saved results in a loss of IDR 3.30. These findings indicate that the BNPB's budget efficiency policy is counterproductive because it weakens national resilience and has the potential to neglect citizens' constitutional rights to security.

Keywords: budget efficiency, disaster management, CBA, constitutional rights

I. INTRODUCTION

Indonesiais the second country with the highest disaster risk in the world after the Philippines (World Risk Report, 2024). This vulnerability is due to Indonesia's location in the Pacific Ring of Fire. This geographical position makes Indonesia prone to earthquakes and tsunamis triggered by underwater seismic activity. Based on data from the National Disaster Management Agency (BNPB), almost all of Indonesia is classified as having a moderate to high risk of disaster in 2024 (BNPB, 2025). This vulnerability shows that effective disaster management is important to minimize the impact of disasters.

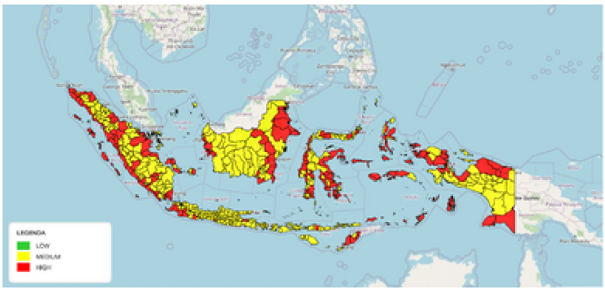

Figure 1. Map of Disaster Risk Levels in Indonesia.
Source: BNPB, 2025. "Indonesian Disaster Risk Index". inaRISK, BNPB.

Disaster management plays an important role in minimizing the impact of disasters. Disaster management includes handling disasters and preventive measures taken to minimize losses. Disaster management is carried out through four important stages: mitigation, preparedness, response, and rehabilitation. However, the effectiveness of this system depends on the allocation of adequate resources, including fiscal resources, institutional capacity, and policy consistency.

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[4] Husni is a law lecturer whose research interests include constitutional and administrative law.

EXTENDED ABSTRACTS

The Impact of Budget Efficiency on Disaster Management and Legal Protection in Indonesia

Naura Salma Taqiyya, Adinda Riski Oktasari, Muhammad Ardy Ardan, Husni Mubarak

The National Disaster Management Agency (BNPB) acts as the main coordinator of disaster management in Indonesia. Based on Law No. 24 of 2007 concerning Disaster Management, which was then followed up with Presidential Regulation No. 8 of 2008, BNPB was formed as an institution tasked with formulating policies, coordinating, and controlling the implementation of disaster management at the national level. In addition, the BNPB is responsible for managing the disaster management budget sourced from the State Budget (APBN). The main source of the BNPB's budget is obtained from the APBN, making the disaster management system in Indonesia vulnerable to changes in fiscal policy, especially the implementation of budget efficiency policies.

BNPB will experience budget efficiency in 2025. Budget efficiency is an effort to optimize public funds through rationalization of spending, elimination of non-priority activities, and improvement of budget performance. The main objective of the budget efficiency policy is to maintain fiscal stability and reduce the budget deficit, which in 2024 reached 2.29% of Gross Domestic Product (GDP) (Kementerian Keuangan, 2025). In practice, budget efficiency is implemented through budget cuts, program delays, and the reallocation of funds to more urgent sectors. Macroeconomically, budget efficiency policies are considered a cost-saving measure and a strategy to maintain fiscal stability. The International Monetary Fund also emphasizes that governments need to build fiscal buffers in normal times and maintain debt sustainability in order to respond flexibly to future shocks (International Monetary Fund, 2022). However, in the context of disaster management, budget efficiency creates a paradox: budget cuts, especially in the mitigation and preparedness stages, can actually increase potential losses and weaken the state's capacity to respond to disasters.

The BNPB's budget efficiency took the form of a 33% cut, from 1.427 trillion to 956.67 billion in 2025. This has led the BNPB to maximize budget allocation for disaster resilience programs, particularly Dana Siap Pakai (Ready-to-Use Fund) or DSP (Prasetyo, 2025). The DSP is responsive and intended for rapid response when disasters occur. However, maximizing reactive budget allocation has the potential to weaken investment in mitigation and preparedness. This has an impact on the vulnerability of the community to disaster threats and has the potential to violate constitutional rights to self-protection and a safe environment, as stipulated in the 1945 Constitution (UUD) and the International Covenant on Civil and Political Rights (ICCPR), which was ratified through Law No. 12 of 2005. Therefore, this study seeks to analyze how the BNPB's budget efficiency policy impacts the effectiveness of disaster management and the fulfillment of citizens' constitutional rights to security.

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EXTENDED ABSTRACTS

The State of HADR in Southeast Asia 2024: Militaries

Keith Paolo Catibog Landicho[1], Alistair D.B. Cook[2]

ABSTRACT

Southeast Asia faces growing disaster risks, intensified by climate change, urbanisation, and structural vulnerabilities. Militaries play a critical role in humanitarian assistance and disaster relief (HADR), providing operational, logistical, and technical capacities that complement civilian efforts. This study contends that ASEAN militaries' engagement in HADR from 2014 to 2024, using defence budgets, assets, participation in exercises, and disaster deployments data, can serve as key indicators to assess ASEAN's progress in disaster management. Drawing on the RSIS HADR Database, the analysis employs time-series, matrix, and social network methods to identify patterns of connectivity and leadership. Findings highlight continued significant impacts from catastrophic disasters comparing two different periods of disaster governance policy development (2004-2013 and 2014-2024); disparities in military response and assistance among member states; and how in the military HADR network, the United States emerges as the central global hub, with Indonesia and Singapore as the most connected ASEAN actors, followed by Malaysia, Thailand, and the Philippines with Cambodia, Vietnam, Laos, and Brunei showing growing inclusion, while Myanmar remains largely peripheral. These findings indicate that, although ASEAN militaries have strengthened cooperation in HADR, learning from past disasters remains incomplete and operational capacities are unevenly distributed across the region.

Keywords: HADR, ASEAN, defence, military, disasters, database

I. INTRODUCTION

Disaster management in Southeast Asia has made significant progress over the last 20 years, with the Association of Southeast Asian Nations (ASEAN) playing a central role (Caballero-Anthony et al., 2023). Since the ratification of the ASEAN Agreement on Disaster Management and Emergency Response (AADMER) in 2005, following the devastation of the 2004 Indian Ocean Earthquake and Tsunami, there has been broad recognition of the region's susceptibility to disasters. To this day, Southeast Asia remains one of the world's most disaster-prone regions (APCC, 2017; ASEAN Secretariat, 2025).

Major disasters such as the 2004 Indian Ocean Tsunami, Cyclone Nargis (2008), and Typhoon Haiyan (2013) have repeatedly tested ASEAN's humanitarian assistance and disaster relief (HADR) capacities. These crises catalysed key policy and institutional reforms, including the creation of AADMER (2005), the AHA Centre (2011), and the "One ASEAN, One Response" Declaration (2016). Collectively, these milestones embody ASEAN's commitment to solidarity and coordinated regional response.

Two decades since AADMER, however, a central question remains: has Southeast Asia truly learned from these major disasters? While policy rhetoric has shifted from reactive to proactive disaster management (S. Nanthini, 2023), it remains uncertain whether lessons have translated into tangible improvements on the ground.

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EXTENDED ABSTRACTS

The State of HADR in Southeast Asia 2024: Militaries

Keith Paolo Catibog Landicho, Alistair D.B. Cook

This paper argues that military engagement in HADR offers a lens to assess ASEAN's learning and resilience in disaster management. Militaries are deeply embedded in regional disaster management because of their operational utility (Trias and Cook, 2023). The scale and nature of their participation indicate state capacity, political will, and regional cooperation which are essential to effective disaster response (ASEAN Regional Forum, 2010; Landicho, 2023; Grare & Levaillant, 2023). Examining HADR through the military dimension thus provides insight into ASEAN's ability to learn, adapt, and institutionalise resilience.

II. OBJECTIVES AND SCOPE

This study investigates whether post-2014 disaster outcomes, measured in economic losses and cost of international assistance provided, reflect measurable improvement and whether military coordination has advanced in parallel with ASEAN's policy evolution. Using data from 2014–2024, with 2004-2013 as a reference point, the analysis evaluates defence budgets, HADR-related assets, military HADR exercises, and international deployments to assess whether ASEAN militaries have become more interconnected and proactive in disaster management.

Four datasets underpin the analysis:

1. **Disaster Impacts and Assistance:** mapping national, ASEAN, and international military involvement.

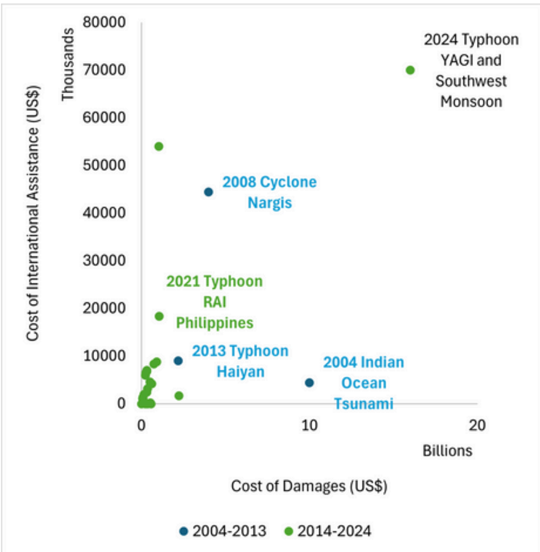

Figure 1. Cost of Damages vs Cost of International Assistance.
Source: AHA Centre, OCHA

Table 1. Disasters and Military Assistance (2014-2024).
Source: The State of HADR in Southeast Asia 2024: Militaries (Cook and Landicho, 2025)

Country	(n) Major disasters	National Military	ASEAN Military	Non-ASEAN Military
Indonesia	4	4	1	3
Laos	3	1	2	0
Malaysia	1	1	0	0
Myanmar	4	4	2	0
Philippines	14	14	2	2
Thailand	1	1	0	0
Vietnam	6	6	1	2

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2. **Defence Budgets and Assets:** to assess state capacity to engage in HADR (Assets focused on airlift and sealift capabilities).

Table 2. Change in Defence Budget and Change in HADR Assets (from 2014 to 2024).
Source: Military Balance+

Country	Budget (Δ)	Budget 2024 as % of GDP	Assets (Δ)
Brunei	29.13	7.6	3 (+3)
Cambodia	855.18	5.52	10 (=)
Indonesia	3,671.56	1.56	108 (+21)
Laos	No data	No data	13 (-2)
Malaysia	-582.72	1.98	25 (-5)
Myanmar	212.90	8.18	30 (+7)
Philippines	3,998.76	2.86	43 (+21)
Singapore	5,374.66	5.72	7 (=)
Thailand	93.53	2.16	123 (+25)
Vietnam	3,540.95	3.34	22 (=)

3. **Military Exercises:** to gauge military HADR engagement through frequency of participation in military HADR exercises.

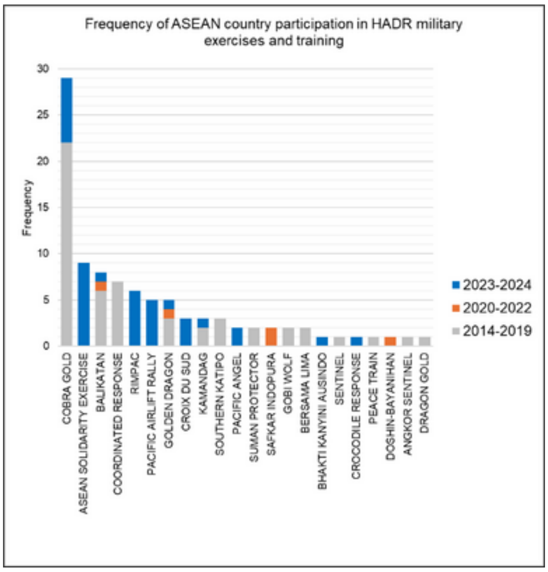

Figure 2. Frequency of ASEAN participation in military HADR exercises.
Source: Military Balance+

4. **Network Centrality Metrics:** to map leadership and connectivity amongst military HADR network countries.

EXTENDED ABSTRACTS

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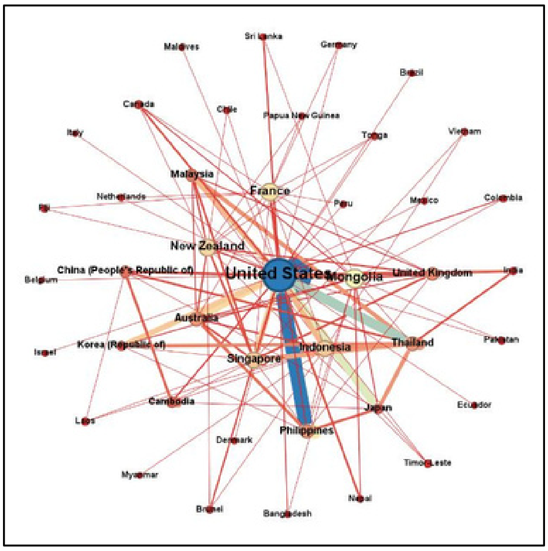

Figure 3. HADR Military Exercises Network.

Source: The State of HADR in Southeast Asia 2024: Militaries (Cook and Landicho, 2025)

Together, these datasets serve as indicators as to whether ASEAN militaries have become more interconnected, capable, and proactive in disaster management.

III. LEARNING FROM PAST DISASTERS: THEN AND NOW

Comparisons between 2004–2013 and 2014–2024 indicate progress in ASEAN's disaster management, yet human and economic costs remain high. The 2004 Indian Ocean Tsunami caused US$10 billion in damages, Cyclone Nargis (2008) approximately US$4 billion, and Typhoon Haiyan (2013) over US$2.2 billion. Compared to more recent disaster events where disaster governance has seen much institutional reform and progress, the 2018 Sulawesi Earthquake, Typhoon Rai (2021), and the combined effects of Typhoon Yagi and the Southwest Monsoon 2024 still produced multi-billion-dollar losses.

Institutional improvements, including early-warning systems, stockpiles, and joint response frameworks, have surfaced and been developed in ASEAN over the last twenty years (ASEAN in 20 Years of AADMER: ASEAN Vision for Global Leadership in Disaster Resilience, October 2025). However, there should be caution when talking about these "gains" to ascertain whether policy has translated into improving regional resilience on the ground. Structural vulnerabilities and limited civilian disaster response capacities continue to drive high-impact outcomes. Disparities remain, with countries like Laos and Myanmar receiving limited support relative to disaster severity.

IV. RESULTS - THE MILITARY DIMENSION

A. Budgets and Assets

Between 2014 and 2024, Singapore (US$15.17 billion) and Indonesia (US$10.93 billion) maintained the largest defence budgets, while Cambodia recorded the fastest growth (+192%). Regional HADR assets increased from 316 to 384, reflecting investment in airlift and sealift-capable units mostly used in HADR (Trias & Cook, 2023; Cook & Landicho, 2025). Thailand and Indonesia dominate deployable assets; even if Singapore only has 7 units, the member state is very active in its regional utilization. Other smaller states, such as Brunei and Laos, maintain a limited capacity presumably for domestic utilization.

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B. Exercises and Engagement

HADR exercises serve operational, strategic, and diplomatic purposes (Murkowski, 2024; Trias & Cook, 2020). Cobra Gold (Thailand–US) had the highest ASEAN participation (29 instances), followed by the ASEAN Solidarity Exercise (Indonesia) and Balikatan (Philippines–US). These engagements strengthen interoperability and embed ASEAN militaries within broader multilateral cooperation networks.

C. Network Analysis: Leadership and Stratification

Table 3. Social Network Analysis Statistics: HADR Military Exercises Network (Top 15 Globally).

Source: The State of HADR in Southeast Asia 2024: Militaries (Cook and Landicho, 2025)

Country	Degree	Betweenness Centrality	Eigenvector Centrality
United States	38	0.6426	1.000
Mongolia	19	0.0689	0.643
France	17	0.0843	0.615
New Zealand	16	0.0642	0.567
Indonesia	15	0.0960	0.520
Singapore	15	0.0530	0.603
Australia	11	0.0025	0.546
Philippines	11	0.0063	0.509
Thailand	11	0.0112	0.436
United Kingdom	10	0.0011	0.497
Malaysia	9	0.0019	0.423
China (People's Republic of)	8	0.0127	0.288
Cambodia	7	0.0024	0.278
Japan	6	0.0016	0.294
Korea (Republic of)	5	0.0004	0.295

Table 4. Social Network Analysis Statistics: HADR Military Exercises Network (ASEAN only).

Source: The State of HADR in Southeast Asia 2024: Militaries (Cook and Landicho, 2025)

Country	Degree	Betweenness Centrality	Eigenvector Centrality
Indonesia	11	0.61111	1.00000
Singapore	9	0.19444	0.92282
Malaysia	5	0.00000	0.60135
Thailand	5	0.00000	0.60135
Cambodia	4	0.00000	0.45984
Philippines	4	0.00000	0.45984
Laos	2	0.00000	0.37092
Vietnam	2	0.00000	0.37092
Brunei	1	0.00000	0.19360
Myanmar	1	0.00000	0.19360

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Social network analysis reveals a structured pattern of HADR military engagement. Globally (Table 3), the United States remains the central hub (degree 38; eigenvector 1.000), linking multiple regional clusters, followed by Mongolia, France, and New Zealand. Within ASEAN (Table 4), Indonesia (degree 11; eigenvector 1.000) and Singapore (degree 9; 0.923) are the most connected, followed by Malaysia, Thailand, and the Philippines. Cambodia, Vietnam, Laos, and Brunei have lower connectivity, while Myanmar remains largely peripheral (degree 1; 0.194) due to political and institutional constraints. This pattern reflects both material capacities and the depth of regional and extra-regional engagement in the military HADR network.

V. CONCLUSIONS

Two decades after the 2004 Indian Ocean Tsunami, ASEAN has progressed in developing regional disaster management frameworks. AADMER and the Declaration on "One ASEAN, One Response" exemplify the embeddedness of cooperation in regional policy. However, records between 2014 and 2024 suggest that the region's learning from past catastrophic disasters has been partial and uneven.

A comparative analysis of disasters from 2004 to 2013 and 2014 to 2024 reveals that while the scale of destruction from major disasters has declined, the costs of damages remain significant, and military assistance patterns still reflect a hierarchical response. Militaries of the Philippines, Indonesia, Singapore, and Thailand are active regional HADR actors, while others remain largely recipients of aid or domestically focused. This differentiation highlights that the shift from reactive to proactive disaster management has advanced institutionally but not uniformly in the region.

Network analysis of military cooperation further reveals that ASEAN's collective learning has produced stronger hubs of interoperability rather than system-wide capacity-building. The disparity of assistance provision and exercises among a few member states reveals asymmetry in HADR cooperation in the region.

Thus, ASEAN's experience over the past two decades reflects both learning and limitations. The region has learned to coordinate, formalize, and communicate more effectively, but not yet to equalize capabilities or ensure proportional assistance, that is, translating the goals set by "One ASEAN, One Response" to on-the-ground changes.

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EXTENDED ABSTRACTS

PARALLEL SESSION 3A

INTERSECTIONALITIES

Session Moderator: Leah P. Dela Rosa

Recipes for Disaster: Feeding Resilience After Disaster

David Lallemant, *represented by* ***Lauriane Chardot***
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Resilient Communities for All and by All: Inclusive DRR (i-DRR) Addressing Vulnerabilities, Valuing Capacities

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International Research Institute of Disaster Science, Tohoku University

Capturing the Most Significant Changes Brought about by a Community-Based Risk Communication Program in a Landslide-Prone Barangay in Malitbog, Bukidnon

Maria Thresha N. Ursolino, *Maria Stella C. Tirol, Juvy Leonarda N. Gopela*
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Capturing the Most Significant Changes Brought about by a Community-Based Risk Communication Program in a Landslide-Prone Barangay in Malitbog, Bukidnon

Maria Thresha N. Ursolino[1], Maria Stella C. Tirol[2], Juvy Leonarda N. Gopela[3]

ABSTRACT

In landslide-prone Barangay Sumalsag, Malitbog, Bukidnon, the RiskCom4DRM program aimed to strengthen disaster preparedness through community-based risk communication. This paper presents results from a Most Significant Change (MSC) evaluation that captured how residents themselves perceived the program's impacts.

Eighteen participants each wrote six MSC stories covering personal, household, and community changes, as well as suggestions and reflections. These were shared in focus group discussions, where participants collectively ranked the most significant changes using metacards and sticker voting. This process sought to place community priorities at the center of analysis, instead of externally prescribed judgments.

Findings point to both practical and relational changes. At the personal level, participants described gaining "kumpiyansa" to interpret early warnings and to speak up in preparedness discussions. At home, families began pre-packing evacuation bags and sharing hazard information with relatives. At the community level, residents coordinated evacuations more smoothly, trusted local messengers more, and set up a communication flow that could reach everyone quickly. Participants specifically valued being "alert, active, and ready."

These findings demonstrate that community-based risk communication goes beyond information delivery. It builds shared understanding, strengthens self-confidence, and mobilizes collective preparedness. The MSC stories shared by the participants underscore that when risk communication is co-developed locally, it becomes embedded in everyday practice rather than remaining as an external prescription. Programs aiming to strengthen disaster preparedness should therefore invest not only in producing clear messages but in creating spaces where communities co-own the process of interpreting, applying, and sustaining these messages over time.

Keywords: Most Significant Change, risk communication, landslide, disaster preparedness

I. INTRODUCTION

Landslide-prone communities face complex challenges in interpreting and acting upon hazard information. In Barangay Sumalsag, Malitbog, Bukidnon, a rural upland area exposed to rainfall-induced landslides, residents encounter inconsistent information flow, uneven risk interpretation, and limited preparedness resources. To address these challenges, the RiskCom4DRM program was implemented to strengthen disaster preparedness through

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[2] Maria Stella C. Tirol earned her BS, MS, and PhD in Development Communication from UPLB. A faculty and researcher for nearly four decades, she has led research, teaching, and extension initiatives, consulting on local and international projects. Her work spans participatory broadcasting, adaptive learning, community-based resource management, food security, rural development, climate change, and disaster risk communication.

[3] Juvy Leonarda N. Gopela earned her BS and MS in Development Communication from UPLB. A University Researcher at UPLB-CDC, she engages in research, extension, and project development. Her work focuses on community media, disaster risk communication, and agricultural biotechnology, with notable contributions to development initiatives.

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community-based risk communication. The program aimed to enhance risk literacy, foster participatory engagement, and mobilize collective action to reduce landslide-related vulnerabilities.

This study employed the Most Significant Change (MSC) technique to evaluate the program, capturing changes as perceived by residents themselves. The MSC approach is particularly suited to exploring multi-dimensional outcomes of participatory interventions, including cognitive, behavioral, and relational dimensions, and provides insights that conventional evaluations may overlook.

II. RESEARCH QUESTIONS

This paper sought to address the following research questions:

1. How do residents of Barangay Sumalsag describe the most significant changes resulting from their participation in the RiskCom4DRM community-based risk communication activities?
2. In what ways have these perceived changes influenced personal, household, and community-level preparedness for landslide hazards?
3. How does the use of the Most Significant Change (MSC) technique illuminate the social, relational, and behavioral dimensions of resilience in a multi-hazard rural context?

III. METHODOLOGY

Eighteen participants were purposively selected to provide diverse perspectives across age, gender, and household roles. Each participant wrote six short MSC stories guided by prompts on personal, household, and community changes, as well as reflections and suggestions for program improvement. Due to logistical constraints, written narratives were prioritized over individual interviews.

Following the story submission, participants joined two focus group discussions (8 to 10 members each). Each story was read aloud while facilitators noted recurring themes and keywords on metacards. Participants then ranked the most significant changes using a sticker-voting process, assigning one to three stickers per theme. Themes receiving the highest votes were identified as the most significant changes for each domain. This approach placed community perspectives at the center of analysis, highlighting locally defined priorities rather than externally prescribed judgments.

Figure 1. Participants from diverse backgrounds reflected on personal, household, and community changes by writing their MSC stories.

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Figure 2. Stories were read aloud in focus groups, allowing participants to compare experiences and identify common themes.

Figure 3. Participants prioritized the most significant changes using sticker voting, ensuring the community's perspective guided the results.

IV. RESULTS AND DISCUSSION

The evaluation revealed a range of participant-perceived changes across personal, household, and community levels, highlighting shifts in knowledge, attitudes, behaviors, and social cohesion.

A. Personal-Level Changes: Strengthened Awareness and Confidence

Participants reported an enhanced understanding of early warning systems, particularly the interpretation of yellow, orange, and red alerts. This improved risk literacy enabled them to respond more effectively during hazardous events. Participants also described increased "kumpiyansa [confidence]" in voicing opinions and participating in preparedness discussions. These outcomes suggest that the program strengthened both cognitive and socio-emotional dimensions of resilience, fostering individual agency in hazard-prone contexts.

B. Household-Level Changes: Improved Trust and Preparedness

At the household level, residents reported two primary changes. First, there was improved trust in information providers, including local government, media, and community organizations, reflecting shared responsibility for hazard communication. Second, families adopted practical preparedness behaviors, such as pre-packing evacuation bags, organizing household evacuation plans, and sharing hazard information with relatives. These findings demonstrate that knowledge was translated into tangible household actions, strengthening family-level resilience during landslide events.

C. Community-Level Changes: Strengthened Collective Preparedness

Participants highlighted strengthened community coordination, including organized evacuations, mutual assistance, and the use of "pagrerekoreda" (mobile sound systems/loudspeakers) to disseminate warnings locally. These changes reflect institutionalized, community-led mechanisms that reinforce official alerts while adapting messaging to local needs. Social cohesion and collective action emerged as central elements of resilience, showing how relational capacities were enhanced alongside practical preparedness.

D. Additional Reported Changes: Emerging Risk-Ready Orientation

Beyond practical outcomes, participants emphasized broader attitudinal changes, summarized in phrases such as "alert, active, and ready" and "ligtas ang may alam na ngayon [those who know are safe]". These statements indicate that residents developed a proactive, risk-aware orientation that complements individual and collective preparedness behaviors, illustrating how participatory risk communication can embed resilience in everyday practice.

V. CONCLUSION AND IMPLICATIONS

The MSC evaluation demonstrates that community-based risk communication through RiskCom4DRM produced layered impacts across personal, household, and community levels. Individuals gained knowledge and confidence, households adopted concrete preparedness behaviors, and communities strengthened coordination and communication flows. Attitudinal shifts toward being "alert, active, and ready" further indicate the embedding of resilience-oriented practices within daily life.

These findings highlight that effective disaster preparedness programs should not only focus on delivering information but also foster participatory engagement, co-developed strategies, and spaces where communities interpret, apply, and sustain messages over time. Participatory evaluation methods, such as MSC, are particularly effective in revealing the social, relational, and behavioral dimensions of resilience often missed by conventional assessments.

Future research could explore the long-term sustainability of these changes, including whether households and communities maintain preparedness behaviors over time, and examine how community-based risk communication strategies perform under different types of hazards or in other landslide-prone contexts.

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PARALLEL SESSION 3B

DESIGNING FOR RESILIENCE

Session Moderator: Ernesto B. Abaya PhD

Digital Modelling of Slope Stability Options as Forest Management Solution to Battery Storm Induced Landslide for the Batad Muyong using Sustainable Drainage System (SUDS) Principles, and Value Criteria Assessment

Avegail P. Casono, *Jose Dan V. Villa Juan*
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Factor Analysis of Convergence in Socio-Technological Infrastructure Using Machine Learning: The Case of Legazpi City's EWS for Multi-Hazard Resilience

Richelle Rhea Reyes Baria
College of Architecture, University of the Philippines-Diliman

Digital Modelling of Slope Stability Options as Forest Management Solution to Battery storm induced Landslide for the Batad Muyong using Sustainable Drainage System (SUDS) Principles, and Value Criteria Assessment:

Avegail P. Casono[1], Jose Dan V. Villa Juan[2]

EXTENDED ABSTRACT

On 2011, Typhoon Quiel hit the Philippines less than four days after Typhoon Pedring. This caused the soil to saturate and weaken, causing heavy erosion and landslide in the Batad terraces leaving a long scar halfway of the terrace's height. In 2018 in the same region, Typhoon Ompong in September, the most destructive typhoon that year and in October, a month after Typhoon Rosita exacerbated the damages.

This alarming case of more frequent storms with lesser time intervals is a threat to the community, perceived as a consequence of climate change. These battery type storms are causing an increased occurrence of water shocks. After a slope stability analysis, it was found that the terraces are stable, but the Muyong (Mountain top forest) is not. To prevent further damage, it needs to be protected, reinforced.

Slope stability solutions were carefully selected and assessed using four Value Criteria: (1) Muyong fabric disturbance, (2) Cultural reinforcement/Suitability, (3) Technology familiarity, transferability/acceptance, (4) Material availability/sustainability. Batad as a Living Cultural Landscape, this is needed, for the solution to appropriately counter battery storms, through the lens of Sustainable Urban Drainage System (SUDS) principles as a failsafe strategy.

The Ifugao has been using these for hundred years, draining away storm water from the Muyong through collecting, storing and filtering before releasing it back to terraces then to its rivers. This study identified the use of intercepting canals will best help minimize the potential impact of future battery storms on the Muyong in terms of storm water discharge.

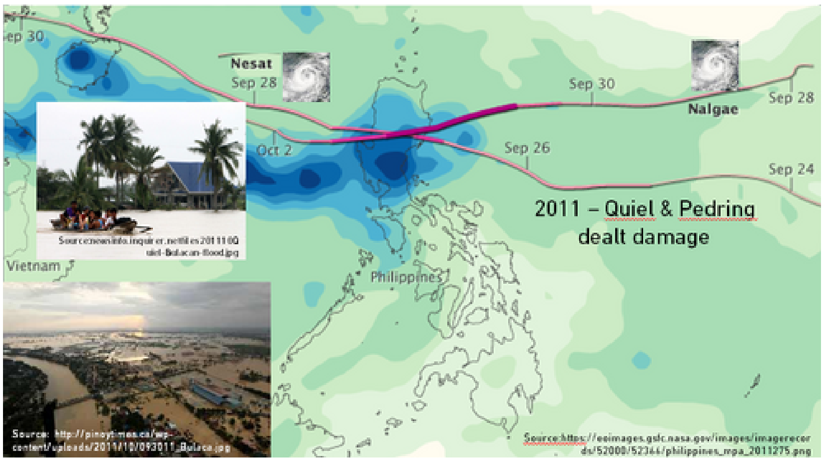

Figure 1. Shorter intervals between storms perceived to be caused by climate change in 2011. It is a four day interval battery storm.
Source: https://eoimages.gsfc.nasa.gov/images/imagerecords/52000/52366 , 2011

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Avegail P. Casono, Jose Dan V. Villa Juan

Figure 2. 20 Million Pesos was the amount of the repairs for the 2011 landslide. The debris was removed. Terraces were rebuilt and the wall between the Muyong and the terraces were repaired for the purpose of protecting the terraces form future debris if it ever erodes again.

Source: whc.unesco.orgendocuments127696, 2014

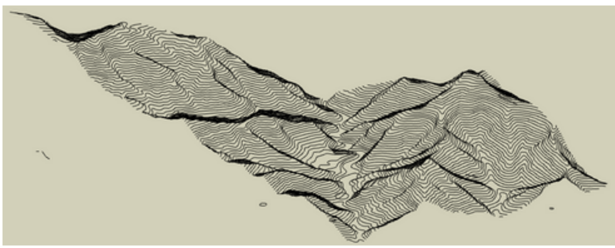

Figure 3. Digital Terrain model from Drone survey.

Source: Belga, 2020

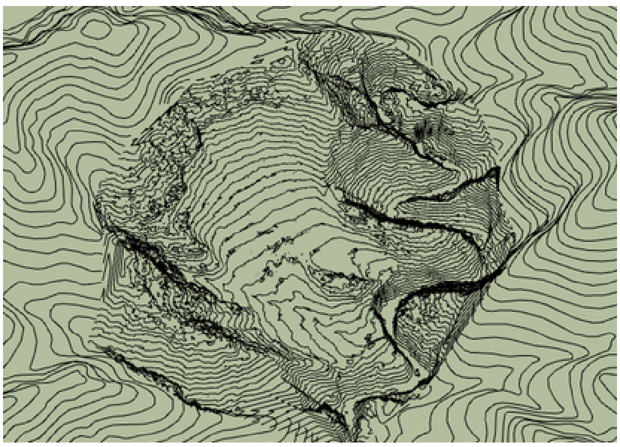

Figure 4. NAMRIA-map derived contour lines of the Batad watershed.
Figure 5. Combined NAMRIA Batad watershed with Drone surveyed contour lines.

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Digital Modelling of Slope Stability Options as Forest Management Solution to Battery storm induced Landslide for the Batad Muyong using Sustainable Drainage System (SUDS) Principles, and Value Criteria Assessment:

Avegail P. Casono, Jose Dan V. Villa Juan

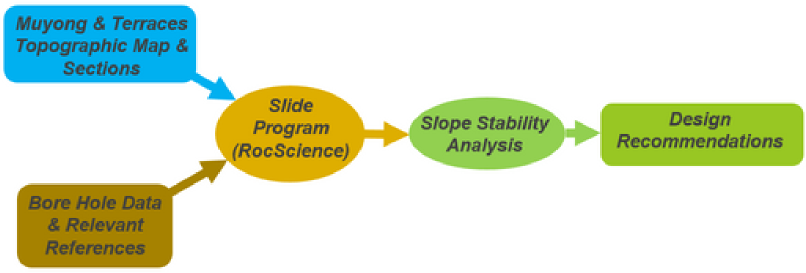

Figure 6. Slope Stability Analysis Methodology Flowchart.

Slope and Topo Analysis Methodology. Using the NAMRIA and Drone data scans, with Civil3d software, topographic surface was generated. Along with the sections, Slope map & Slope analysis. Findings were documented from date generated with Sketch-up and Cad software, 3D model creation of Muyong and the Terraces.

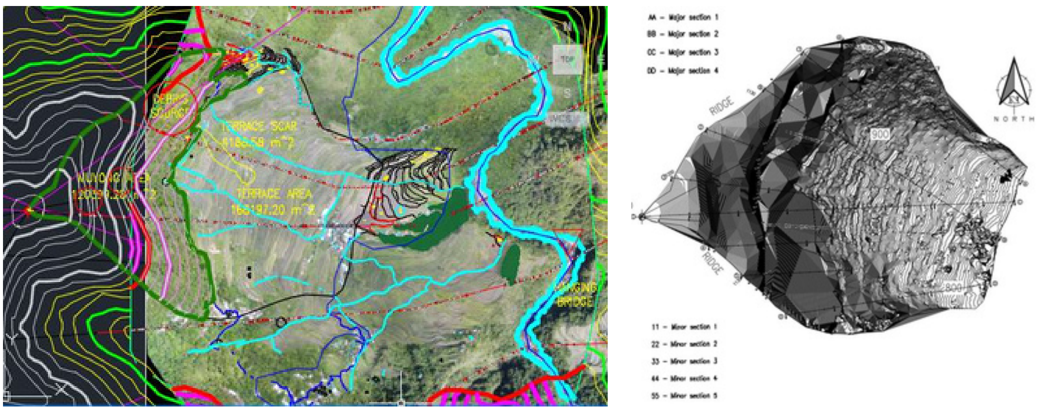

Figure 7. Funnel form location is different from Actual Debris Source. This is north oriented plan view of Muyong project boundary & the Terraces below. The 260m x 20m landslide scar was plotted and it showed a different location source of the debris, far from the closer contours where the funneling or concentration of surface run-off should have occurred. Actual scar scene from the upper right of this frame.
Source: Muyong & Terrace Plot by the Researcher. Terrace scar picture - John Chua, 2012

Slope Stabilization Analysis. To determine if indeed the Muyong forest was unstable a test was conducted on available bore hole data (secondary) & other relevant data. A Geotechnical consultation was conducted and application of Slide Program (RocScience) for slope stability Analysis. From the findings it is indeed unstable, especially now with the threats of battery storms, finding ways of supporting the Muyong forest further is important.

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Avegail P. Casono, Jose Dan V. Villa Juan

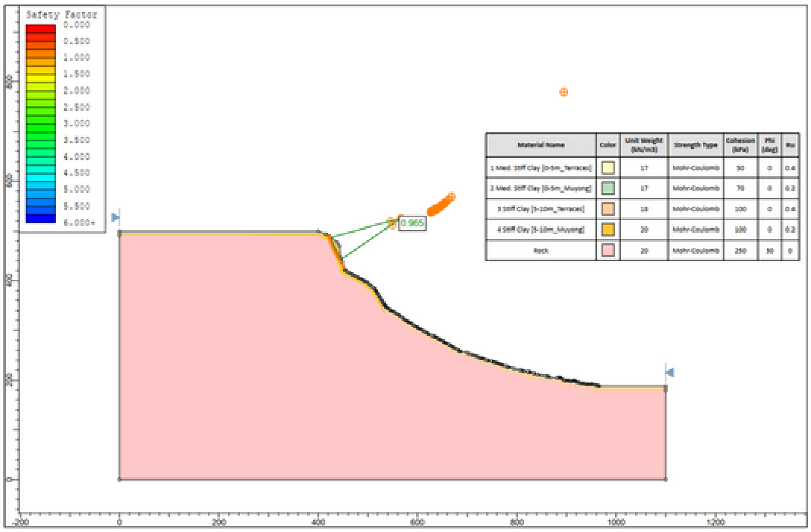

Figure 8. Section BB - 10 m Soil. Source: Casono-Reyes 2021.

Table 1. Applicability (acceptability) filter to Slope stability options for the Batad Muyong Site.

Method			Description	Applicable? YES or NOT	REMARKS
ID	Solution Option	Principle			
A	Re-planting or Bioengineering	Reforestation	Replantation to reduce surface runoff and increase ground water storage	YES	not intrussive and beneficial to root mesh reinforecment
B	Intercepting Canals using Sustainable Drainage Systems (SDS)	Drainage Improvement	Drainage system to control surface runoff, subsurface runoff, and water seepage.	YES	this will be highly responsive to the rain-induced threat of landslide
C	Soil Cutting	Change Slope Geometry	Changing on slope geometry by cutting and filling.	NOT	this is not applicable for the trees in the Muyong has to be conserved to maintain stability.
D	Soil Dowelling		Reducing or halting downslope movements on well-defined shear surface using piles.	NOT	Equipment or machine destructive to transport to terrace and muyong site.
E	Soil Improvement	Increase Soil Strength	Adding substances to increase mechanical properties (cohesion and shear strength) of soil or increasing shear resistance by compaction or preloading.	NOT	too intrusive; this is not applicable for the trees in the Muyong has to be conserved to maintain stability.
F	Soil Piling		Soil piling using drilled piers.	NOT	Equipment or machine destructive to transport to terrace and muyong
G	Soil Nailing		Reinforcement is installed horizontally or sub-horizontally to improve the shearing resistance of the soil by acting	YES	Applicable to steep slopes but requires experts and professionals and funding for repair if ever needed.
H	Gabion	Provide Retention	Gravity retaining wall using gabion with meshes.	YES	Applicable but requires experts and professionals and extra funding for material repair if ever needed.
I	Stone Wall (Traditional Terracing)		Gravity retaining wall using stone masonry.	YES	Very applicable and very familiar for the Ifugao people
J	Reinforced Concrete Wall		Cantilever retaining wall using reinforced concrete.	YES	Applicable but requires experts and professionals and funding for repair if ever needed.
K	Sheet Piling		Retaining wall using sheet pile, made of precast concete, steel or wood.	NOT	Equipment or machine destructive to transport to terrace and muyong
L	Geosynthetic Reinforced Wall		Reinforcing slope using geosynthetic layers.	NOT	too intrusive; this is not applicable for the trees in the Muyong has to be conserved to maintain stability.

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Table 2. Results of scoring assessment. Reforestation, the highest score at 100 and at second spot a tie between sustainable drainage canals and traditional terracing at 95 and gabion solution at 85.

Filtered & Selected Solutions Options	Muyong /Forest fabric disturbance (30%)	Cultural Reinforcement & Suitability (30%)	Technology, familiarity & acceptance (20%)	Material Availability & Sustainability (20%)	Suitability, Applicability & Acceptability Score (100%)
A. Reforestation	30	30	20	20	100
B. SDS - drain improv.	25	30	20	20	95
C. Soil Nailing	25	15	5	5	50
D. Gabion	25	25	20	15	85
E. Traditional Terracing	25	30	20	20	95
F. Contemporary RC wall	25	20	5	15	65

Figure 9. Reforestation

Figure 10. Terracing

Figure 11. Intercepting Canals & Channels

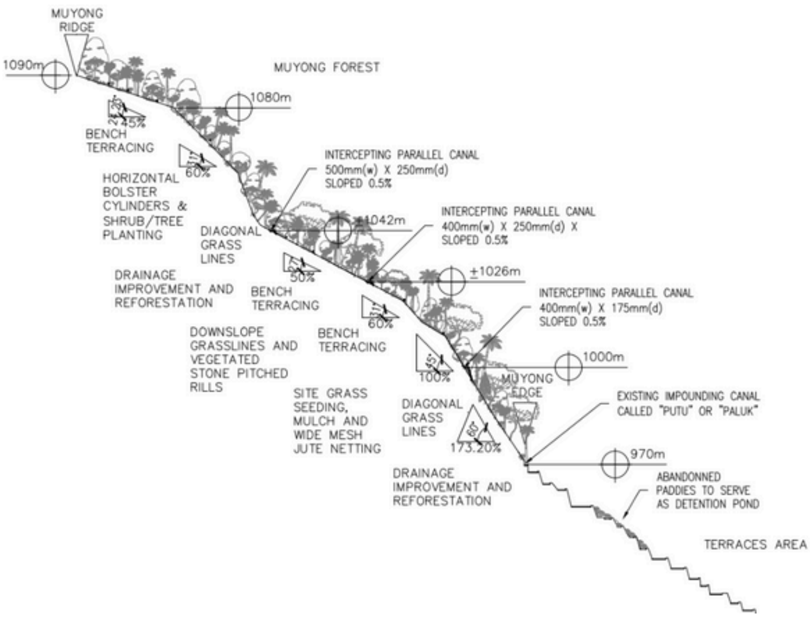

Figure 12. The Blow-up Section at the Scour Alignment Section of the Muyong area showing the layout of the intercepting parallel canals and the existing impounding canal below and right next to the terraces.

Keywords: Sustainable Urban Drainage System (SUDS), Muyong, Landslide, surface water run-off, erosion

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Digital Modelling of Slope Stability Options as Forest Management Solution to Battery storm induced Landslide for the Batad Muyong using Sustainable Drainage System (SUDS) Principles, and Value Criteria Assessment:

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Factor Analysis of Responsive Spatial Design (RSD) in Socio-Technological Infrastructure (STI), Using Machine Learning for Legazpi City's Multi-Hazard Resilience

Richelle Rhea R. Baria[1]

EXTENDED ABSTRACT

This research advances the conceptual and empirical frontiers of Socio-Technological Infrastructure (STI) convergence through the lens of responsive spatial design as a critical dimension of multi-hazard resilience in urban settings, focusing on Legazpi City, Philippines. STI is a new concept that the author is proposing in order to expand knowledge on urban design and systems thinking. STI builds on foundational socio-technical systems (STS) theory by scaling the interactive optimization of social and technical subsystems into urban-scale infrastructures that integrate community knowledge, innovative technology, and adaptive spatial arrangements. Responsive spatial design (RSD) embodies this convergence, manifesting in dynamic spatial configurations that enable hazard-sensitive urban environments, early warning system (EWS) enhancement, and coordinated emergency response in the face of complex, overlapping natural hazards.

Legazpi City's unique multi-hazard exposure—including volcanic eruptions of Mt. Mayon, typhoons, and a significant tsunami risk—provides a real-world laboratory to investigate how responsive spatial design functions as an example of STI convergence. Further, the study addresses these sub-research questions, namely (1) What are the components of RSD and STI, and why is RSD an important dimension of STI; (2) In what aspects do the social component and technological component of each system interact and benefit from each other; (3) What are the factors of responsive spatial design that have significant correlations and perform as high regressors for multi-hazard resilience?; (4) How can machine learning, and random forest programs be used to test the factors and propose a model for the 3 barangays' (Barangay Cabagnan West, Puro, and Rawis) responsive spatial design approaches.

This study employed a mixed-methods approach integrating statistical and AI techniques to analyze responsive spatial design within socio-technological infrastructure (STI) framework for multi-hazard resilience in Legazpi City. Data were collected from community surveys, interviews, and GIS spatial datasets. These datasets include spatial configurations analyzed through space syntax methods that identify critical evacuation streets across three barangays. The overarching goal is to test factors efficiently and model multi-hazard resilience outcomes while forecasting urban design intervention scenarios.

Factor analysis was used to uncover latent variables from observed indicators by grouping correlated variables into meaningful factors representing social, technological, and urban design dimensions. Machine learning algorithms, particularly the random forest method, were employed to test the relative importance of these factors and develop robust regression and classification models. GIS space syntax analysis using Normalized Angular Integration (NAIN) and Normalized Angular Choice (NACH) further quantified spatial accessibility and route preference of street segments. NAIN measures how integrated a street is within the overall network based on angular changes, while NACH assessed how often a street lies on

[1] Richelle Rhea R. Baria is an architect and assistant professor in the University of the Philippines College of Architecture, specializing in architecture, architectural lighting, urban design, disaster resilience, and coastal development planning. With over 20 years of experience, she integrates design-based research to enhance smart, resilient cities. She pursues a PhD in Designed and Built Environment Studies.

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shortest paths across the network. These metrics identify spatial hierarchies critical for evacuation and circulation planning, forming essential inputs to the factor and machine learning analyses.

Central to the study is the operationalization of STI convergence as a socio-technical co-design process that actively involves local communities, urban planners, and technologists in shaping responsive spatial configurations tailored to Legazpi's hazard profile. This participatory innovation process ensures alignment between technological assets—like real-time sensor networks and spatial data platforms—and social structures including communication networks and community mobilization mechanisms. These convergence reflect the STI principle of joint optimization, which improves the city's disaster readiness through design-based solutions.

The outcomes validate factor model detailing the sub-components of responsive spatial design as dimensions of STI convergence and a robust machine learning-based framework that reliably predicts multi-hazard resilience performance. This integrated model offers actionable insights for policymakers, planners, and disaster risk managers. Furthermore, the Legazpi case serves as a scalable example for other Philippine cities and similarly exposed global contexts, and demonstrates how responsive spatial design informed by advanced analytic techniques can advance the science and practice of holistic urban resilience.

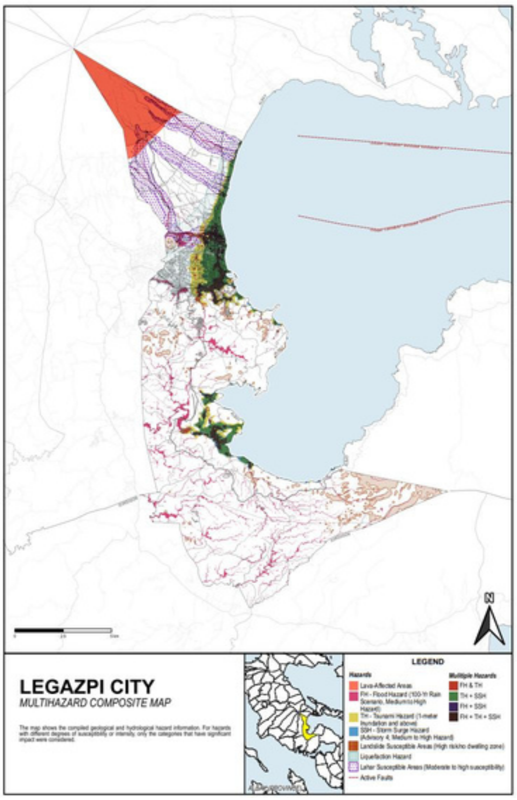

Figure 1. Legazpi City Multi-Hazard Composite Map. This map shows the vulnerable and exposed areas of Legazpi City, with respect to the multiple hazards identified for this study. *Source: Baria (2025)*

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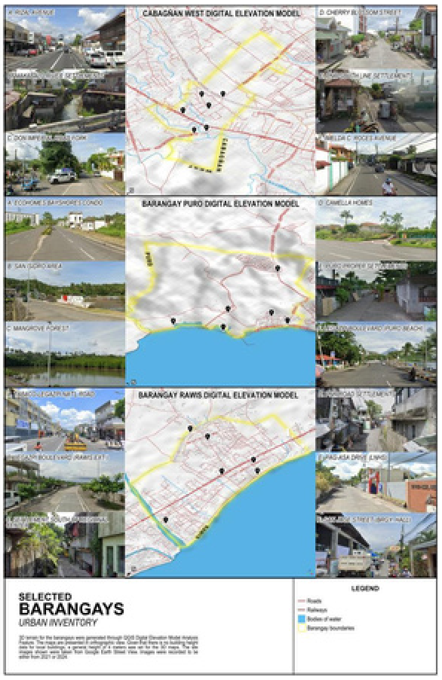

Figure 2. The 3 Barangays Urban Inventory. This map shows the different urban design features, such as the quality of the streets, the types, number of stories of buildings, and different land and water forms the define the sites.
Source: Baria (2025)

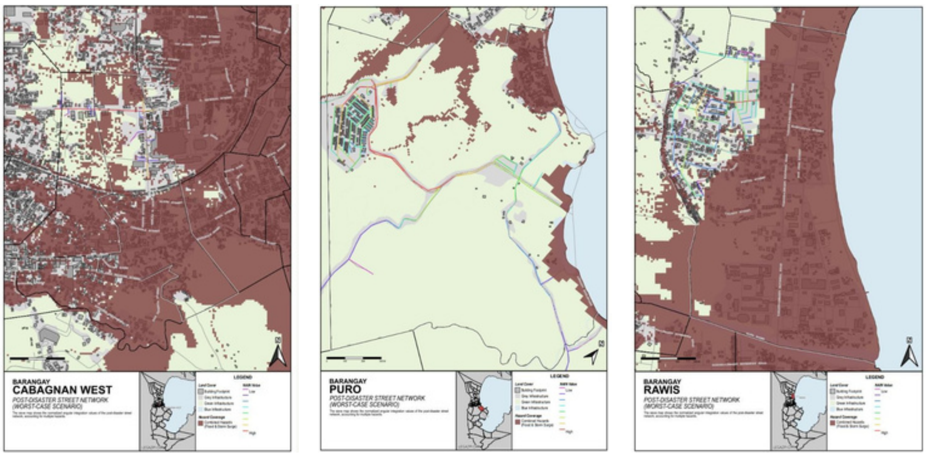

Figure 3 to 5. The 3 Barangays Post-Disaster NAIN Analysis. Shaded in brown are the high-risk areas and simulated areas affected after a combination flood and storm surge disaster. Highlighted in red are the identified new roads that will be crucial for accessibility. They are the main street in Purok 5 in Bgy Rawis, South Road north of Bgy Cabagnan West, and Tourism Mega Highway, in Bgy Puro
Source: Baria (2025)

Keywords: Responsive Spatial Design, Socio-Technological Infrastructure, Legazpi City, Multi Hazard Resilience, Factor Analysis, Machine Learning

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EXTENDED ABSTRACTS

PARALLEL SESSION 3C

HERITAGE ENVIRONMENTS AND CLIMATE JUSTICE

Session Moderator: Cathe Desiree S. Nadal PhD

ARKITEKTURANG PAMANA, HANDA SA ANUMANG SAKUNA" (Preserving Architectural Heritage Through Disaster Resilience): Integrating Disaster Risk Reduction and Climate Adaptation in the Conservation of Modern Architectural Heritage Amidst Urbanization in Metro Manila

Crisanto B. Lustre II
College of Architecture, University of the Philippines-Diliman

Explaining Nonlinear Relationships Between Community Factors and Heat-Related Illnesses Using Machine Learning

Minyeong Park, *Jung Eun Kang, Song Ju Lee, Wonshil Hwang*
Pusan National University

EXTENDED ABSTRACTS

Explaining Nonlinear Relationships Between Community Factors and Heat-Related Illnesses Using Machine Learning

Minyeong Park[2], Jung Eun Kang[1], Song Ju Lee[2], Wonshil Hwang[2]

ABSTRACT

The aim of this study is to analyze the nonlinear relationships between regional characteristics and the occurrence of heat-related illnesses, providing valuable insights for the development of heatwave-related policies. Machine learning algorithms and SHAP values, known for their effectiveness in analyzing nonlinear relationships, were utilized. Regional characteristic variables were constructed based on the three components of risk assessment —hazard, exposure, and vulnerability—and the model was trained using a 7-year dataset from 2013 to 2019. SHAP values were calculated for the algorithm that demonstrated the best performance. The analysis revealed that apparent temperature, the proportion of elderly residents, and water accessibility had a positive impact on the number of heat-related illness cases per administrative district population as their values increased. Conversely, the proportion of urbanized areas and the proportion of people with disabilities were found to have a negative impact. Notably, the apparent temperature showed a sharp positive effect at 36°C, while the number of outdoor workers exhibited a significant positive impact within specific high-value ranges. Additionally, the accessibility of heatwave shelters positively influenced the occurrence of heat-related illnesses in administrative districts where a higher concentration of shelters was located around 250 meters. These findings support more effective, locally tailored policies.

Keywords: Heat-related illnesses, machine learning, Seoul

I. INTRODUCTION

Global warming has intensified the frequency and severity of heatwaves, heightening the risk of heat-related illnesses (HRIs) worldwide (Feng et al., 2022; IPCC, 2023). Urban areas with extensive impervious surfaces amplify heat exposure, whereas green spaces provide cooling effects that mitigate thermal stress (Kotharkar et al., 2019). These relationships are well recognized; however, this study aims to empirically examine whether such urban environmental characteristics actually influence the incidence of HRIs. Traditional regression models often fail to capture the complex and non-linear interactions among climatic, environmental, and socioeconomic variables. Therefore, this study employs explainable artificial intelligence (XAI) to analyze how hazard, exposure, and vulnerability factors affect HRI incidence at the district level. By integrating risk-assessment components with machine-learning techniques (Obermeyer & Emanuel, 2016), this research seeks to provide new insights into the mechanisms of heat-related health risks and contribute to strengthening urban climate resilience and adaptive capacity under accelerating climate change.

II. METHODS

This study examined the incidence of heat-related illnesses (HRIs) across 425 administrative districts ("dong") in Seoul, South Korea. Seoul was selected as the study area because it is

[1] She is the corresponding author of this paper and a Professor in the Department of Urban Planning and Engineering at Pusan National University. Her main research areas include urban spatial planning, climate change adaptation, urban disaster prevention planning, spatial analysis using GIS, and environmental planning.
[2] They are Ph.D. students in the Department of Urban Planning and Engineering at Pusan National University. Their research focuses on urban climate resilience and heat exposure spaces. Their primary research interests include urban climate, climate change adaptation, and spatial data analysis.

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highly urbanized, experiences severe heat-related risks, and provides extensive public data, ensuring analytical reliability and policy relevance. Each dong varies in size from 0.2 to 12 km², with populations between 1,000 and 50,000.

Based on an integrated risk–vulnerability framework, sixteen explanatory indicators were developed: hazard (maximum and apparent temperature), exposure (population density, urbanized area ratio), sensitivity (older adults, infants, low-income residents, people with disabilities, outdoor workers), and adaptive capacity (access to parks, green spaces, medical facilities, pharmacies, water areas, and heat shelters). The dependent variable was the incidence rate of HRIs, calculated per district during summer months (June–August) from 2013 to 2019, with missing data replaced by the nearest available year.

A four-step analytical process was applied: (1) constructing indicators, (2) training 18 machine-learning regression models via PyCaret, (3) selecting the optimal model based on performance metrics, and (4) interpreting the results using SHapley Additive exPlanations (SHAP). SHAP analysis identified key variables and revealed non-linear relationships between environmental and socioeconomic factors and heat-related illness risk in Seoul.

III. RESULTS

To identify the factors influencing the incidence of heat-related illnesses (HRIs) in Seoul, 18 machine-learning algorithms were trained. Among them, the Light Gradient Boosting Machine (LGBM) achieved the highest performance (R^2 = 0.73), indicating that non-linear models capture complex relationships more effectively than linear ones. Using this model, SHAP analysis was conducted to generate a dot plot, which identified the proportion of older adults, urbanized area ratio, and accessibility to medical facilities, cooling shelters, and water areas as the major influencing factors. The results showed that higher proportions of older adults, lower urbanized area ratios, shorter distances to medical facilities, and longer distances from water areas were associated with higher HRI incidence rates. For variables that could not be fully interpreted from the dot plot, dependence plots were examined. Apparent temperatures above 36 °C were found to represent a critical threshold that sharply increased HRI risk. Moreover, the dependence plot revealed that the effectiveness of cooling shelters declined beyond a 250 m threshold. The number of outdoor workers also showed a non-linear positive relationship with HRI risk, indicating that as their numbers increased, the risk of heat-related illnesses rose disproportionately.

This study found that accessibility to water areas significantly reduces heat-related illness incidence, highlighting their cooling benefits. Enhancing water access, optimizing heat shelter locations, and expanding support for outdoor workers—such as rest areas, cooling devices, and energy subsidies—are essential for protecting vulnerable populations during heatwaves.

EXTENDED ABSTRACTS

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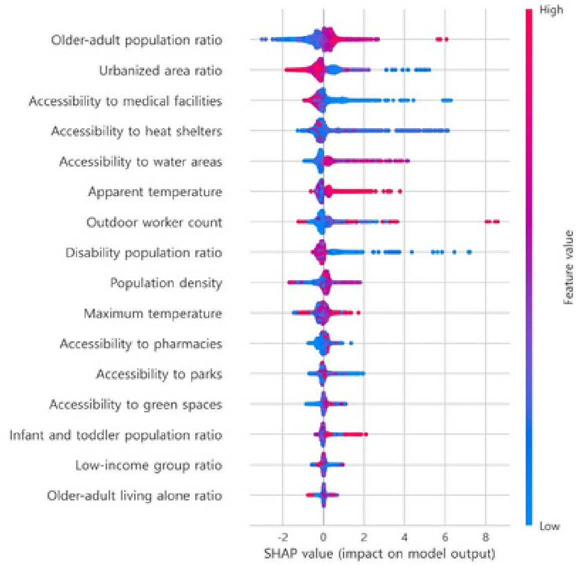

Figure 1. Summary dot plot of LGBM

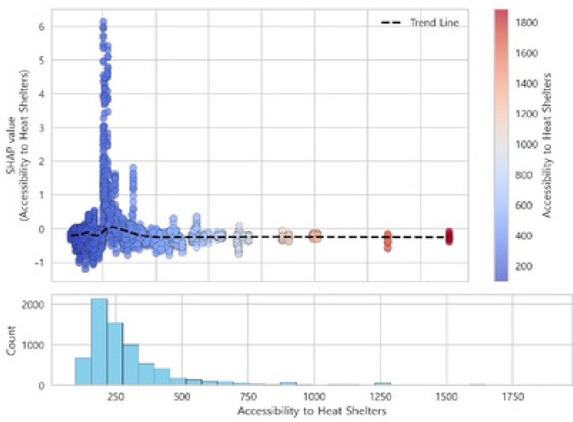

Figure 2. Dependence plot of Heat Shelters

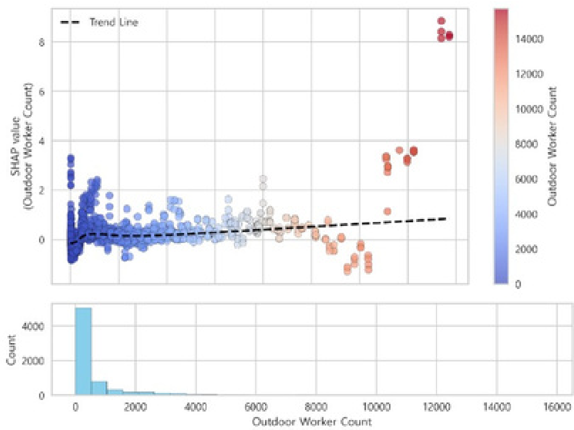

Figure 3. Dependence plot of Outdoor Worker count

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IV. CONCLUSION

This study used explainable AI to analyze physical and sociodemographic factors influencing heat-related illnesses in Seoul. Apparent temperature, urbanization, elderly ratio, outdoor workers, and water accessibility were key predictors. Findings support targeted urban heat mitigation policies, though spatial data limits and Seoul's unique context constrain broader generalization.

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EXTENDED ABSTRACTS

PARALLEL SESSION 3D

POLICY & GOVERNANCE

Session Moderator: Ma. Charisma Malenab PhD

Metro Manila Flood Control as Performative Governance?

***Pamela G. Cajilig*[1]*,* *Timothy James Cipriano[2], Tieza Mica Santos[3], Narod Eco[4]*

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[2] Philippine Normal University
[3] Technische Universitat
[4] AGHAM

Modernizing Quezon City's Building Risk Data with AI and Earth Observation

***Joshua Dimasaka*[1]*,* *Fouad Bendimerad[2], Renan Tanhueco[2], Christian Geiß[3], Emily So[1],*

[1] Cambridge University Centre for Risk in the Built Environment (CURBE)
[2] Earthquakes and Megacities Initiative (EMI)
[3] Georisks and Civil Security, Earth Observation Center, German Aerospace Center

Enhancement of Vessel Systems for Resilient Sulfur Mining in Volcanic Environments: A Case Study on Efficiency, Safety, and Sulfur Purity at Ijen Crater

M Ardy Ardan, *Mohammad Arsy Darmawasyah, Muhammad Ridwan Ghani Abhirama, Ir. Welayaturromadhona*
University of Jember

EXTENDED ABSTRACTS

Metro Manila Flood Control as Performative Governance?

Pamela Gloria Cajilig[1]**,** Timothy James Cipriano[2], Narod Eco[3], Monica FA W Santos[4], Tieza Mica Santos[5]

ABSTRACT

This paper interrogates the performative character of flood governance in Metro Manila by examining the first phase of the Metro Manila Flood Control Program, which focuses on the rehabilitation and construction of pumping stations. In the context of climate change, intensifying extreme rainfall and slower-moving, stronger cyclones have led to prolonged and heavier precipitation events. These have been exemplified by the successive impacts of Tropical Storm Gaemi (Caring), Tropical Storm Koguma (Dante), and Typhoon Chaba (Emong) during the week of July 21, 2025. The intense flooding associated with these cyclones reignited public criticism of the program's efficacy considering substantial public investment. By triangulating findings from archival research, spatial analysis, and flood modeling, the paper reveals how the program's technocratic orientation fails to address systemic vulnerabilities. It also shows the critical possibilities of integrating the lens of performance in cross-disciplinary research to analyze symbolic displays of action and infrastructural investment vis a vis long-term, climate-responsive, and socially transformative solutions.

Keywords: flood control, performance studies, flood risk, flood governance, infrastructure

Between July 2024 and August 2025, Metro Manila endured an extraordinary sequence of hydrometeorological events. Habagat (Southwest Monsoon)–enhanced Tropical Storm Gaemi(Carina) in 2024, followed by Tropical Storm Francisco (Dante) and Typhoon Co-may (Emong) in 2025, produced overlapping rain bands that submerged large sections of the metropolis. These events exposed the fragility of the capital region's flood control system and reignited scrutiny of the Metro Manila Flood Management Program (MMFMP). Despite substantial government and multilateral investment, persistent flooding prompted congressional investigations and public outrage, with critics charging that the city's flood control measures are increasingly "performative."

What does it mean to call flood governance performative? This paper addresses that question by drawing on performance theory in political science and performance studies to examine how bureaucratic actors "perform" governance under the institutional, political, and sociotechnical conditions of the Philippine infrastructural state. We analyze how decisions around infrastructure and engineering are staged, narrated, and enacted—as display, practice, and legitimation—to sustain authority, fulfill state mandates, and respond to scrutiny.

[1] Pamela Gloria Cajilig conducts research at the intersections of anthropology, design, disaster, and climate-health adaptation. She conducts training in gender and community inclusion for nature-based flood risk management for Asia Pacific practitioners at the World Wildlife Fund USA Environment and Disaster Management Program. She serves as Professorial Lecturer at the University of the Philippines College of Architecture.

[2] Timothy James Cipriano is Assistant Professor of Geography at the Philippine Normal University, concurrently serving as both Head of the Center for Transformative Education (CTE) and Head and Chief Researcher of the Geography and GeoSpatial Training and Research Laboratory (GeoSTaR Lab) of the Faculty of Behavioral and Social Sciences.

[3] Narod Eco is a researcher working on understanding disasters and disaster risk though the intersecting lenses of geosciences, community development, social sciences, decolonization, and conservation. He is based in the College of Social Work and Community Development, University of the Philippines.

[4] Monica FA W Santos trained in anthropology at the University of the Philippines Diliman and at the University of Illinois at Urbana-Champaign. She teaches at the Department of Anthropology and is currently Director of the Office for Initiatives in Culture and the Arts at UP Diliman.

[5] Tieza Santos is a researcher, development professional, and public policy and governance specialist. Her interests include climate resilience, urban metabolism, sustainability transformation of complex social-ecological-technological systems, environmental policy and resource governance (water-food-energy nexus), and sustainable finance. She works on cities, urban, and peri-urban regions in Southeast Asia and Europe.

Metro Manila Flood Control as Performative Governance?

Pamela Gloria Cajilig, Timothy James Cipriano, Narod Eco, Monica FA W Santos, Tieza Mica Santos

We argue that Metro Manila's flood regime operates simultaneously as hydraulic intervention and political theater. Complementing performance theory with sociotechnical systems (STS) transition framework and the anthropology of infrastructure, we examine flood governance as performance through the public staging, narration, and embodied practice of competence, control, and care under conditions of risk and accountability. In contexts of limited administrative capacity, fragmented authority, and high public expectation, visible infrastructures—pumping stations, dredging convoys, embankments, and "river parks"—also function as communicative devices that render the state legible and active in the eyes of citizens.

Phase 1 of the MMFMP, focused on rehabilitating and constructing pumping stations as the primary defense against intensifying rainfall, anchors the analysis. Across the metropolis, tensions have surfaced between metro-wide schemes and city-level programs. Local governments in Quezon City, Pasig, Manila, and Marikina have advanced locally tailored flood mitigation—from river-corridor developments to detention basins and drainage upgrades—that sometimes complement, compete with, and often temporally misalign with national plans. These misalignments reveal a fragmented, multi-level governance field marked by overlapping mandates, divergent tempos of action, and conflicting flood management paradigms. We examine how lateral and vertical coordination—and its limits—are experienced by bureaucrats and the public.

Examining the MMFMP through STS transition framework, posits infrastructure as a socio-political assemblage through co-evolution of technologies and institutions that enable or inhibit transformation toward normative goals. Metro Manila's flood regime remains locked in technocentric path dependence, where large-scale, visible engineering solutions serve as symbols of state capacity. Building on formulations of performative governance—the deployment of visual, verbal, and gestural symbols of good governance—we argue that infrastructural visibility powerfully shapes how governance is perceived and enacted. Under capacity constraints and heightened expectations, the prominence of large projects functions both as practical response and as a means of rendering government action legible.

The paper examines the MMFMP using archival and policy analysis; discourse analysis of media content and congressional proceedings; and flood modeling that focuses on four urban sites–Quezon City, Pasig, Manila, and Marikina–which span the Pasig–Marikina watershed and the Manila Bay delta. This multi-scalar design captures how institutional and geographic mismatch affects the articulation of flood control priorities. It also contextualizes the governance architecture dynamics that includes the Department of Public Works and Highways (DPWH), the Metropolitan Manila Development Authority (MMDA), city governments, and multilateral finance institutions.

The analysis investigates how performative governance interacts with sociotechnical regime lock-in, reinforcing reliance on visible infrastructure and inhibiting experimentation with adaptive, nature-based, or participatory approaches. Early evidence suggests that flood control projects serve not only as hydraulic solutions but also as communicative devices that legitimizes state presence. Each crisis amplifies this performative cycle: agencies must be seen acting even when systemic vulnerabilities remain unaddressed and corruption from many of these projects remain rampant.

Modernizing Quezon City's Building Risk Data with AI and Earth Observation

Joshua Dimasaka[1], Fouad Bendimerad[2], Renan Ma. Tanhueco[3], Christian Geiß[4], Emily So[5]

ABSTRACT

Developing, maintaining, updating, and forecasting city-scale building risk data is costly yet essential for tracking progress toward the UN Sendai Framework for Disaster Risk Reduction 2015-2030. Although advances in information technology and big data have enabled a shift from low- to high-resolution mapping, current state-of-practice methods remain limited in detail and accuracy due to the challenges in coarse-to-fine-grained mapping across spatiotemporal scales. To address these challenges, we develop a novel spatiotemporal framework that integrates the rich information from time-series Earth Observation data and leverages recent advances in artificial intelligence, including graph deep learning, state-space modeling, and probabilistic inference. Through an academic research collaboration with Earthquakes and Megacities Initiative (EMI) and Quezon City Disaster Risk Reduction and Management Office (QCDRRMO), we present a flexible probabilistic framework and an open-access dataset comprising annual spatiotemporal 10-meter maps of building exposure and physical vulnerability for Quezon City, Philippines, from 2016 to 2030, along with associated uncertainty estimates. Beyond demonstrating the potential of AI and Earth Observation in modernizing building risk data, our work has offered a dynamic approach to disaster risk auditing by capturing spatiotemporal changes in exposure and vulnerability, thereby empowering local governments with data-driven insights for effective disaster risk reduction.

Keywords: probabilistic, regional risk, machine learning, exposure, vulnerability, Earth Observation

I. INTRODUCTION

In 2022, the Earthquakes and Megacities Initiative (EMI) and the government of Quezon City conducted its climate and disaster risk assessment using an improved geospatial building exposure and physical vulnerability database (EMI, 2022), combining another prior study (Allen et al., 2014) and a high-resolution digital elevation map.

With the increasing availability of Earth Observation data and rapid advancement in artificial intelligence techniques, we extend the 2022 assessment using the annually aggregated 10-meter maps of publicly available Sentinel 2 multispectral imagery (Copernicus Sentinel data, 2025a, 2025b), proximity to road networks, and temporal building height data from Google Open Buildings 2.5D Temporal (Sirko et al., 2023).

Combining graph deep learning, state-space modeling, and variational inference using time-series data and prior expert belief systems in a weakly supervised or coarse-to-fine-grained manner (Dimasaka et al., 2025a, 2025b), we probabilistically infer and forecast the likelihood of

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each physical vulnerability class at finer-grained spatial resolution and annual attribution from 2016 to 2030 using the learned city-wide dynamics of urban development and interdependencies from various Earth Observation data.

II. METHODOLOGY AND FINDINGS

This work used the comprehensively validated data, developed by EMI (2022), in coordination with the Quezon City Disaster Risk Reduction and Management Office (QCDRRMO) for scientific research purposes only.

We introduce Graph Variational State-Space Model (GraphVSSM), a novel spatiotemporal framework that uniquely addresses the unstructured data of built environment, limited historical observations, and variational inference for categorical probabilistic modelling of building typology classes (Dimasaka et al., 2025a). Among its modular components, we further describe the exposure-to-vulnerability modelling as Graph Categorical Structured Variational Autoencoder (GraphCSVAE), which has also been applied to other case studies in Bangladesh and Sierra Leone for post-disaster analyses (Dimasaka et al., 2025b).

For an overview of findings, we show that examining the derived posterior parameters of our GraphVSSM reveals insights into the regional spatiotemporal dynamics of building exposure and physical vulnerability. Our findings also demonstrate that incorporating prior knowledge into the learning optimization task to address weak multi-class supervision allows the GraphVSSM to balance supervised learning with deep probabilistic coarse-to-fine-grained updating (Dimasaka et al., 2025a).

Given the page limitation of this extended abstract, further details and results are provided in the accompanying preprints.

III. CONCLUSION AND NEXT STEP

Relevant to key local decision makers in monitoring the efforts to reduce disaster risk, our work demonstrates a city-wide spatiotemporal updating or auditing of the existing building exposure and physical vulnerability database, aided by advanced machine learning techniques and satellite imagery. For future work, we recommend the incorporation of building-level information, even sparse or incomplete, in achieving more accurate higher-order analyses.

ACKNOWLEDGEMENT

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EXTENDED ABSTRACTS

Enhancement of Vessel Systems for Resilient Sulfur Mining in Volcanic Environments: A Case Study on Efficiency, Safety, and Sulfur Purity at Ijen Crater

M Ardy Ardan[1], Mohammad Arsy Darmawansyah[2], Muhammad Ridwan Ghani Abhirama[3], Ir. Welayaturromadhona[4]

ABSTRACT

Kawah Ijen, an Indonesian volcano situated in eastern Java, is characterized by an exceptionally acidic crater lake and active fumaroles that emit molten sulfur and sulfurous gases. The lake's pH, frequently below 0.3, creates a perilous environment for sulfur extraction, which predominantly relies on traditional manual techniques. Local miners utilize metal pipes to collect condensed molten sulfur; however, this process is significantly affected by environmental variables such as temperature and wind direction. Artisanal sulfur extraction faces multiple challenges, including contamination from volcanic ash and metal oxides, exposure to hazardous gases like sulfur dioxide and hydrogen sulfide, and inefficient sulfur collection (Caudron, et al., 2015). Sulfur dioxide levels along mining routes often surpass safety thresholds, leading to health issues such as ocular irritation, coughing, and respiratory ailments (Susetyo, et al., 2024). Furthermore, a substantial quantity of sulfur is lost or compromised during transportation, negatively impacting yield and overall efficiency. This research endeavors to enhance the resilience of sulfur mining at Ijen through the implementation of a passive pre-filter system designed to improve sulfur purity and mitigate contamination. Positioned at the gas inlet, this pre-filter effectively separates coarse solid particles from the incoming gas stream before it reaches the condensation zone. Operating passively, the system demands minimal maintenance and is compatible with existing artisanal methods. Expected benefits include elevated sulfur purity, reduced maintenance requirements, augmented mining efficiency, and decreased air pollution. The proposed intervention is both cost-effective and sustainable, aligning with the objectives of bolstering worker safety, improving environmental performance, and ensuring operational viability within this challenging volcanic landscape.

Keywords: Sulfur extraction, Artisanal mining, Kawah ijen, Passive filtration system, Sulfur dioxide exposure, Mining efficiency

I. INTRODUCTION

Kawah Ijen, also known as Mount Ijen, is a volcanic complex situated in eastern Java, Indonesia. Standing approximately 2,799 meters above sea level, it features one of the world's most acidic crater lakes and numerous fumarolic vents. These vents emit molten sulfur and sulfurous gases that naturally condense within metal pipes as they cool (Caudro, et al., 2015). The lake exhibits an exceptionally low pH, often below 0.3, and its hydrothermal system is characterized by continuous emissions of sulfur dioxide gas and acidic fluids. While these conditions facilitate the condensation of elemental sulfur, they simultaneously create an extremely hazardous environment for human activities (Demelle, et al., 2000).

Sulfur extraction at Ijen continues to rely on traditional manual techniques. Local miners insert short metal pipes into fumarolic vents, allowing hot vapor to pass through and condense into molten sulfur as it cools. This molten sulfur then solidifies at the pipe exits. Workers manually break the solidified sulfur into smaller fragments and transport the material out of the crater

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on foot across challenging, uneven terrain (Caudron, et al., 2015). This process involves minimal mechanization and is entirely dependent on environmental variables such as temperature, rainfall, and wind direction, which directly influence condensation efficiency and the purity of the collected sulfur.

The artisanal nature of this operation presents several significant challenges. Firstly, the sulfur recovered from the pipe outlets frequently contains contaminants, including volcanic ash, metallic oxides, and fine particulates that adhere to cooling surfaces or are introduced during manual handling (Demelle, et al., 2000). These impurities diminish product quality and increase the expenses associated with further refining. Secondly, miners operate in an environment with elevated concentrations of noxious gases, particularly sulfur dioxide and hydrogen sulfide. According to Susetyo, et al. (2024), sulfur dioxide levels measured along miners' routes varied between 3.14 and 18.24 milligrams per cubic meter, considerably exceeding permissible air quality standards. Many miners report symptoms such as ocular irritation, coughing, headaches, and respiratory distress. Such exposure poses both immediate discomfort and long-term health risks (Akbar, 2022). Lastly, a portion of the vapor does not condense effectively, and a substantial quantity of solid sulfur is lost or damaged during transport, consequently reducing overall yield and efficiency. The field measurements of sulfur dioxide concentrations recorded by Susetyo, et al. (2024) are summarized in Table 1 below.

Table 1. Field measurements of SO2 concentration and working conditions at Ijen Crater
Source: Susetyo, et al., 2024

Sampling point	1		2	3	4	5	6
SO_2 concentration (mg/m^3)	3.14		3.46	3.62	6.29	18.24	16.98
Time activities (hr)	3.5		0.5	0.75	0.5	0.25	2.5
Distance (m)	150		180	180	150	75	75
Humidity (%)	80		80	80	80	80	80
Average SO_2 concentration (mg/m^3)		8.2					

Enhancing the resilience of sulfur mining at Ijen is thus imperative. This concern aligns closely with the theme of "Resilience Reviews and Projections: Multi-Hazard Entanglements of Society, Environment, and Technology in Space, Time and Place." Improving safety and environmental performance while maintaining operational feasibility contributes to the social resilience of the local community. Safeguarding miners' health is an ethical obligation, increasing sulfur yield offers economic advantages, and reducing emissions helps preserve the surrounding ecosystem. Any intervention must remain affordable, operate passively, be easy to maintain, and withstand extreme volcanic conditions.

Enhancement of Vessel Systems for Resilient Sulfur Mining in Volcanic Environments: A Case Study on Efficiency, Safety, and Sulfur Purity at Ijen Crater

M Ardy Ardan, Mohammad Arsy Darmawansyah, Muhammad Ridwan Ghani Abhirama, Ir. Welayaturromadhona

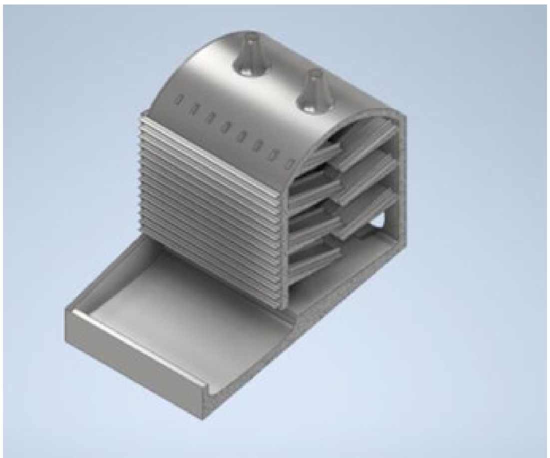

Figure 1. 3D Design Sulfur Mining System
Source: Susetyo, et al., 2024

This study introduces a passive pre-filter or pre-separator system positioned at the gas inlet upstream of the condensation chamber. This design removes coarse solid particles from the incoming gas stream before it reaches the condensation zone. The filter operates by directing the gas into a tangential circular path, which causes heavier particles to separate and fall into a small, removable chamber. Miners can periodically empty this chamber without interrupting the process. The cleaner gas then proceeds upward into the primary vessel, where it condenses into liquid sulfur, which subsequently flows through an outlet pipe. Residual non-condensed gas is discharged through a vent situated above the vessel, safely away from the workers. The integration of this filter at the inlet is anticipated to decrease contamination, reduce maintenance requirements, and enhance sulfur purity. Furthermore, this system is projected to improve the effectiveness and efficiency of the sulfur production process by obviating the need for subsequent melting and impurity filtration stages, given that the sulfur passing through this system will already be free of contaminants. Additionally, the reduction of fine particulates minimizes air pollution in the vicinity of the mining area. As the system operates without external power and incorporates very few moving parts, it is compatible with the artisanal techniques currently employed at Ijen. The proposed modification seeks to implement a low-cost, resilient, and sustainable improvement that enhances both worker safety and the efficiency of sulfur recovery.

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EXTENDED ABSTRACTS

PARALLEL SESSION 4A

CITIZEN SCIENCE

Session Moderator: Jerome V. Cleofas PhD

Measuring Hospital Accessibility and Infrastructure Criticality for Clustered Urban Informalities during Flood Hazard

Emmarie Rose Cruz Josue
College of Architecture, University of the Philippines-Diliman

Designing Emergent Learning for Disaster Education: Challenges and Possibilities of XR Implementation under Japan's GIGA School Policy

Sachiko Takane, *Rajib Shaw*
Graduate School of Media and Governance, Keio University

Empowering Youth for Coastal Resilience: The Earth Alive Inter School Challenge in Singapore

Lauriane Chardot[1], *Yasmin Basir[1], Li Hui Mok[2], Ezzati Nur Zukri[3]*
[1] Earth Obsevatory of Singapore, Nanyang Technological University
[2] Science Centre Singapore
[3] Public Utilities Board, Singapore

Inequitable Flood Resilience in the Mahanadi Delta: Urban Protection vs. Rural Flood Vulnerability in Cuttack City and Peripheral Villages

Biswajit Minji, *Padmini Pani*
Center for the Study of Regional Development, Jawaharlal Nehru University

EXTENDED ABSTRACTS

Enhancement of Vessel Systems for Resilient Sulfur Mining in Volcanic Environments: A Case Study on Efficiency, Safety, and Sulfur Purity at Ijen Crater

Emmarie Rose Cruz Josue

EXTENDED ABSTRACT

Sampaloc, a recognized area in Manila City, has long been known for being particularly susceptible to flooding. The district's urban environment, drainage deficiencies, and geographic location are the main causes of this ongoing problem, as they all increase the likelihood of flooding during times of heavy precipitation or typhoons. The people who live in crowded informal settlements are among the most impacted. Due to a lack of safe and affordable housing, these communities frequently live in low-lying, hazardous areas, making them more vulnerable to natural disasters like floods. As a result, they have much less access to basic services, especially medical care in an emergency.

The objective of this study is to map and systematically evaluate the accessibility of hospitals from Sampaloc's clustered informal communities in both normal and flood-disturbed situations. The study finds population density centroids that represent informal clusters using sophisticated Geographic Information System (GIS)-based network analysis. When assessing travel routes to medical facilities, these centroid nodes are used as starting points. To give a thorough picture of the district's risk areas, the study also uses historical flood data to overlay the spatial distribution of potential flood hazards.

In order to assess the hospitals' accessibility for people living in informal settlements, particularly considering flood hazard scenarios, the methodological framework uses GIS-based network evaluation tools. Travel time is the main indicator used to evaluate accessibility since it provides a realistic picture of how quickly people can get to hospital services in a variety of circumstances. The Dijkstra algorithm, a well-known computational method for determining the shortest or fastest paths within a network, is incorporated into the investigation to accomplish this. The two main scenarios that the algorithm is used for are an undisturbed scenario, in which all streets and routes are assumed to be open and accessible, and a disrupted scenario, in which flooding renders some paths impassable.

Flood hazard classification based on historical flood frequency data is also included in the disrupted scenario; in particular, 5-year, 50-year, and 100-year flood events are analyzed. By integrating these time-bound flood scenarios, the study accounts for both frequent, lower-magnitude floods and rare but highly disruptive flooding occurrences. Using the average speed of a typical family car as the standard mode of transportation, the best driving routes to hospitals from each cluster are identified under each scenario. Travel times are computed to account for actual emergency response circumstances in both routine and interrupted scenarios.

Additionally, the study uses statistical modeling to calculate the probability that residents from different areas will be able to get to hospitals in a variety of scenarios. This part of the study acknowledges that because of flood levels, road closures, and changing hazard conditions, real-world emergencies frequently entail uncertainty and variable route selection.

The research's long-term goal is to produce comprehensive maps and time-bound analyses that can guide public health policy, disaster risk reduction, and urban planning. The results of the visualization and measurement of accessibility gaps can aid in the creation of focused interventions meant to improve healthcare access for Sampaloc's most vulnerable populations, particularly during floods. The Dijkstra algorithm in conjunction with the GIS-based methodology offers a reliable and data-driven interface for quick scenario analysis

Enhancement of Vessel Systems for Resilient Sulfur Mining in Volcanic Environments: A Case Study on Efficiency, Safety, and Sulfur Purity at Ijen Crater

Emmarie Rose Cruz Josue

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and route optimization.

The analysis's findings provide subtle insights into how road network configurations and flood hazards interact. In certain instances, even during moderately severe flooding, access to hospitals can be maintained due to the road network's resilience. But in other cases, especially in the 100-year flood scenario, there are significant disruptions that result in long travel times and significant changes to the best routes. Significantly, hospitals that serve Cluster B are found to be most impacted; in contrast to the 5-year flood scenario, the 100-year flood scenario results in significant path modifications. This result emphasizes how crucial it is to consider both the frequency and the intensity of flood events when evaluating urban risk.

Overall, the study shows that Sampaloc's informal settlements' hospital accessibility is extremely vulnerable to flood hazards, with the degree of disruption differing depending on the cluster and flood scenario. By combining historical flood data with GIS-based network analysis, emergency responders, urban planners, and policymakers can prioritize infrastructure upgrades, improve emergency response plans, and gain a better understanding of spatial vulnerabilities. This research contributes to the broader discourse on urban resilience by highlighting the critical need for inclusive, data-informed approaches to disaster preparedness and healthcare accessibility in flood-prone urban environments.

Keywords: informality, work pattern, Sampaloc Manila, GIS

Designing Emergent Learning for Disaster Education: Challenges and Possibilities of XR Implementation under Japan's GIGA School Policy

Sachiko Takane[1]**,** Rajib Shaw[2]

ABSTRACT

This study examines the challenges and possibilities of using XR (Extended Reality) in disaster education under Japan's GIGA School Initiative. An "XR Bosai Lab" (Bosai in Japanese is disaster preparedness) was established at a public junior high school in Izu City, Shizuoka Prefecture, to explore next-generation approaches to disaster education. The analysis confirmed a gap between the vision of the Initiative—promoting creativity, collaboration, and individualized learning—and the institutional and technical constraints in Japanese schools, such as network restrictions and strict security policies. Field practice revealed that strict protocols regarding external devices, including VR headset handling, long encryption keys, and whitelist-based access, significantly hindered the flexibility required for student-driven emergent learning. On the other hand, adaptive measures such as portable Wi-Fi, offline task design, and peer-to-peer support made it possible to maintain continuity and collaboration. Students used XR as tools for content creation and experience sharing, and developed disaster drills tailored to their local context. Here, emergent learning refers not only to presenting experiences but also to the emergence of new ideas and relationships during the learning process. Based on these findings, embedding XR into daily school practice requires institutional resilience, flexible design, and sustainable resource allocation. These insights are not limited to Japan but also provide useful implications for the international challenge of ICT utilization and the future of disaster education under institutional constraints.

Keywords: informality, work pattern, Sampaloc Manila, GIS

I. INTRODUCTION

In recent years, global interest in disaster education using XR (Extended Reality) technologies has increased (Fernández et al., 2023; Makransky & Mayer, 2022). The importance of disaster education in responding to climate-related and natural hazards is clearly stated in Goal 13.3 of the United Nations' 2030 Agenda for Sustainable Development (United Nations, 2015). In today's disaster-prone world, education must go beyond knowledge transmission to foster situational judgment and collaboration through experiential and active learning (Nakano & Yamori 2021). XR provides immersive environments through VR and AR that bridge real and virtual worlds, and its integration into educational contexts has been shown to enhance motivation, realism, and disaster awareness (Radianti et al., 2020; Lu et al., 2022). This study focuses on the early-stage implementation of an "XR Bosai Lab" in Izu City, Japan, established under the GIGA School Initiative, to examine the challenges that emerged in introducing XR for disaster education and to propose approaches for utilizing emerging technologies in school settings.

II. JAPAN'S GIGA SCHOOL INITIATIVE

Japan's GIGA School Initiative (Global and Innovation Gateway for All) was approved in 2019 to promote equitable, individualized, and collaborative learning through one device per student

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[2] Shaw is a professor at the Graduate School of Media and Governance, Keio University, Japan. His research interests include disaster risk reduction, climate change adaptation, and community resilience.

and high-speed networks (MEXT, 2019). The nationwide deployment of digital devices and school networks has significantly advanced, yet institutional and technical constraints remain. Security policies and centralized network management often limit the use of external devices and flexible Internet access. While these measures ensure safety, they tend to restrict experimentation and innovation in daily school practice. As noted by the OECD (2021), infrastructure alone does not guarantee improved learning outcomes; institutional flexibility and operational frameworks are essential.

III. METHODS

This study examined the initial implementation of the "XR Bosai Lab," established in June 2025 at a junior high school in Izu City, Shizuoka Prefecture (Figure 1). The project was launched through collaboration between a university research institute and the local government to explore how XR could promote student-led disaster learning under institutional and technical constraints. Ten students aged 13 to 15 voluntarily participated, each using a personal Chromebook provided under the GIGA School Initiative. The lab incorporated map-based learning and local hazard exploration using Meta Quest 3 devices and XR applications. Students created VR and AR content to visualize community-specific disaster risks and designed original disaster drills, which were later shared with local residents as part of community outreach activities.

IV. FINDINGS

The field implementation revealed several institutional and technical constraints that affected the integration of XR into disaster prevention education. Connection issues, lengthy Wi-Fi encryption keys, and strict security protocols for external devices posed barriers to smooth operation. These constraints reflected Japan's GIGA School Initiative's emphasis on safety and centralized control, which limited flexibility and experimentation. Teachers and students faced delays in accessing online content and synchronizing devices, prompting adaptive measures such as portable Wi-Fi, offline task design, and peer-to-peer support.

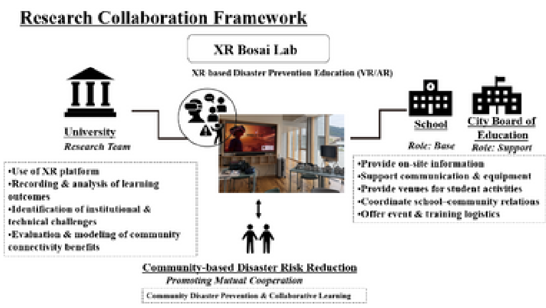

Figure 1. Research collaboration framework for XR-based disaster prevention education under the GIGA School Initiative.

According to Wallet (2016), while ICT has already been integrated into primary and secondary education in many developed countries, institutional and administrative conditions must be established to maximize its impact. Interviews with ICT support staff from the city board of education provided concrete evidence of this issue, revealing persistent restrictions on network and device use, dependence on external approval for system access, and unstable connectivity during XR activities. These findings highlight that institutional flexibility and resilience are essential to sustaining innovation and promoting emergent, collaborative learning in school-based disaster education.

V. CONCLUSION

This study demonstrated the significance of establishing an "XR Bosai Lab" as a learner-centered and sustainable framework for disaster education within school settings. While initial implementation revealed institutional and technical challenges, the case study clarified practical solutions under Japan's GIGA School Initiative. The integration of technology into disaster education reflects the global movement toward ICT-based learning (OECD, 2021; UNESCO, 2012). XR is expected to evolve into a sustainable model linking institutional resilience, pedagogical design, and resource allocation.

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Inequitable Flood Resilience in the Mahanadi Delta: Urban Protection vs. Rural Flood Vulnerability in Cuttack City and Peripheral Villages

Biswajit Minji, Padmini Pani

ABSTRACT

Urban areas in the river delta are highly prone to flood hazard due to their geomorphological and hydrological settings. The Cuttack city in the apex of the Mahanadi Delta have witnessed flood hazards frequently due to overflow flow of Mahanadi River flow, at present the city is protected by engineering structures such as barrages and embankments. Conversely, the rural areas around the city get flooded every year. The study examines what is the disparity level between flood resilience mechanism in city areas and rural areas. The study used satellite imagery Synthetic Aperture Radar (SAR) data, Digital elevation model, Land use and land cover data, Survey of India maps, topographical maps, historical flood data, and a focused group survey of affected villages. Satellite-based flood mapping and monitoring were carried out for the year 2022 (16-24 August) using Sentinel-1A SAR. Findings highlight that city has grown significantly from 1990 to 2024 and encroached the deltaic plain and 261 villages are affected to floods, particularly due to overbank flow of Mahanadi River during the peak discharge period, while the city is unaffected, which raises the critical question of equitable disaster risk reduction. The city is protected by engineering constructions but the community role and knowledge of the local dwellers play vital role to protect the village during the flood and after the flood. Therefore, the study suggests the need for equitable, integrated flood management strategies.

Keywords: flood resilience; urban-rural flood vulnerability; flood risk governance

I. INTRODUCTION

As the Cuttack city situated along the banks of Mahanadi River and characterizing with rapid growth, hence understanding the precise impacts of city development on the hydromorphological state of the river Mahanadi is essential for environmentally responsible urban planning. Investigation of hydromorphological alterations resulting from city development and constructions of hydraulic structures may assist in examination of the health of the river system. Additionally, by determining how vulnerable villages are to flooding in the highly anthropogenically (Urban development and hydraulic structures) disturbed river stretch, flood control measures can be implemented effectively that can boost resilience, preserve safety and wellbeing of the villagers living around the river.

II. METHODOLOGY

Firstly, the Land use and land cover classification have been carried out using Random Forest classifier in Google Earth Engine (GEE) environment and the built-up class is extracted from 1990 to 2024 to monitor the physical expansion of the Cuttack city and major engineering construction along the river were identified. Secondly, the Satellite-based flood mapping and monitoring were carried out for the year 2022 (16-24 August) using Sentinel-1A SAR in GEE environment, thereby the river flood extent in the villages was determined. Lastly, flood inventory conducted by adopting focused group discussion in the flood affected villages. Lastly, the comparison made between the strategies and developmental activities in the city and surrounding rural areas and hence the self-resilience mechanism of the local dwellers in the villages to combat the impact of the flood are identified.

Inequitable Flood Resilience in the Mahanadi Delta: Urban Protection vs. Rural Flood Vulnerability in Cuttack City and Peripheral Villages

Biswajit Minji, Padmini Pani

III. RESULT AND ANALYSIS

The result of the study depicts that the city has expanded from 12.14 sq.km to 83.55 sq.km for the period 1955 to 2024. Major construction like ring road as embankment around the city and river front developmental activities be seen along the Mahanadi River. The flood extent map depicted that the city areas are less affected due to overbank flow of water from Mahanadi River, but the surrounding rural areas are flooded during peak discharge period. It has been identified that combinedly 261 villages in the three blocks viz. Athagad, Tangi-Choudwar and Salepur were flooded in 2022.The mechanism of flood resilience in the city and surrounding areas denote the huge difference in the two spaces.

IV. CONCLUSION AND RECOMMENDATIONS

Human interventions in the upper section of the Mahanadi Delta modifies its natural settings which led to the flood hazard in the region but the city spaces are less impacted due to its resilience structure while the rural areas lack in protecting from the flood. Thus, the integrated and inclusive approach can be adopted in designing the resilience structure in the both areas, thereby flood impacts in the village areas can be minimised.

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EXTENDED ABSTRACTS

PARALLEL SESSION 4B

RESILIENT DESIGN & TECHNOLOGY

Session Moderator: Honorio T. Palarca PhD

Time-Series Estimation of Fault Slip from GNSS Data using Deep Learning: Application to the Nankai Subduction Zone

***Yo Fukushima*[1],** *Ryo Nakagawa*[2], *Masayuki Kano*[2], *Keisuke Yano*[3], *Yutaro Okada*[1], *Yasuke Takana*[4], *Kazuro Hirahara*[5]

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Green Spaces as an Adaptation Measure for Urban Heat Island Phenomenon and Flooding: A Comparative Analysis of Urban Morphology Types of Two Select Zones in Barangay Central, Quezon City

***Jose Dan V. Villa Juan*[1],** *Maria Elisa B. Manuel*[2], *Juan Ismael A. Vallejo*[3]

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An Analysis of Factors Contributing to Regional and Sectoral Vulnerability in Large-Scale Disasters

***Tadashi Uchiyama*[1],** *Miwa Abe*[1], *Yuri Nakagawa*[2]

[1] Tokai University
[2] Takasaki University of Commerce

A Critical Infrastructure Proximity & Community Flood Vulnerability Perception Analysis of Brgy. 638 using 3-Dimensional Visualization

Adrian Jim R. Reyes

College of Architecture, University of the Philippines-Diliman

EXTENDED ABSTRACTS

Time-Series Estimation of Fault Slip from GNSS Data using Deep Learning: Application to the Nankai Subduction Zone

Yo Fukushima[1,2], Ryo Nakagawa[1], Masayuki Kano[3], Keisuke Yano[4], Yusuke Tanaka[5], Yutaro Okada[2], Kazuro Hirahara[6,7]

ABSTRACT

It is important to monitor fault slip along major plate boundaries in order to issue warnings or prepare for major earthquakes. With the expansion of dense GNSS (GPS) networks, diverse fault slip types including slow slip events (SSEs) have been observed along major plate boundaries. However, their small amplitudes, often comparable to background noise, make automatic detection difficult. We developed a deep learning method that directly estimates spatiotemporal slip distributions of SSEs from GNSS displacement data without complex manual preprocessing.

By applying the method to the GNSS data collected during 1996–2023, we successfully detected most previously reported short-term SSEs and identified additional unrecognized events along the Nankai subduction zone in western Shikoku, Japan. These results demonstrate that the approach can extract weak deformation signals buried in noise and map them into high-resolution fault slip distributions.

This study highlights the potential of deep learning for geodetic fault-slip monitoring. Such methods are promising not only for detecting slow slip events but also for monitoring magma accumulation and migration beneath volcanoes, providing a practical framework for real-time detection of subtle deformation signals that may precede major seismic or volcanic events.

Keywords: deep learning, GNSS, GPS, slow slip events, earthquake, monitoring

I. INTRODUCTION

It has long been known that some parts of plate boundaries experience locking and sudden slip, while other parts stably creep. Over the past three decades, researchers have discovered that “slow earthquakes” are also ubiquitous along several plate boundary zones, including the Nankai subduction zone in southwestern Japan and the Cascadia subduction zone off the Pacific coast of North America (e.g., Peng & Gomberg, 2010). Among these slow earthquakes, slow slip events (SSEs) are characterized by fault slip that occurs so gradually that they do not radiate seismic waves.

Some SSEs have been observed to precede major earthquakes (Obara & Kato, 2016), leading to the idea that certain types of SSEs may act as triggers for large earthquakes. Consequently, the occurrence of an anomalous SSE is taken as one of the three criteria to disseminate a warning of major earthquakes along the Nankai subduction zone (so-called Nankai Trough earthquakes) (Obara & Kato, 2016; Fukushima et al., 2023).

The detection of signals of SSEs, especially those called short-term SSEs, is challenging because they can only be captured by geodetic methods, such as the Global Navigation

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Time-Series Estimation of Fault Slip from GNSS Data using Deep Learning: Application to the Nankai Subduction Zone

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Satellite System (GNSS), that measure the crustal deformation, and the signal amplitudes are often in the same level as the noise (e.g., Nishimura et al., 2013;). For this reason, previous studies have developed SSE detection methods composed of a complex chain of processing (Nishimura et al., 2013; Okada et al., 2022).

In recent years, deep-learning methods have been shown to be effective in detecting SSE signals from geodetic data (e.g., Tanaka et al., 2025). However, such previous studies did not attempt to estimate the location, spatial extension, and magnitude of the slip, which are crucial for interpretation and insufficient for monitoring purposes. In this study, we developed a high-performance deep learning method that directly estimates spatiotemporal slip distributions of SSEs from GNSS displacement data without complex manual processing. The method is applied to western Shikoku, Japan, where many SSEs have been previously found. By benchmarking against the previously found events, we demonstrate the effectiveness of the method.

II. METHOD

We developed a deep learning–based framework to estimate fault slip distributions from GNSS displacement data that have low signal-to-noise ratios. This method consists of two convolutional neural networks (CNNs): a noise-reduction interpolator and a slip estimator. The first model converts sparse and noisy GNSS displacements into a spatially continuous displacement field, and the second estimates the fault slip distribution on a predefined plate interface. Both models were trained using ~3.2 million synthetic datasets generated from elastic dislocation theory with added Gaussian noise. The method was tested and then applied to GNSS data from 1996–2023 around western Shikoku, Japan, an area known for frequent short-term slow slip events (SSEs).

III. RESULTS

Synthetic tests demonstrated that our method accurately retrieved slip distributions, even when the input displacement signals were comparable to noise. The method successfully suppressed spurious “ghost” slips and achieved high variance reduction (>90%) for most test cases. The minimum detectable event size was estimated at around Mw 5.8.

By applying the method to the GNSS data collected during 1996–2023, we successfully detected most previously reported short-term SSEs (Okada et al., 2022; Sekine et al., 2010) (Figure 1) and identified additional unrecognized events along the Nankai subduction zone in western Shikoku, Japan. These results demonstrate that the approach can extract weak deformation signals buried in noise and map them into high-resolution fault slip distributions.

IV. CONCLUSIONS

Our method provides an efficient and robust approach for estimating spatiotemporal slip distributions of SSEs directly from GNSS data without complex manual preprocessing. The method achieves high detection capability and spatial accuracy, surpassing traditional geodetic inversion techniques. Its sequential applicability to time-series data enables near–real-time monitoring of small-amplitude transient fault slips along major plate boundaries, offering a promising tool for geodetic observation networks and earthquake hazard assessment.

EXTENDED ABSTRACTS

Time-Series Estimation of Fault Slip from GNSS Data using Deep Learning: Application to the Nankai Subduction Zone

Yo Fukushima, Ryo Nakagawa, Masayuki Kano, Keisuke Yano, Yusuke Tanaka, Yutaro Okada, Kazuro Hirahara

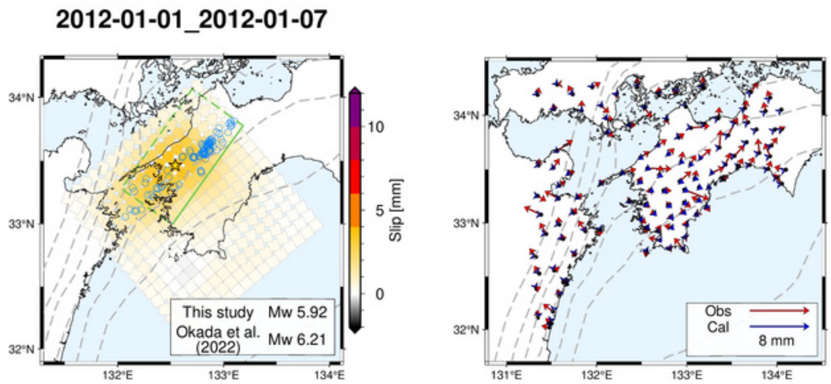

Figure 1. Example of a slow slip event detected during the period during 1 to 7 January 2012. (Left) Estimated slip along the Nankai subduction plate interface in the western Shikoku area in SW Japan. The broken lines indicate the contour of plate interface depth drawn with 10km interval. Green rectangle indicates the SSE model estimated by Okada et al. (2022), and the color on small squares and the star indicates the slip distribution of the SSE obtained in this study and the location of the maximum slip, respectively. Blue open circles indicate the location of low-frequency earthquakes. (Right) Comparison of the observed GNSS displacements (red) and the predicted displacements calculated from the slip model shown on the left panel.

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Green Spaces as an Adaptation Measure for Urban Heat Island Phenomenon and Flooding: A Comparative Analysis of Urban Morphology Types of Two Select Zones in Barangay Central, Quezon City

Jose Dan V. Villa Juan[1], Maria Elisa B. Manuel[2], Juan Ismael A. Vallejo[3]

ABSTRACT

This study examines how urban green spaces support climate change adaptation by mitigating Urban Heat Island (UHI) effects and reducing flood risks in Quezon City, Philippines. Using GIS and the STAR Tool, it analyzes two zones in Barangay Central with contrasting morphologies under three land-cover scenarios: existing, increased built-up, and increased green infrastructure. Stakeholder interviews assess adaptive capacities and current green space policies. Results are expected to show that more green coverage lowers surface temperature and runoff, emphasizing green infrastructure's role in resilient urban planning. The study offers policymakers data-driven guidance for sustainable, climate-adaptive urban design.

Keywords: STAR Tools, Urban Heat Island (UHI), Green Spaces, Climate Change Adaptation, Urban Flooding

I. INTRODUCTION

Global warming increased climate change, intensifying urban vulnerabilities of heat stress and flooding. Rapid urbanization, dominated by impervious and heat-retaining materials, amplifies the Urban Heat Island effect and disrupts natural hydrological processes. In the Philippines, these risks prevail. This study examines the relationship between urban morphology, land surface temperature, and runoff in two Quezon City barangays, highlighting the potential of urban green spaces in climate adaptation.

Rapid urbanization in the Philippines has transformed surface cover and urban morphology, increasing impermeability and intensifying the urban heat island (UHI) effect, which raises temperatures, degrades air quality, and heightens energy and health risks. It also exacerbates flooding by reducing natural infiltration and overloading drainage systems. This study investigates how variations in urban morphology and surface cover across 2 zones in Bgy. Central, Quezon City influence temperature, runoff, UHI, and flooding, while exploring the mitigating role of green spaces. Covering a 1.34 sq km area, the analysis uses surface cover data and climate scenarios—historical (1971–2000) and projected (2036–2065) rainfall and temperature datasets from PAGASA—alongside a 2016 zoning map from Quezon City LGU, employing an online tool to assess land cover impacts on surface temperature and runoff within the recommended range of 0.04–5 sq km.

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[3] Juan Ismael A. Vallejo is an architect, environmental planner, and real estate professional with more than twelve years of public- and private-sector experience, holds a Master of Arts in Urban and Regional Planning, and has worked on projects advancing design innovation, environmental sustainability, and inclusive spatial development.

Green Spaces as an Adaptation Measure for Urban Heat Island Phenomenon and Flooding: A Comparative Analysis of Urban Morphology Types of Two Select Zones in Barangay Central, Quezon City

Jose Dan V. Villa Juan, Maria Elisa B. Manuel, Juan Ismael A. Vallejo

II. METHODOLOGY

Adapting Raza et al's (2021) methodology, integrating secondary data review and GIS-based urban morphology analysis of two zones in Barangay Central. Surface covers are quantified to assess permeable and impervious areas while STAR (Surface Temperature and Runoff) Tools simulated three land cover scenarios – existing, built-up, and green infrastructure - to evaluate green spaces' effects on UHI and flooding. Stakeholder interviews complemented the analysis.

A. Surface Temperature and Runoff (STAR) Tools

STAR tools evaluate surface temperature and runoff under different land cover and climate scenarios. Adapted for Quezon City, parameters of temperature, rainfall, and soil type were localized using 2050 forecasts. Input for STAR tools customized based on local data, including medium-range emission scenarios and forecasts for 2050. Local surface temperature, runoff, projected seasonal temperature increases, and rainfall changes parameters integrated, as illustrated in Table 8-1 for temperature, Table 8-2 for rainfall changes, and Table 8-3 for extreme event frequencies.

Table 8-1. Seasonal temperature increases (in °C) in 2050 under medium-range emission scenario in cities/municipalities in NCR

Source: PAGASA (2018). Observed and Projected Climate Change in the Philippines

NCR	Observed Baseline (1971-2000)				Change in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Metro Manila	26.1	28.8	28.0	27.4	2.0	2.1	1.8	1.9

Table 8-2. Seasonal rainfall change (in %) in 2050 under medium-range emission scenario in cities/municipalities in NCR

Source: PAGASA (2018). Observed and Projected Climate Change in the Philippines

NCR	Observed Baseline (mm) (1971-2000)				Change in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Metro Manila	107.5	198.5	1170.2	758.7	-17.3	-38.5	21.3	3.7

Table 8-3. Frequency of extreme events in 2020 and 2050 under medium range emission scenario in cities/municipalities in NCR

Source: PAGASA (2018). Observed and Projected Climate Change in the Philippines

NCR	No. of Days w/ Tmax >35°C		No. of Dry Days		No. of Days w/ Rainfall > 200mm	
	OBS	2050	OBS	2050	OBS	2050
Metro Manila	1095	3126	7476	6220	9	17

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Use of the surface temperature and surface runoff tools involves Defining the Study Area, encoding the Parameter Values on interactive interface, and analyzing the results.

III. FINDINGS

Study focuses on a case barangay with the highest population, largest land area, and one of the lowest population densities, where UHI effects have been documented in Quezon City by Alcantara et al. (2019). Their findings show that residential, industrial, and commercial areas reach average surface temperatures of about 33.5°C—1.5°C to 7.5°C higher than institutional zones, parks, and agricultural or water areas. In Barangay Central, land surface temperatures exceed the city's mean Urban Thermal Field Variance Index (UTFVI), with spatial patterns (Figures 9-1a and 9-1b) revealing distinct zones experiencing stronger UHI. These variations in temperature and urban morphology make Barangay Central a suitable case study for comparative analysis.

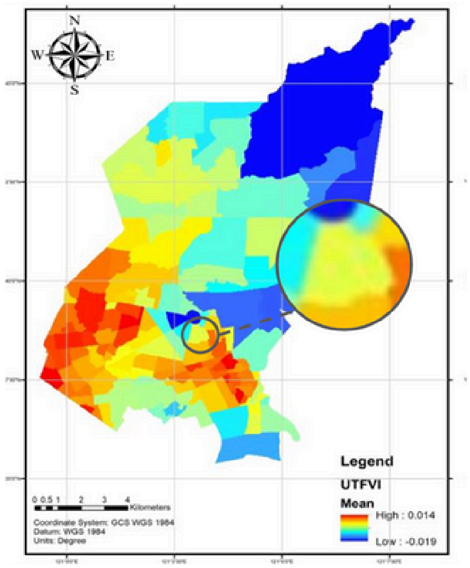

Figure 9-1a. Mean and Spatial Variation Urban Thermal Field Variance Index in Quezon City, 2019

Source: Alcantara, et al. (2019)

EXTENDED ABSTRACTS

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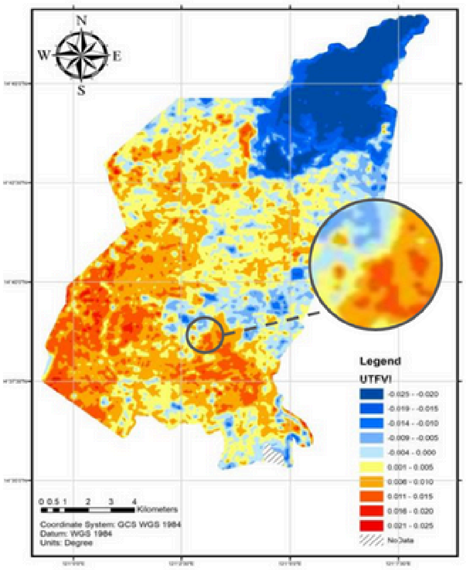

Figure 9-1b. Mean and Spatial Variation Urban Thermal Field Variance Index in Quezon City, 2019
Source: Alcantara, et al. (2019)

A. Urban Morphology Types (UMT)

UMT maps help green space allocation within urban areas. UMT is mapped using the current 2016 zoning map showing land uses for the two selected zones Figure 9-2.

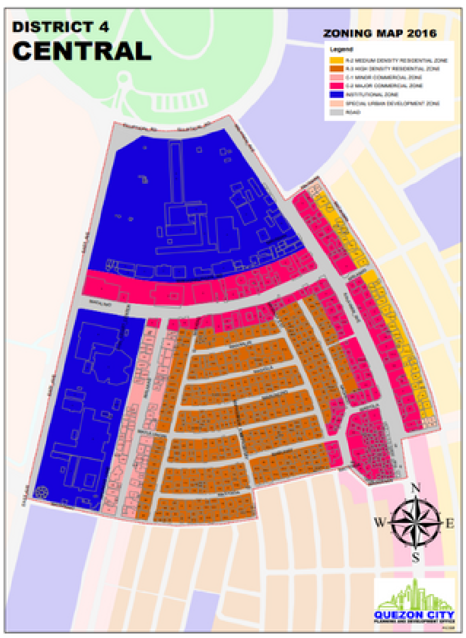

Figure 9-2. Urban Morphology Types (UMT) of the two selected zones of Barangay Central
Source: QCPDO, Zoning Ordinance 2016

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The UMT of the two zones was digitized using GIS and Google Earth (2024). GIS aggregated the UMT using existing land use by encoding all the code for UMT shown in Table 9-1.

Table 9-1. Surface cover types used for the surface temperature and runoff tools with comparison to land use

Urban Morphology Types	Surface Temperature	Surface Runoff	Code
Residential, Commercial, Institutional, Industrial, Recreational, (Built-up Areas)	Buildings	Buildings	BD
Roads	Major Roads	Other Impervious Surfaces	IS
Utility, Vacant Lands	Other Impervious Surfaces		
Open Spaces, Water, Reservoir, Forest, Agriculture	Green and Blue Surfaces	Trees, Shrubs, Mown Grass, Cultivated Surfaces, and Water	GBS
Cemetery	Bare Soil or Gravel Surfaces	Bare Soil or Gravel Surfaces	BSGS

Figure 9-3 shows the different UMT identified in the two selected zones in Barangay Central. Table 9-2 compares the percent share of each UMT in the two zones with the percent difference between both.

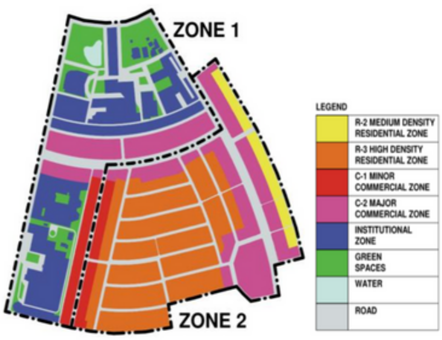

Figure 9-3. Surface cover types used for the surface temperature and runoff tools with comparison to land use

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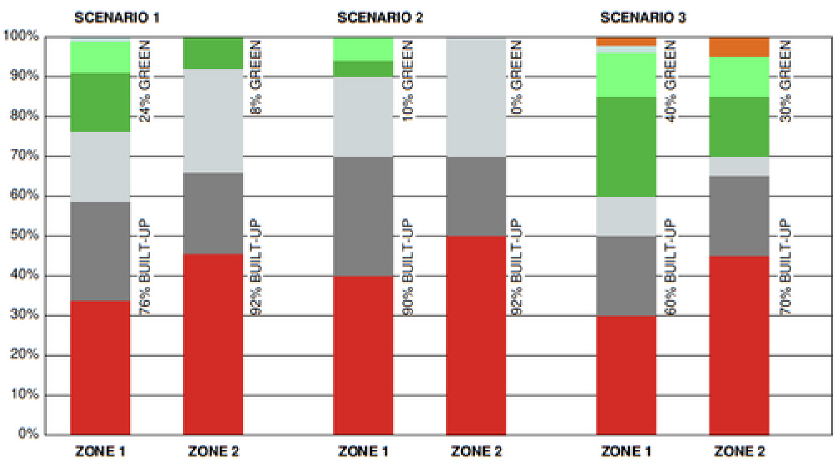
Figure 9-2. Distribution of UMT Areas of the two selected zones of Barangay Central

Urban Morphology Types	Zone 1	Zone 2	Difference
R-2 Medium Density Residential Zone	0.00%	5.62%	-5.62%
R-3 High Density Residential Zone	0.00%	46.59%	-46.59%
C-1 Minor Commercial Zone	4.74%	0.00%	4.74%
C-2 Major Commercial Zone	13.21%	23.31%	-10.10%
Institutional Zone	36.70%	0.00%	36.70%
Green Spaces	15.78%	0.00%	15.78%
Water	1.14%	0.00%	1.14%
Road	28.43%	24.48%	3.95%
Total	100%	100%	-

B. Built-up and Green Spaces Distribution

After defining UMTs, land cover is analyzed for impervious, evapotranspiration, and bare soil areas.

Figure 9-4 shows surface cover analysis of the two zones under the 3 scenarios. Information derived from this analysis is required to determine surface temperature and surface runoff. For Zone 1, 24% of the total area consists of evapotranspiration surfaces in contrast to 76% impervious surfaces. For Zone 2, 8% of the land surface is evapotranspiration showing a built-up density.



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	Scenario 1		Scenario 2		Scenario 3	
Surface Cover	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2
Buildings	33.74%	45.60%	40.00%	50.00%	30.00%	45.00%
Major Roads	24.89%	20.35%	30.00%	20.00%	20.00%	20.00%
Other Impervious Surfaces	17.71%	26.18%	20.00%	30.00%	10.00%	5.00%
Trees	14.67%	7.88%	4.00%	0.00%	25.00%	15.00%
Shrubs	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%
Mown Grass	2.46%	0.00%	3.00%	0.00%	6.00%	5.00%
Rough Grass	5.51%	0.00%	2.00%	0.00%	5.00%	0.00%
Water	1.02%	0.00%	1.00%	0.00%	2.00%	0.00%
Bare Soil or Gravel Surfaces	0.00%	0.00%	0.00%	0.00%	2.00%	5.00%
Total	100%	100%	100%	100%	100%	100%

Figure 9-4. Percent Distribution of Surface Cover of the two selected zones of Barangay Central

C. Land Cover Scenarios

Three (3) land cover scenario are established demonstrating potential impact of green spaces to surface temperature and runoff: Scenario 1: Existing land cover (baseline), Scenario 2: Increase in built-up area development, and Scenario 3: Increase in green infrastructure.

SCENARIO 1: EXISTING LAND USE COVER		Z1	Z2
	BUILDINGS	33.74%	45.60%
	MAJOR ROADS	24.89%	20.35%
	OTHER IMPERVIOUS SURFACES	17.71%	26.18%
	TREES	14.67%	7.88%
	SHRUBS	0.00%	0.00%
	MOWN GRASS	2.46%	0.00%
	ROUGH GRASS	5.51%	0.00%
	WATER	1.02%	0.00%
	BARE SOIL OR GRAVEL SURFACES	0.00%	0.00%

Figure 9-5. Surface Cover of the two selected zones of Barangay Central under Scenario 1

EXTENDED ABSTRACTS

Green Spaces as an Adaptation Measure for Urban Heat Island Phenomenon and Flooding: A Comparative Analysis of Urban Morphology Types of Two Select Zones in Barangay Central, Quezon City

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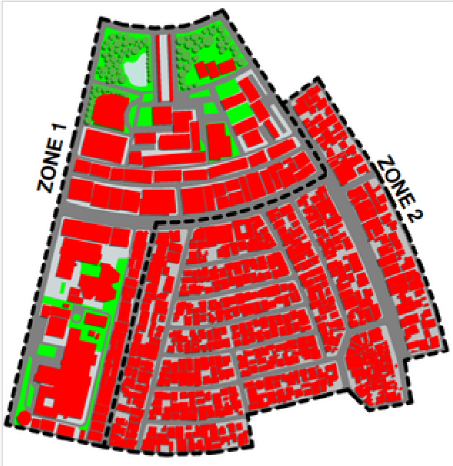

SCENARIO	2: INCREASE IN BUILT-UP AREA	Z1	Z2
	BUILDINGS	40.00%	50.00%
	MAJOR ROADS	30.00%	20.00%
	OTHER IMPERVIOUS SURFACES	20.00%	30.00%
	TREES	4.00%	0.00%
	SHRUBS	0.00%	0.00%
	MOWN GRASS	3.00%	0.00%
	ROUGH GRASS	2.00%	0.00%
	WATER	1.00%	0.00%
	BARE SOIL OR GRAVEL SURFACES	0.00%	0.00%

Figure 9-6. Surface Cover of the two selected zones of Barangay Central under Scenario 2 - Increased Built-up

SCENARIO	1: INCREASE IN GREEN AREAS	Z1	Z2
	BUILDINGS	30.00%	45.00%
	MAJOR ROADS	20.00%	20.00%
	OTHER IMPERVIOUS SURFACES	10.00%	5.00%
	TREES	25.00%	15.00%
	SHRUBS	0.00%	5.00%
	MOWN GRASS	6.00%	5.00%
	ROUGH GRASS	5.00%	0.00%
	WATER	2.00%	0.00%
	BARE SOIL OR GRAVEL SURFACES	2.00%	5.00%

Figure 9-5. Surface Cover of the two selected zones of Barangay Central under Scenario 3 - Increased Green Areas

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1. Surface Temperature

STAR Tools assesses surface temperature and land-cover relationships in two zones using modified default inputs to match barangay conditions. Two additional scenarios—one with increased built-up development and another with enhanced green infrastructure—were also evaluated. For temperature scenarios, the baseline temperature is based on 1971–2000 data. The projected scenarios for the 2050s use medium-range emission estimates with 10%, 50%, and 90% probability levels. 2050s scenario represents a 30-year period from 2031–2065. The projected mean temperature for March, April, and May (MAM) in 2050 was calculated as:

MAM T2050 = (Baseline) + (Projected2050)
MAM T2050 = (28.8°C) + (2.1°C)
MAM T2050 = 30.9°C
MAM T2050 ≅ 31°C

Tables 9-3 to 9-4 provides an overview of the input values, including the modified land cover and temperature data.

Table 9-3. Amended values for surface temperature for Barangay Central Zone 1

	Land Cover Scenarios		
Land Cover	**Scenario 1**	**Scenario 2**	**Scenario 3**
Buildings	33.74%	40.00%	30.00%
Major Roads	24.89%	30.00%	20.00%
Other Impervious Surfaces	17.71%	20.00%	10.00%
Green and Blue Surfaces	23.65%	10.00%	35.00%
Bare Soil or Gravel Surfaces	0.00%	0.00%	5.00%
Total	100%	100%	100%
Temperature Scenarios			
2050s high temperature - 10% probability level			31.0°C
2050s high temperature - 50% probability level			31.0°C
2050s high temperature - 90% probability level			31.0°C
Baseline temperature (1971 - 2000)			28.8°C

Table 9-4. Amended values for surface temperature for Barangay Central Zone 2

	Land Cover Scenarios		
Land Cover	**Scenario 1**	**Scenario 2**	**Scenario 3**
Buildings	45.60%	50.00%	45.00%
Major Roads	20.35%	20.00%	20.00%
Other Impervious Surfaces	26.18%	30.00%	5.00%
Green and Blue Surfaces	7.88%	0.00%	25.00%
Bare Soil or Gravel Surfaces	0.00%	0.00%	5.00%
Total	100%	100%	100%
Temperature Scenarios			
2050s high temperature - 10% probability level			31.0°C
2050s high temperature - 50% probability level			31.0°C
2050s high temperature - 90% probability level			31.0°C
Baseline temperature (1971 - 2000)			28.8°C

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The tool processes equations and algorithms using the provided inputs, results of which are summarized in Tables 9-5 and 9-6.

Table 9-5. Summary of the results by temperature and land cover scenario

Maximum surface temperatures (°C)			
Study Area: Barangay Central Zone 1			
Temperature Scenarios	Land Cover Scenario		
	Scenario 1	Scenario 2	Scenario 3
2050s high temperature 10% probability level	35.4°C	41.5°C	32.1°C
2050s high temperature 50% probability level	35.4°C	41.5°C	32.1°C
2050s high temperature 90% probability level	35.4°C	41.5°C	32.1°C
Baseline temperature (1971 - 2000)	34.3°C	39.9°C	31.0°C

Table 9-6. Summary of the results by temperature and land cover scenario

Maximum surface temperatures (°C)			
Study Area: Barangay Central Zone 2			
Temperature Scenarios	Land Cover Scenario		
	Scenario 1	Scenario 2	Scenario
2050s high temperature 10% probability level	42.9°C	49.0°C	34.9°C
2050s high temperature 50% probability level	42.9°C	49.0°C	34.9°C
2050s high temperature 90% probability level	42.9°C	49.0°C	34.9°C
Baseline temperature (1971 - 2000)	41.3°C	46.8°C	33.7°C

2. Surface Runoff

The tool assessed surface runoff in two zones by analyzing how land-surface cover influences runoff, using adjusted inputs that reflect current conditions plus two additional scenarios—one with increased built-up development and another with expanded green-infrastructure interventions. Rainfall inputs combined baseline precipitation data from 1971–2000 with projected medium-range 2050s precipitation for 2031–2065, incorporating 10%, 50%, and 90% probability levels consistent with the surface-temperature analysis. These projections provided the estimated mean rainfall values for June, July, and August (JJA) in 2050:

JJA R2050 = [(Baseline + (Baseline) x (Projected2050)]
JJA R2050 = [(1170.2mm) + (1170.2mm) x (21.3%)]
JJA R2050 = 1419.5mm
JJA R2050 ≅ 1420mm/90days = (15.8mm) ≅ 16mm; 1170mm/90days = 13mm

Daily extreme rainfall is projected to rise from 13 mm in 2020 to 16 mm by 2050, and these precipitation values—together with land-cover and zone parameters—were used in the STAR tool to generate results based on its built-in equations and algorithms.

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IV. ANALYSIS

A. Barangay Central Zone 1 (Surface Temperatures)

The chart shows a consistent 35.4 °C maximum surface temperature across all 2050s midrange probability levels under existing conditions, compared to the 1971–2000 baseline value of 34.3 °C. With increased built-up development, maximum temperatures rise to 41.5 °C for all 2050s probability levels, higher than the baseline of 39.9 °C, while an enhanced green-infrastructure scenario lowers these values to 32.1 °C (and 31.0 °C under baseline parameters). For Zone 1, this translates to a 17.23% temperature increase from 35.4 °C to 41.5 °C under intensified development, and a 9.32% decrease to 32.1 °C under the green-infrastructure scenario.

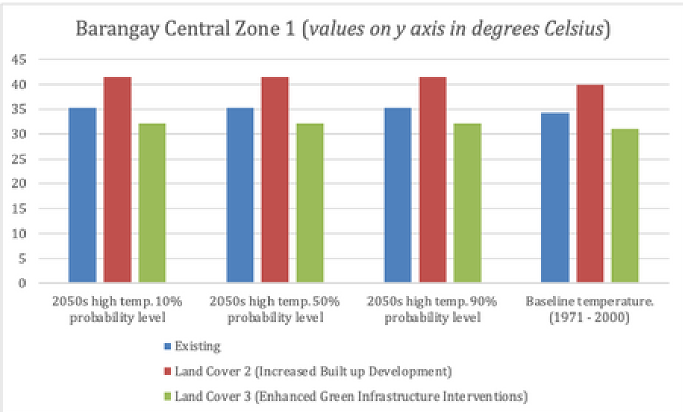

Figure 9-8. Surface Temperature Results for Barangay Central Zone 1 for 3 Land Cover Scenarios

Temperature scenario using Baseline temperature (1971-2000), shows an increase of 16.32% in maximum surface temperature from 34.3 °C to 39.9 °C under the increased built up scenario. For the same temperature scenario, a 9.62% decrease in maximum surface temperature from 34.3 °C to 31 °C under the enhanced green infrastructure scenario.

B. Barangay Central Zone 2 (Surface Temperatures)

Using the STAR Tool, maximum temperatures for Zone 2 remain consistent at 42.9 °C across the 2050s midrange 10%, 50%, and 90% probability levels under existing conditions, compared to a baseline of 41.3 °C (1971–2000). Increased built-up development raises maximum temperatures to 49.0 °C for all 2050s probabilities, with a baseline equivalent of 46.8 °C, representing a 14.21% and 13.31% increase respectively. Conversely, enhanced green-infrastructure interventions reduce 2050s maximum temperatures to 34.9 °C (an 18.64% decrease) and to 33.7 °C (an 18.40% decrease) under baseline conditions.

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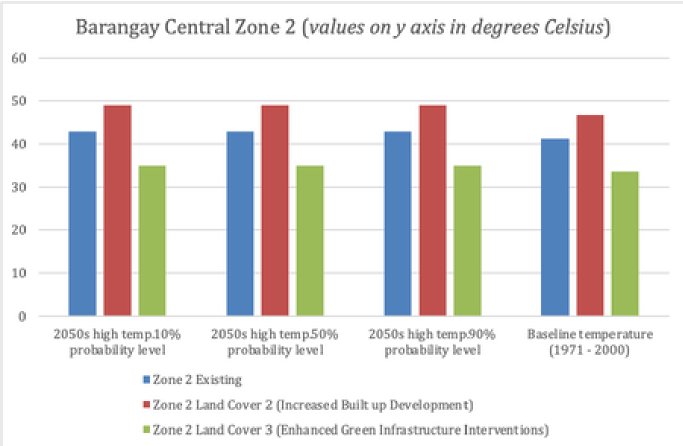

Figure 9-9. Surface Temperature Results for Barangay Central Zone 2 for 3 Land Cover Scenarios

Temperature scenario using Baseline temperature (1971-2000), shows an increase of 16.32% in maximum surface temperature from 34.3 °C to 39.9 °C under the increased built up scenario. For the same temperature scenario, a 9.62% decrease in maximum surface temperature from 34.3 °C to 31 °C under the enhanced green infrastructure scenario.

C. Comparison of Zone 1 and Zone 2 of Bgy. Central (Surface Temperatures)

Across all three land-surface scenarios, Zone 2 consistently shows higher maximum surface temperatures than Zone 1. Under the existing land-cover scenario and 2050s midrange temperature probabilities (10%, 50%, 90%), Zone 2 reaches 42.9 °C compared to Zone 1's 35.4 °C, a 21.18% difference and a 7.5 °C temperature gap; under baseline conditions (1971–2000), Zone 2 remains higher at 41.3 °C versus 34.3 °C, a 20.40% increase (7 °C difference). With increased built-up development, Zone 2 again records higher temperatures at 49 °C compared to Zone 1's 41.5 °C for the 2050s scenarios—an 18.07% increase and a 7.5 °C gap—while baseline conditions show Zone 2 at 46.8 °C versus Zone 1 at 39.9 °C, a 17.29% difference (6.9 °C gap). Even under enhanced green-infrastructure intervention, Zone 2 maintains higher temperatures at 34.9 °C across the 2050s probability levels, exceeding Zone 1 by 2.8 °C (8.72%) for those same scenarios and by 2.7 °C (8.70%) under baseline (1971–2000) temperatures.

D. Barangay Central Zone 1 (Surface Runoff)

According to the STAR Tool, Zone 1 runoff under existing conditions is 78.2% across the 2050s high-precipitation 10%, 50%, and 90% probability levels, compared to a higher 81.8% baseline (1971–2000). With increased built-up development, runoff rises to 87.3% for all 2050s probability levels and 89.5% under baseline precipitation, while enhanced green-infrastructure interventions reduce runoff to 67.8% for the 2050s scenarios and 72.6% under baseline conditions. Overall, the 2050s scenarios show an 11.63% increase in runoff (78.2% to 87.3%) under the built-up scenario and a 13.29% decrease to 67.8% with green-infrastructure improvements; under baseline precipitation, runoff increases by 9.41% (81.8% to 89.5%) with more built-up areas, while enhanced green infrastructure lowers it by 11.24% to 72.6%.

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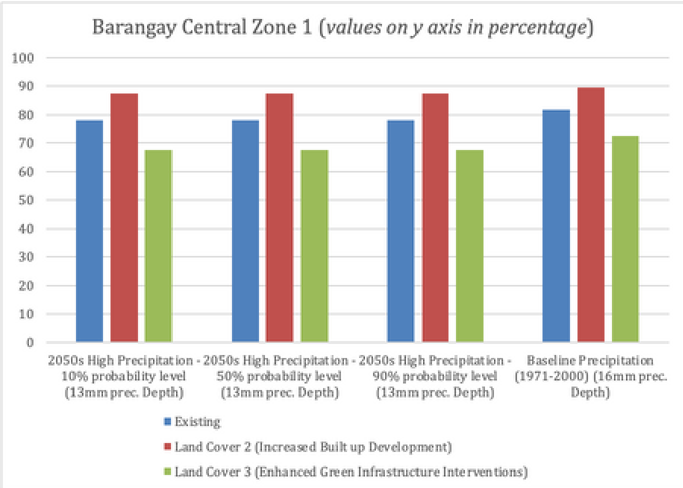

Figure 9-10. Surface Runoff Results for Barangay Central Zone 1 for 3 Land Cover Scenarios

E. Barangay Central Zone 2 (Surface Runoff)

Under existing conditions, STAR Tools show a consistent runoff percentage of 89.8% across the 2050s high-precipitation 10%, 50%, and 90% probability levels, while the baseline period (1971–2000) reflects a slightly higher runoff of 91.6%. With increased built-up development, runoff rises to 95.4% for the same 2050s precipitation probabilities and reaches 96.2% under baseline precipitation. In contrast, the green-infrastructure scenario reduces runoff to 78.6% for the 2050s precipitation probabilities and to 82.1% under the baseline precipitation parameter.

For Zone 2, the 2050s high-precipitation scenarios show a 6.23% increase in runoff—from 89.8% to 95.4%—under the increased built-up scenario. Under the enhanced green-infrastructure scenario, the same precipitation probabilities result in a 12.47% decrease, from 89.8% to 78.6%. For baseline precipitation, runoff increases by 5.02% (from 91.6% to 96.2%) under increased built-up development, while enhanced green infrastructure produces a 10.37% decrease, reducing runoff from 91.6% to 82.1%.

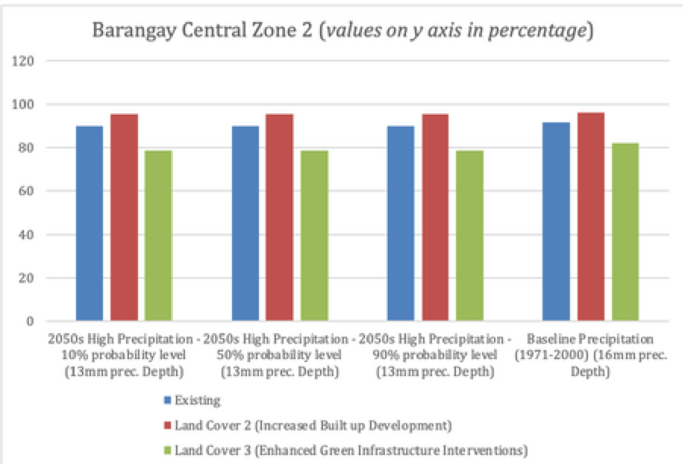

Figure 9-11. Surface Runoff Results for Barangay Central Zone 2 for 3 Land Cover Scenarios

Green Spaces as an Adaptation Measure for Urban Heat Island Phenomenon and Flooding: A Comparative Analysis of Urban Morphology Types of Two Select Zones in Barangay Central, Quezon City

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F. Comparison of Zone 1 and Zone 2 of Bgy. Central (Surface Runoff)

Across all land-surface scenarios, Zone 2 consistently exhibits higher runoff than Zone 1. Under existing land cover and 2050s high-precipitation conditions, Zone 2 records 89.8% runoff versus Zone 1's 78.2%, a 14.83% difference, and remains 11.6 points higher across the 2050s scenarios; under baseline precipitation (1971–2000), Zone 2 reaches 91.6% compared to Zone 1's 81.8% (an 11.98% or 9.8-point gap). With increased built-up development, Zone 2 again shows higher runoff at 95.4% compared to Zone 1's 87.3%, a 9.27% (or 8.1-point) increase, and under the baseline period rises to 96.2% versus Zone 1's 89.5% (a 7.4% or 6.7-point difference). Even under enhanced green-infrastructure interventions, Zone 2 maintains higher runoff at 78.6% across the 2050s precipitation levels, exceeding Zone 1 by 10.8 points (15.92%) under equivalent precipitation scenarios and by 9.5 points (13.08%) under baseline precipitation conditions.

V. DISCUSSION

C. Green Spaces for CCA + Mitigation

1. Surface Temperature

The results as per these three (3) land-cover scenarios were based on the following and encoded into the STAR Tools interface. Results show increased built-up development raises temperatures. Green spaces lower temperature, with both zones displaying the same trend. Zone 2 consistently shows higher temperature values than Zone 1 as it contains more impervious surfaces. Zone 1 has more green and open areas and reduces heat. Both zones reflect the same pattern of rising temperatures with greater built-up areas and decreasing temperatures with enhanced green infrastructure.

Table 9-13. Surf. Temp. Scenarios encoded

Temperature Scenarios	
2050s high temperature - 10% probability level	31.0°C
2050s high temperature - 50% probability level	31.0°C
2050s high temperature - 90% probability level	31.0°C
Baseline temperature (1971 - 2000)	28.8°C

2. Surface Runoff

The results were based on the following:

Table 9-14. Precipitation Scenarios encoded

Precipitation Scenarios	
2050s high precipitation - 10% probability level	16mm
2050s high precipitation - 50% probability level	16mm
2050s high precipitation - 90% probability level	16mm
Baseline precipitation (1971 - 2000)	13mm

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Based on the precipitation scenarios, produced are runoff results for each land-cover condition. Both zones show that built-up development increases runoff, while green and open spaces reduce it, as reflected in the charts for Zones 1 and 2. Zone 2 consistently exhibits higher runoff values because it contains more buildings and impervious surfaces and fewer green and blue areas. Overall, both zones follow the same trend of increasing runoff with more built-up areas and decreasing runoff with enhanced green infrastructure.

VI. CONCLUSION

Two Barangay Central zones were analyzed, showing that Zone 2 consistently has higher surface temperature and runoff, while the green and blue spaces in Zone 1 help reduce both. These findings align with studies by The Mersey Forest & University of Manchester (2011) and Raza et al. (2021), confirming vegetation's role in mitigating UHI and runoff, with Scenario 3 emphasizing green spaces as key climate-adaptation measures. Overall, the results highlight the importance of green infrastructure for resilient urban policy and design, supported by tools like STAR that help visualize land-cover impacts and guide LGU interventions.

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EXTENDED ABSTRACTS

An Analysis of Factors Contributing to Regional and Sectoral Vulnerability in Large-Scale Disasters

Tadashi Uchiyama[1]**,** Miwa Abe[1], Yuri Nakagawa[2]

ABSTRACT

In recent years, Japan has experienced an increasing number of natural disasters, many of which have resulted in forced evacuations. Despite the evident differences in occupational structures and lifestyles between urban and rural populations, resettlement policies have largely failed to account for regional characteristics and industrial compositions. Furthermore, limited research has examined how changes in the number of businesses and establishments before and after major disasters vary across regions and industries, and how these variations reflect underlying vulnerabilities.

This study aims to analyze changes in industrial structures at the municipal level across Japan, with a particular focus on identifying regions that have undergone significant transformations. Using data from the Economic Census conducted by the Statistics Bureau of Japan, principal component analysis (PCA) was applied to a sample of 1,905 municipalities for the years 2009 and 2014. Municipalities exhibiting substantial shifts in principal component scores were interpreted as having experienced notable changes in industrial composition. Cluster analysis was then used to classify these municipalities into three groups based on the direction and magnitude of change.

The results revealed that several prefectures—including Shimane, Shiga, Toyama, Kagawa, Iwate, Miyazaki, Ōita, and Ishikawa—had a relatively high number of municipalities with significant industrial transformation. Potential vulnerability factors were explored from the perspectives of regional characteristics, disaster impacts, and economic restructuring. Common factors identified include population aging and decline, labor shortages in primary industries, infrastructure and farmland damage due to natural disasters, industrial reorganization and offshore relocation, and disparities in urbanization and transportation infrastructure.

Further empirical analysis using diverse datasets is necessary to validate these vulnerability factors and to inform more regionally sensitive resettlement and recovery policies.

Keywords: Natural Disasters, Industrial Structure, Municipal-Level Analysis, Principal Component Analysis (PCA), Regional Vulnerability

I. INTRODUCTION

In Japan, the number of natural disasters has been increasing in recent years, and forced evacuations associated with such disasters have been consistently observed over time. Given the differences in occupations and lifestyles between urban and rural residents, it is reasonable to assume that their needs for resettlement support also differ. Nevertheless, past discussions on resettlement policies have largely overlooked regional characteristics and industrial structures.

Moreover, few studies have examined how changes in the number of businesses and establishments before and after major disasters vary by region and industry, and how these variations reflect the vulnerability of specific regional-industrial configurations.

Therefore, the purpose of this report is to analyze changes in regional industries at the

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municipal level across Japan, and to identify the vulnerability factors in regions that experienced significant industrial shifts. In particular, the study aims to examine whether the Great East Japan Earthquake of 2011 led to structural changes in industries, especially in the Tohoku region.

II. METHODOLOGY

This study utilizes data from the Economic Census conducted by the Statistics Bureau of Japan, which surveys the status of business establishments and corporate activities across municipalities in each prefecture. The census provides fundamental structural information on industries, employment size, and other attributes of establishments and enterprises.
The specific analytical procedures are as follows:

- A sample of 1,905 municipalities across Japan is used, with the variables listed in Table 1 serving as the basis for analysis.
- Principal Component Analysis (PCA) is conducted for two time points: 2009 and 2014, to derive principal component scores.
- Municipalities exhibiting significant changes in principal component scores between the two time points are interpreted as regions with notable shifts in industrial structure.
- For these regions, further investigation is conducted into potential vulnerability factors, including natural disasters and social issues, to explore the underlying causes of industrial transformation.

Table 1. Data Used for Principal Component Analysis

Data Source	Variables
Economic Census (2009), (2014)	Number of establishments in agriculture, forestry, and fisheries
	Number of employees in agriculture, forestry, and fisheries
	Number of non-agricultural establishments (excluding public administration)
	Number of non-agricultural employees (excluding public administration)
	Number of public administration establishments
	Number of public administration employees

The term non-agricultural, forestry, and fisheries industries refers to the aggregation of the following sectors:

- Mining, quarrying, and gravel extraction
- Construction
- Manufacturing
- Electricity, gas, heat supply, and water
- Information and communications
- Transport and postal services
- Wholesale and retail trade
- Finance and insurance
- Real estate and goods rental and leasing
- Academic research, professional and technical services
- Accommodation and food services
- Personal services and entertainment

- Education and learning support
- Medical care and welfare
- Compound services
- Other services

III. ANALYSIS RESULTS

A scatter plot of the principal component scores derived from the Principal Component Analysis (PCA) is presented in Figure 1, where red dots represent the year 2009 and blue dots represent the year 2014. The first principal axis reflects the overall scale of industrial activity, while the second axis distinguishes between types of industries: a positive direction on the second axis indicates a relatively large presence of primary industries, including agriculture, whereas a negative direction indicates a predominance of secondary and tertiary industries.

Using the principal component scores for each municipality and the magnitude of change between 2009 and 2014 as variables, a cluster analysis was conducted, resulting in three distinct groups (Figure 2). Green indicates regions with a strong shift toward primary industries, including agriculture; orange indicates regions with a strong shift toward secondary and tertiary industries; and gray represents regions with minimal change in industrial structure.

Table 2. Total Variance Explained

Component	Eigenvalue	Variance (%)	Cumulative (%)
1	3.643	60.721	60.721
2	1.649	27.477	88.197
3	0.372	6.202	94.399
4	0.222	3.708	98.107
5	0.070	1.174	99.281
6	0.043	0.719	100.000

Table 3. Component Matrix

Variable	Component 1	Component 2
Number of establishments in agriculture, forestry, and fisheries	0.619	0.754
Number of employees in agriculture, forestry, and fisheries	0.622	0.754
Number of non-agricultural establishments (excluding public administration)	0.873	-0.357
Number of non-agricultural employees (excluding public administration)	0.827	-0.471
Number of public administration establishments	0.912	0.077
Number of public administration employees	0.772	-0.395

IV. DISCUSSION

Eight prefectures were identified as having a relatively high number of municipalities with significant changes in industrial composition. For these regions, the factors contributing to industrial transformation between 2009 and 2014 were examined from the perspectives of regional characteristics, natural disasters, and economic structure, as summarized in Figure 2. While several common factors were identified, the analysis remains largely speculative.

An Analysis of Factors Contributing to Regional and Sectoral Vulnerability in Large-Scale Disasters

Tadashi Uchiyama, Miwa Abe, Yuri Nakagawa

Figure 1. A scatter plot of the principal component scores derived from the Principal Component Analysis

Common Factors:

- Aging population and demographic decline
- Shortage of labor in agriculture, forestry, and fisheries
- Infrastructure and farmland damage caused by natural disasters
- Industrial restructuring and offshore relocation of manufacturing
- Regional disparities in urbanization and transportation infrastructure

Further analysis using more diverse datasets is necessary to empirically validate the vulnerability factors identified in this study.

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EXTENDED ABSTRACTS

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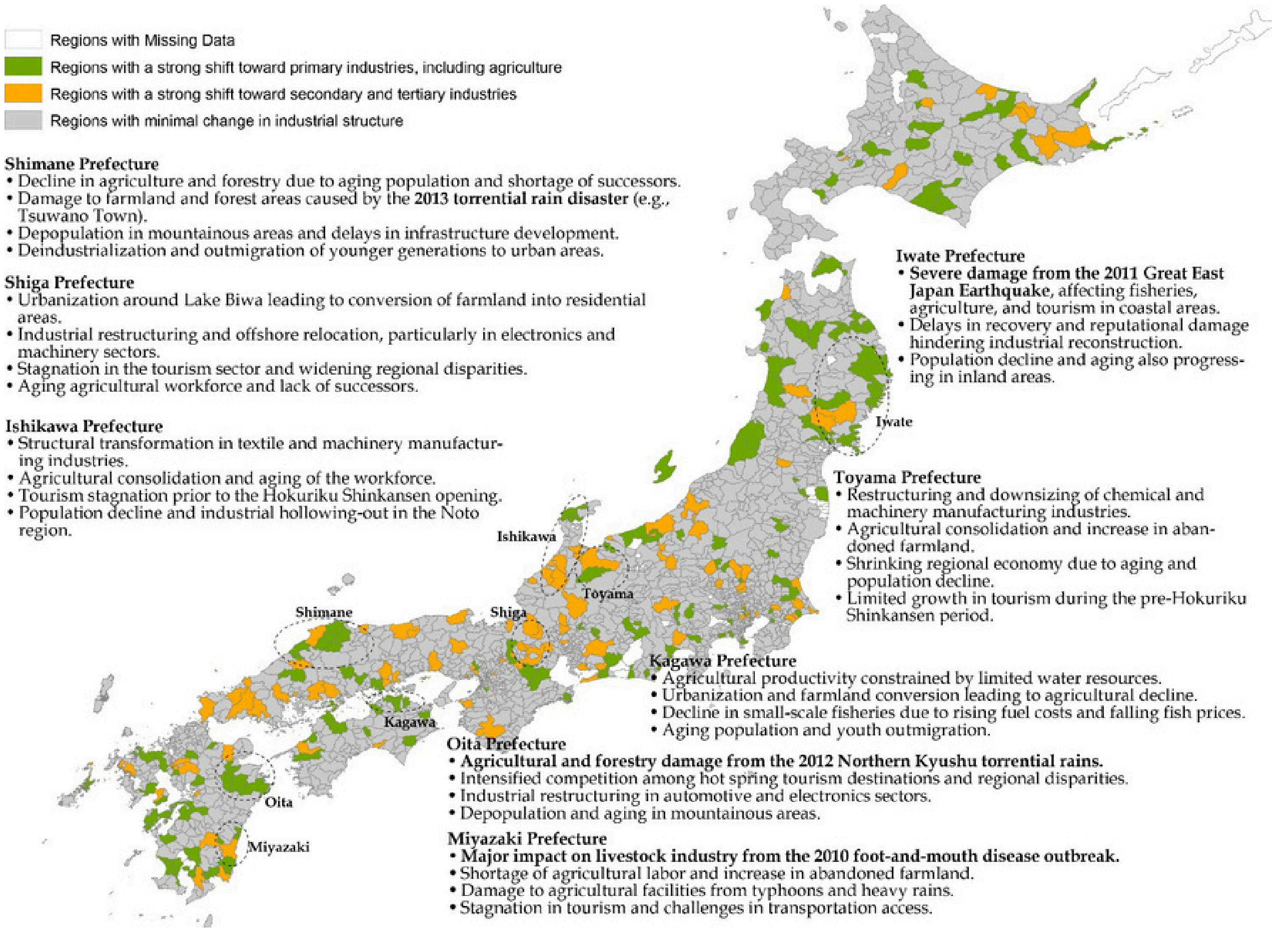

Figure 2. Cluster Analysis Results

A Critical Infrastructure Proximity & Community Flood Vulnerability Perception Analysis of Brgy. 638, San Miguel, Manila using 3-Dimentional Visualization

Adrian Jim R. Reyes[1]

ABSTRACT

This research explores how awareness of the proximity of critical infrastructure influences community perception of flood vulnerability, and assesses the role of 3-dimentional visualization in enhancing this understanding. Focusing on Brgy. 638, San Miguel in Manila, a flood-prone urban area, the study integrates spatial analysis and virtual technology to examine whether 3-dimentional visualization can improve risk awareness and support disaster preparedness. Using geospatial mapping, the study identifies the location of critical infrastructure—such as hospitals, schools, and fire, and police stations—relative to Brgy. 638 San Miguel, Manila. This spatial data informs both 2D maps and 3-dimentional visualization used in the research. A structured survey captures residents' levels of awareness, perceived vulnerability, and attitudes toward flooding. Statistical methods then assess the relationship between residents' perceived proximity to critical infrastructure and their perceived flood risk. To evaluate the effectiveness of communication tools, participants were exposed to both 2D maps and 3-dimentional visualization. Pre- and post-assessments measure changes in understanding and perception, allowing for comparison between traditional and immersive approaches. Community feedback is also gathered to assess the clarity, usability, and overall impact of 3-dimentional visualization as a tool for risk communication. The findings are expected to reveal how spatial awareness and immersive experiences influence public perception of flood vulnerability. By comparing the cognitive impact of 2D and 3-dimentional visualization tool, the study contributes to the development of more effective communication strategies for flood risk and infrastructure resilience. Ultimately, this research supports the use of emerging technologies in community-based disaster risk reduction, offering insights for local governments, planners, and educators aiming to build more informed and resilient communities.

Keywords: Proximity, critical infrastructure, flood vulnerability, community perception, 3D visualization

I. INTRODUCTION

Flooding remains one of the most frequent and disruptive hazards affecting urban communities in the Philippines, particularly in low-lying urban area such as Barangay 638, San Miguel, Manila (Kurata et al., 2023). Given the community's proximity to the Pasig River and dense built environment, floods pose persistent threats to safety, property, and mobility. Effective disaster preparedness relies not only on physical infrastructure but also on residents' awareness of their environment—specifically, their knowledge of the location and accessibility of critical infrastructures such as hospitals, schools, police, and fire stations (Dvir et al., 2022; Sritart et al., 2020; Tariverdi et al., 2023). Previous studies have suggested that limited spatial awareness can increase vulnerability by delaying response actions and reducing confidence in institutional support.

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EXTENDED ABSTRACTS

A Critical Infrastructure Proximity & Community Flood Vulnerability Perception Analysis of Brgy. 638, San Miguel, Manila using 3-Dimentional Visualization

Adrian Jim R. Reyes

This study investigates how awareness of the proximity of critical infrastructure influences residents' perceived vulnerability to flooding and explores how three-dimensional (3D) visualization can enhance public understanding of flood risks. Traditional two-dimensional (2D) maps, while informative, often fail to convey spatial depth and scale. In contrast, 3D visualizations may improve comprehension by allowing users to spatially situate themselves within hazard zones (Gmelch et al., 2020; Zhu & Li, 2020). Thus, this research aims to (1) determine the statistical relationship between residents' proximity awareness of critical infrastructure and their perception of flood vulnerability, and (2) evaluate the perceived clarity, usefulness, and effectiveness of 3D visualizations as tools for flood risk communication. By integrating geospatial mapping, survey analysis, and virtual visualization, the study contributes to the growing field of participatory and technology-supported disaster risk reduction.

II. METHODOLOGY

A mixed-methods approach integrated spatial mapping, quantitative analysis, and community feedback to examine flood risk perception in Barangay 638. Geospatial analysis using GIS and Project NOAH identified the locations of hospitals, schools, and emergency facilities relative to residential areas, determining their proximity and accessibility. A structured survey of 93 residents, derived from Cochran's formula, collected demographic data, perceived infrastructure proximity, flood experiences, and four risk perception indicators—likelihood, fear, controllability, and impact—adapted from Liu et al. (2022). A composite Risk Perception Index (RPI) was computed to quantify overall vulnerability. The Pearson correlation test ($p < 0.05$) assessed the relationship between awareness of infrastructure proximity and perceived flood vulnerability, supplemented by scatterplots and linear regression to visualize trends.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

r	=	correlation coefficient
x_i	=	values of the x-variable in a sample
$\bar{x}$	=	mean of the values of the x-variable
y_i	=	values of the y-variable in a sample
$\bar{y}$	=	mean of the values of the y-variable

To evaluate visualization effectiveness, participants viewed both 2D and 3D flood hazard maps illustrating flood depth and duration. Post-assessment surveys measured clarity, confidence, and perceived usefulness, with descriptive and qualitative analyses revealing that 3D visualization enhanced understanding, engagement, and perceived relevance of flood risk information.

III. RESULTS AND ANALYSIS

Results show that residents of Brgy. 638 have limited spatial awareness of critical infrastructure, with fewer than one-third correctly identifying the proximity of hospitals, schools, police, and fire stations. This lack of accurate knowledge may hinder access to emergency services and delay evacuation during floods. Most respondents recognized flooding as a recurring hazard—49.4% rated it as "likely," and 22.6% as "generally likely." While fear levels were moderate, many perceived floods as uncontrollable, reflecting limited self-efficacy.

The Pearson correlation (r = –0.23, p = 0.037) revealed that higher awareness of infrastructure proximity slightly reduced perceived vulnerability, though it explained only 5.3% of the variance, suggesting other psychological and experiential factors also shape perceptions. Exposure to three-dimensional (3D) flood maps significantly enhanced understanding and engagement, with 82% of participants accurately interpreting hazard levels and 72% reporting increased motivation to plan preventive actions. Overall, 3D visualization proved to be a valuable communication tool, improving risk comprehension, confidence, and preparedness among residents in flood-prone communities.

Table 1. Summary visualization of correlation analysis

Metric	Interpretation
Correlation (r)	-0.23
Direction	Negative
Trendline	Y = -0.52X + 4.29
Significance (p)	0.037
Implication	Higher proximity awareness slightly reduces perceived flood risk

Figure 1. 2D Flood hazard map of Brgy. 638
Source: NOAH - Nationwide Operational Assessment of Hazards, n.d.

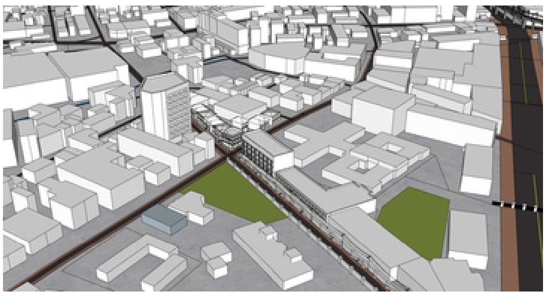

Figure 2. 3D Flood hazard map of Brgy. 638

IV. CONCLUSION AND RECOMMENDATION

The study concludes that while Brgy. 638 residents are aware of flood risks, their inaccurate perception of critical infrastructure locations increases their sense of vulnerability. A weak negative correlation indicates that greater spatial awareness slightly reduces perceived risk by improving confidence in emergency access. Three-dimensional (3D) visualization proved more

A Critical Infrastructure Proximity & Community Flood Vulnerability Perception Analysis of Brgy. 638, San Miguel, Manila using 3-Dimentional Visualization

Adrian Jim R. Reyes

effective than 2D maps in enhancing clarity, comprehension, and motivation. Future research should expand coverage, include qualitative and longitudinal approaches, and strengthen collaboration with local governments. Improving digital accessibility and guided 3D exposure can further enhance preparedness and resilience in flood-prone urban communities.

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PARALLEL SESSION 4C

MEASUREMENT OF RESILIENCE

Session Moderator: John Arvin R. Manaloto PhD

A Construction-Based Risk Assessment Framework for Informal Settlements in Flood-Prone CAMANAVA

Charles Kevin Menor
De LaSalle College of Saint Benilde

Evaluating Baseline Resilience: A Performance Study of 237 Barangays in Bataan's "1Bataan Barangay Resilience Awards" Prepare Phase

Abigail Cruz CatapangYuri Nakagawa[1], *Kristine P. Ortega[2], Maricel A. Javier[2], John Romar J. Martin[2], John Denver D. Catapang[2]*
[1] College of Architecture, University of the Philippines-Diliman
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Transformative Resilience to Disaster in Korea: Measurement and Key Determinants

Mijin Choo, *D.K. Yoon*
Yonsei University

EXTENDED ABSTRACTS

A Construction-Based Risk Assessment Framework for Informal Settlements in Flood-Prone CAMANAVA

Charles Kevin A. Menor[1]

ABSTRACT

Metro Manila's CAMANAVA region comprising Caloocan, Malabon, Navotas, and Valenzuela is among the most flood-prone areas in the Philippines. Its low-lying terrain, land subsidence, and dense informal settlements create overlapping vulnerabilities that intensify disaster risk. This study presents the CAMANAVA Construction-Based Risk Assessment Framework (CCRAF), a tool for identifying structural weaknesses in informal housing within flood-prone zones. Integrating on-site inspections, community interviews, and GIS mapping, the framework evaluates building stability, material condition, and drainage exposure. It introduces a traffic-light risk system that enables local governments to prioritize retrofitting, relocation, or technical assistance. The resulting CAMANAVA Informal Housing Risk Profile (CIHRP) supports RA 10121 and the NDRRMP 2020–2030, promoting evidence-based planning for resilient urban housing.

Keywords: Construction-based assessment, informal settlements, flood-prone areas, urban resilience, disaster risk reduction

I. INTRODUCTION

The CAMANAVA district of Metro Manila—Caloocan, Malabon, Navotas, and Valenzuela—frequently experiences flooding due to river overflow, heavy rainfall, and land subsidence (Environmental Science for Social Change, 2019). Informal settlements, often built along waterways, heighten exposure to these hazards. Over 100,000 informal settler families occupy flood-prone zones in Metro Manila (Housing and Urban Development Coordinating Council, 2020).

While the Disaster Risk Reduction and Management Act (RA 10121) and the NDRRMP 2020–2030 emphasize proactive, community-based strategies (Congress of the Philippines, 2010; NDRRMC, 2020), localized tools for informal areas remain limited (Ballescas et al., 2021). The CAMANAVA Construction-Based Risk Assessment Framework (CCRAF) addresses this by linking construction-based evaluation with local risk planning to strengthen resilience in high-risk communities.

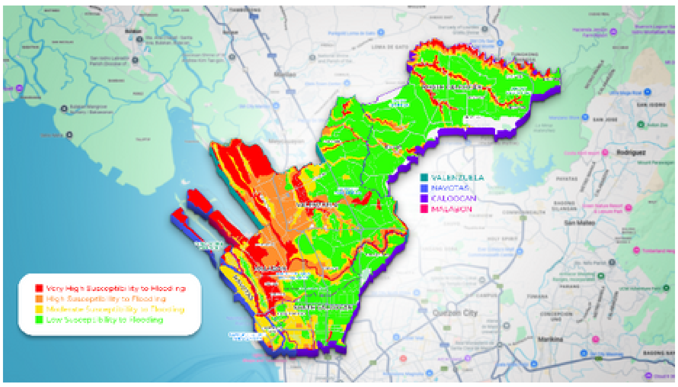

Figure 1. A broad-view flood susceptibility map of CAMANAVA.

[1] Charles Kevin A. Menor, a licensed architect, currently serving as a faculty member of the College of Architecture at National University - Manila, and the principal architect of 7cm Architectural Services, actively engaged in design and construction management, with research interests in resilient housing and urban disaster risk reduction.

A Construction-Based Risk Assessment Framework for Informal Settlements in Flood-Prone CAMANAVA

Charles Kevin A. Menor

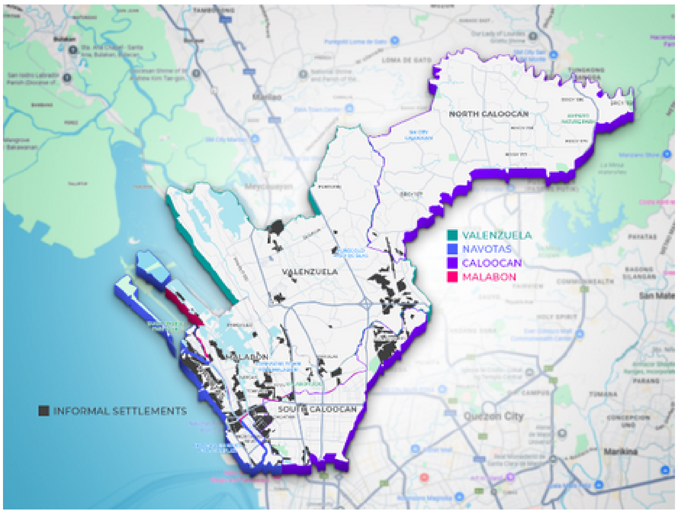

Figure 2. Informal Settlements map of CAMANAVA.
Source: Base Map (Malia Rivera 2021)

II. METHODOLOGY

The CCRAF integrates four components: structural assessment, participatory data collection, content analysis, and GIS mapping.

A. On-Site Structural Assessment

A visual checklist evaluated the condition of foundations, walls, roofs, and drainage systems. Results revealed that most informal houses lacked structural stability and failed to meet building safety standards.

Table 1. Interpreted Compliance / Defect Rate in CAMANAVA Informal Houses (Flood-Prone Slum Areas)

Risk Indicator Category	Qualitative Risk Assessment (R.I. Score Range)	Likelihood of Defective / Non-Compliant Houses (R.I. Score 2-3)	Key High Risk (Score 3) Indicators
1. Foundation & Structure	HIGH RISK (2–3)	70% - 90%	1.1 Very low elevation, exposed to flooding (locational defect). 1.2 Severe erosion/undermining 1.3 Major cracks/structural deformities (due to non-durable materials and flood stress). 1.4 Extensive dampness/structural damage
2. Roof & Anchoring	MODERATE to HIGH RISK (2–3)	65% - 85%	2.1 Severe damage, major gaps (due to non-durable/lightweight materials) 2.2 Frequent ponding/clogged drains (due to lack of urban planning) 2.3 Loose/missing anchors.
3. Sanitary & Drainage	HIGH RISK (3)	85% - 100%	3.1 Adjacent to public drainage/waterway (danger zone location). 3.2 Severely clogged with debris (structures blocking drains). 3.3 Frequent/serious infestation (due to stagnant water and waste) 3.4 Absent or heavily damaged sewerage/plumbing (lack of formal service access).
4. General Condition	MODERATE to HIGH RISK (2–3)	75% - 95%	4.1 Severe infestation/structural compromise (decay on non-treated wood from dampness). 4.2 Extensive peeling/mold. 4.3 Hazardous/unsecured wiring (informal connections). 4.4 Very poor, unsafe environment.
OVERALL RISK RATING	High Risk (2.3 – 3.0)	75% - 95%	The vast majority of houses are classified as Unsafe, requiring urgent retrofitting or relocation due to cumulative risk factors.

B. Participatory Data Collection

Community leaders, residents, and local builders were interviewed to document adaptive practices such as elevated floors and stilt-type construction, guiding practical and community-based risk reduction (Mercer et al., 2007; UNDRR, 2017).

A Construction-Based Risk Assessment Framework for Informal Settlements in Flood-Prone CAMANAVA

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C. Content Analysis of Codes and Laws

An analysis of the National Building Code (PD 1096) showed that while it enforces safety standards, its rigid application limits use in informal areas (Lian, 2018). CCRAF offers an adaptable framework aligned with informal housing realities.

D. GIS-Based Hazard Mapping

Field data were geo-coded and overlaid on flood-hazard maps to identify overlaps between flood-prone areas and informal settlements.

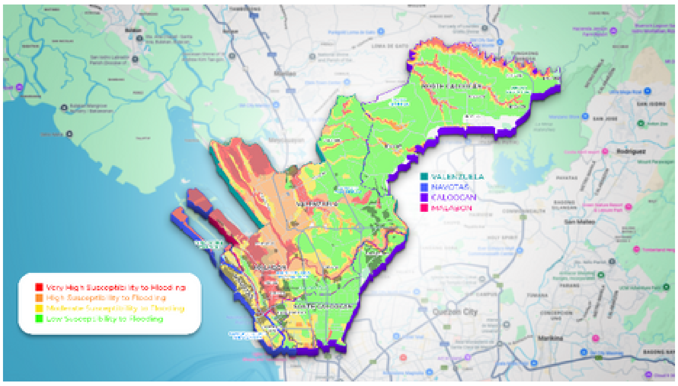

Figure 3. Overlaid Map of Flood-Prone Zones and Informal Settlements in CAMANAVA

III. RESULTS AND ANALYSIS

The CAMANAVA Informal Housing Risk Profile (CIHRP) translates CCRAF findings into a traffic-light risk system—red for high, yellow for moderate, and green for low risk. This categorization allows LGUs to prioritize interventions, allocate resources efficiently, and integrate DRRM into city land-use plans.

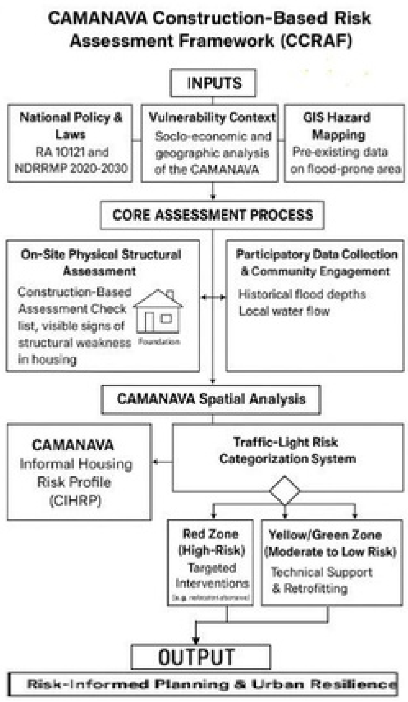

Figure 4. CAMANAVA CCRAF Framework Diagram

The CIHRP supports collaboration among LGUs, NGOs, and communities in implementing retrofitting, relocation, or self-recovery initiatives, consistent with the principles of RA 10121 and the NDRRMP 2020–2030.

IV. CONCLUSION AND RECOMMENDATIONS

The CAMANAVA Construction-Based Risk Assessment Framework offers a replicable, practical, and context-specific model for addressing flood risk in informal settlements. By integrating technical assessment, community participation, and GIS-based analysis, it strengthens the link between national DRRM policy and local implementation. It is recommended that LGUs adopt the CIHRP in their risk-informed planning and replicate the framework in other flood-prone areas of Metro Manila to promote resilient, inclusive, and sustainable housing development.

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Asian Development Bank (2015); Ballescas et al. (2021); Congress of the Philippines (2010); Environmental Science for Social Change (2019); Gero et al. (2015); Housing and Urban Development Coordinating Council (2020); Lian (2018); NDRRMC (2020); Mercer et al. (2007); UNDRR (2017); City of Malabon (2022); City of Navotas (2021); City of Valenzuela (2020); Geoportal Philippines (n.d.); ArcGIS StoryMaps (n.d.).

Evaluating Baseline Resilience: A Performance Study of 237 Barangays in Bataan's "1Bataan Barangay Resilience Awards" Prepare Phase

Abigail S. Cruz-Catapang[1], Kristine P. Ortega[2], Maricel A. Javier[3], John Romar J. Martin[4], John Denver D. Catapang[5]

ABSTRACT

This paper presents a quantitative and descriptive analysis of the baseline resilience performance of 237 barangays in Bataan, Philippines during the Prepare Phase (Year 1) of the 1Bataan Barangay Resilience Awards. Mandated by Provincial Ordinance No. 17, Series of 2023, the program utilizes the Barangay Resilience Bingo Scorecard (BRBS) to evaluate preparedness across five core pillars: Human Development (HD), Local Economy (LE), Infrastructure (IN), Environment (EN), and Human Security (HS) [1, 1]. The objective is to identify systemic strengths and critical vulnerabilities to inform evidence-based policy formulation for subsequent phases.

The data reveals significant heterogeneity, with high-performing Local Government Units (LGUs) (Abucay, mean 9.22) contrasting sharply with critically non-compliant LGUs (Orani, mean 0.83). A major finding is that low scores are often rooted in administrative failures—specifically, the deficient submission of Means of Verification—rather than the complete absence of local programs. Pillar-specific analysis shows strong performance in Human Development , while Infrastructure, Local Economy, and Environment are identified as critical vulnerability domains. Granular data pinpoints severe, province-wide gaps in P.IN.2 (Network of Evacuation Areas), P.LE.3 (Access to Economic Stimulus), and P.EN.1 (Organization for Waste Management). Based on this baseline, the research proposes a framework for a longitudinal study and recommends that the Year 2 (Adapt Phase) strategy must transition toward targeted capacity building and institutionalizing physical and financial safeguards to bridge the gap between social readiness and structural resilience.

Keywords: DRRM, Bataan, Resilience, BRBS

I. INTRODUCTION

The Province of Bataan is a strategically important peninsula located in Central Luzon, Philippines. The peninsula is historically significant and currently a major economic and industrial hub. It is classified as a 1st income class province, signaling its high revenue generation and fiscal health. The province is home to key economic centers, including the 1st class Municipalities of Mariveles, which hosts a major economic zone, and Limay, 2nd richest municipality in the country in 2022 (Antalan, 2023), as well as the provincial capital, City of Balanga, a recently upgraded 2nd class component city.

Despite its economic significance, Bataan acknowledges its vulnerability to natural and human-induced hazards, including geophysical, hydrometeorological and environmental threats. In response to this challenge, the Provincial Government has implemented a formal, strategic commitment to enhancing community resilience, mandated by the Philippine Disaster Risk Reduction and Management Act of 2010 (Republic Act No. 10121) (Court, 2010).

This commitment is operationalized through the "1Bataan Barangay Resilience Awards," an incentive-based program established by Provincial Ordinance No. 17, series of 2023 (Bataan,

The research team is led by Cruz-Catapang[1], a faculty member at BPSU and a PhD candidate at UP Diliman. Other team members include BPSU faculty members Catapang[5] and Ortega[2], as well as Javier[3] and Martin[4]—who serve on the technical committee of The 1Bataan Resilience Council, which is led by Ortega.

2023). This initiative aims to build local community resilience by integrating climate and disaster risk into local planning, processes, and budgeting at the barangay level, the smallest administrative level in the Philippines.

The program uses the Barangay Resilience Bingo Scorecard (BRBS), a diagnostic assessment tool developed in collaboration with the National Resilience Council (NRC).

Figure 1. The Province of Bataan.
Source: Google Maps 2025.

This framework assesses a barangay's readiness across five critical pillars of resilience:

- Human Development (HD)
- Local Economy (LE)
- Infrastructure (IN)
- Environment (EN)
- Human Security (HS)

The program is structured around a long-term, three-year implementation timeframe: Prepare (Year 1), Adapt (Year 2) and Transform (Year 3). The BRBS system is not merely a preparedness checklist but a mechanism for auditing governance effectiveness and administrative compliance. It recognizes that political commitment and institutional discipline are the stronger determinants of early-stage resilience performance compared to municipal wealth alone.

Evaluating Baseline Resilience: A Performance Study of 237 Barangays in Bataan's "1Bataan Barangay Resilience Awards" Prepare Phase

Abigail S. Cruz-Catapang, Kristine P. Ortega, Maricel A. Javier, John Romar J. Martin, John Denver D. Catapang

A. The BRBS Framework and Scoring Mechanism

The core assessment tool is the Barangay Resilience Bingo Scorecard (BRBS), a diagnostic instrument developed in collaboration with the National Resilience Council (NRC) and the 1Bataan Resilience Council (Bataan, 2023). This program is structured around a long-term, three-year implementation timeframe, phased as: Prepare (Year 1), Adapt (Year 2), and Transform (Year 3).

The current analysis focuses exclusively on the Prepare Phase (Year 1), where barangay officials self-assess their foundational readiness across six resilience pathways embodied in five key pillars, using 15 priority indicators:

1. Human Development (HD): Focuses on social safety nets and health system planning.
2. Local Economy (LE): Concentrates on fundamental financial preparedness and business risk assessment.
3. Infrastructure (IN): Addresses early warning systems, evacuation readiness, and settlement regulation.
4. Environment (EN): Covers waste and ecosystem management.
5. Human Security (HS): Pertains to violence prevention, conflict resolution, and the management of human mobility and migration patterns (social preparation for relocation) (Bataan, 2023)

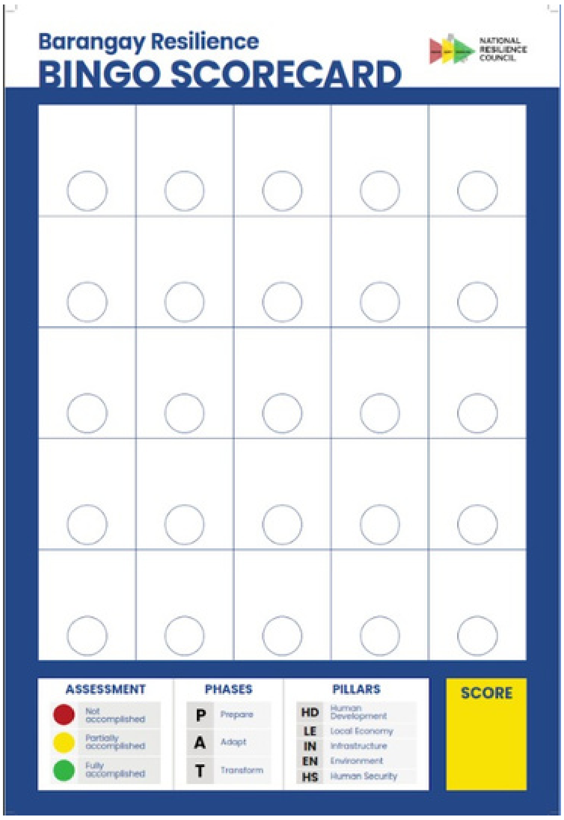

Figure 4. Barangay Resilience Bingo Scorecard.
Source: Image by the authors.

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Performance in the Prepare Phase is scored using a color-coded system: indicators that are Not Accomplished (Red) receive 0 points; Partially Accomplished (Yellow) receive 0.5 points; and Fully Accomplished (Green) receive 1 point.

The scoring structure demonstrates a clear progression designed to reward sustained institutional effort. While the maximum score per indicator in the Prepare Phase is 1.0, this increases to 2.0 in the Adapt Phase and 3.0 in the Transform Phase. This escalating reward mechanism ensures that financial benefits are not front-loaded and that barangays are incentivized to move beyond basic administrative compliance towards demonstrable institutionalization and operational innovation across the three years.

The inclusion of the Seal of Healthy Barangay bonus (up to 5 points) profoundly affects the final total score, sometimes accounting for over 30% of a barangay's final point total. For example, Omboy in Abucay achieved 14.5 total points, suggesting exceptional performance and organizational capacity. The high weight assigned to this bonus demonstrates that barangays with strong pre-existing governance frameworks, as measured by broader provincial health or governance standards, possess an institutional capacity advantage that acts as a significant multiplier effect on overall BRBS resilience scores.

Figure 5. Awarding of Php 1 Million Pesos for the top performing barangay for Year 1 of BRBS.
Source: Photo grab from Joet Garcia facebook page.

B. Critical Interpretation of Baseline

Validation is rigorous, involving an initial review by the Municipal/City Steering Committee (composed of DRRMOs and Bataan Peninsula State University representatives) followed by a final ranking from the Provincial Steering Committee.

An administrative complexity arises from the requirement for barangays to submit Means of Verification (MOVs) to validate their self-assessed scores. When multiple barangays within an LGU record a total score of zero, this results must be interpreted as a deep-seated institutional deficiency rather than merely a failure in physical preparedness. For instance, the systematic recording of zero points across all 15 indicators and all five pillars, as observed in numerous barangays in certain LGUs, is statistically improbable given basic government functions. This pattern strongly indicates a fundamental institutional failure – a lack of political will, training, or organizational capacity to properly document and submit the required MOVs for the BRBS self-assessment and validation process. Therefore, the BRBS Prepare Phase scores function not just a measure of inherent capacity, but as a critical audit of local governance effectiveness and administrative compliance.

III. AGGREGATE PROVINCIAL RESILIENCE BASELINE (YEAR 1)

A. Overall Performance Distribution and Compliance Analysis

The baseline data reveals high variance in preparedness across Bataan's LGUs. A score exceeding 10.0 points in the Prepare Phase represents a highly accomplished baseline, as the maximum base score is 15. The top individual performer, Omboy, Abucay, achieved 14.5 points, indicating near-maximum preparedness.

However, a significant number of barangays exhibited critical non-compliance, severely skewing the municipal averages downwards. In Dinalupihan, for instance, Roxas and Dalao barangays received low scores (1.0 and 1.0, respectively), specifically attributed to "late submission of MOVs". The most severe case of non-compliance is observed in Orani, where data shows clusters of zero or minimum scores, with the LGU averaging 0.83. Similarly, Mariveles reported nine of its eighteen barangays with zero scores.

This pervasive incidence of zero scores suggests that the fundamental failure of the Prepare Phase for these lowest-ranking barangays was not necessarily a lack of resilience programs in operation, but rather a profound deficiency in administrative capacity and bureaucratic compliance—the ability to compile, verify, and submit the necessary documentation (MOVs) required by the steering committees. This administrative bottleneck must be resolved before substantive progress on operational resilience can be achieved in Year 2. High-scoring LGUs, such as Abucay and Bagac (mean scores of 9.22 and 7.61, respectively), are likely characterized by longer-standing DRRM maturity or dedicated municipal support that enabled their barangays to successfully meet the rigorous documentation requirements for "Green" ratings.

B. Comparative Municipal Ranking (Mean Total Scores)

The ranking of LGUs by mean total score clearly delineates the provincial readiness landscape, showing high performance inertia in some areas and significant administrative deficits in others.

The top-performing LGUs (Abucay, Bagac) are generally smaller and geographically less complex than larger, highly industrialized LGUs (Mariveles, Limay). However, the finding that Mariveles, a low-ranking municipality, also produced a high individual score (Sisiman, 11.0 points) demonstrates that high resilience performance is often localized and dependent on barangay-level leadership and initiative, even within a less compliant municipal ecosystem.

The overall low mean scores of Balanga City (5.02, rank 7) is particularly concerning, as the municipality contains highly vulnerable coastal communities like Tortugas and Puerto Rivas Ibaba. When highly physically and socioeconomically vulnerable communities score poorly on the preparation checklist, the resulting disaster risk is compounded. This structural relationship implies that intervention in the Adapt Phase must be exponentially prioritized in these low-scoring, high-risk coastal zones.

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Table 1. Comparative Municipal Resilience Performance (Prepare Phase, Year 1)

Municipality	Total Barangays (N)	Mean Total Score	Provincial Rank	Observations (Compliance/ Vulnerability)
Abucay	9	9.22	1	High compliance and performance
Bagac	14	7.61	2	High performance, generally coastal
Hermosa	23	6.37	3	Mid-to-high range
Dinalupihan	46	6.29	4	Largest LGU, mid-range performance, some compliance noted
Orion	23	5.41	5	Mid-range
Samal	13	5.35	6	Mid-range
Balanga City	25	5.02	7	Lower range, contains highly vulnerable coastal
Pilar	19	4.58	8	Lower range
Limay	12	4.21	9	Lower range, industrial area
Mariveles	18	2.61	10	High non-compliance (50% zero scores), industrial area
Morong	5	2.20	11	Low sample size, critically low performance
Orani	29	0.83	12	Critical non-compliance (27/29 barangays scoring 0/3)

IV. PILLAR-SPECIFIC PERFORMANCE ANALYSIS: IDENTIFYING DOMAINS OF STRENGTH AND VULNERABILITY

Analyzing the mean scores across the five pillars reveals a consistent pattern of societal preparedness preceding physical and economic readiness across the province.

A. Inter-Pillar Comparison: Provincial Mean Scores

This analysis is based on the Barangay Resilience Bingo Scorecard (BRBS), a tool used to assess community preparedness across five critical pillars. The chart below shows the average performance for the entire province of Bataan in each pillar. A higher score, extending further from the center, indicates greater resilience.

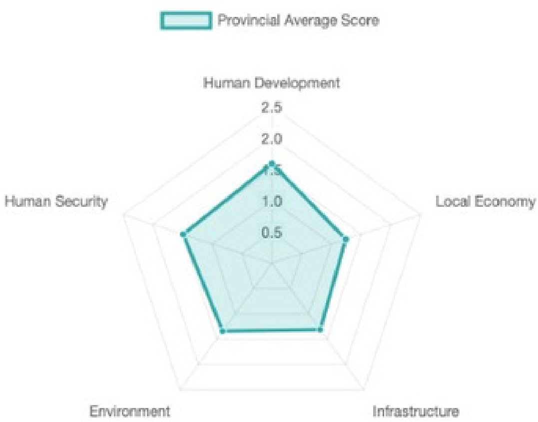

Figure 6. The Big Picture: Provincial Resilience Averages.
Source: Google, 2025

Evaluating Baseline Resilience: A Performance Study of 237 Barangays in Bataan's "1Bataan Barangay Resilience Awards" Prepare Phase

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Provincially, Bataan shows strong performance in Human Security and Human Development. However, there are opportunities for growth, particularly in strengthening the Local Economy and enhancing Environmental resilience to better prepare for future challenges.

Table 2. Inter-pillar Comparison: Provincial Mean Scores

Municipality	Mean Score					Primary Vulnerability
	HD	LE	IN	EN	HS	
Abucay	3.72	1.83	1.83	1.89	2.11	Infrastructure / Local Economy (Relative)
Bagac	3.14	1.46	1.39	1.57	1.46	Infrastructure / Local Economy
Dinalupihan	2.76	1.70	1.77	1.84	1.63	Human Security / Local Economy
Hermosa	3.19	2.07	1.48	1.96	1.57	Infrastructure / Human Security
Limay	2.46	0.88	0.50	1.38	0.96	Infrastructure (Critical)
Mariveles	2.39	1.25	0.55	1.15	1.16	Infrastructure (Critical)
Morong	1.25	0.55	0.40	0.60	0.70	All Pillars (critically low)

The chart below ranks Bataan's 12 municipalities based on the average total resilience score of their barangays. This provides a high-level overview of overall performance across the province.

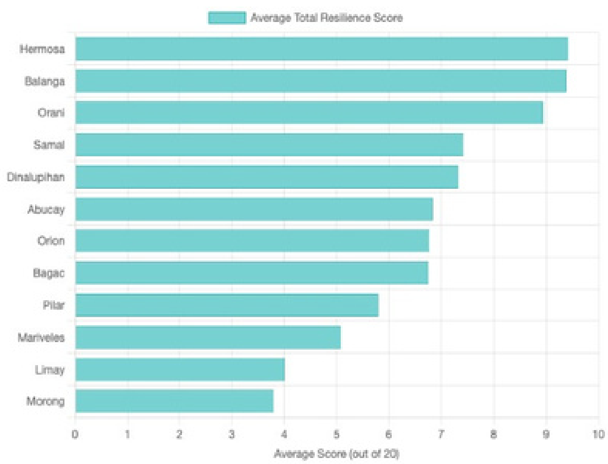

Figure 7. Municipal Performance: A Comparative Look.
Source: From the authors.

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B. Deep Dive: Human Development (HD) and Human Security (HS)

Human Development stands as a clear provincial strength. The highest-scoring indicators typically fall under HD, such as P.HD.1 (Facilitate Access to Social Safety nets) and P.HD.3 (DRRM in Health Planning). This outcome reflects that Bataan's DRRM strategy began with prioritizing immediate social welfare and pre-disaster health planning, which is typical of competent LGUs focusing first on social safety administration.

The succeeding charts illustrates a deep dive into municipality performance by Resilience Pillar.

Figure 8. Performance by Resilience Pillar – Human Development focuses on health, education, and social welfare. This pillar measures a community's capacity to care for its people.
Source: From the authors.

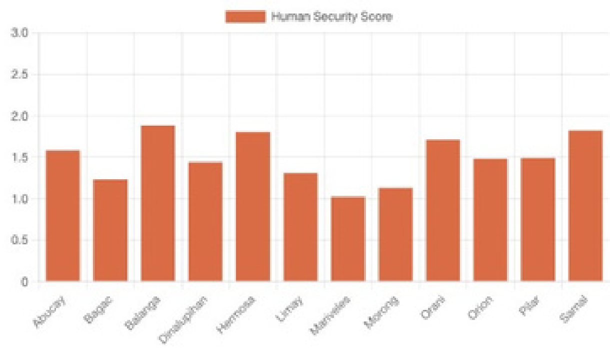

Figure 9. Human security. Concerns the safety of the community, including peace and order, conflict resolution and management of migration.
Source: From the authors.

In contrast, Human Security (HS) lags HD, particularly in P.HS.3 (Capacity building on Migration and Migration Patterns, Human mobility, Community affairs and development). This dimension is particularly weak in industrial and urbanizing LGUs like Mariveles and Limay , which experience significant internal migration and manage complexities related to Informal Settler Families. The low scores demonstrate a clear institutional challenge in integrating population dynamics and social preparation for relocation into current DRRM planning, a critical component of comprehensive human security.

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C. Deep Dive: Infrastructure (IN), Local Economy (LE), and Environment (EN)

Infrastructure is consistently the lowest scoring pillar province-wide, reflecting a severe readiness gap in physical systems. Given that Bataan is a peninsular province highly exposed to coastal flooding, typhoons, and storm surge, the generalized failure in the Infrastructure pillar, especially concerning P.IN.2 (Network of Evacuation Areas and temporary shelters), represents a critical life safety vulnerability. The reliance on strong social programs (HD) cannot mitigate risks associated with structural failure or inadequate evacuation protocols, highlighting a structural misalignment between social and physical preparedness.

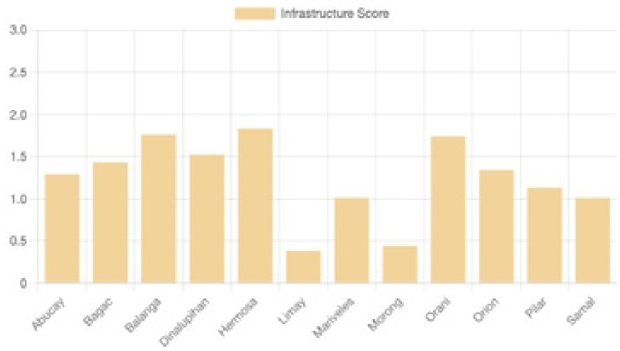

Figure 10. Infrastructure. Evaluates the durability and reliability of critical facilities like roads, communication lines and evacuation centers.
Source: From the authors.

The Local Economy pillar also exhibits profound weakness, particularly in P.LE.3 (Facilitate access to Economic stimulus). This finding indicates that fundamental mechanisms for community-level financial resilience are lacking. Barangays have not adequately established pathways to facilitate access to crucial post-disaster funding, loans, or subsidies, which is essential for business continuity and recovery. This institutional weakness poses a substantial threat to long-term community recovery, as lack of economic preparedness can initiate protracted poverty cycles following significant hazard events.

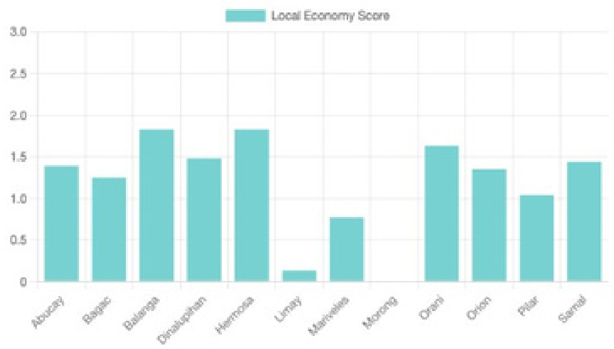

Figure 11. Local Economy score. This assesses the stability and diversity of local livelihoods and businesses, which are crucial for recovery after a disaster.
Source: From the authors.

The Environment pillar is weak, despite some moderate scores in awareness (P.EN.3: Information Education and Communication). The practical management indicators, P.EN.1 (Organization for Waste Management) and P.EN.2 (Pollution management strategies), show low compliance. The poor scores in P.EN.1 are highly consequential because inadequate Solid Waste Management (SWM) frequently results in clogged drainage systems, directly exacerbating inland flood risk during heavy rainfall, thereby undermining broader resilience efforts.

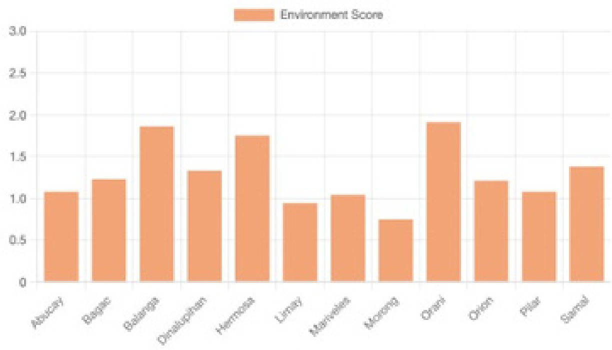

Figure 12. Infrastructure. Evaluates the durability and reliability of critical facilities like roads, communication lines and evacuation centers.
Source: From the authors.

V. GRANULAR ANALYSIS OF PREPARE PHASE INDICATORS (P.X.X)

A granular review of the 15 specific indicators allows for the isolation of actionable policy intervention points, prioritizing where the foundational systemic failures reside.

A. Identification of Top 5 Accomplished Indicators (Systemic Strengths)

The highest mean scores consistently fall under administrative and social readiness:

P.HD.1 (Facilitate Access to Social Safety nets): The highest scoring indicator provincially, confirming the successful institutionalization of mechanisms for social registration and welfare access.

P.HD.3 (Disaster Risk Reduction and Management in Health Planning): Second strongest, indicating effective prioritization and documentation of health-related DRRM planning.

P.IN.3 (Early Warning Systems in place): Moderate performance suggests widespread adoption of basic EWS technologies and protocols, indicating readiness in planning communication.

P.HS.2 (Enhance the functions of the Barangay Peace and Order Council): Demonstrates that existing peace and order structures are being leveraged and documented for resilience planning.

P.LE.1 (Risk-informed Database/Inventory of Businesses): Moderate strength, showing that the preliminary step of mapping economic assets has begun, which is necessary for future economic resilience planning.

B. Identification of Bottom 5 Critical Gaps (Systemic Vulnerabilities)

The lowest scoring indicators represent critical gaps demanding immediate and targeted intervention, as they directly undermine life safety and recovery capacity.

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P.IN.2 (Network of Evacuation Areas and temporary shelters): This indicator consistently scores near zero across multiple LGUs, tying for the lowest in Morong (0.0 average). This failure suggests a critical gap between theoretical planning (EWS readiness, P.IN.3) and physical implementation, indicating inadequate availability, readiness, or documentation of safe evacuation centers. This structural deficiency presents an unacceptable risk to life during major hazards.

P.LE.3 (Facilitate access to Economic stimulus): Also tied for the lowest in Morong (0.0 average). This outcome confirms the administrative weakness in linking grassroots businesses and livelihoods to municipal, provincial, or national financial assistance mechanisms, making the subsequent Adapt Phase goals related to facilitating financial resources (A.LE-2) practically unattainable without remedial action.

P.EN.1 (Organization for Waste Management): This essential foundational indicator scored critically low. Despite some environmental awareness (P.EN.3), the required physical and administrative organization for Solid Waste Management (SWM) is non-existent or undocumented in many areas. This administrative failure directly exacerbates physical hazard exposure by contributing to flooding.

P.EN.2 (Pollution management strategies): Generally low scores reflect a provincial absence of formalized, documented strategies for pollution mitigation, relying primarily on general awareness rather than formalized action plans.

P.HS.3 (Capacity building on Migration and Human mobility): Low scores confirm that the complexities of rapid population change, human mobility, and the necessary social preparation for relocation are not yet adequately integrated into baseline barangay planning.

Table 3. Provincial Ranking of Prepare Phase Indicators (P.x.x) by Mean Score (Aggregated Status)

Indicator	Pillar	Indicator Description (Abbreviated)	Systemic Status	Policy Focus Implication
P.HD.1	HD	Access to social safety nets	High strength	Sustain success, integrate with Universal Health Care (T.HD.2)
P.HD.3	HD	DRRM in Health Planning	High strength	Sustain success, aim for BDRRMH Plan Institutionalization (T.HD.3)
P.IN.3	IN	Early Warning Systems in place	Moderate	Upgrade technology, strengthen risk communication (A.IN.3)

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P.HS.2	HS	Barangay Peace Order Council functions	Moderate	Integrate security with displacement planning (A. HS.1, A. HS.3)
P.LE.1	LE	Risk-informed database/inventory of businesses	Moderate	Convert database into structured financial readiness plans (A.LE.1)
P.IN.1	IN	Support to regulation of settlements	Low vulnerability	Enforcement gap; requires stronger municipal support for land use
P.EN.2	EN	Pollution management strategies	Low vulnerability	Urgent technical assistance required for strategy formalization
P.HS.3	HS	Capacity building on Migration	Low vulnerability	Link with infrastructure planning (relocation) (T.HS.2)
P.EN.1	EN	Organization for waste management	Critical gap	Requires mandatory institutional compliance and physical resource provision (MRFs)
P.LE.3	LE	Facilitate access to economic stimulus	Critical gap	Develop standardized micro-finance access templates and LEDIPO intervention
P.IN.2	IN	Network of evacuation areas and temporary shelters	Critical gap	Immediate prioritization for capital projects and operational readiness

VI. POLICY SYNTHESIS AND IMPLICATIONS FOR CAPACITY BUILDING (YEAR 2: ADAPT PHASE)

The transition to the Adapt Phase requires focused intervention guided by the clear gaps identified in the baseline. The Provincial Steering Committee must leverage this data to ensure capacity building addresses demonstrated weaknesses rather than perceived needs.

EXTENDED ABSTRACTS

Evaluating Baseline Resilience: A Performance Study of 237 Barangays in Bataan's "1Bataan Barangay Resilience Awards" Prepare Phase

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A. Addressing Administrative Non-Compliance and Data Integrity

The widespread occurrence of zero scores due to administrative non-compliance (as exemplified by Orani and specific barangays in Dinalupihan) necessitates a dedicated intervention focusing on governance and documentation. Year 2 capacity building must explicitly incorporate training on Means of Verification (MOVs) requirements and proper bureaucratic compliance. A tiered support system should be established, whereby LGUs with critically low compliance (Mean Score ≤ 3.0) receive intensive administrative guidance before being eligible for advanced technical assistance, ensuring that documented administrative readiness precedes operational funding.

B. Strategic Alignment of Prepare Phase Gaps with Adapt Phase Indicators (A.x.x)

The identified critical gaps in the Prepare Phase (P.x.x) must be directly mapped and accelerated into the Adapt Phase (A.x.x) objectives:

Infrastructure (IN): The fundamental failure in P.IN.2 (Evacuation Network) requires immediate action to operationalize A.IN-2 (Operationalizing network of Evacuation Centers and community-led evacuation system). This involves joint capital expenditure planning and operational readiness verification conducted by Barangay officials, Municipal/City DRRMOs, and Engineering Offices.

Local Economy (LE): The administrative inability to facilitate economic stimulus (P.LE.3) must transition directly into A.LE-1 (Financial Management) and A.LE-2 (Facilitate Financial and technical resources for Businesses). These interventions should be led by the Local Economic Development and Investment Promotion Office (LEDIPO), providing standardized templates and direct technical assistance for financial planning and resource access.

Environment (EN): The profound lack of basic organization for waste management (P.EN.1) must target A.EN-3 (Participatory Solid Waste Management or waste diversion practices). This includes strict enforcement of local SWM ordinances and investment in foundational infrastructure such as Material Recovery Facilities (MRFs), a need explicitly documented in certain barangays.

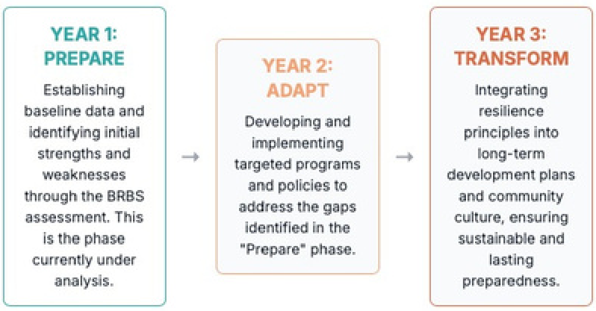

Figure 13. The Path Forward: A Phased Approach to Resilience.
Source: From the authors.

C. Recommendations for Steering Committee Validation Protocols

To ensure integrity and drive genuine improvement, the Steering Committee must enhance its validation protocols. Claims of indicator "inapplicability" must be rigorously scrutinized, moving beyond mere self-assessment. In cases like Orani, the committee must determine if the zero scores reflect true programmatic absence or administrative abandonment, requiring a root-cause analysis before determining appropriate Year 2 intervention strategies. Furthermore, the technical expertise of the BPSU representatives should be leveraged to design specialized MOVs and capacity workshops that specifically address the complex structural weaknesses in IN, LE, and EN, ensuring that validation verifies demonstrable operational readiness, rather than simple document compilation.

VII. FRAMEWORK FOR FUTURE RESEARCH: ADVANCING THE BRBS LONGITUDINAL STUDY

The detailed baseline assessment provides the necessary quantitative foundation for a longitudinal, scholarly investigation into the effectiveness of incentive-based governance interventions on community resilience. The future research paper should transition from descriptive analysis to focusing on predictive capability, causality, and intervention efficacy over the multi-year BRBS implementation period.

A. Core Research Questions and Hypotheses

The proposed research should address the following key questions:

RQ1: To what extent does initial performance in the Prepare Phase (Year 1) predict the trajectory and rate of improvement in the Adapt Phase (Year 2)?

Hypothesis 1 (H1): Performance Inertia: Barangays scoring in the highest decile (>10.0 points) in Year 1 will exhibit a statistically higher net gain in the Adapt Phase score compared to mid-range performers (5.0–8.0 points), demonstrating that established governance structures facilitate rapid capacity absorption and scaling.

RQ2: How do geographical factors and demographic vulnerability indices correlate with differential performance across the five resilience pillars?

Hypothesis 2 (H2): Vulnerability Penalty: Coastal barangays identified as highly vulnerable to sea level rise (e.g., Balanga's Tortugas and Puerto Rivas Ibaba) will show significantly lower mean scores and slower progression rates in the Infrastructure (IN) and Environment (EN) pillars compared to inland barangays, reflecting the intrinsically higher complexity and cost of achieving structural resilience in high-risk environments.

RQ3: What is the primary causal factor driving non-compliance (zero scores) in the Prepare Phase—administrative capacity, resource deficiency, or lack of LGU political will?

Hypothesis 3 (H3): Administrative Failure Dominance: Non-compliance (zero scores) will be primarily linked to deficiencies in P.HD.1 (Access to Social Safety nets) and P.LE.1 (Risk-informed Database), indicating that the failure is fundamentally a breakdown in administrative documentation and data readiness, rather than a failure of physical infrastructure operations (such as EWS implementation, P.IN.3).

B. Proposed Methodology: Longitudinal, Mixed-Methods Approach

The study must utilize the BRBS data as a longitudinal dataset, integrating quantifiable data analysis with qualitative validation to explore causal mechanisms.

Quantitative Analysis (Scorecard Data): The methodology should involve Analysis of Variance

(ANOVA) to compare mean pillar scores across the 12 LGUs and clusters defined by industrial status or coastal exposure. Regression modeling should utilize Year 1 Pillar Scores, coastal status, and industrial profile as independent variables to predict the Year 2 net performance change. This data set must integrate scores across Prepare (Year 1), Adapt (Year 2), and, ultimately, Transform (Year 3) data to track sustained systemic progress.

Qualitative Analysis (Case Studies): A mixed-methods approach requires the selection of three comparative case study pairs based on Year 1 performance: (1) High Score/High Risk (e.g., Sisiman, Mariveles), (2) Low Score/High Risk (e.g., Tortugas, Balanga), and (3) Zero Score/Non-Compliant (e.g., Mabayo, Morong). Semi-structured interviews and Focus Group Discussions (FGDs) with Barangay Captains, DRRM personnel, and members of the Municipal/City Steering Committee must be conducted to systematically determine the administrative, resource, and political barriers preventing the achievement of "Green" status in critical indicators (P.IN.2, P.LE.3, P.EN.1).

C. Scope and Significance of the Study

This research would serve as a critical systems-level evaluation of a mandated, incentive-based DRRM policy in a geographically and economically vulnerable provincial setting, offering novel insights into local governance metrics within the Philippine context. The findings will provide evidence-based guidance to the Provincial Government for mid-course policy correction during the implementation of the Adapt and Transform Phases (Year 2 and Year 3), ensuring that the awards program effectively stimulates sustained, systemic resilience improvements rather than simply rewarding basic administrative documentation.

Table 4. Proposed Research Paper Structure and Longitudinal Hypotheses.

Paper section	Focus / Objective	Key Hypothesis (H)	Relevance to BRBS Phases
Introduction	Contextualizing the BRBS as a DRRM intervention and longitudinal study methodology	H1: Barangays with higher initial scores in the Prepare Phase will demonstrate a statistically faster rate of improvement in the Adapt Phase	Links Year 1 performance (Prepare) to Year 2 efficiency (Adapt).
Research Methodology	Defining quantitative metrics for performance change (Year 1 vs Year 2) and selection of qualitative case studies	H2: Socio-economic vulnerability indices (e.g., coastal exposure) will inversely correlate with performance gains in the Infrastructure and Environmental pillars (P.IN., P.EN.)	Contextualizes structural barriers against physical pillars (IN/EN)

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Findings: Performance Dynamics	Analysis of performance variance and pillar-specific trends from Year 1 to Year 2.	H3: Non-compliance in Year 1 (zero score) is primarily driven by administrative capacity gaps (P.HD.1, P.LE.1) rather than lack of operational resources (P.IN.3, P.EN.3).	Explores the causality of Year 1 administrative failure.
Discussion and Conclusion	Policy synthesis and implications for sustaining the Transform Phase	H4: LGU-led capacity building (as determined by Steering Committee interviews) will significantly mitigate critical gaps (P.IN.2, P.LE.3) identified in the Prepare Phase.	Measures of effectiveness of Year 1 policy interventions.

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EXTENDED ABSTRACTS

Transformative Resilience to Disaster in Korea: Measurement and Key Determinants

Mijin Choo[1], D. K. Yoon[2]

ABSTRACT

Disaster resilience extends beyond absorbing and recovering from disaster, it encompasses long-term adaptation to recurring crises, evolving into transformative resilience. While theoretical discussions emphasize the evolving and adaptive nature of resilience, empirical research still tends to focus on static assessments, overlooking adaptability and process of change. This study quantitatively examines transformative resilience to disasters by analyzing resilience changes over time and identifying influencing regional capacities. Transformative resilience was defined as the ratio of 2022 to 2012 resilience, reflecting a region's capacity to shift toward greater resilience. Resilience was mathematically measured for 177 local municipalities in South Korea in 2012 and 2022, using resilience curve based on employee numbers. This study examined the factors contributing to transformative resilience to disasters in terms of social, human, economic, institutional, physical, and environmental capacity, using generalized linear models. The findings highlight that adaptability and experiential learning are critical for enhancing transformative resilience, along with strengthened social and human capacities. Specifically, improvements in dynamic capacities such as community belonging, population diversity, and institutional efforts contribute positively to resilience, while physical vulnerability like deteriorated housing has a negative effect. This study offers an empirical framework for assessing transformative resilience to disasters and emphasizes the need for social and institutional adaptive strategies, contributing to providing practical guidance for policymakers to improve disaster resilience in community.

Keywords: Transformative resilience, Resistance, Recovery, Adaptability, Regional capacity

I. INTRODUCTION

Interests in resilience, which refers to the ability to withstand external shocks and recovery quickly (Folke, 2016; Meerow et al., 2016; Martin & Sunley, 2020) continues to grow, with an increasing shift from static concept, such as engineering resilience toward dynamic concepts like (socio-)ecological and transformative resilience. Transformative resilience emphasizes adaptive and sustainable change that evolves with urban systems (Elmqvist et al., 2019; Trippl et al., 2024). However, many empirical studies still approach resilience from an engineering perspective, focusing on short-term recovery from individual shocks rather than long-term adaptive transformations. Some regions maintain functionality aftershocks, while others repeatedly experience decline and recovery, revealing the need for a broader temporal perspective. In this context, this study aims to evaluate the city's resilience in response to two major disaster shocks and to assess transformative resilience in South Korea. This study measures resilience focusing on the years of 2012 and 2022, based on the number of employees as a proxy indicator. Additionally, this study seeks to identify the multidimensional regional capacity factors that impact transformative resilience.

[1] Dr. Choo is a postdoctoral researcher in the Department of Urban Planning and Engineering at Yonsei University. Her research interests lie in analyzing transformative urban resilience based on multidimensional urban data, focusing on disaster management and urban planning strategies to mitigate vulnerabilities and enhance adaptive capacity through multivariate data analysis.

[2] Dr. Yoon is a Professor of the Department of Urban Planning and Engineering at Yonsei University. He teaches and conducts research in the areas of urban environmental planning, disaster policy and planning, disaster vulnerability and capacity assessment, and spatial analysis using Geographic Information Systems.

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II. METHODOLOGY

This study analyzes 177 municipalities in South Korea that experienced direct damage from typhoons in both 2012 and 2022, covering the period from 2012 to 2024. Resilience is conceptually defined by the attributes of resistance, recovery, and adaptability, and quantitatively evaluated, using the number of employees as a proxy indicator (Table 1). A conceptual resilience curve can be illustrated as shown in Figure 1.

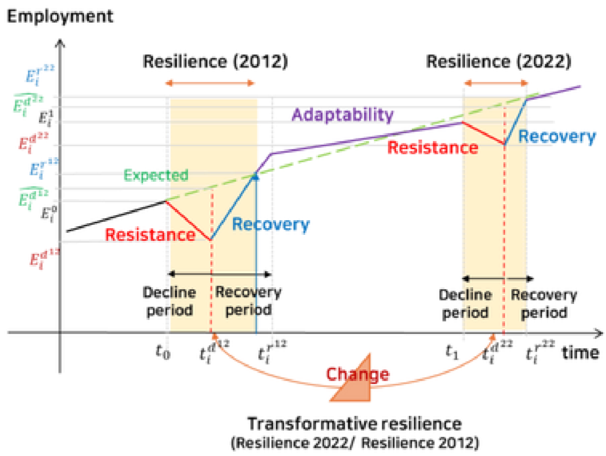

Figure 1. Conceptual resilience curve following a major shock.

To identify the determinants of resilience, a Generalized Linear Model (GLM) is used. The dependent variable is resilience in 2012 and 2022 and transformative resilience. Independent variables include multidimensional regional capacity variables and four control variables.

III. GATHERED DATA

This study used the number of employees as proxy variable for assessing resilience. We used 'Regional establishment labor force survey' in Korea, which has been conducted on a semiannual basis from 2011 to 2024. As for the regional capacity variables, they are organized into six dimensions: social, human, economic, physical, institutional, and environmental. Moreover, control variables are used to account for broader contextual factors related to population and disaster damage. Table 2 lists the variables included in each dimension.

Table 1. Definitions and formula of resilience.

Concept	Conceptual definition	Formula
Resistance	The ability to withstand and absorb external shock.	$(\Delta E_i^d - \Delta \widehat{E_i^d}) / \left\| \Delta \widehat{E_i^d} \right\|$
Recovery	The ability to return to a pre-shock or change to a new state in response to an external shock.	$\log\{(E_i^r - E_i^d)/(t_i^r - t_i^d)\}$
Resilience	The ability to adapt well to a changed new state after recovering from the shock.	$\begin{cases} (Recovery/\|Resistance\|) & if\ Resistance < 0 \\ (Recovery/\min(\|Resistance\|)) & Otherwise \end{cases}$
Adaptability	The ability to withstand and absorb an external shock and return to or change to a new state that is better than the state before the shock.	$y = a + bx (y = employment, x = time)$
Transformative resilience	The ability of a city to transform into one with higher resilience according to changes in multidimensional regional capacities in response to various external shocks.	$(Resilience\ 2(2022)/Resilience1(2012))$

ΔE_i^d: the observed change in the number of employees in region i during decline period,
$\Delta \widehat{E_i^d}$: the expected change based on the national change rate, E_i^d: the lowest employment point
E_i^0: the number in the first half of 2012 (2022) before the shock, E_i^r: the employment level at the endpoint
t_i^d: the trough, t_i^r : one year later from trough

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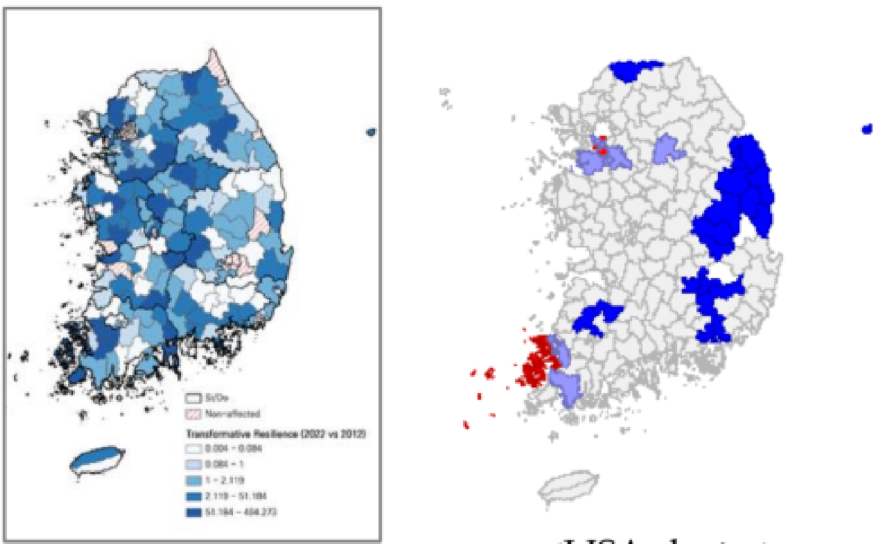
Table 2. The list of regional capacity variables.

Regional capacity			
Dimension	**Variable**	**Dimension**	**Variable**
Social	Volunteer participation	Institutional	Disaster compensation and relief fund
	Sense of belonging		Local safety index
	Social trust		Flood insurance
Human	Public officials		Water retention area
	Foreigner rate	Physical	Stormwater drainage
	Age diversity		Deteriorated house
Economic	Temporary & daily workers		Impervious area
	Business change rate	Environmental	Park area
	Industrial concentration		Green area
Control variables			
Population	Population growth	Hazard exposure	Property damage
	Urban		Human losses

Ⅳ. RESULTS AND ANALYSIS

Figure 2 shows the spatial distribution of transformative resilience and its spatial cluster. Table 3 analyzes the drivers of transformative resilience, measured as the ratio of resilience in 2022 to 2012, incorporating adaptability and disaster experience during the post-recovery period. Both adaptability and learning from shocks significantly enhance transformative resilience, increasing it by 1.67 and 1.69 times, respectively.



<Resilience level> <LISA cluster>

Figure 2. Spatial distribution and cluster of transformative resilience.

Social belonging strengthens resilience, while population diversity further promotes it (1.53-1.80 times). Economically, business change fosters resilience (+9.8%), whereas industrial concentration weakens it (-38%). Institutional improvements, such as expanding water retention basins and raising local safety index grades, enhance resilience (1.3-1.9 times). Physical deterioration, represented by old housing, lowers resilience (-11.3%), while increased green space improves it (+10.5%). Among control variables, population growth change positively influences transformative resilience (+24.7%). Overall, adaptability, social diversity, and institutional capacity emerge as critical drivers of long-term transformative resilience.

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Table 3. The result of GLM (influential factors of transformative resilience).

Dimension	Variable	Coef.	Exp (β)	Robust S.E.
Adaptability	Adaptability	.51281**	1.67	.25269
	Experience	.52267**	1.6865	.22699
Social capacity	Volunteer participation	-.01489	.9852	.01354
	Sense of belonging	.02795**	1.0283	.01428
	Social trust	.25393	1.2891	.38584
Human capacity	Public officials	-.07374	.9289	.10825
	Registered foreigners	.42449**	1.5288	.17964
	Age diversity	.58655*	1.7978	.31692
Economic capacity	Temporary/daily worker	.00092	1.0009	.02503
	Business change rate	.09364***	1.0982	.02601
	Industrial concentration	-.47985***	.6189	.13782
Institutional capacity	Disaster compensation relief fund	.08185	1.0853	.10017
	Water retention area	.25660*	1.2925	.14233
	Flood insurance	-.06213*	.9398	.03441
	Local safety index	.62577**	1.8697	.29778
Physical capacity	Stormwater drainage	.07350	1.0763	.07612
	Deteriorated house	-.11953***	.8873	.03147
	Impervious area	-.05545	.9461	.03819
Environmental capacity	Park area	.01387	1.014	.01039
	Green area	.09971*	1.1049	.05232
Control variables	Population growth	.22074***	1.247	.05022
	Urban area	.68181	1.9775	.72617
	Property damage	.04136	1.0422	.04953
	Human losses	-.01227	.9878	.00985
Cons		-1.4740	-	1.39596
Number of obs / df		177/152		
Log likelihood		-698.38588		
(1/df) Pearson		2.6416		
AIC		8.1739		
BIC		69.2652		

Ⅴ. CONCLUSION AND RECOMMENDATIONS

This study quantified transformative resilience across Korean municipalities affected by 2012 and 2022 disasters, revealing that adaptability, social capital, and population diversity are key drivers of resilience change over time. The findings emphasizes that resilience is not static but evolves through learning and multidimensional shifts in local capacity. However, data limitations and differences across worker groups constrained the analysis, suggesting that future research should incorporate detailed policy data and longer-term time-series approaches to capture dynamic resilience pathways.

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PARALLEL SESSION 4D

RESILIENT DESIGN & TECHNOLOGY

Session Moderators: Nicolo Precioso C. Del Castillo PhD

Utilization of weather data obtained from meteorological observation in schools for school disaster risk reduction management and education

Yusuke Yamane*[1]*, *Mitsuko Otsuyama*[2]*, Saki Arima-Shirai*[2]

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[2] SEEDS Asia

The Conceptualization and Implementation of Disaster Prevention Education Programs through Multistakeholder Collaboration - Case Study: Matsuyama City, Japan

Daniel Gjorgievski, *Roger Baars*

Kyoto University

EXTENDED ABSTRACTS

Utilization of Weather Data Obtained from Meteorological Observation in Schools for School Disaster Risk Reduction Management and Education

Yusuke Yamane[1]**,** Mitsuko Otsuyama[2], Saki Arima-Shirai[3]

ABSTRACT

The Philippines is highly prone to meteorological hazards, with increasing extreme events such as the record-breaking heatwave in April 2024 drawing national attention. In response, the Department of Education authorized school heads to decide on class suspensions or shifts to distance learning during extreme weather events. However, many schools lack localized weather observation equipment and clear criteria to support such decisions. This study examines how school-based weather observation can enhance disaster risk reduction (DRR) management and strengthen meteorological education through youth engagement.

Inabanga North Central Integrated School in Bohol Province was selected as the model site. An Automatic Weather Station (AWS) was installed to record meteorological situations in the school with real-time access available via mobile devices. Fifteen high school students, organized as the Youth Weather Observation Team (YoWOT), received capacity-building training and documented 354 pages of weather diaries, photos, and videos. They later conducted peer-to-peer lessons for Grade 4 learners (n:40) using analogue instruments, integrating observation-based learning into the classroom.

Post-training assessments showed significant improvement in meteorological knowledge and proactive behavior among YoWOT members, while younger learners demonstrated increased awareness of weather instruments and phenomena. The localized data also supported school-level decision-making, highlighting gaps with official PAGASA records. The study demonstrates that youth-led weather observation effectively bridges weather education and disaster management, fostering evidence-based action in hazard-prone school environments.

Keywords: weather, observation, education, decision-making, peer-to-peer, localized data

I. INTRODUCTION

The Philippines frequently experiences meteorological hazards such as typhoons, floods, and extreme heat (ADB, 2021). During the record-breaking heatwave of April 2024, the Department of Education (DepEd) authorized school heads to suspend face-to-face classes or shift to distance learning. However, many schools lack weather observation tools and clear criteria to guide such decisions. If weather observation is conducted in school, school head can take decision-making to ensure learner safety based on the weather data observed in school. In addition, weather data obtained in school can be utilized effectively in meteorological and disaster education for students (e.g., Takafuji et al. 2004, Yamane et al. 2017).

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Utilization of Weather Data Obtained from Meteorological Observation in Schools for School Disaster Risk Reduction Management and Education

Yusuke Yamane, Mitsuko Otsuyama, Saki Arima-Shirai

OFFICIAL STATEMENT

ON CLASS SUSPENSIONS AND SHIFTING TO ADM DUE TO HIGH HEAT INDEX, OTHER CALAMITIES

4 April 2024 - In light of the high heat index experienced in different parts of the country, the Department of Education (DepEd) reiterates the provisions of Department Order 037 issued in 2022, which provides guidelines on the cancellation or suspension of classes and work in schools in the event of natural disasters, power outages/power interruptions, and other calamities.

Specifically, DepEd has given the school heads the authority and discretion to suspend the conduct of in-person classes and shift to alternative delivery modes (ADM) in cases of extreme heat and other calamities that may compromise the health and safety of learners, teachers, and non-teaching personnel. This measure was the subject of OASOPS No. 2023-077 issued last 20 April 2023, and OUCT and OUOPS Memorandum dated 28 February 2023 (Implementation of Alternative Delivery Mode (ADM) in All Public Elementary and Secondary Schools).

Given that DepEd supervises more than 47,000 schools nationwide, it is in the best interest of the learning community to have localized assessments for timely response and interventions to ensure the welfare of learners and personnel.

Thank you.

Figure 1. Picture of Statement Post from DepEd on class suspensions and shifting to alternative delivery modes due to heat index, other calamities.

Source: Department of Education. Attributed from the official facebook post on April 4,2024 [Web].

II. OBJECTIVE

This study aimed to examine how school-based meteorological observation can (1) enhance evidence-based decision-making in Disaster Risk Reduction Management (DRRM), and (2) strengthen meteorological Disaster Risk Reduction Education (DRRE) through youth engagement. The research project was implemented by a collaborative team consisting of the authors from Tokoha University and SEEDS Asia, with Inabanga North Central Integrated School (INCIS) in Bohol Province, the Philippines, selected as the model school by DepEd and SEEDS Asia.

III. METHODOLOGY

To demonstrate how school-based meteorological observation can support decision-making in DRRM, an Automatic Weather Station (AWS; Vantage Pro2) was installed at Inabanga North Central Integrated school as a model school to record weather elements. The system allows real-time data access through a mobile application, enabling both teachers and students to monitor local conditions instantly. By comparing locally observed data with official announcements and records from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the project examined potential discrepancies that highlight the value of localized monitoring for school safety.

Fifteen high school students formed the Youth Weather Observation Team (YoWOT) and participated in a 1.5-day capacity-building program in August 2024. The training covered meteorological fundamentals, instrument operation, and the use of AWS data for disaster management and introduction of weather diary. Following the training, YoWOT members maintained individual weather diaries and collectively documented a total of 354 pages of local weather observations, photographs, and videos.

On February 12, 2025, YoWOT members completed a questionnaire assessing knowledge retention and behavioral changes since their initial training. Subsequently, during the final review session, they developed and conducted peer-to-peer lessons for 40 Grade-4 learners using analogue instruments such as thermometers, anemometers, and barometers following with national curriculum called MATATAG (DepEd., 2023). These interactive sessions integrated observation-based learning into the elementary science curriculum. After conducting the lessons, YoWOT members completed a post-session questionnaire to measure changes in knowledge and attitudes resulting from both observation and teaching experiences.

IV. RESULT

As DRRM perspective, on 20 July 2024, the AWS recorded an intense rainfall event of 44.6 mm within 30 minutes (Figure 2), while the nearest PAGASA station in Mactan reported only 2.2 mm over 24 hours (Table 1). This discrepancy highlighted the necessity of localized observation to support timely and evidence-based decision-making in school.

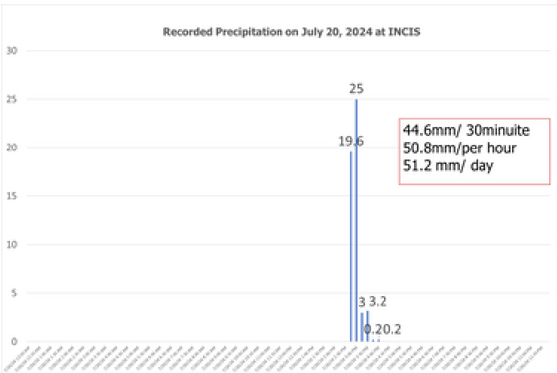

Figure 2. Trend graph of 15-minute rainfall generated based on the data extracted data by the installed AWS.

Figure 3. Condition of the elementary school, recorded at 15:08 (PST), showing side gutters in front of the classrooms nearly overflowing after 44.6 mm of rainfall within 30 minutes.

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Utilization of Weather Data Obtained from Meteorological Observation in Schools for School Disaster Risk Reduction Management and Education

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Table 1. PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) record for July 2024, highlighted in yellow by SEEDS Asia

Source: PAGASA

2024 July	Pressure	Temperature							Wind Speed/Direction	
Day of the Month	Station Pressure	Maximum	Minimum	**Mean**	Mean Relative Humidity	Rainfall (mm)	Heat Index	Average Speed (mps)	Prevailing Direction
1	1005.7	31.9	26.4	29.2	78	2.0	39	002	280
2	1007.2	31.0	27.0	29.0	84	3.8	36	001	090
3	1008.6	31.6	25.8	28.7	74	10.8	38	003	040
4	1007.3	29.2	25.8	27.5	88	5.8	34	002	220
5	1005.3	31.2	27.1	29.2	79	0.0	37	001	200
6	1006.1	31.8	27.1	29.5	71	0.0	38	002	060
7	1005.8	31.8	26.4	29.1	76	1.0	38	003	050
8	1005.6	32.5	24.7	28.6	80	74.8	39	002	190
9	1006.7	31.8	25.6	28.7	81	13.4	37	002	250
10	1006.9	31.2	26.2	28.7	82	T	38	002	040
11	1005.4	31.6	26.2	28.9	76	8.5	38	002	060
12	1003.9	30.2	26.2	28.2	82	2.5	36	002	200
13	1004.4	30.6	25.6	28.1	84	9.1	36	003	210
14	1005.4	30.3	25.0	27.7	80	73.4	35	003	220
15	1005.8	31.0	25.3	28.2	80	5.0	36	001	320
16	1005.9	29.4	25.2	27.3	82	15.3	35	002	020
17	1005.3	26.8	25.0	25.9	92	21.5	31	001	270
18	1005.8	30.0	25.3	27.7	86	5.7	36	002	220
19	1005.9	31.4	25.3	28.4	80	2.4	37	003	200
20	1006.6	32.4	26.0	29.2	75	2.2	38	003	200
21	1005.7	33.1	28.0	30.6	71	0.0	41	003	220
22	1005.3	33.0	27.7	30.4	70	0.0	40	004	220
23	1005.2	30.6	25.0	27.8	76	11.8	37	005	180
24	1004.3	31.2	27.2	29.2	80	T	38	003	200
25	1004.5	33.3	27.7	30.5	75	0.0	44	003	220
26	1006.4	33.6	27.2	30.4	73	T	39	003	180
27	1007.9	30.9	25.5	28.2	83	3.6	37	001	310
28	1006.9	32.0	25.2	28.6	82	12.4	39	002	360
29	1007.0	31.0	26.6	28.8	78	T	34	002	320
30	1007.8	32.4	26.0	29.2	78	0.0	33	002	320
31	1008.6	32.0	26.0	29.0	79	0.2	38	002	270
TOTAL	31189.2	970.8	809.3			285.2		072	
MEAN/ EXTREM E	1006.1	31.3	26.1	28.7	79			002	040

Following this, YoWOT members began posting advisory messages on the school bulletin board such as "Sudden rain is expected, so bring an umbrella," demonstrating the translation of meteorological data into daily disaster preparedness actions at the school level.

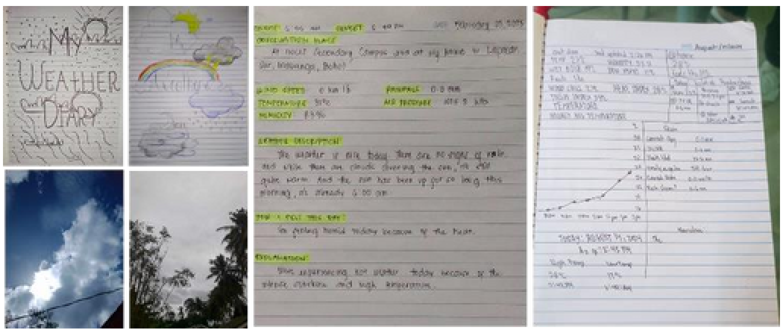

Figure 4. Collage picture of weather diary entries by YoWOT members.

Also, Post-training assessments indicated a marked improvement in the meteorological knowledge of YoWOT members, with average test scores increasing from 10.5 to 13 points.

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Analysis of the weather diaries showed that students who continued recording for more than five days achieved higher accuracy in identifying weather conditions and related impacts, suggesting both cognitive and behavioral engagement with local meteorological phenomena (Table 2).

Table 2. Relationship between average score of knowledge test and the period for which weather diaries were written.

	More than 5 days	Less than 5 days
No of students	7	7
Average score of knowledge test	11.85/12	7.99/12

During peer-to-peer sessions, 40 Grade 4 learners demonstrated significant improvement in identifying meteorological instruments such as thermometers, anemometers, and barometers, with recognition rates rising from 15% before the session to 51% after the session. This confirmed the effectiveness of youth-led, hands-on weather education in fostering early understanding of weather at certain level.

Figure 5. Peer-to-peer session conducted by YoWOT members.

V. CONCLUSION

This study demonstrated that integrating school-based meteorological observation with educational activities can significantly enhance both meteorological literacy and DRRM at the school level. The installation of an AWS enabled the collection of localized, real-time data, providing evidence for informed decision-making—particularly in situations where official PAGASA data were insufficient to capture micro-scale conditions.

Through capacity-building and youth participation, high school students became capable of interpreting meteorological data, communicating risks, and promoting a culture of safety within their school community. The peer-to-peer lessons further extended these benefits to younger learners, reinforcing scientific curiosity and practical awareness from an early stage.

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The project demonstrated the potential of youth-led weather observation as an effective educational and DRRM approach that bridges science learning and protective action. It also provides a scalable model for integrating localized meteorological monitoring into the formal education system in the country.

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This research project was implemented with the generous support of the WNI WxBunka Foundation, whose assistance made it possible to conduct the activities and achieve the outcomes described in this study.

The authors wish to express their sincere appreciation to INCIS for serving as the model school, and to DepEd Region VII and Bohol Division Office for their continued collaboration and guidance throughout the implementation.

Special thanks are also extended to the teachers and students—particularly the members of YoWOT for their active participation and commitment, which made this project meaningful and impactful.

Conceptualization and implementation of disaster prevention education programs through multistakeholder collaboration: The case study of Matsuyama City, Japan

Daniel Gjorgievski, Roger Baars

ABSTRACT

Disaster Prevention Education (DPE) is crucial for building resilient communities and reducing vulnerability to natural hazards, especially in disaster-prone regions such as Japan. Although significant investment has been made in developing DPE curricula and engaging communities, less attention has focused on fostering collaboration among diverse stakeholders during the planning and implementation phases of educational programs.

This study investigates stakeholder interactions in the development and implementation of a DPE program in Matsuyama City (Japan), focusing on collaboration among governments, schools, non-governmental organizations, community groups, and academic institutions. Using a mixed-method approach, the research examines the "Seamless All-Generation Disaster Prevention Education Program" as an exemplar of collaborative educational planning.

Data collection involved semi-structured interviews with key stakeholders and participant surveys to evaluate the roles, contributions, advantages, and challenges faced during both the conceptualization and implementation phases. The findings reveal critical success factors for effective stakeholder engagement and identify common advantages and barriers to collaboration in DPE.

The study provides a detailed framework that offers practical guidance for developing more effective DPE programs in Japan and beyond.

Keywords: Disaster Prevention Education, Matsuyama City, Seamless All-Generation Disaster Prevention Education Program

I. INTRODUCTION

Disaster Prevention Education (DPE) is vital for building resilient communities, especially in disaster-prone regions like Japan. This study examines Matsuyama City's " Seamless All-Generation Disaster Prevention Education Program", launched in 2019, to promote intergenerational disaster education through a collaborative approach. Despite significant investment in DPE curricula and community engagement, limited attention has been paid to stakeholder collaboration during planning and implementation phases. The literature reveals knowledge gaps in such multi-stakeholder cooperation, where efforts to build consensus often encounter practical challenges and conflicts among stakeholders. (Okunola, 2024) This study explores stakeholder interactions in developing and implementing DPE, focusing on collaboration among governments, schools, NGOs, community groups, and academic institutions.

II. RESEARCH OBJECTIVES AND QUESTIONS

The study examines collaboration processes among different stakeholders during conceptualization and implementation phases, as well as the challenges and opportunities that emerge. Two research questions guide the investigation:

1. What are the advantages and challenges associated with the conceptualization phase of the DPE program?

Conceptualization and implementation of disaster prevention education programs through multistakeholder collaboration: The case study of Matsuyama City, Japan

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2. What are the advantages and challenges encountered during the implementation phase of the DPE program?

III. METHODOLOGY

A mixed-method approach was adopted, combining surveys and semi-structured interviews. The survey targeted two groups: 1) Matsuyama City's disaster prevention program participants and 2) members of the Matsuyama City Disaster Prevention Education Council, with selected council members also being interviewed. This dual approach enabled a better understanding of the program from both organizational and participatory perspectives. A total of 89 participants—including civil servants, private or corporate members, teachers, students, NPOs, and residents of various ages—completed the survey, while 8 council members participated in interviews.

IV. RESULTS

A. Survey Analysis

Regarding the effectiveness of collaborative approaches, 89.9% of surveyed participants expressed favorable views (65.2% strongly agree, 24.7% agree), with an average score of 4.3 (SD = 1.114). These findings align with recent studies emphasizing that multi-stakeholder collaboration enhances disaster management through pooled resources and expertise (Johnson et al., 2023; Octaviana, 2025; Okunola, 2024). However, these overwhelmingly positive responses warrant further careful interpretation. Kaliterna and Eklund (2025) note that despite widespread endorsement of multi-stakeholder partnerships (MSP), significant implementation challenges persist, with partnerships often failing to realize their full potential.

B. Thematic Analysis

Six key themes emerged from open-ended responses: 1) disaster awareness, 2) capacity building, 3) institutional support and program structure, 4) inclusivity and accessibility, 5) collaboration, coordination, communication, and networking, and 6) experiential and practical learning.

Regarding collaboration, participants noted that "the program is designed through the involvement of various organizations," establishing a structured multi-stakeholder framework that enhances disaster literacy. However, challenges arise when "the interface for collaboration" functions poorly, particularly when roles are ambiguously defined, communication is deficient, and stakeholder engagement is inadequate.

C. Interview Insights

A council member from the Matsuyama Chamber of Commerce and Industry highlighted the need for continuous adaptation: "Japan is facing a declining birthrate, an aging population, and overall population decline, raising concerns that traditional disaster prevention measures may be insufficient to maintain community functions after a disaster. Given these societal changes, it is necessary to update disaster prevention strategies continuously, and the program itself should be regularly reviewed and adapted to reflect current realities."

Conceptualization and implementation of disaster prevention education programs through multistakeholder collaboration: The case study of Matsuyama City, Japan

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V. DISCUSSION AND CONCLUSION

The results highlight the effectiveness of the collaborative approach in Matsuyama City's DPE program across multiple dimensions. However, specific challenges remain, particularly in role clarification, communication mechanisms, and sustained stakeholder engagement.

This study advances the field of disaster prevention education by providing a detailed framework for stakeholder collaboration in DPE programs. The framework addresses both structural and procedural elements essential for sustainable multi-stakeholder partnerships, offering practical guidance for developing more effective programs in DPE, while acknowledging the gap between idealized collaboration and implementation realities.

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EXTENDED ABSTRACTS

PARALLEL SESSION 5A

CITIZEN SCIENCE

Session Moderator: Michael T. Ang PhD

Earthquake Numerical Simulation for Catastrophe Modelling: Study Case in Greater Jakarta Region

Dzaky Irfansyah, *Alif Azfar Badaruddin*
PT Reasuransi MAIPARK, Indonesia

Geomorphological Changes and Management Strategies for the Marikina River: A 20-Year Assessment of Erosion and Accretion Dynamics

Camille Cassandra Albon Avila, *Madonna P. Danao*
College of Architecture, University of the Philippines-Diliman

Understanding Urban Flood Risks in Varanasi Through Climate Trends and Land Use Changes

Shahensha Sarkar, *Narender Verma*
Department of Geography, Banaras Hindu University, India

EXTENDED ABSTRACTS

Earthquake Numerical Simulation for Catastrophe Modelling: Study Case in Greater Jakarta Region

Dzaky Irfansyah[1]**,** Alif Azfar Badaruddin[2]

ABSTRACT

Jakarta is Indonesia's largest city in an active seismic zone and faces high earthquake risk. However, risk can be potentially enhanced by basin amplification from deep sedimentary structure beneath Jakarta. Both geological complexity and economic importance of Jakarta push for accurate ground motion modelling (GMM). While Ground Motion Prediction Equation (GMPE) has been widely used in GMM, there has not been an Indonesia-specific GMPE to address local geology, such as soft soil and complex basin structure, to capture amplification factor in seismic hazard design. To incorporate Jakarta Basin in GMM, we use numerical simulation by putting subsurface model (layering & structure) and event catalogue in virtual domain to simulate earthquake propagation. In the absence of Indonesian GMPE, we compare results with the global GMPE set from the Pacific Earthquake Engineering Research (PEER) Center. Numerical simulation results in irregular Modified Mercalli Intensity (MMI) distribution that reflects basin amplification, with some events forming "belt zone", reaching up to MMI XI (Violent). In contrast, GMPE creates underestimated ground motion for events above Mw6.0 given the exclusion of Jakarta Basin. In our CAT Model, numerical simulation leads to higher average annual loss (AAL) more than 7 times higher than GMPE in financial loss calculation, which is caused by higher MMI scale by 2-3 due to basin amplification. Numerical simulations that consider basin amplification in CAT Model will enable more accurate risk calculation for a region with huge economic value like Jakarta.

Keywords: basin amplification, Ground Motion Model, numerical simulation, CAT model

I. INTRODUCTION

Jakarta is one of the largest cities in Southeast Asia and Indonesia's economic hub. Jakarta is located on the island of Java, the most populous island in Indonesia. The island lies to the north of Sunda Arc where the Australian Plate is subducting beneath Sunda block. The tectonic plate boundaries also lead to the distribution of shallow crustal faults across the island (Koulali, et al., 2017), including presumably active faults around Jakarta (Supendi, et al., 2025). This makes Jakarta poses high earthquake risk due to its proximity to earthquake sources. However, the earthquake risk might not be contributed by distances to fault alone. Jakarta is situated on soft sedimentary basin, where it could create stronger ground motion due to its soft lithology and basin geometries that may entrap seismic waves to propagate outward (Rial, Satlzman, & Ling, 1992). Basin amplification has been observed such as in Mexico City during 1985 Michoacan earthquake (Singh & Ordaz, 1993). The existence of sedimentary basin below Jakarta make Jakarta potentially susceptible to similar hazards.

Both geological complexity and economic significance of Jakarta lead to larger needs for accurate ground motion modelling (GMM). While Ground Motion Prediction Equation (GMPE) has been widely used as conventional GMM for seismic hazard analysis due to its relative ease of implementation and low computational cost (Douglas & Edwards, 2016), there is currently no local or Indonesia-specific GMPE that accounts for geological characteristics like soft lithology and basin structure, which are essential for incorporating amplification in seismic hazard design for Indonesia. In the absence of specific GMPE, physics-based earthquake numerical

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simulation can be employed. These simulations use theoretical propagation of seismic waves to mimic seismic response when encountering heterogeneous properties and record the synthetic ground motion. The method can be used in an area where there is no modern record of devastating earthquake in the face of potentially high earthquake risk like Jakarta. This study aims to enhance earthquake risk assessment by comparing numerical simulation with those obtained using conventional GMPE-based approaches for Greater Jakarta region.

II. DATA AND METHODOLOGY

This research implemented numerical simulations by embedding subsurface model and Baribis Fault event scenarios in virtual domain to replicate earthquake propagation.

The subsurface model of Jakarta was adopted from a previous geophysical study (Ry, Cummins, Herjani, & Widiyantoro, 2023). The Baribis Fault was selected as the earthquake source in this study, as it has recently been identified as the nearest seismic source to Jakarta yet not considered in the current national hazard map of Indonesia (Widiyantoro, et al., 2022). Event scenarios for Baribis Fault were constructed based on fault parameters suggested by Widiyantoro et al., 2022 (Table 1).

Table 1. Baribis Fault parameters used in this study, based on Widiyantoro et al., 2022.

Fault Parameters	Value
Maximum magnitude (Mw)	7.5
Dip (degrees)	57
Slip rate (mm/yr)	5
Fault type	Reverse fault
Fault length	100 km

We used SPECFEM2D (Jeroen, Komatitsch, & Liu, 2008) to run 2D simulation to run 202 events and extract Peak Ground Acceleration (PGA) from synthetic seismogram of each simulation to compare it with PGA calculated by global GMPE set from the Pacific Earthquake Engineering Research (PEER). The PGA would then be converted to Modified Mercalli Intensity (MMI), as ground motion intensity parameter which more common for public due to its quantitative description of earthquake shaking intensity level. In addition, the MMI is also displayed in shake map format for visual comparison.

Table 2. GMPE equations used in this study.

Equation	Reference	Weight
Ground motion prediction equation (GMPE)	(Abrahamson, Silva, & Kamai, 2014)	0.25
	(Boore, Stewart, Seyhan, & Atkinson, 2014)	0.25
	(Campbell & Bozorgnia, 2014)	0.25
	(Chiou & Youngs, 2014)	0.25
Ground motion to intensity conversion equation (GMICE)	(Worden, Gerstenberger, Rhoades, & Wald, 2012)	1

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The Vs30 data from the United States Geological Survey (USGS) (Wald & Allen, 2007) (Heath,, Wald, Thompson, & Scmocyk, 2020) were used as soil parameters to incorporate local-site effect for GMPE-based approach.

III. RESULTS AND ANALYSIS

The result shows notable differences between numerical simulations and GMPE. GMPE creates radial pattern of MMI distribution of ShakeMap, which reflects more on earthquake geometrical spreading (Figure 1). In contrast, numerical simulations produce irregular MMI distribution, particularly higher MMI within Jakarta Basin that indicates stronger ground motion due to basin amplification (Figure 2). Numerical simulations integrate more local geology than GMPE with its Vs30 parameter, which creates complex ground motion distribution and might be unique in different event. It is reflected on heterogeneous structures across the basin, with deep elongated basin depression in southern Jakarta might concentrate amplification, creating more severe ground motion than anywhere within basin area to manifest as belt-shaped zone of higher MMI. Higher ground motion area that forms as concentrated zone might lead to "damage belt", a narrow zone of severe damage like the one in 1995 Kobe Earthquake (Kawase, 1996).

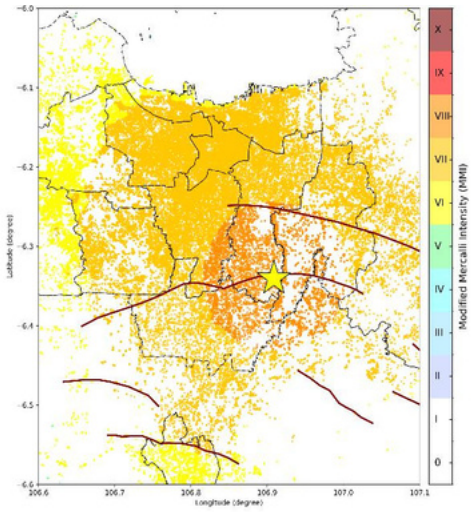

Figure 1. Shakemap MMI Distribution from GMPE of Mw6.5 Baribis Fault events.

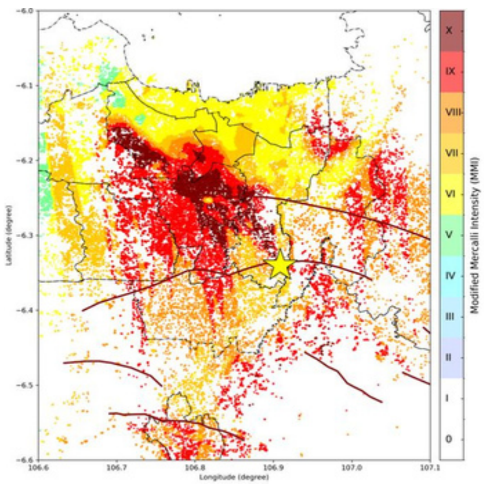

Figure 2. Shakemap MMI Distribution from numerical simulation of same Mw6.5 event as Figure 1.

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Numerical simulation produces smaller-to-zero losses compared to GMPEs for below Mw6 event and conversely, higher losses for numerical simulation from events with magnitude above Mw6.

To evaluate the impact of both the numerical and GMPE-based approach on economic risk or loss, we used catastrophe model comprising hazard, vulnerability, and inventory module (Grossi & Kunreuther, 2005):

$$Loss = hazard\ x\ vulnerability\ x\ inventory \qquad (1)$$

The MAIPARK Catastrophe Model (MCM)—an in-house model developed by MAIPARK—was utilized for this study. Dummy data were applied for both vulnerability and inventory module, as the primary objective of this study is to compare the effect of the hazard module on the resulting loss estimates.

Risk level was quantified in terms of Average Annual Loss (AAL), representing the expected loss for each year in average. AAL can be calculated as a function of annual probability of event occurrence *pi* and an associated loss *Li* (Grossi & Kunreuther, 2005):

$$AAL = \sum_i p_i L_i \qquad (2)$$

The numerical simulation approach produced AAL in percentage of inventory up to seven times higher than those derived from GMPE approach, with AAL values of 0.054% and 0.0073%, respectively. This is due to granularity of numerical simulation to capture basin amplification which resulting higher intensity, especially on large magnitude events.

IV. CONCLUSION AND RECOMMENDATIONS

The application of numerical simulations within catastrophe modeling (CAT-Model) provides a more detailed representation of earthquake hazard, particularly for large-magnitude scenarios. This approach helps to prevent loss underestimation by capturing complex local effects—such as basin amplification—and reduces uncertainty through the incorporation of locally derived geological and geophysical data. Compared to the conventional GMPE-based approach, numerical simulations demonstrate their potential to enhance the accuracy and reliability of seismic risk assessment, especially in urban areas like Jakarta that are characterized by heterogeneous subsurface conditions.

To further improve the robustness and applicability of this study, future research is recommended to:

1. Utilize the most recent seismic source parameters that incorporate the updated segmentation of the Baribis Fault; and
2. Employ actual exposure datasets and corresponding vulnerability functions to more accurately reflect the true level of seismic risk.

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Geomorphological Changes and Management Strategies for the Marikina River: A 20-Year Assessment of Erosion and Accretion Dynamics

Camille Cassandra Albon Avila[1], Madonna P. Danao[2]

ABSTRACT

The Marikina River, a principal river channel that supports Metro Manila's urban areas as well as the agricultural and natural landscapes along its course, continues to undergo geomorphological changes that threaten the stability of its banks. Increasing land use pressures and more frequent hydrometeorological events have intensified erosion and accretion processes, making it critical to assess which sections are most susceptible to degradation. This study examines the river's bank dynamics from 2004 to 2024, focusing on how erosion and accretion have reshaped its morphology across natural, agricultural, and urban segments. Using satellite imagery, time-series mapping, field observations, and a scoring-based Multi-Criteria Decision Analysis (MCDA), 77 river edge profiles were evaluated based on slope, soil type, land use, vegetation cover, and flood susceptibility. Results show that most profiles were in degraded or moderately stable condition: 2 profiles qualified for Preservation, 24 for Conservation, 42 for Improvement, and 9 for Creation, indicating high susceptibility and the need for major intervention. Erosion-dominant trends were more common in natural and agricultural areas with steep slopes, sparse vegetation, and unstable soil. Urban segments remained relatively stable due to engineered protections, though some localized changes still occurred. This study proposes tailored management strategies such as replanting vegetation, erosion control, and soil stabilization. It also offers a replicable framework for identifying riverbank susceptibility and informing resilience-based planning in fluvial systems.

Keywords: Geomorphological dynamics; Marikina River; Bank erosion; Accretion; Multi-Criteria Decision Analysis (MCDA); River resilience

I. INTRODUCTION

The Marikina River, stretching approximately 30 kilometers from Wawa Dam to its confluence with the Pasig River, is a key tributary of the Marikina River Basin (Figure 1). Originating from the Sierra Madre Mountains, it traverses natural forests, agricultural lands, and urban centers, supporting both ecosystems and densely populated communities (Figure 2). However, the river's banks continue to experience significant geomorphological changes that threaten stability and increase flood risk.

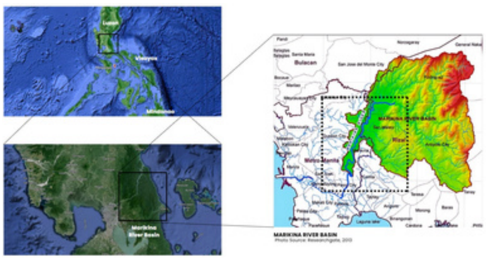

Figure 1. Marikina River Basin from Development, Calibration and Validation of a Flood Model for Marikina River Basin, Philippines and its applications for flood forecasting, reconstruction, and hazard mapping (Adapted).
Source: Research Gate (2013).

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EXTENDED ABSTRACTS

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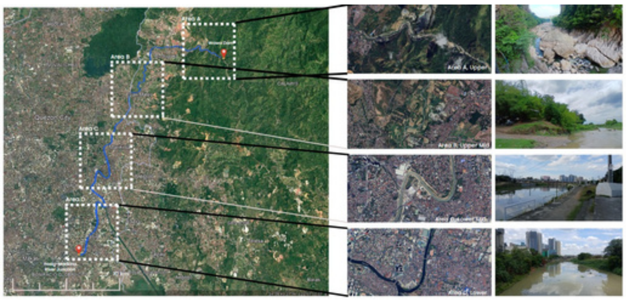

Figure 2. Satellite Photos of Marikina River (Adapted).
Source: Google Earth (2024).

The geomorphological processes of erosion and accretion drive much of the river's change (Figure 3). Erosion occurs along outer bends or steep slopes with unstable soil and sparse vegetation, leading to the retreat of riverbanks and loss of land. In contrast, accretion takes place on inner bends where sediments are deposited, forming bars and floodplains that reshape the channel over time (Charlton, 2008). These natural processes are influenced by river hydraulics, bank material composition, topographic slope (Fan et al., 2020), and vegetative cover (Luna, 2016), but can be greatly intensified by human and climatic factors (Chen et al., 2023).

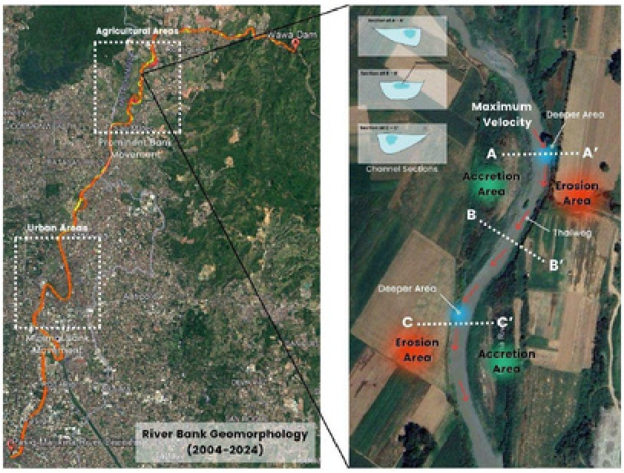

Figure 3. Satellite Photos of Marikina River Stream Segment (Adapted).
Source: Google Earth (2024).

Figure 4. Marikina river dredging (left) & Untreated wastewater inflow from market (right).
Source: Author (2025).

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Figure 5. Temporal accretion on previously eroded banks in agricultural land.
Source: Author (2025).

Rapid urbanization has replaced vegetated areas with impermeable surfaces, while deforestation, quarrying, and land conversion have altered runoff and sediment balance (Iglesias & Yu, 2008) (Figure 4). These disturbances have accelerated erosion (Figure 5) and siltation, especially during major typhoons such as 2009 Ondoy, 2014 Glenda, 2020 Ulysses, and 2024 Carina, which trigger abrupt morphological shifts (Grove et al., 2013; Zhang, 2022) (Figure 6 & 7). In urban zones, floodwalls and riprap provide localized protection but disrupt natural flow, often transferring erosion downstream (Villa Juan, 2004).

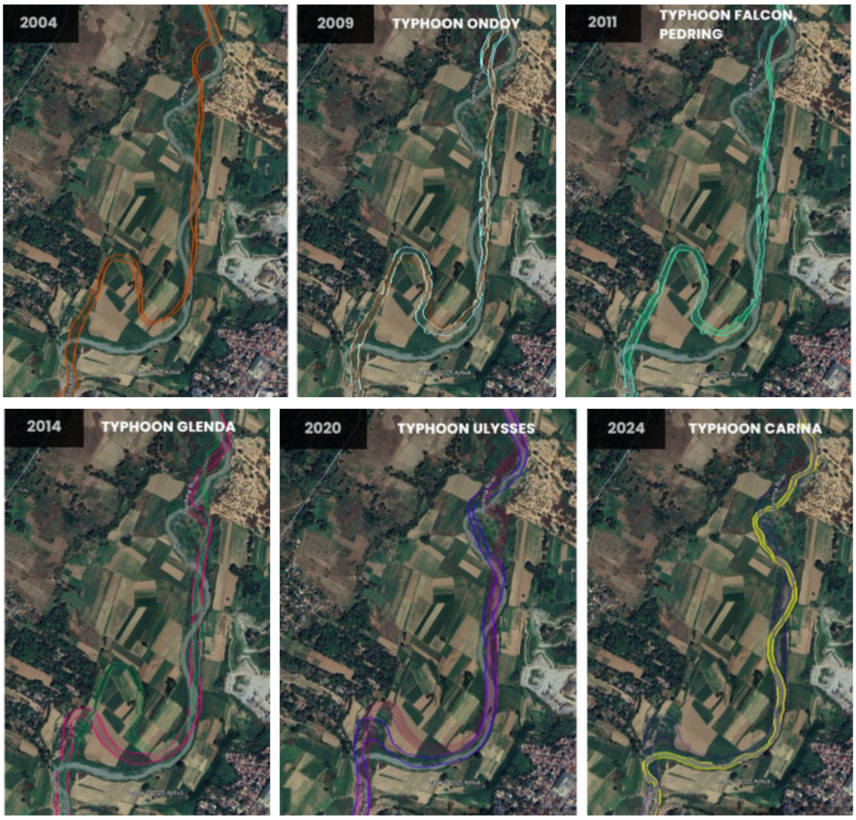

Figure 6. Satellite Photos of Marikina River Stream Segment Showing Bank Movement from 2004-2024 (Adapted).
Source: Google Earth (2024).

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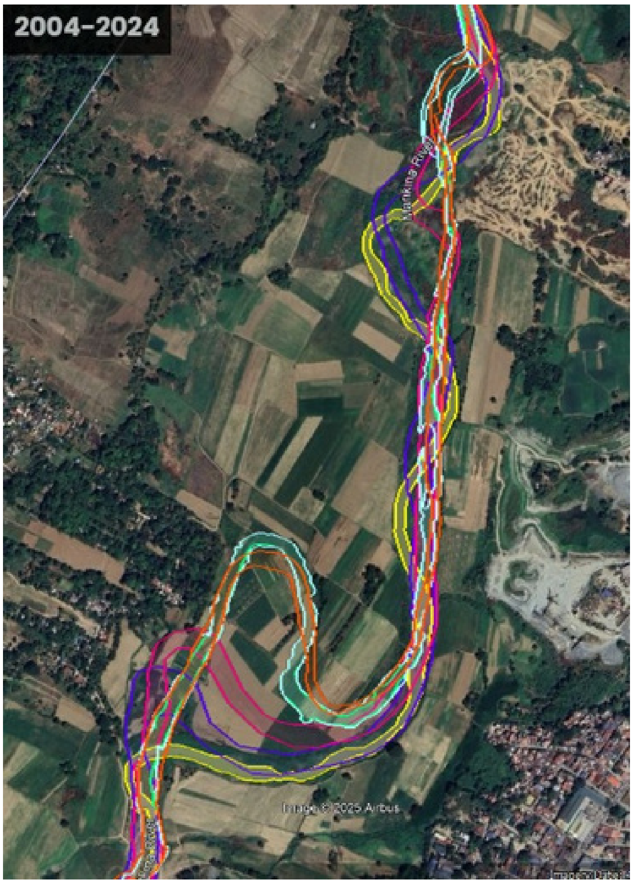

Figure 6. Satellite Photo of Marikina River Stream Segment Showing Overlayed Bank Movement from 2004-2024 (Adapted).
Source: Google Earth (2024).

Understanding how natural, hydrological, and human factors interact through the continuous cycle of erosion and accretion is essential for identifying vulnerable areas and formulating sustainable riverbank management strategies.

II. STUDY SCOPE & METHODS

The study assessed the geomorphological dynamics of the Marikina River, emphasizing the relationship between bank attributes and erosion–accretion processes. The 35-km stretch from the Pasig River junction to Wawa Dam was divided into three representative zones: a natural area in Montalban, an agricultural area in San Mateo, and an urban area in Marikina and Pasig. Each 5-km zone was subdivided into 1-km segments, with a 50-m buffer on both sides of the channel to capture active riparian processes. In total, 15 km of river length and 1.5 km^2 of edge zones were analyzed. (Figure 8)

Temporal assessment covered 2004–2024, focusing on intervals following major typhoons: 2004–2009 Ondoy, 2009–2011 Falcon and Pedring, 2011–2014 Glenda, 2014–2020 Ulysses, and 2020–2024 Carina. Methods included adapted satellite imagery analysis (Billah, 2018) (Figure 9), field verification (Figure 11, 12, 13), and profiling (Pukowiec-Kurda et al., 2019) (Figure 10), and evaluation through Multi-Criteria Decision Analysis (MCDA) (Navarra, 2013).

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Parameters: slope, soil, vegetation, land use, and flood susceptibility guided the scoring and classification of riverbank condition, leading to area-specific management recommendations. (Figures 14, 15, 16)

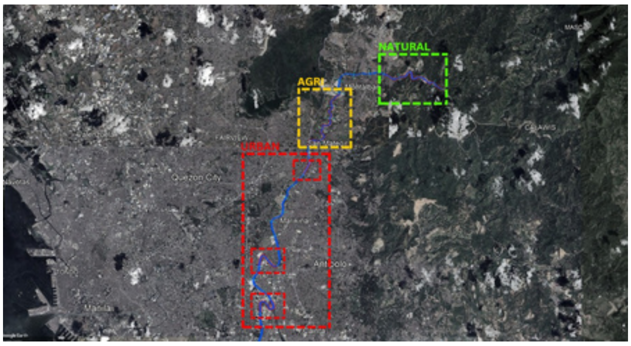

Figure 8. Satellite photos of Marikina river study area & extents (Adapted).
Source: Google Earth (2024).

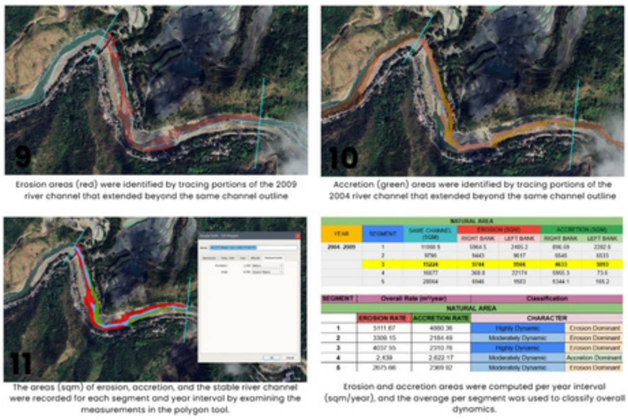

Figure 9. Satellite Photos of Marikina River Stream Segment Showing Steps 9-11 of Bank Erosion-Accretion Mapping (Adapted).
Source: Google Earth (2024).

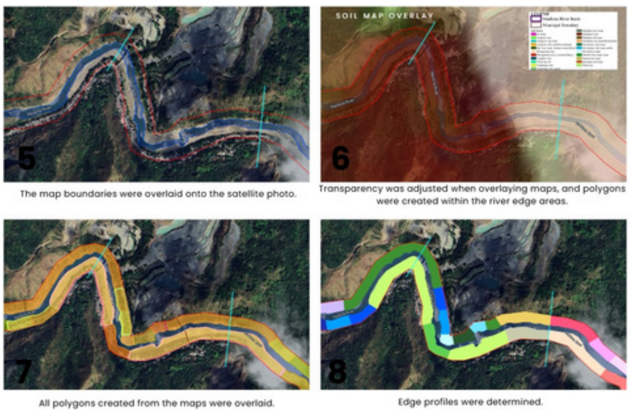

Figure 10. Satellite Photos of Marikina River Stream Segment Showing Steps 5-8 of River Edge Profiling (Adapted).
Source: Google Earth (2024).

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Figure 11. Sample field photos of the natural study area.

Figure 12. Sample field photos of the agricultural study area.

Figure 13. Sample field photos of the urban study area.

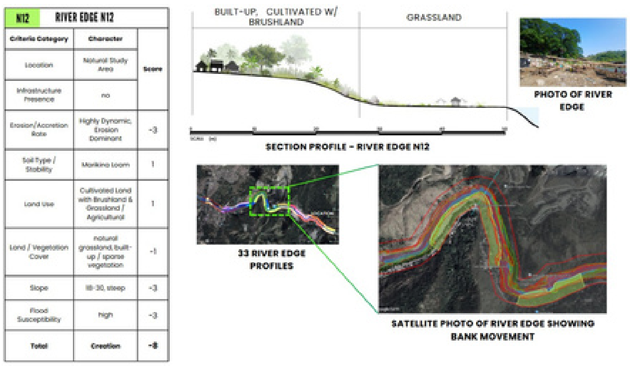

Figure 14. Example of evaluated & profiled river edge in the natural study area (Adapted).
Source: Photo by Author (2025), Satellite images from Google Earth (2024).

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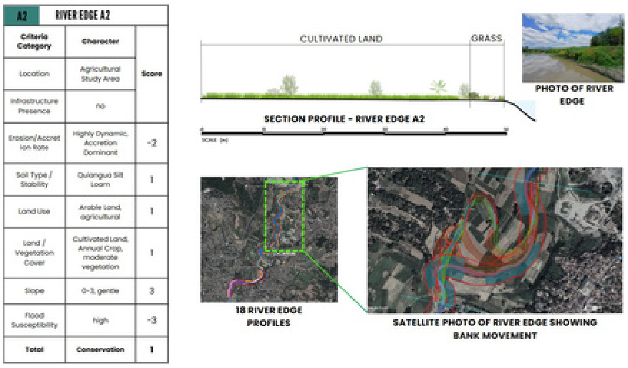


Figure 15. Example of evaluated & profiled river edge in the agricultural study area.
Source: Photo by Author (2025), Satellite images from Google Earth (2024)

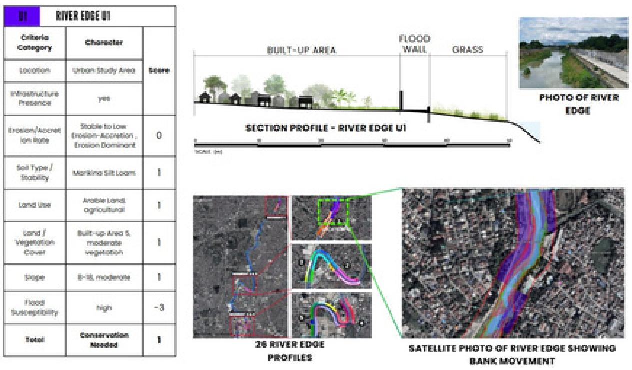
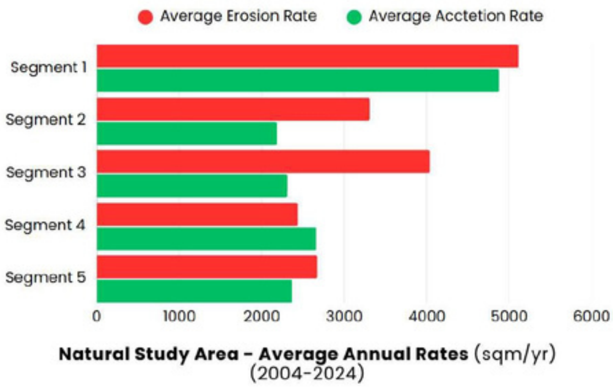


Figure 16. Example of evaluated & profiled river edge in the urban study area (Adapted).
Source: Photo by Author (2025), Satellite images from Google Earth (2024)

III. RESULTS & DISCUSSION

From 2004–2024, erosion and accretion patterns varied by landscape type (Figure 17). Agricultural zones showed the most dynamic shifts due to unstable soils and sparse vegetation (Figure 19). Natural areas experienced alternating erosion and deposition (Figure 18), while urban zones remained relatively stable due to engineered reinforcement, though localized erosion persisted (Figure 20).



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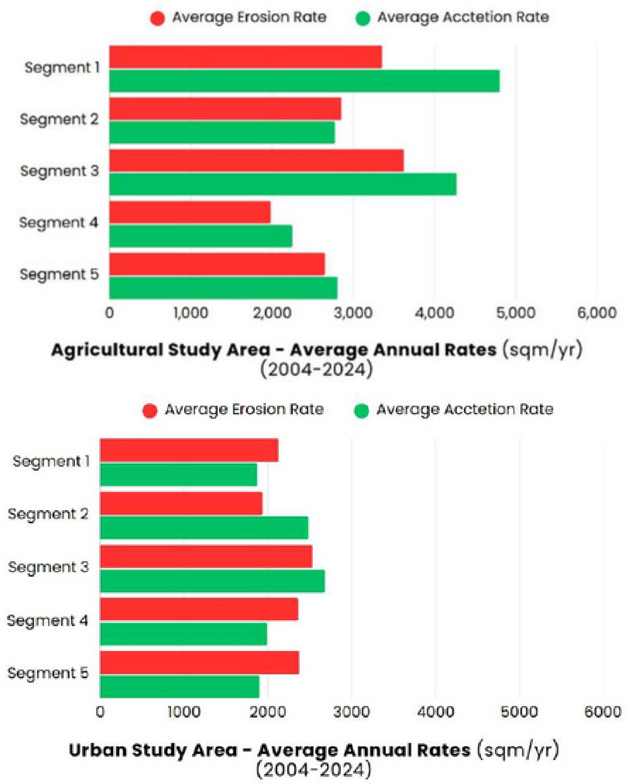

Figure 17. Summary of bank erosion & accretion rates 2004-2024 in Natural, Agricultural, and Urban Study Areas.

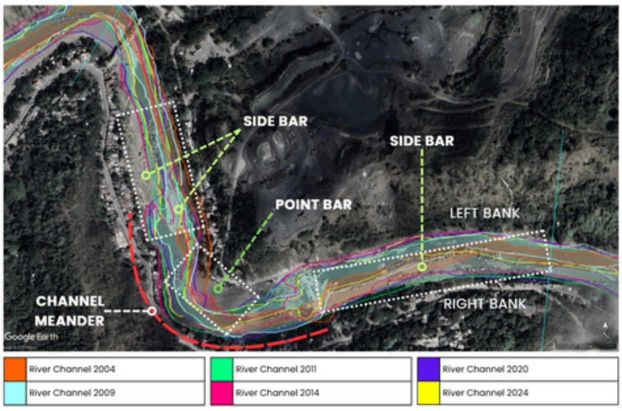

Figure 18. Natural study area segment 3 - 2004-2024 river channel (Adapted).
Source: Google Earth (2024)

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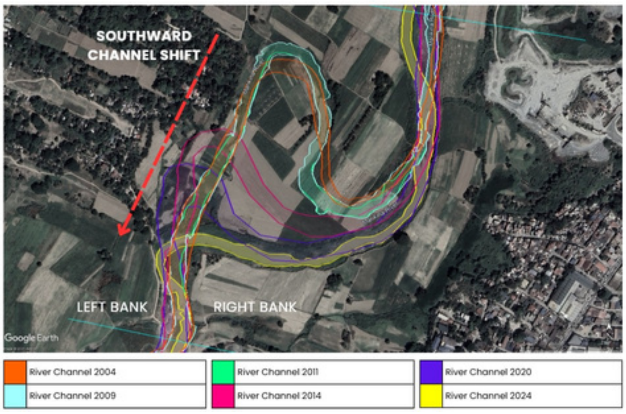

Figure 19. Agricultural study area segment 3 - 2020 -2024 river channel (Adapted).
Source: Google Earth (2024)

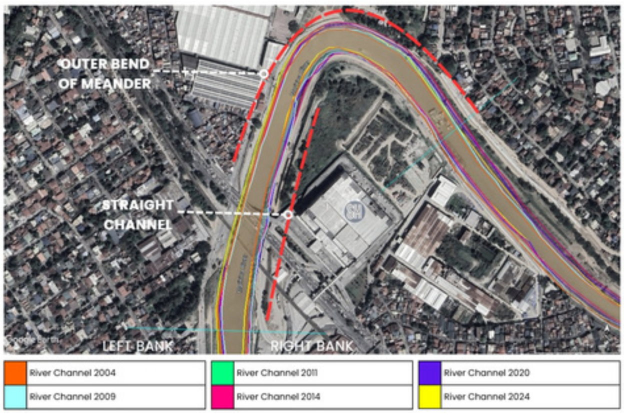

Figure 20. Urban study area segment 3 - 2004 vs 2024 river channel (Adapted).
Source: Google Earth (2024)

Of the 77 profiles analyzed, 2 were classified under Preservation, 24 under Conservation, 42 under Improvement, and 9 under Creation, indicating widespread degradation but also restoration potential (Figure 21, 22, 23). The results reveal that no single factor drives riverbank change; rather, the interaction of slope, soil, vegetation, and flood exposure governs geomorphic behavior.

Natural zones eroded rapidly where steep slopes and land disturbance weakened soils, while agricultural areas supported accretion when vegetation and soil cohesion were present. In urban zones, cohesive clay loam and structural controls confined erosion and promoted limited sediment buildup.

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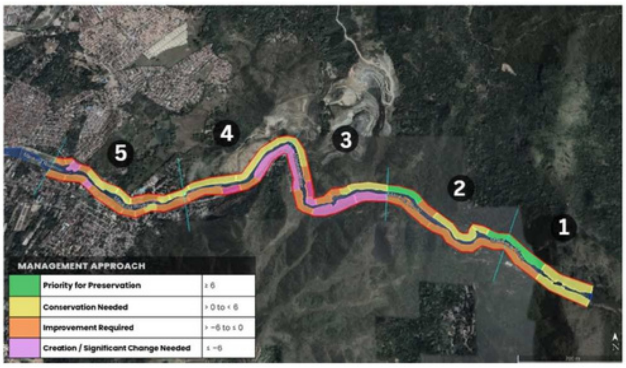


Figure 21. Natural study area Management Approach (Adapted).
Source: Google Earth (2024)

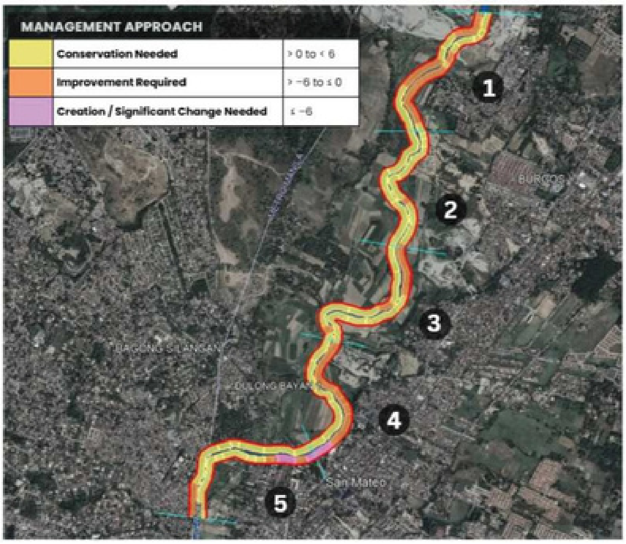


Figure 22. Agricultural study area Management Approach(Adapted).
Source: Google Earth (2024)

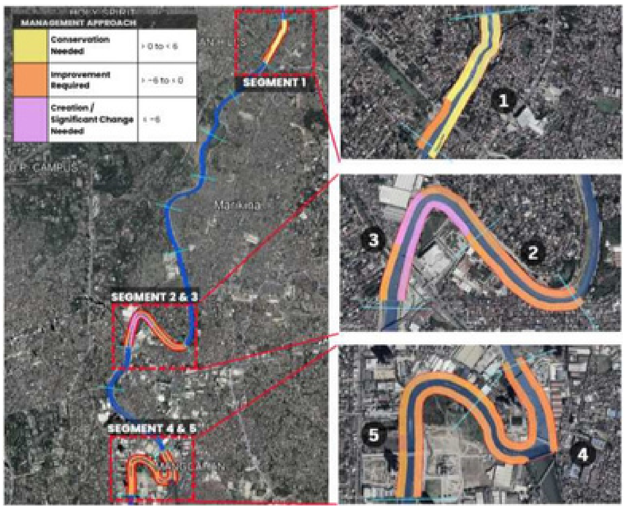
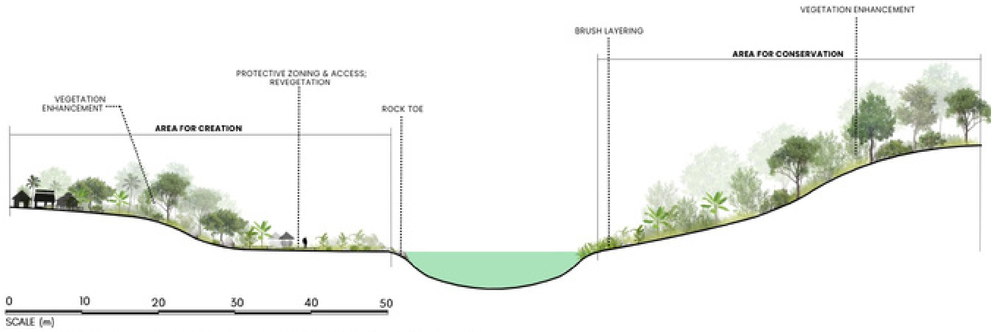


Figure 22. Urban study area Management Approach(Adapted).
Source: Google Earth (2024)

Management approaches were formulated per area:

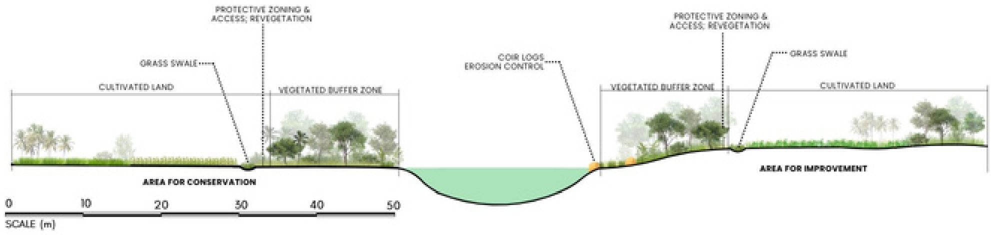
- Natural areas need protection of stable segments, reforestation, and runoff control in disturbed zones.



SECTION PROFILES - RIVER EDGE N12 (LEFT) & N14 (RIGHT)

Figure 24. Example elevation of applied management strategies on river edge N12 - area for creation (left) & N14 - area for conservation (right) in the natural study area.

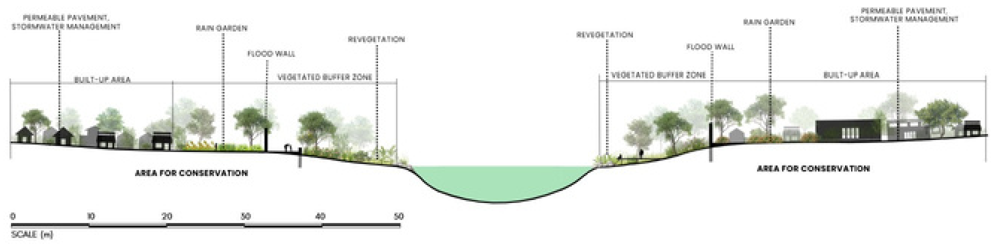
- Agricultural areas require buffer reinforcement, riparian replanting, soft-engineering erosion control, and land-use regulation near banks.



SECTION PROFILES - RIVER EDGE A2 (LEFT) & A4 (RIGHT)

Figure 25. Example elevation of applied management strategies on river edge A2 - area for conservation (left) & A4 - area for improvement (right) in the agricultural study area.

- Urban areas benefit from hybrid nature-based solutions: vegetated ripraps, bioswales, and green belts to balance flood control with ecological recovery.



SECTION PROFILES - RIVER EDGE U1 (LEFT) & U2 (RIGHT)

Figure 26. Example elevation of applied management strategies on river edge U1 - area for conservation (left) & U2 - area for conservation (right) in the urban study area.

The results emphasize that sustainable riverbank management requires aligning natural geomorphic processes with adaptive, site-specific interventions. The integration of time-series mapping and MCDA offers a systematic and transferable approach for evaluating riverbank stability and informing long-term landscape planning.

Geomorphological Changes and Management Strategies for the Marikina River: A 20-Year Assessment of Erosion and Accretion Dynamics

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IV. CONCLUSION

The study revealed how erosion and accretion reshaped the Marikina River's morphology from 2004–2024, highlighting the influence of slope, soil, vegetation, land use, and flood susceptibility on bank stability. Using Google Earth Pro and a scoring-based approach, it demonstrated a practical framework for geomorphological assessment even without advanced GIS tools. Most riverbanks were moderately stable to degraded, emphasizing the need for targeted management.

While engineered structures in urban areas offer short-term protection, they often redirect erosive energy downstream, leading to channelization and ecological decline. In contrast, nature-based approaches such as restoring riparian vegetation and allowing controlled channel movement promote long-term resilience. Future river management should focus on integrating updated hydrological data, local participation, and nature-based design to strengthen adaptive and sustainable riverbank management in the Marikina River and similar fluvial systems.

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Understanding Urban Flood Risks in Varanasi Through Climate Trends and Land Use Changes

Shahensha Sarkar[1], Narender Verma[2]

ABSTRACT

Varanasi, one of the world's oldest living cities, is facing growing challenges from urban flooding. In recent years, rapid construction, shrinking open spaces, and changing weather patterns have made the city more vulnerable to floods, especially during heavy rains. This study looks at how land use changes and extreme climate events together shape flood risks in the city. Using satellite images from 2000 (Landsat 5) and 2020 (Landsat 8), we mapped changes in land cover with the help of Google Earth Engine and the Random Forest method. The results showed a clear rise in built-up areas, particularly in low-lying neighborhoods. We also studied daily rainfall and temperature data from 1981–2020 provided by the India Meteorological Department. Climate indices such as Consecutive Wet Days (CWD), Consecutive Dry Days (CDD), RX1day, and R95p showed that intense short bursts of rainfall have increased, often occurring alongside very hot days. When we overlaid these climate patterns with maps of population density and drainage networks, we identified specific areas near the Ganga riverfront as high-risk flood zones. These are places where heavy rain, heat stress, and poor drainage combine to make floods more severe. Our findings show that floods in Varanasi are not just caused by rain—they are the result of several hazards acting together. This calls for better urban planning, stronger drainage systems, and the use of geospatial tools to protect both people and the city's heritage in the face of a changing climate.

Keywords: Urban flooding; Varanasi; land use change; climate extremes; multi-hazard; resilience

I. INTRODUCTION

Urban flooding is now recognized as one of the most urgent challenges facing cities worldwide, particularly in countries of the Global South where rapid growth often runs ahead of infrastructure development (Jha, Bloch, & Lamond, 2012). In India, many cities have seen more frequent and intense flooding over the last two decades, a trend closely linked to climate variability and the expansion of built-up areas without proper planning (Gupta, Nair, & Paul, 2020).

Varanasi presents a particularly important case for study. As one of the world's oldest continuously inhabited cities, it combines dense population, fragile urban systems, and a wealth of cultural heritage that is increasingly at-risk during flood events (Singh, 2019). While major metropolitan centers such as Mumbai and Chennai have been widely studied for their flood risks (Patankar, 2019), medium-sized heritage cities like Varanasi have received far less attention. Moreover, few studies bring together land use and land cover (LULC) changes with climate indices and geospatial tools to understand the nature of flood risk. This study seeks to address that gap by examining how the intersection of land use change and climate extremes is shaping the multi-hazard flood profile of Varanasi.

II. METHODOLOGY

This study combines remote sensing, climate data analysis, and geospatial techniques to assess urban flood risk in Varanasi. For land use and land cover (LULC) analysis, satellite images from Landsat 5 (2000) and Landsat 8 (2020) were obtained and processed using the Google

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Earth Engine platform. A Random Forest classifier was applied to detect changes in land cover, and the outputs were validated through accuracy assessment methods commonly used in remote sensing studies (Lillesand, Kiefer, & Chipman, 2015).

To capture climate variability, daily gridded rainfall and temperature data for the period 1981–2020 were collected from the India Meteorological Department (IMD). Climate indices recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI), such as Consecutive Wet Days (CWD), Consecutive Dry Days (CDD), RX1day, and R95p, were computed using Python-based tools (Zhang et al., 2011). Finally, spatial analysis was carried out in a GIS environment to overlay land use changes, climate extremes, population density, and drainage patterns in order to identify flood-prone zones within the city.

III. RESULTS AND DISCUSSION

The LULC analysis shows that built-up areas in Varanasi increased by over 50 % between 2000 and 2020, replacing open and agricultural lands. The most rapid expansion occurred along the Varuna and Assi rivers, which coincide with flood-prone low-lying zones.

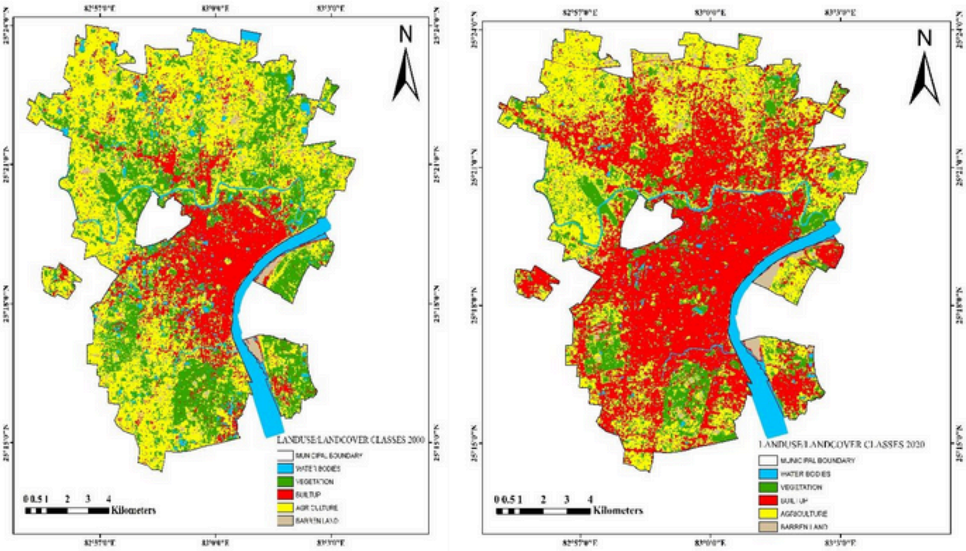

Figure 1. Land Use/Land Cover change in Varanasi (2000–2020) showing built-up expansion along the river corridors.

Climate indices derived from IMD data reveal a declining trend in total rainfall but a rising frequency of short-duration extreme events (RX1day and R95p).

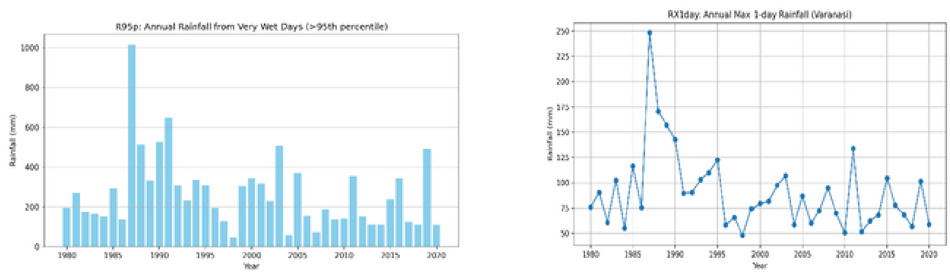

Figure 2. Trend of rainfall extremes (RX1day and R95p) in Varanasi (1980–2020).

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Integration of urban growth and rainfall extremes allowed classification of wards into high, moderate, and low-risk zones.

Table 1. Flood-risk distribution across wards of Varanasi.

Flood Risk Category	No. of Wards	Total Area (ha)	% of Total Area
High Risk	37	5187.96	34.12%
Moderate Risk	36	5024.03	33.04%
Low Risk	37	4993.38	32.84%
Total	110	15,205.37	100%

The results indicate that unplanned built-up growth has intensified flood susceptibility, especially where extreme rainfall coincides with encroached floodplains.

IV. CONCLUSION AND RECOMMENDATIONS

This study highlights that Varanasi's increasing flood risk is strongly influenced by rapid and unplanned urban expansion combined with changes in rainfall extremes. Between 2000 and 2020, built-up areas increased by over half, significantly reducing natural infiltration zones. Although total rainfall showed a declining trend, the frequency of short, intense rainfall events increased, aggravating flood situations in low-lying wards.

The integration of remote sensing, climate indices, and GIS-based analysis effectively identified 37 wards as high-risk and highly vulnerable. These findings emphasize the need for improved urban drainage systems, stricter land-use regulation in flood-prone areas, and the inclusion of climate-based flood assessment in city planning. Future research can build upon this framework by integrating real-time rainfall monitoring and socio-economic vulnerability indicators for more comprehensive flood management strategies.

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PARALLEL SESSION 5B

RESILIENT DESIGN & TECHNOLOGY

Session Moderators: Isidoro R. Malaque III PhD

EXTENDED ABSTRACTS

Hottest Summer on Record: Reconstructing Urban Rhythms Through Temporal Adaptation and Thermal-Based Zoning

Danielle Macanas[1]**,** Philippe Jiro Coronado[2]

ABSTRACT

Climate change has intensified urban temperatures to unprecedented levels, forcing cities—particularly in tropical regions such as the Philippines—to confront the growing uninhabitability of daytime environments. This study examines how escalating heat and the urban heat island effect are transforming urban temporality, prompting a shift from daytime to nighttime activity. It investigates how spatial organization can adapt through thermal-based zoning that prioritizes comfort, resilience, and flexibility amid rising temperatures. Guided by the Event-Based Spatial (EBS) framework, the research explores program overlap as an essential condition of climate-adaptive design, wherein multiple user groups, functions, and building typologies coexist and interact within limited urban space. Through the synthesis of literature, surveys, interviews with practitioners, and site analysis, the study maps these interactions across dynamic layers categorized as functional, relational, and hierarchical. These layers are analyzed through dynamics and the lens of entropy to measure how overprogramming, user congestion, and spatial hierarchy breakdowns affect urban performance and livability. The results indicate that conventional zoning systems, which rely on density and daytime operation, are inadequate for managing the complex rhythms and intensified nocturnal activity of heat-stressed cities. The proposed thermal-based zoning framework reorganizes space according to temperature gradients and behavioral patterns, enabling a more fluid, adaptive urban structure. Integrating passive cooling, multi-temporal use, and thermally informed design strategy presents an operative device – one that mediates energy, time, and human activities while being responsive to both environmental and social shifts, envisioning cities that sustain livability and function amid the challenges of extreme heat.

Keywords: thermal-based zoning, program overlap, nocturnal urbanism, entropy, spatial dynamics, climate adaptation

I. INTRODUCTION

Rising global temperatures and intensifying urban heat islands are forcing cities to confront unprecedented challenges in maintaining livability, particularly in tropical regions such as the Philippines. As daytime environments grow increasingly hostile, urban life is progressively shifting toward nocturnal adaptation, revealing the need to rethink zoning systems traditionally anchored in daylight and density. Existing research on heat mitigation emphasizes technological and ecological strategies, yet few studies address how temporal behavior and

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[2] Jiro Coronado is an architect graduated from De La Salle - College of Saint Benilde (DLS-CSB, 2015), in the Philippines. He is a full-time associate professor, teaching design classes from basic to advanced levels in the undergraduate architecture program at De La Salle - College of Saint Benilde (DLS-CSB). Additionally, he is a member in good standing of the United Architects of the Philippines (UAP-Manila Taft Chapter). He also runs his own emerging design firm, JC Design Commune (JCDC), in the Philippines, focusing on residential and hospitality projects since 2018. He served as an Assistant Professor to Carlos Pita and Ricardo Devesa at Universitat Ramon Llull – La Salle Barcelona for undergraduate students. He finished his postgraduate studies of Master's degree in Integrated Architectural Design at Universitat Ramon Llull - La Salle Barcelona (ETSAL-URL) in 2024.

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spatial use will evolve when daytime heat becomes physiologically unbearable. This study extends its inquiry a hundred years into the future, projecting a scenario where extreme heat fundamentally alters urban life, and survival depends on adaptive temporal and spatial organization. Guided by the Event-Based Spatial (EBS) framework, it examines how program overlap and dynamic interaction among users, functions, and spaces can sustain urban activity under such extreme conditions. Using entropy as an analytical tool, the research evaluates how overprogramming, user friction, and breakdowns of spatial hierarchy affect the city's rhythm and functionality. The findings indicate that static zoning cannot accommodate the complexity of nocturnal urban systems. The study proposes a thermally responsive zoning model that aligns spatial structure with temperature and human behavior, envisioning resilient, livable cities capable of enduring a future defined by unbearable heat.

II. METHODOLOGY

The study uses a mixed-method approach supported by interviews and questionnaires to gather data on spatial use, user behavior, and adaptation to heat. Interviews with architects and urban planners provide professional insights, while questionnaires capture public perception and experience of extreme heat.

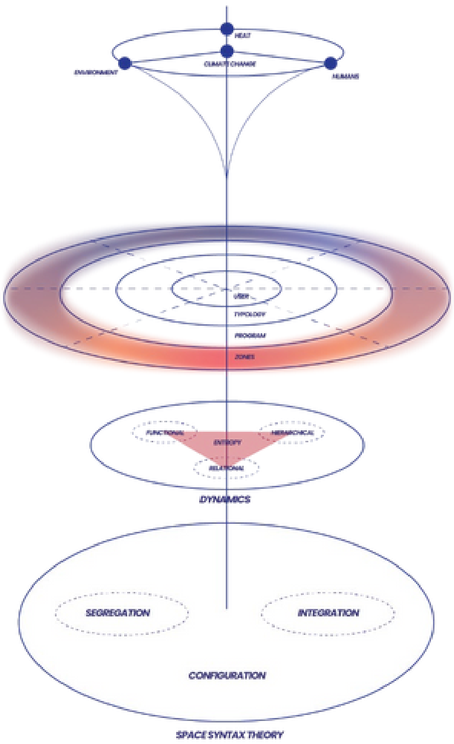

Figure 1. Event-Based Spatial (EBS) Framework.
Source: Author.

The proposed study employs an Event-Based Spatial (EBS) Framework that reconceptualizes urban space as a dynamic product of interactions among users, programs, and typologies. Grounded in Tschumi's assertion that architecture emerges from the intersection of space, movement, and event, the framework positions users as active agents whose behaviors and rhythms generate spatial events. "Programs" encompass diverse activities such as rest, mobility, commerce, and education (Wang et al., 2020; Jing et al., 2022), while "typology" refers to the built environments—plazas, sidewalks, or buildings—that host these events. The EBS framework identifies four key dynamics: Functional, Relational, Hierarchical, and Entropy, each examining spatial compatibility, social interaction, power structures, and complexity (Charitonidou, 2022; Symonov, 2024; Pickett et al., 2016). By mapping overlapping events and their temporal relationships, this model reveals spatial synergies and conflicts, offering an adaptive method for reconfiguring zoning and enhancing urban resilience through empirically grounded, behavior-responsive design.

III. GATHERED DATA

The study engaged two participant groups to ensure a comprehensive understanding of climate adaptation in urban contexts. The first group—composed of residents, students, and commuters—responded to a survey on behavioral adaptations, thermal comfort, and the effects of rising temperatures on daily routines. The second group included licensed architects and urban professionals interviewed for their expertise in climate-responsive design, zoning, and nocturnal urbanism. By integrating public experiences with expert insights, the study captured both the lived realities of heat exposure and the professional perspectives necessary to assess the spatial and design implications of implementing thermal-based zoning in urban environments.

IV. RESULTS AND ANALYSIS

The survey revealed that most participants, primarily women aged 21–25 and 50–59, experience significant thermal discomfort, rating daytime heat intensity at 4 out of 5 despite access to cooling devices. Respondents observed rising temperatures, with noon identified as the most unbearable period. Heat negatively affected mood, productivity, and sleep, prompting behavioral adaptations such as shifting activities to cooler nighttime hours. Participants expressed strong interest in public spaces designed for nighttime use and thermal comfort. However, safety concerns—particularly poor lighting and visibility—limited nighttime activity. Overall, findings highlight worsening heat impacts and a growing demand for safe, climate-responsive urban spaces.

V. CONCLUSION AND RECOMMENDATION

This study concludes that the intensifying heat caused by climate change is not only a climatic crisis but a spatial and temporal one—disrupting long-standing urban routines and demanding a reconfiguration of how cities function through time. The proposed shift toward nocturnal urbanism and thermal zoning offers a new paradigm where design is guided by temperature, rhythm, and adaptability rather than static density and daylight dependency. By identifying system overlaps among users, typologies, and programs, this research demonstrates how cities can evolve into flexible environments that respond to thermal realities while maintaining livability.

The study aims to address and mitigate program overlap through thermal-based zoning and temporal organization. By regulating spatial and temporal interactions, urban areas can minimize congestion, reduce entropy, and enhance comfort, safety, and functionality under extreme heat conditions. It is recommended that future urban planning integrate thermal comfort as a central design parameter, supported by adaptive zoning frameworks that account for varying exposure levels throughout the day. Further interdisciplinary collaboration among architects, climatologists, and policymakers is crucial to transform urban spaces into resilient, thermally adaptive systems that sustain life beyond the heat.

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A Multi-Criteria Risk Assessment of Typhoon-Induced Flooding in Sorsogon, Philippines: Integrating Hazard, Exposure, and Social Vulnerability for Community Resilience Through a Site-Sensitive Design Approach

Angelina Isabel Hernandez Destajo[1], John Ernest F. Jose[2]

ABSTRACT

The Province of Sorsogon, located within the typhoon corridor of the Bicol Region, has been recurrently affected by flood events triggered by extreme precipitation, raising particular concerns regarding the extent and severity of damage across the province. Hence, this study conducted a multi-criteria risk assessment integrating hazard, exposure, and vulnerability parameters to evaluate the degree of flood susceptibility across the province. The Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) were used to determine parameter weight and spatial correlations. Results indicated that extreme precipitation (60.65%) and slope (17.13%) were the primary hazard contributors, while land use and land cover (71.43%) had a strong influence on exposure levels. Within the vulnerability component, emergency preparedness (22.51%), type of built-up structures (22.51%), and population of persons with disabilities (20.75%) exhibited the highest influence on overall risk. These results were substantiated by survey responses and expert interviews that identified low-lying, densely populated urban areas such as Sorsogon City as highly susceptible to flood impacts. The study proposed a context-responsive housing typology that incorporated elevated construction, flood-adaptive materials, and inclusive accessibility measures. Recommendations included integrating these spatial and architectural strategies into existing housing programs, land-use regulations, and local development planning. The research established an evidence-based framework that linked spatial analysis, social vulnerability assessment, and architectural planning to support data-driven decision-making for flood risk reduction in typhoon-exposed communities.

Keywords: typhoon-induced flood disaster, risk assessment, disaster management, AHP, GIS, Sorsogon

I. INTRODUCTION

Flooding is one of the most persistent and destructive environmental hazards worldwide, often resulting in severe physical damage, economic disruption, and loss of life. It occurs when rainfall and surface runoff exceed the capacity of natural and engineered drainage systems, inundating settlements, agricultural areas, and infrastructure. The World Bank (2020) and the Organization for Economic Cooperation and Development (OECD, 2016) identified floods as among the costliest recurring disasters globally, with estimated damages reaching tens of billions of U.S. dollars annually. The increasing frequency and intensity of extreme precipitation events highlight the need for comprehensive, science-based approaches to flood risk assessment and mitigation (Diriba et al., 2023).

Sorsogon Province experiences recurring floods due to its proximity to major water bodies like

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the Pacific Ocean, Sorsogon Bay, and the San Bernardino Strait. The province's mixed coastal and lowland terrain and the presence of Sorsogon Bay contribute to slow surface runoff and poor drainage during prolonged rainfall. In 2024, consecutive typhoons produced rainfall exceeding 200 millimeters within 24 hours, resulting in severe inundation, over PHP 6.7 billion in losses to agriculture and infrastructure, and the displacement of more than forty thousand residents (Office of Civil Defense [OCD], 2024).

Flooding in Sorsogon is not solely a hydrological concern but also a manifestation of socio-spatial vulnerability. The province's exposure is intensified by unregulated land conversion, informal settlements along waterways, and insufficient drainage capacity. Despite the mandates of the Philippine Disaster Risk Reduction and Management Act of 2010 (Republic Act 10121), local mitigation efforts remain largely reactive and fragmented, focusing on engineering solutions rather than preventive and community-based approaches (Oro & Benavides, 2020). The absence of high-resolution spatial data further constrains the ability of local governments to delineate hazard zones accurately and allocate resources effectively. Conventional interventions tend to isolate environmental, spatial, and social datasets, resulting in generalized assessments that fail to represent localized risk dynamics (Oro & Benavides, 2020). Contemporary flood risk analysis, therefore, requires the integration of these components to capture the complex interactions that define vulnerability. GIS plays a critical role in developing spatially explicit flood models that identify high-risk zones and inform urban and regional planning (Diriba et al., 2023). AHP complements these tools by assigning relative weights to multiple flood-related parameters, ensuring consistency and minimizing subjectivity in analysis (Luu et al., 2020). The combined use of GIS and AHP has been widely applied in flood risk studies across Asia to evaluate susceptibility and guide targeted mitigation measures.

II. METHODOLOGY

A. Study Area

The study area covered the Province of Sorsogon, located at the southernmost portion of the Bicol Peninsula in Luzon, Philippines. It has a total land area of approximately 2,119.01 square kilometers and lies between 12°50' north latitude and 123°55' east longitude. The province is bounded by Albay to the north, the Philippine Sea to the east, the San Bernardino Strait to the south, and the Ticao and Burias Passes to the west and northwest. Sorsogon Bay is situated at the center, influencing the province's drainage pattern and coastal morphology. Administratively, it consists of fourteen municipalities and one component city, serving as the provincial capital and primary urban center. The province exhibits a combination of coastal, lowland, and upland physiographic features, making it highly relevant for spatial and hydrological assessment of flood-prone settlements. Figure 1 illustrates the geospatial configuration of the study area.

EXTENDED ABSTRACTS

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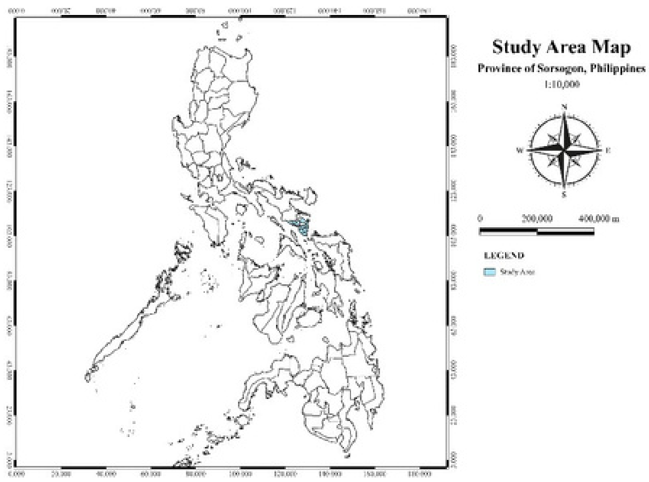

Figure 1. Location of Sorsogon Province as study area.

B. Description of Methods, Design, and Tactic

Flood risk was defined as the combined outcome of three elements: hazard, exposure, and vulnerability. Hazards were quantified through meteorological and hydrological indicators such as rainfall intensity, slope and elevation level, and flood depth. Exposure measured the spatial distribution of people, assets, and infrastructure in flood-prone areas using GIS-based indicators, including population density, land use, and proximity to water bodies. Vulnerability was evaluated through socio-economic variables such as community size, density, and building typology, which represented the capacity to cope with and recover from flood impacts. A descriptive-analytical framework was applied, combining spatial analysis, statistical evaluation, and comparative techniques. Primary and secondary data were utilized, including rainfall intensity, flood records, and socio-economic indicators obtained from PAGASA, local government offices, and DRRM agencies. These datasets were processed through GIS and Digital Elevation Models (DEMs) to identify flood-prone areas and assess environmental vulnerability. GIS-based mapping integrated flood extents with current land use and elevation to produce flood risk gradients that guided further analysis. AHP was employed to assign weights to parameters influencing flood risk. A pairwise comparison matrix determined the relative importance and consistency of each factor, producing normalized weights that ranked the parameters according to their contribution to overall flood risk.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdot & a_{1n} \\ a_{21} & a_{22} & \cdot & a_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ a_{n1} & a_{n2} & \cdot & a_{nn} \end{bmatrix}, a_{ii} = 1, a_{ji} = \frac{1}{a_{ji}}, a_{ij} \neq 0 \qquad (1)$$

$$A * w = A_w, \lambda_i = \frac{(A*w)i}{w_i}, A_w = \lambda_{max}, \lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \lambda_i \quad (2)$$

and

$$CI = \frac{\lambda_{max} - n}{n-1}, CR = \frac{CI}{RI} \qquad (3)$$

III. DATA GATHERED

1. Flood Hazard Parameters

The spatial distribution of flood hazard parameters in Sorsogon was generated using Quantum Geographic Information System (QGIS) with datasets from PAGASA, NAMRIA-DENR, and IfSAR models. Rainfall interpolation from the Legazpi, Masbate, and Catarman stations showed values between 333 and 432 millimeters across the province. The slope map indicated flat to steep gradients, with most built-up areas situated in low-lying coastal zones. Elevation data from IfSAR revealed levels ranging from 0 to 800 meters above sea level, with higher terrain concentrated around Mount Bulusan and its upland surroundings. Soil analysis identified five primary types—clay and clay loam, sandy and sandy loam, silt loam, hydrosol, and gravel deposits. Clay and hydrosol soils exhibited high flood susceptibility due to poor permeability and high water retention, while sandy and gravel soils showed lower risk. Coastal areas, primarily composed of beach sands and clay loam, were most susceptible to flooding and coastal hazards.

2. Flood Exposure Parameters

Population density mapping identified Sorsogon City as the most densely populated municipality, while Donsol, Castilla, Juban, and Matnog exhibited lower concentrations. Household distribution followed a similar pattern, with the highest counts recorded in Sorsogon City. The LULC map showed that most of the province was occupied by agricultural and forested areas, while built-up zones were concentrated along coastal regions, riverbanks, and in some mountainous settlements. These patterns indicated that population and built-up area concentrations corresponded with high exposure to flood hazards, particularly in urbanized coastal areas where land conversion and settlement expansion increased runoff accumulation and reduced the natural absorption capacity of the terrain.

3. Flood Vulnerability Parameters

Demographic analysis showed a slightly male-dominant population, with an overall ratio of 103 males for every 100 females. The mean age distribution ranged from 25 to 32 years, with Barcelona recording the highest average age. Household income averaged between ₱15,000 and ₱25,000 per month, with higher earnings reported in Sorsogon City, Bulan, and Pilar.

The population of persons with disabilities (PWDs) was highest in Sorsogon City and Bulan, reflecting increased vulnerability to flood hazards. Educational attainment was predominantly at the elementary level across most municipalities, while Sorsogon City showed a higher proportion of high school graduates. Survey data indicated limited emergency preparedness, with the highest reported readiness in Donsol and Bulan. Housing assessment revealed that 70% of respondents resided in single-storey dwellings, which increased structural susceptibility during flood events.

4. Survey and Interview Results

The survey conducted across eight municipalities in Sorsogon Province yielded a representative set of responses, with the highest participation recorded in Donsol (25%), followed by Sorsogon City (20%) and Prieto Diaz (15%). Respondents consistently reported experiencing flooding both during typhoon events and periods of intense rainfall without typhoon activity. Flood levels typically rose from ankle to knee depth, lasting between two and six hours before subsiding. These recurrent flood episodes frequently caused power interruptions and damage to residential properties. Approximately 40% of respondents acknowledged that their homes were vulnerable to flooding, 35% believed otherwise, and 25% were uncertain. The perceived causes included proximity to rivers or coastal areas and the lack of adequate or properly maintained drainage systems.

Regarding structural resilience, 45% of respondents expressed confidence in the capacity of their homes to withstand flood events, 40% were uncertain, and 15% considered their dwellings structurally inadequate. A majority of respondents (90%) recognized the importance of architecture in reducing flood risks, recommending storm drainage improvements (23.4%), permeable ground surfaces (18.8%), elevated housing and flood-resistant materials (17.2%), amphibious housing (12.5%), and green infrastructure such as rain gardens (10%).

Insights from an interview with an architect from the Provincial Engineer's Office supported these observations and provided a professional perspective on the relationship between the built environment and hydro-meteorological hazards. The architect emphasized that the province's vulnerability stemmed from its geographic exposure to coastlines and rivers, compounded by inadequate drainage infrastructure, deforestation, and unregulated urban expansion. Many residential structures were constructed from lightweight materials such as wood or bamboo and were located in flood-prone areas, particularly informal settlements and low-lying zones. Poor road connectivity and limited evacuation routes further constrained disaster response.

The architect also noted that structural failures, including dike and bridge collapses during major flood events, revealed deficiencies in design and maintenance. While engineering interventions such as seawalls provided partial protection, these were insufficient without integrated strategies involving proper zoning, drainage improvement, and ecosystem-based approaches. The interview underscored that resilient architecture, elevated housing, durable materials, and green infrastructure must be integrated into long-term urban planning to enhance adaptive capacity and reduce community-level flood vulnerability.

IV. RESULTS AND ANALYSIS

This section consolidates the findings from the flood hazard, exposure, and vulnerability assessments conducted in the province of Sorsogon, integrating both spatial and statistical analyses derived from AHP, GIS, and community-based surveys and interviews. The synthesis contextualizes how each dimension: hazard, exposure, and vulnerability, contributes to the overarching flood risk and addresses the central research problem: assessing the spatial and socio-environmental determinants of typhoon-induced flooding in Sorsogon, Philippines.

A. Synthesis of Parameters and Spatial Indicators

The multi-criteria analysis showed that extreme precipitation constituted the most dominant flood hazard factor, accounting for 60.65% of the total hazard weight, followed by slope and

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and elevation at 17.13% each, and soil type at 5.09%. This pattern aligned with the rainfall intensity distribution which indicated higher precipitation levels in the northern and southeastern municipalities.

Table 1. Final weights and percentage weights of all criteria for hazard, exposure, and vulnerability parameters.

Parameters	Weights w_i	Percentage Weights
Hazard Parameters		
Extreme Values of Precipitation (P)	0.606481	60.65 %
Slope (S)	0.171296	17.13 %
Elevation (E)	0.171296	12.13 %
Soil Type (ST)	0.050926	5.09 %
Exposure Parameters		
Population Density (PD)	0.142857	14.29 %
Number of Households (NH)	0.142857	14.29 %
Land Use/Land Cover (LU/LC)	0.714286	71.43 %
Vulnerability Parameters		
Gender Ratio (GR)	0.036093	3.61 %
Average Age (AA)	0.056804	5.68 %
Average Income (AI)	0.046055	4.61 %
Population of Persons with Disabilities (PWD)	0.207549	20.75 %
Highest Educational Attainment (HEA)	0.203241	20.32 %
Emergency Preparedness (EP)	0.225129	22.51 %
Types of Built-up Structures (TBS)	0.225129	22.51 %

In terms of flood exposure, Land Use and Land Cover (LU/LC) registered the highest weight at 71.43%, indicating that areas with high urbanization and extensive impermeable surfaces were more prone to surface runoff accumulation. Exposure mapping confirmed that Sorsogon City had the highest level of exposure due to its dense population, concentration of built-up areas, and limited green or permeable spaces. The vulnerability assessment identified Emergency Preparedness (EP) and Types of Built-up Structures (TBS) as the most influential factors, each contributing 22.51% to the overall vulnerability score. High vulnerability was also associated with larger populations of persons with disabilities, lower educational attainment, and structurally inadequate housing types. Spatial analysis indicated that Sorsogon City exhibited the highest vulnerability due to its demographic density, socio-economic disparities, and insufficient disaster preparedness measures.

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B. Integration of Flood Risk Mapping

The integration of the weighted parameters produced a comprehensive flood risk map that classified the municipalities into five categories ranging from very low to very high risk. The analysis identified Sorsogon City as having the highest flood risk, reflected by its consistent classification under the very high category across hazard, exposure, and vulnerability domains. Barcelona and Pilar followed with elevated vulnerability scores and multiple high-ranking indicators.

In contrast, municipalities such as Donsol, Irosin, and Matnog were categorized under low to very low flood risk due to lower exposure levels, reduced hazard occurrence, and greater adaptive and recovery capacities. This variation demonstrated the spatial heterogeneity of flood risk across the province and emphasized the necessity of localized assessment and management strategies that consider site-specific environmental and socio-economic conditions.

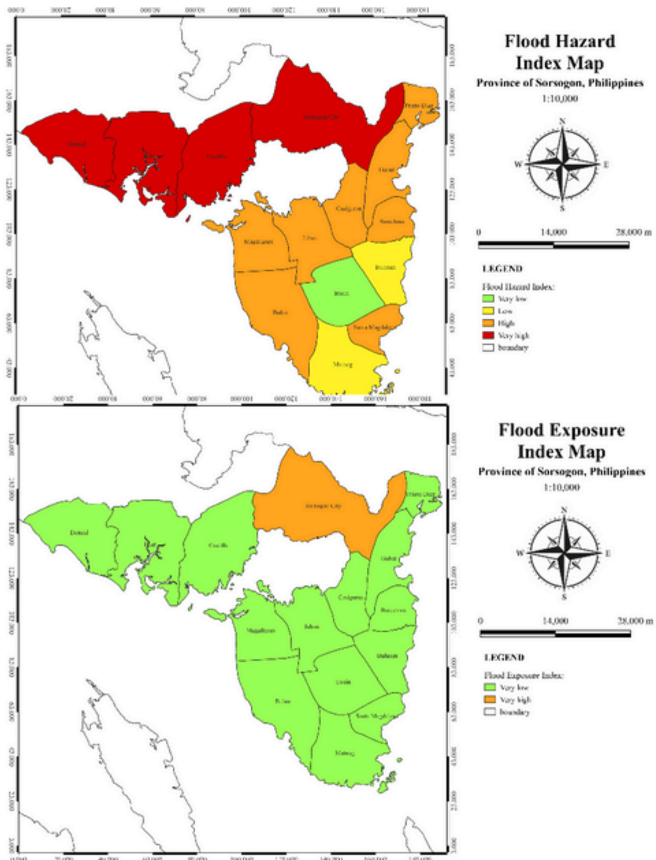

Figure 2-3. Integrated flood hazard and exposure index maps of Sorsogon Province.

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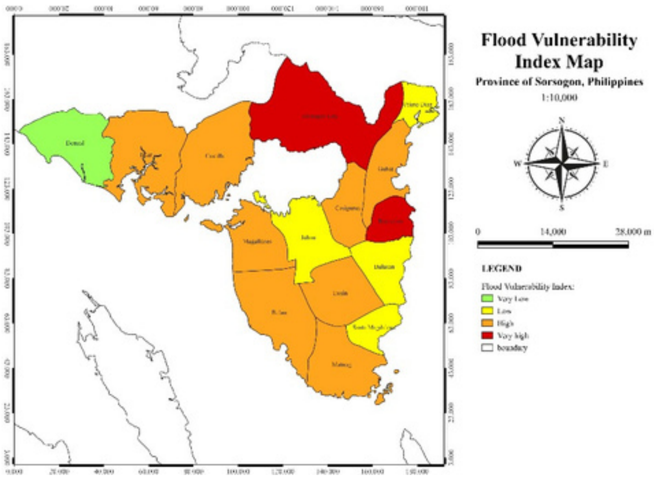

Figure 4. Integrated flood vulnerability index map of Sorsogon Province.

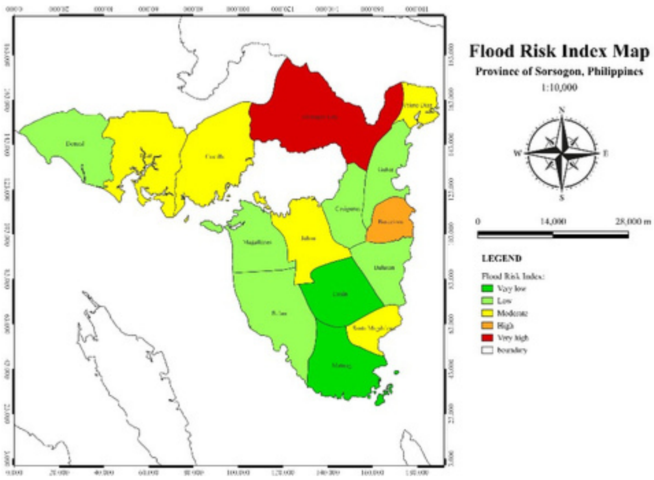

Figure 5. Integrated flood risk index map of Sorsogon Province.

C. Correlation with Community Perceptions and Expert Insights

The community survey substantiates the technical findings by revealing residents' perceived vulnerabilities. A majority acknowledged recurrent flood experiences, with the primary causes linked to proximity to water bodies and inadequate drainage. Respondents also emphasized the role of architecture and urban planning in mitigating flood damage, advocating for solutions such as improved drainage systems, permeable surfaces, elevated structures, and green infrastructure.

The professional insights from the Provincial Engineer’s Office corroborate the spatial and survey data. The architect interviewed emphasized that poorly planned settlements, insufficient drainage, and construction in hazard-prone areas magnify the impacts of flooding. The observations support the need for integrated planning approaches, combining zoning regulations, nature-based solutions, and resilient design practices.

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In summary, the data synthesis reveals that flood risk is not merely a function of environmental exposure, but also a consequence of socio-economic vulnerability and planning deficits. The AHP-based modeling validated by consistency indices ensures robustness in the prioritization of risk factors, and the spatial outputs provide a visual framework for identifying critical intervention areas. Ultimately, this chapter illustrates how a combination of meteorological, physical, and human factors interact to shape flood risk. The study reinforces the necessity for multi-sectoral strategies that consider both structural and non-structural measures in reducing disaster impacts. Furthermore, it establishes a replicable methodology for flood risk assessment that can inform policy-making, urban planning, and community resilience initiatives in other typhoon-prone regions.

V. CONCLUSION AND RECOMMENDATIONS

The study demonstrated that flooding in Sorsogon is primarily influenced by land management practices, settlement distribution, and the structural configuration of the built environment. The absence of risk-sensitive spatial planning and the proliferation of impervious surfaces have intensified flood exposure in both urban and peri-urban zones. Stakeholder insights revealed that many dwellings, particularly those in informal settlements, were constructed without adequate consideration of site elevation, drainage flow, or material durability, resulting in heightened structural vulnerability. These findings underscored the necessity of integrating environmental data, spatial analytics, and socio-economic indicators to inform localized and evidence-based flood risk management strategies.

A coordinated approach linking architectural design, urban policy, and community participation is essential to strengthen resilience. The study recommends the institutionalization of localized flood-resilient design standards that promote adaptive housing typologies, elevated structures, and the use of durable, flood-resistant materials. Green and blue infrastructure, including permeable pavements, vegetated swales, and retention areas, should be incorporated into urban design to restore infiltration and reduce surface runoff. Strengthening emergency preparedness data collection and participatory risk mapping at the barangay level is likewise recommended to enhance local decision-making and governance capacity.

The findings further emphasized the need to align spatial planning and design practice with the broader agenda of climate adaptation and disaster risk reduction. Architecture and urban planning should not be treated as isolated technical disciplines but as proactive instruments for community resilience. By adopting site-sensitive and inclusive design strategies, local governments and practitioners can advance toward safer, more adaptive, and sustainable built environments. The integration of risk-informed design, ecological infrastructure, and participatory governance offers a path forward for Sorsogon and similar flood-prone provinces in building long-term resilience against climate-induced hazards.

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EXTENDED ABSTRACTS

Mainstreaming Education as an ACE Pillar towards Climate Change Adaptation and Disaster Risk Reduction

Decibel Faustino Eslava[1] represented by **Rosemarie Laila D. Areglado-Dimasuay**[1], Maria Victoria Espaldon[1], Antonio Contreras[1], Loucel Cui[1], Maria Regina V. Regalado[1], Eduardo C. Calzeta[1], Dhannielle Grace C. Bernardo[1], Ma. Ericha M. Amante[1], Wesley S. Gagarin[1]

ABSTRACT

Education on climate change adaptation (CCA) and disaster risk reduction (DRR), delivered through formal schooling and community-based initiatives, can catalyze the paradigm shift needed to build a resilient, equitable, and climate-conscious society. By shaping long-term habits, values, and behaviors, education bridges the gap between scientific knowledge and everyday practice. Nevertheless, despite advances in scientific and technical expertise, the translation of CCA and DRR knowledge into concrete action remains limited, particularly at the community and individual levels. This disconnect is pronounced in many parts of Asia, where low awareness of fundamental climate and disaster risk concepts persists, producing multiplier effects such as maladaptive practices, limited preparedness, and weak community-scale risk reduction.

Addressing this barrier to resilience requires the systematic mainstreaming of CCA-DRR education into national education systems and broader societal learning processes. In the Philippines, this endeavor is complicated by persistent challenges, including low foundational literacy and numeracy among students, as well as curricula overloaded with competing priorities. These constraints hinder the integration of new content areas such as CCA and DRR, even as climate impacts intensify. The task is therefore twofold: introduce CCA-DRR education and embed it in pedagogically sound, contextually relevant, and goal-aligned ways that strengthen learning outcomes while enabling climate-informed decision-making and action.

This presentation examines strategies for mainstreaming CCA-DRR education within the Philippine context, drawing on insights from key informant interviews and sectoral consultations with national government agencies, civil society organizations, and higher education institutions. Stakeholders represent sectors identified in the National Adaptation Plan (NAP) and the Nationally Determined Contributions (NDC) Implementation Plan, including agriculture, water resources, ecosystems and biodiversity, energy, transport and communication, waste management, livelihoods and industries, health, cultural heritage, and land use and human settlements. Engaging these actors reveals opportunities to align education initiatives with national climate and development priorities, while highlighting coordination gaps, capacity constraints, and areas where education can accelerate cross-sectoral outcomes.

Central to the analysis is the Action for Climate Empowerment (ACE) framework, which enables societal participation in climate action across six pillars: education, training, public awareness, public participation, public access to information, and international cooperation. Although numerous programs, projects, activities, and policies (PPAPs) have been launched in the Philippines to address mitigation and adaptation, efforts remain fragmented, duplicative, and insufficiently aligned with the principles of ACE. A recent stocktake identified critical gaps: low ACE awareness among stakeholders, limited budget allocations for education-related initiatives, and overlapping programs within the education sector that dilute impact and impede measurable progress.

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To organize and strengthen implementation, the Theory of Change (ToC) framework was applied to clarify long-term outcomes, map causal pathways, and specify interventions required to achieve desired changes, while supporting the development of indicators to assess ACE performance. The strategic framework for ACE in the Philippines was developed through this ToC lens, beginning with an assessment of current conditions and the articulation of desired changes. From an education perspective, this means recognizing systemic barriers—such as low foundational skills and overloaded curricula—alongside opportunities to embed climate and disaster risk concepts within teaching and learning processes and grounding the ACE Strategy in education positions schools, universities, and community learning spaces as critical entry points for building climate literacy, fostering adaptive behaviors, and empowering learners to participate meaningfully in climate action.

The presentation introduces the Philippines' ACE Strategy and proposes approaches for the education sector to advance national climate and resilience goals. Priority actions include embedding CCA-DRR education within ongoing education reforms, strengthening educator capacity through preservice and in-service training, integrating place-based, experiential learning and indigenous/local knowledge, and leveraging community-based platforms to reach vulnerable populations. The strategy highlights the importance of stronger intersectoral coordination, increased investment in resilience-oriented education, and the explicit alignment of PPAPs with ACE principles to prevent duplication, enhance coherence, and maximize impact. Monitoring and evaluation mechanisms—grounded in ToC-derived indicators—are proposed to track implementation fidelity, equity, and outcomes across diverse contexts.

Mainstreaming CCA-DRR education is not merely a technical or curricular exercise; it is a societal imperative. Equipping learners of all ages with the knowledge, skills, and values required to understand and respond to climate risks can catalyze broader cultural and behavioral change. This, in turn, can bridge the gap between knowledge and practice, ensuring that scientific and technical advances translate into tangible improvements in resilience at the community level. The Philippine experience—marked by both constraints and innovation—offers transferable lessons for countries seeking to integrate CCA-DRR education into national strategies. Aligning education with the ACE framework and grounding interventions in a robust Theory of Change provides a coherent, inclusive, and effective pathway toward a climate-resilient future in which education functions as a strategic lever for sustained, equitable transformation.

Keywords: Climate change and DRR education, societal resilience, Action for Climate Empowerment (ACE)

I. INTRODUCTION

Action for Climate Empowerment (ACE) is a term used by the UN Framework Convention on Climate Change (UNFCCC) referring to work under Article 6 of the Convention and Article 12 of the Paris Agreement. The ACE strategy seeks to create transformative responses and empower society to participate in climate action through education, training, public awareness, public participation, public access to information, and international cooperation.

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The Philippines currently has numerous policy initiatives and support mechanisms that relate to Action for Climate Empowerment (ACE). Firstly, Republic Act No. 9729, the Philippine Climate Change Act of 2009, includes ACE-related provisions which are reflected in the mandates of key national agencies - Climate Change Commission (CCC), Department of Education (DepEd), Philippine Information Agency (PIA), and Department of Environment and Natural Resources (DENR). The National Climate Change Action Plan (NCCAP) 2011-2028 outlines ACE strategies to enhance Filipino knowledge and capacity to address climate change. The Philippine Development Plan (2023-2028) supports this by incorporating multi-stakeholder approaches to increase climate action and disaster resilience. The National Adaptation Plan (2023-2050) aims to strengthen climate action by integrating international conventions into national policies. Additionally, the Presidential Proclamation on Global Warming and Climate Change Consciousness Week and the National Environmental Awareness and Education Act promote environmental conservation and climate change awareness.

The development of the strategic framework for Action for Climate Empowerment (ACE) in the Philippines took into account the country's current challenges in addressing climate change impacts. Through the lens of the theory of change (ToC) framework, the document identified the present situation and the desired changes, forming the basis for formulating the national strategic direction for ACE in the Philippines.

A. Theory of Change Framework

Presented in Figure 1 is the ToC framework, which links ACE to address the current situation and achieve the desired change in mitigating the impacts of climate change. According to the World Risk Report 2023, the Philippines ranks first worldwide in terms of disaster risk, with a world risk index of 46.86. This indicates that the Philippines is highly vulnerable to multiple climate change impacts, such as tropical cyclones, coastal and riverine floods, droughts, and sea level rise. Additionally, the Philippines has limited efforts to build adaptive and resilient capacities to address these impacts. The limited adaptive and resilience capacities are due to insufficient government interventions in adaptation measures, limited support for climate change-related research, and low public awareness and engagement.

Furthermore, the Philippines is committed to meeting global carbon reduction targets by mid-century. According to the submitted Nationally Determined Contribution (NDC), the Philippines aims for a 75% reduction in carbon emissions. However, these targets assume funding support from the global community to implement necessary mitigation measures; otherwise, the target reverts to only 2.5% due to insufficient financial capacity to undertake necessary actions. As a result of high vulnerability and low adaptive and resilience capacity, the Philippines experiences significant casualties and damage to properties and infrastructure due to climate-induced disasters.

These scenarios impede the country's economic growth. The NDC, the National Climate Change Adaptation Plan (NCCAP), and the new National Adaptation Plan (NAP) outline necessary interventions through plans and programs to achieve net-zero emissions by mid-century and enhance climate adaptive and resilience capacities. The realization of climate change goals—reduced casualties, minimized damages, and sustained economic growth with

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low-carbon futures—can only be achieved if all members of society are empowered to accelerate social and sectoral climate actions. Empowering the public can be achieved through the implementation of the national ACE across its six pillars: education, training and capacity building, public awareness, public participation, public access to information, and international cooperation.

Once society is empowered and engaged in climate action, a just and climate-conscious community will help achieve climate change mitigation and adaptation goals. However, the current implementation of ACE strategies faces several challenges, including limited awareness among national government agencies (NGAs) and the public regarding climate actions, limited integration of the six ACE pillars, insufficient budget mainstreaming to facilitate ACE integration across all sectors, and inadequate logical and policy support for ACE integration. These challenges were identified through key informant interviews (KII) conducted for this project.

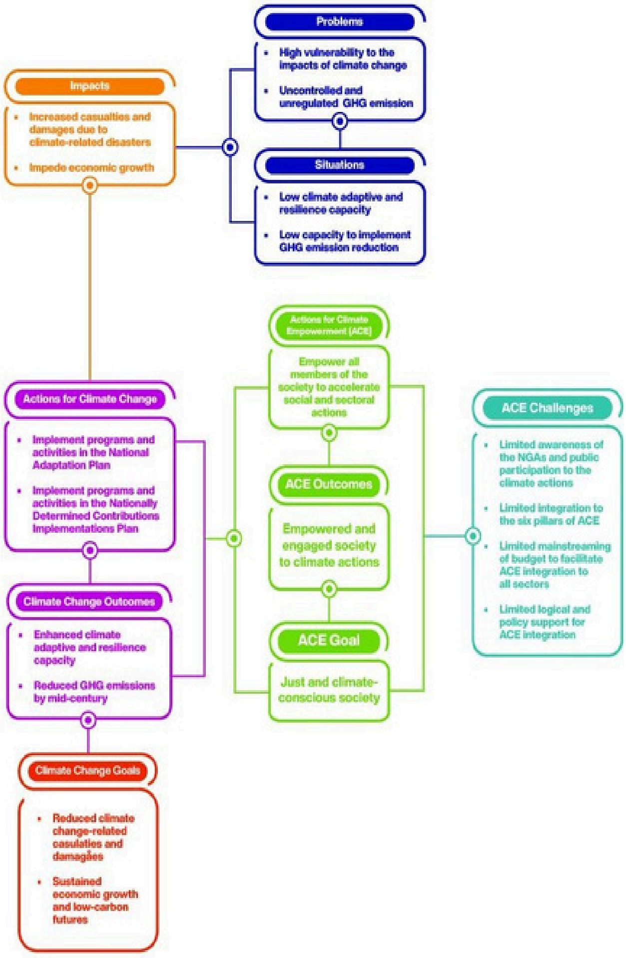

Figure 2. Theory of Change framework for ACE.

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B. Education

Education seeks to bring about profound, long-term changes in understanding, particularly among young people. It involves developing educational curricula, training trainers and teachers, and adequate pedagogies. The results of a successful program would ultimately be a population whose deep-seated appreciation of the climate challenge leads to greater national action and commitment.

Our individual lifestyles and current development paradigm are closely linked to the drivers of climate change. By shifting our attitudes and behaviours, we can influence its trajectory—and education is the catalyst for that shift. In fact, the UNFCCC's case studies across 17 countries demonstrate that climate education embeds empowering actions in communities and societies, fostering outcomes that endure and flourish.

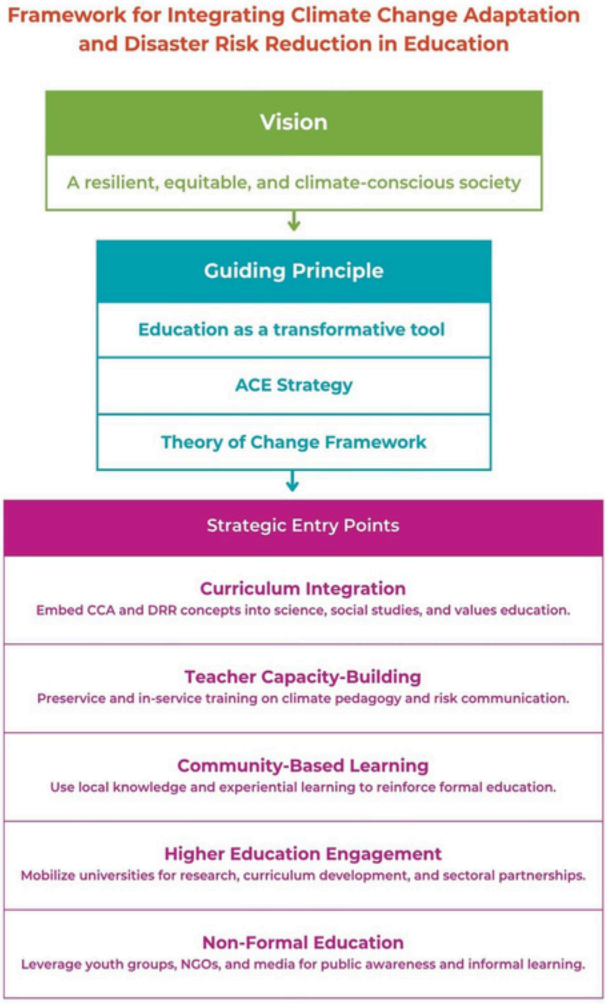

Figure 3. Framework for integrating CCA and DRR in education.

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EXTENDED ABSTRACTS

PARALLEL SESSION 5C

COMPLEX DISASTERS

Session Moderator: Lorelei De Viana PhD

A Systematic Analysis of Types and Characteristics of Multi-Hazards

D.K. Yoon[1], *Mijin Choo[1], Dong In Kim[1], Yeora Chae[2], Soyoon Kim[1],*

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Semantic-based Evaluation of a Modified HSEEP Framework (T-DEEP) for Complex Hazard Preparedness in Taipei: Insights from Hotwash Feedback via SOM

Tsung-Yi Pan[1], *Lo-Yi Chen[1], Jing-Ting Wang[2], Cheng-Chi-Cheng[2]*

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Local Industries and Complex Disasters in Garut, Indonesia

Kumiko Fujita[1], *Takako Izumi[2], Miwa Abe[3], Tadashi Uchiyama[3]*

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EXTENDED ABSTRACTS

A Systematic Analysis of Types and Characteristics of Multi-Hazards

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ABSTRACT

The frequency of multi-hazard events has increased in recent years, with the concurrent occurrence of high-risk disasters intensifying overall damage. Effectively managing these compound risks requires a proactive understanding of their patterns, damage mechanisms, and management implications. Although research on multi-hazard risks has grown, few studies have explored the full process, impact, and corresponding management strategies. This study analyzed research trends on multi-hazard risks through topic modeling and network analysis, using bibliographic data from international publications. We collected 1,837 articles from 556 journals indexed in the Web of Science between 2000 and 2022. Using Latent Dirichlet Allocation (LDA), we identified key topics and classified multi-hazard risks into seven types based on their component combinations. This study also conducted centrality analysis to examine relationships among keywords, uncovering patterns related to hazard development, primary damage targets, and disaster management response. The results highlight frequent attention to NATECH, flood and landslide-related multi-hazard risks. Moreover, damage varies by multi-hazard risks type, ranging from infrastructure and ecological systems to public health. These findings provide more effective and context-specific decision-making for disaster management agencies and local governments. By outlining how different multi-hazard risks evolve and whom they affect, the study supports the development of tailored risk management strategies.

Keywords: Multi-hazard, Topic modeling, Network analysis

I. INTRODUCTION

Disasters increasingly evolve into multi-hazards that generate compound impacts through linkages among different hazards. Multi-hazards arise when multiple hazards occur simultaneously or sequentially, producing complex and cascading effects (van den Hurk et al., 2023). In multi-hazard risk management, it is critical to anticipate and manage not only the direct effects of individual hazards but also the unpredictable impacts stemming from their interactions (Dargin et al., 2021; Banerjee & Mohapatra, 2024). Understanding how a single hazard develops into a multi-hazard situation requires analyzing the causal networks that link hazards and amplify their impacts. Prior research has largely focused on statistical data or bibliometric analyses of multi-hazard literature (Dargin et al., 2021; Kim et al., 2022), yet it has not fully addressed the distinctive characteristics of entities affected by each multi-hazard type, the mechanisms through which multi-hazards evolve, or the management approaches

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[3] He is a master's student in the Department of Urban Planning and Engineering at Yonsei University. His research focuses on disaster management and disaster vulnerability assessment, based on Geographic Information Systems and big data analytics.

[4] Dr. Chae is a senior research fellow at Korea Environment Institute. She is specialized in integrated assessment of climate change and air pollution. Her recent work includes "Socio-economic impacts of heatwave, Living lab based heatwave policy optimization". She obtained PhD. in climate change policy analysis at University of Cambridge, UK.

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A Systematic Analysis of Types and Characteristics of Multi-Hazards

D. K. Yoon, Mijin Choo, Dong In Kim, Yeora Chae, Soyoon Kim

applicable to each. To address these gaps, this study analyzes global research trends on multi-hazards through topic modeling and network analysis Topic modeling identifies key multi-hazard types emphasized in existing studies, while topic-specific keyword and network analyses reveal their unfolding mechanisms, affected entities, and disaster-management approaches.

II. METHODOLOGY

This study preprocessed bibliographic data using Python before analysis. Tokenization was conducted with Gensim, stop words were removed using NLTK, and Bigram/Trigram models combined frequent co-occurring terms (e.g., 'debris flow'). Lemmatization and synonym unification were performed using spaCy to create word-level data for topic modeling. Topic modeling was conducted using the LDA (Latent Dirichlet Allocation) model in Mallet, which optimizes topic-word relationships through Gibbs sampling. The number of topics and keywords was determined based on coherence scores. Additionally, network analysis using Gephi examined keyword centrality and connectivity within each topic, constructing topic-specific keyword networks derived from co-occurrence frequencies identified through topic modeling.

III. GATHERED DATA

This study used bibliographic data (titles, abstracts, and keywords) from 1,837 academic papers on multi-hazard published in 556 international disaster-related journals between 2000 and 2022. Data were collected from the Web of Science using 16 multi-hazard related keywords (Table 1). Extended bibliographic information was then used for topic modeling and network analysis to identify research trends and thematic structures.

Table 1. Keywords for searching articles related to complex disaster.

Keywords	
Cascading disaster; Cascading hazard	Concurrent disaster; Concurrent hazard
Compound disaster; Compound hazard	Multiple disaster; Multiple hazard
Consecutive disaster; Consecutive hazard	Disaster chain; Natech
Coinciding disaster; Coinciding hazard	Multi-hazard; Multihazard

IV. RESULTS AND ANALYSIS

Table 2 presents the seven topics derived through topic modeling and 25 keywords for each topic. Topics were named by the associations among keywords based on frequencies of occurrence, which are classified into the mechanism of complex disaster occurrence (M), the sub-disasters constituting a complex disaster (D), the targets of complex disaster (T), the activities for complex disaster management (A), and others (ETC, E).

Topic 1 concerns Natech disasters, where natural hazards trigger technological or industrial accidents. Topic 2 involves rainfall-induced floods and landslides. Topic 3 covers compound disasters combining natural hazards and infectious disease. Topic 4 relates to earthquake-induced collapses and fires. Topic 5 includes climate-change driven heatwaves, droughts, and wildfires. Topic 6 addresses coastal disasters from storm surges and sea-level rise, and Topic 7 covers earthquake-tsunami complex disasters. Furthermore, the results of network analysis of major keywords by type of complex disasters are shown in Figure 1. The font size of each node (keyword) represents the weighted degree of the node, indicating the higher weighted degree of a node, the stronger relationship with many other nodes.

Table 2. Results of topic modeling.

No	Topic (Multi-hazard type)	Keywords
Topic 1	Natech	Exposure (E), Cascading (M), Health (T), Accident (D), Complex (M), Coupling (M), Evacuation (A), Protection (A), Triggering (M), Storage (T), Plant (T), Chemical (T), Equipment (T), Gas (T), Explosion (D), Industry (T), Cumulative (M), NATECH (D), Pipeline (T), Disease (D), Oil (T), Lightning (D), Injury (D), Nuclear (T), Domino effect (M)
Topic 2	Multi-hazards compounded by rainfall, flood, and landslides	Flood (D), Landslide (D), Chain (M), Rainfall (D), Prediction (A), Triggering (M), Monitoring (A), Slope (T), Remote sensing (A), River (T), Erosion (D), Simulation (A), Debris flow (D), Surface (T), Combination (M), Rock (T), Geological (E), Sediment (E), Mountain (T), Dam (T), Lake (T), Deposit (D), River basin (T), Avalanche (D), Discharge (D)
Topic 3	Multi-hazards compounded by hurricane and pandemic	Resilience (A), Infrastructure (T), Response (A), Preparedness (A), Warning (A), Hurricane (D), Policy (A), Recovery (A), Knowledge (A), Practice (A), COVID-19 (D), School (T), Training (A), Society (T), Community (T), Shelter (T), Pandemic (D), Education (A), Insurance (A), Guideline (A), Coordination (A), Funding (A), Shock (D), Restoration (A), Economy (T)
Topic 4	Earthquake-related multi-hazards	Structure (T), Design (A), Earthquake (D), Wind (D), Fire (D), Building (T), Fragility (E), Response (A), Collapse (D), Blast (D), Experiment (A), Multi-hazard (M), Column (T), Resistance (A), Capacity (A), Concrete (E), Joint (E), Temperature (D), Wall (T), Vibration (E), Retrofit (A), Property (T), Thermal (D), Robustness (A), Reinforcement (A)
Topic 5	Climatic multi-hazards	Climate (D), Adaptation (A), Compound (M), Economic (T), Environmental (T), Sustainability (A), Drought (D), Volcano (D), Sensitivity (E), Wildfire (D), Forecasting (A), Heatwave (D), Cyclone (D), Stress (E), Ecosystem (T), Volcanic eruption (D), Precipitation (D), Meteorological (D), Temperature (E), Agriculture (T), Food (T), Duration (E), Ecological (T), Dry (D), Livelihood (T)
Topic 6	Coastal hazard-related multi-hazards	Coast (T), Plan (A), Community (T), Social (A), Reduction (A), Mitigation (A), Physical (A), Government (A), Capacity (A), Storm (D), Communication (A), Stakeholder (E), Storm surge (D), Typhoon (D), Household (T), Sea level (E), Sea (E), Agency (A), Protection (A), Governance (A), Inundation (D), Groundwater (D), Institutional (A), Participation (A), Technical (A)
Topic 7	Tsunami-related multi-hazards	Earthquake (D), Scenario (A), Bridge (T), Emergency (A), Simulation (A), Combination (M), Tsunami (D), Simultaneous (M), Mitigation (A), Rescue (A), Sequence (M), Robustness (A), Corrosion (D), Multi-hazard (M), Collaboration (A), Foundation (E), Pier (T), Tunnel (T), Sensor (A), Continuous (M), Collision (D), Maintenance (A), Friction (E), Casualty (T), Frequency (E)

Ⅴ. CONCLUSION AND RECOMMENDATIONS

This study identified detailed types and characteristics of complex disasters through topic modeling and network analysis, emphasizing differences in unfolding mechanisms, damage targets, and management strategies. The findings highlight the need for tailored disaster management approaches that reflect each complex disaster's unique nature, main damage targets, and appropriate management stages.

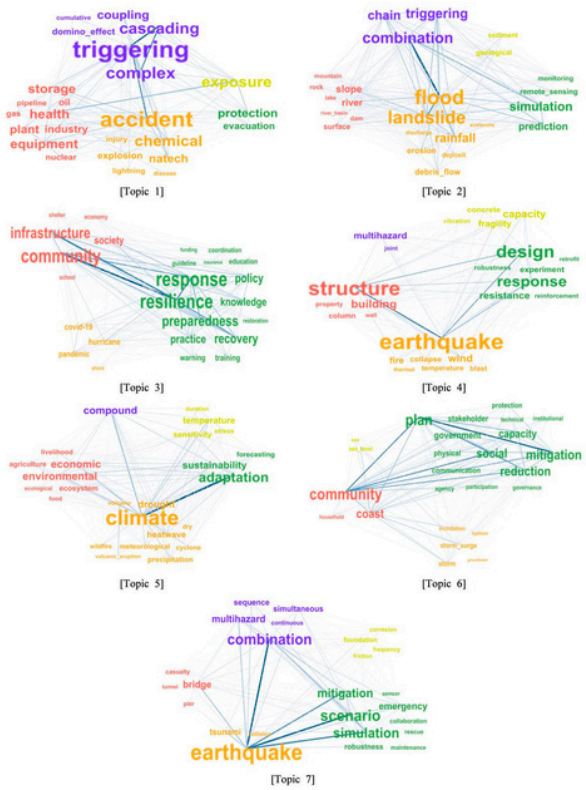

Figure 1. Results of network analysis for each topic.

EXTENDED ABSTRACTS

A Systematic Analysis of Types and Characteristics of Multi-Hazards

D. K. Yoon, Mijin Choo, Dong In Kim, Yeora Chae, Soyoon Kim

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ACKNOWLEDGEMENTS

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Semantic-based Evaluation of a Modified HSEEP Framework (T-DEEP) for Complex Hazard Preparedness in Taipei: Insights from Hotwash Feedback via SOM

Tsung-Yi Pan, Lo-Yi Chen, Jing-Ting Wang, Cheng-Chi Cheng

ABSTRACT

Complex, large-scale disasters challenge urban preparedness systems, requiring integrated and data-driven evaluation frameworks. This study introduces the Taipei Disaster Exercise Evaluation Program (T-DEEP), an adaptation of FEMA's HSEEP tailored to Taipei's multi-level administrative structure. Between 2024 and 2025, T-DEEP guided tabletop exercises, functional drills, and full-scale simulations across city-level, departmental, and district offices. We collected over 600 hotwash feedback entries to assess preparedness effectiveness. Utilizing semantic analysis, we vectorized textual feedback and applied an unsupervised Self-Organizing Map (SOM) model to categorize hidden patterns across participant responses. By examining neuron feature vectors, we identified recurring themes reflecting strengths, gaps, and areas for enhancement in Taipei's disaster exercise regime. Results demonstrate that combining a localized exercise framework with AI-enabled semantic clustering provides a robust, quantifiable approach for evaluating complex disaster preparedness. This approach offers valuable insights for cities seeking to adapt exercise frameworks and leverage AI for evidence-based disaster preparedness improvement.

Keywords: T-DEEP, HSEEP, Semantic analysis, Self-Organizing Map (SOM), Evidence-based disaster preparedness

I. INTRODUCTION

In the face of escalating threats from complex, large-scale disasters in urbanized areas, traditional disaster preparedness and evaluation systems are being challenged as never before. This situation underscores the critical need for an integrated, data-driven exercise evaluation framework that can be adapted to local contexts. This study introduces the Taipei Disaster Exercise Evaluation Program (T-DEEP) (Taipei City Disaster Management Office, 2025), a framework localized from the U.S. Federal Emergency Management Agency's (FEMA) Homeland Security Exercise and Evaluation Program (HSEEP). T-DEEP is specifically tailored to align with the unique multi-level administrative structure of the Taipei City Government. The core objective of this research is to validate the effectiveness of the T-DEEP framework and leverage artificial intelligence (AI) to conduct in-depth semantic analysis of qualitative post-exercise feedback, thereby establishing an objective and quantifiable model for assessing disaster preparedness.

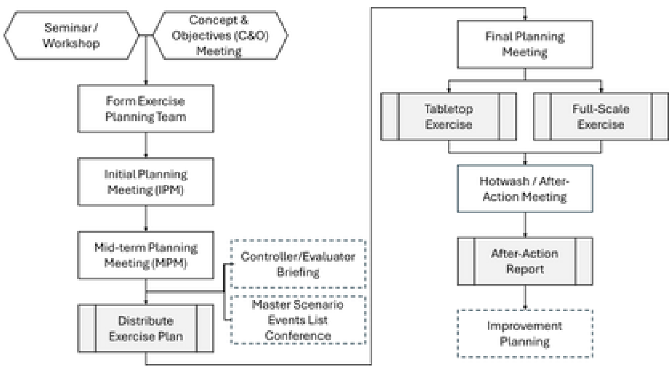

Figure 1. The flowchart of T-DEEP.

Semantic-based Evaluation of a Modified HSEEP Framework (T-DEEP) for Complex Hazard Preparedness in Taipei: Insights from Hotwash Feedback via SOM

Tsung-Yi Pan, Lo-Yi Chen, Jing-Ting Wang, Cheng-Chi Cheng

II. METHODOLOGY

Between 2024 and 2025, this study utilized the T-DEEP framework to guide a series of disaster response exercises across Taipei's city, department, and district office levels. These exercises included tabletop simulations, functional drills, and full-scale exercises. Following these events, a total of 636 individual feedback entries were collected from front-line response personnel through the "Hotwash" mechanism.

To extract deep, underlying patterns from this extensive textual data, a multi-stage AI-assisted analytical process was employed. First, we utilized several large language models (including ChatGPT, Gemini, Grok, and Deepseek) to perform initial text mining on the 636 feedback entries, generating a preliminary list of keywords. This list was then reviewed and refined by disaster management experts, who finalized a set of 28 keywords that best represent the core issues of disaster exercises in Taipei.

Subsequently, the SentenceTransformer model (Devika et al., 2021) was applied to conduct a keyword-based semantic analysis of the 636 entries. This model calculated the semantic similarity score between each feedback text and the 28 keywords, successfully transforming the participants' subjective feelings and qualitative opinions into a set of quantitative data vectors suitable for machine learning analysis.

Finally, these semantically quantified vectors were fed into an 11x11 dimension Self-Organizing Map (SOM) model (Kohonen, 2001) for unsupervised learning and training. The SOM is capable of clustering high-dimensional data on a topological map, grouping similar feedback entries into adjacent neuron nodes. This process provides a visual representation of the overall distribution and latent correlations among all participant feedback.

III. RESULTS AND FINDINGS

Through the SOM's clustering analysis, the 636 semantically quantified data entries were successfully mapped onto the 11x11 topology, creating a clear "Post-Exercise Feedback Topology Map" as shown in Figure 2. This map not only revealed hidden patterns among different opinion clusters but also highlighted the common focal points of responders after experiencing the T-DEEP modular exercises.

The analysis clearly indicated that among numerous topics, the importance of "Information Systems and Tools" emerged as the most significant shared cognition. The neuron feature vectors on the topology map showed that feedback from personnel, regardless of their administrative level or professional role, was highly concentrated on the performance of existing information platforms, the need for integration across inter-agency systems, and concerns about the timeliness of data transmission. This suggests that the T-DEEP framework's design effectively guided participants to recognize and reflect upon the critical role of digital tools and information management in complex disaster scenarios.

IV. CONCLUSION AND RECOMMENDATIONS

This study successfully demonstrates that combining the localized T-DEEP exercise framework with AI-driven semantic analysis offers an innovative and robust quantitative method for evaluating urban complex disaster preparedness. The results not only validate the feasibility of

Semantic-based Evaluation of a Modified HSEEP Framework (T-DEEP) for Complex Hazard Preparedness in Taipei: Insights from Hotwash Feedback via SOM

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this hybrid approach but also prove its effectiveness in unearthing profound insights that are difficult to capture through traditional qualitative analysis alone.

The strong consensus among responders regarding "Information Systems and Tools" serves as a critical reference for the Taipei City Government to enhance its future disaster response capabilities. It is recommended that resources be prioritized for optimizing response information systems, establishing cross-domain data-sharing mechanisms, and enhancing the digital application training for relevant personnel. Overall, the evaluation methodology The strong consensus among responders regarding "Information Systems and Tools" serves as a critical reference for the Taipei City Government to enhance its future disaster response capabilities. It is recommended that resources be prioritized for optimizing response information systems, establishing cross-domain data-sharing mechanisms, and enhancing the digital application training for relevant personnel. Overall, the evaluation methodology proposed in this research provides a valuable and replicable model for other cities worldwide that are striving to advance evidence-based disaster preparedness.

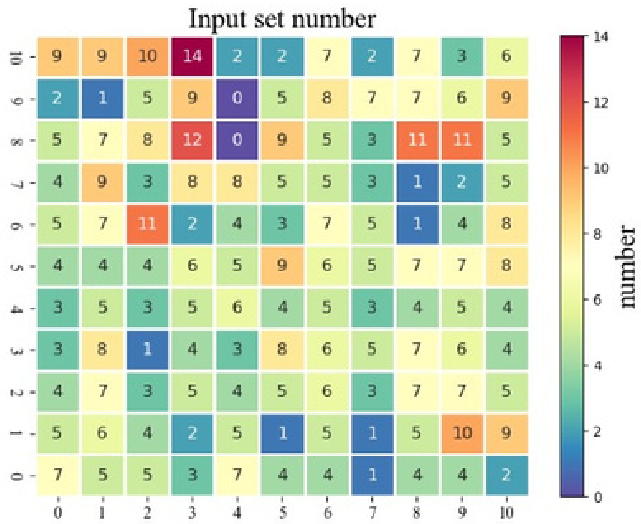

Figure 2. The 11x11 topology, "Post-Exercise Feedback Topology Map."

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EXTENDED ABSTRACTS

Local Industries and Complex Disasters in Garut, Indonesia

Kumiko Fujita[1]**,** Takako Izumi[2], Miwa Abe[3], Tadashi Uchiyama[4]

ABSTRACT

Garut Regency is surrounded by mountains, volcanoes, valleys, and cliffs. Due to its geographical conditions, Garut Regency faces multiple natural hazards, and each disaster and complex disasters significantly affect local industries. Volcanic eruption, tsunami, flood, landslide, and COVID-19 are selected as five critical hazards in "Regional Disaster Management Planning 2022-2026" for Garut Regency. However, the selection of hazards by local officials in Garut District across multiple sectors are different. Flood, landslide, epidemic, pollution and drought were selected as the five high-risk hazards. Understanding the reasons behind these differences will be useful for future planning of regional disaster management of both Garut District and Regency. By analyzing the reasons behind the selections of pollution and drought, it was found that industrial, economic and environmental causes were involved. The land of the Garut Regency is fertile and suitable for agriculture. Garut is also famous for animal husbandry such as sheep farm. In addition, the leather industry has recently contributed to the regency's economic activity. These key industries are affected to the result of the selection of five high-risk hazards. There is a concern that frequent flood will spread industrial wastes to farmland and residential areas. This causes health issues and social conflicts. Drought has a negative impact on agriculture which is the key industry of Garut, and it causes food crisis. These linkages to other issues were mentioned by the local officials and academics across multiple sectors, and they discussed how to address these challenges for future disaster risk reduction plans.

Keywords: complex disasters, local industries, risk identification, Indonesia

I. INTRODUCTION

Garut Regency (Fig. 1) covers an area of 3,065.19 km2. There are 14 potential hazards, and volcanic eruption, tsunami, flood, landslide, COVID-19 are selected as highly focused five hazards in "Regional Disaster Management Planning 2022-2026 for Garut Regency." A workshop for prioritization /ranking of critical hazards was held in Garut District in 2024.

Figure 1. Location of Garut Regency and District.

[1] Kumiko Fujita: International Consortium on Landslides, Kyoto, Japan: She has more than 20 years of experience in education and research for natural hazard-induced disaster risk reduction.
[2] Takako Izumi: International Research Institute of Disaster Science, Tohoku University, Sendai, Japan
[3] [4] Miwa Abe and Tadashi Uchiyama: School of Humanity and Sciences, Tokai University, Kumamoto, Japan

EXTENDED ABSTRACTS

Local Industries and Complex Disasters in Garut, Indonesia

Kumiko Fujita, Takako Izumi, Miwa Abe, Tadashi Uchiyama

II. HAZARD IDENTIFICATION FOR GARUT DISTRICT

The process of identifying natural, technical and biological hazards is different. Since the purpose of the workshop is identifying all hazards, the process is original. Participants are local officials and university faculties across multiple sectors who work with local people or have chances to talk to the local people in and around Garut District. There were 31 participants from 25 organizations. They were divided into six groups to ensure that participants from the same organization did not overlap. Each group had five or six participants with different job description. Each group selected hazards and prioritized critical five hazards. The total number of selected critical five hazards were 30. The number of each hazard were counted, and ranked as the top five hazards, which are flood, landslide, epidemic, pollution, and drought. The results were different from the regional planning for Garut Regency (Fig.2). Flood and landslide are major disasters for a long time and well recognized. Epidemic, pollution, and drought are rather recently recognized disasters.

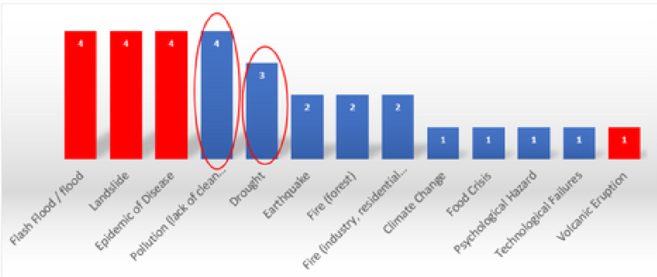

Figure 2. Selected hazards in the workshop (5 critical hazards x 6 groups = 30 hazards in total)

Five critical hazards: 1. Flood (4), 2. Landslide (4), 3. Epidemic (4), 4. Pollution (4), and 5. Drought (3)

Red circles: newly selected hazards, pollution and drought

Red bars: five critical hazards, “volcanic eruption, tsunami, flood, landslide, and COVID-19” in “Regional Disaster Management Planning 2022-2026” (Tsunami was not selected in the workshop.)

III. LOCAL INDUSTRIES AND COMPLEX DISASTERS

The local industries affect the result of the selection. The major industries in Garut District are agriculture, animal husbandry and leather industry. In Garut, animal skins are available from neighboring areas at affordable prices, and the abundance of animal skin waste is also used as a variety of leather goods that have a selling value as an export product. It is expected that leather industry support Garut's economy.

Garut Regency has always been prone to floods and landslides, and rainfall-induced landslide is the trigger of debris flow and flash flood in the downstream areas. This is a well-known complex disaster in Garut. In the workshop, the complex disasters of pollution and flood are focused, since floods spread pollutants from the tanneries to nearby farms.

Agricultural drought is one of the most important food security issues in Indonesia (Daruati et al., 2013). The shortage of food affects the feed for livestock, then it affects the leather production indirectly. Although, dry spells are increasing and wet spells are decreasing in Garut (Ruminta et al., 2023), the demand for water is increasing for the use of agriculture, other local industries, and drinking water because of the increasing population.

IV. INVOLVEMENT OF MULTISECTORAL PARTICIPANTS

When conducting hazard identification, the selection varies depending on who participates. The workshop was held specifically for local government officials and academics who interact with businesses and residents in the Garut District. As a result, hazard identification was conducted with an awareness of local industrial development. In addition, discussions among them reflect the current state of disaster prevention tailored to local economic development and living conditions. Therefore, the selected hazards are considered to accurately reflect the current situation.

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PARALLEL SESSION 5D

DESIGNING FOR RESILIENCE

Session Moderator: Gloria B. Teodoro PhD

Risk Resilient Housing Prototypes for Informal Settlements in the Philippines

Joshua Bolchover *represented by* ***Lewis James Maplethorpe***
The University of Hong Kong

An Analysis of Prison Cell Design Through Computational Fluid Dynamics (CFD): Analyzing Thermal Perception and Optimal Airflow for Occupant Comfort in Compliance with Ashrae Standards

Stephen Allen Beliganio De Guzman, *John Ernest F. Jose*
National University-Manila

Opportunities for Integrating Flood Resilience into Environmental Management of the Pansipit River System, Batangas, Philippines

Efren John Benedicto Buno, *Patricia Ann J. Sanchez, Loucel E. Cui, Janice B. Sevilla-Nastor*
University of the Philippines-Los Banos

EXTENDED ABSTRACTS

Risk Resilient Housing Prototypes for Informal Settlements in the Philippines

Joshua Bolchover[1]

ABSTRACT

The Philippines is ranked first on the WorldRiskIndex 2023 as the country with the highest disaster risk worldwide. Located in the "Pacific Ring of Fire", it is exposed to multiple hazards such as floods, earthquakes, storm surges, droughts, and volcanic eruptions that impact 74% of the country's population. (Global Facility for Disaster Reduction and Recovery, 2017). In 2021, the cost of damage due to extreme events and natural disasters amounted to Php68.8 billion (US$ 1,172,640,960) (UN-Habitat, 2023).

The 3.7 million families living in slums and high-risk areas are amongst the most vulnerable to the effects of extreme natural events. Most homes are often self-built, made of temporary materials, and are therefore subject to collapse during seismic or climatic events such as typhoons. On average, 22 tropical cyclones occur each year, putting residents at risk of losing their homes which can lead to them living in temporary shelters for extended periods whilst trying to rebuild.

There is a need to identify design pathways to in-situ upgrading for climate and disaster resilient housing for informal settlements that can provide residents with an option for safe, energy efficient housing with access to basic infrastructure within their existing communities.

This paper will present a model for an in-situ disaster resilient housing type that is designed for informal settlements in Manila. The project will demonstrate how the model has increased seismic and typhoon resilience, integrates sanitation infrastructure; innovates sustainable models of construction; yet remains affordable.

Keywords: informal settlements; in-situ upgrading; incremental growth; prefabricated design; disaster resilience; Philippines

I. INTRODUCTION

The WorldRiskIndex consistently identifies the Philippines as the country with the highest latent disaster risk, reflecting high exposure to cyclones, earthquakes, floods, storm surges, and sea-level rise, together with structural social vulnerabilities (BusinessWorld, 2023; The ASEAN Daily, 2024). This geographic and climatological reality—an archipelagic nation located along the Pacific "Ring of Fire" and within the Northwest Pacific typhoon belt—means that an estimated majority of the population and large swathes of urban land remain subject to repeated hazard impacts. According to UN-Habitat, nearly 74 percent of the Philippine population is directly exposed to one or more natural hazards (UN-Habitat, 2023). These overlapping risks have generated escalating human and economic losses: in 2021 alone, natural disasters caused an estimated ₱68.8 billion (approximately US $1.17 billion) in damage (Adarne et al., 2024).

Alongside this, the Philippines faces an escalating urban housing crisis: UN-Habitat (2023) estimates a national housing backlog of approximately 6.5 million units (2022 baseline) and identifies roughly 3.7 million informal settler families (ISFs) who are disproportionately

[1] Joshua Bolchover is an architect and Professor at The University of Hong Kong. His work focuses on innovating design strategies in developing regions undergoing rapid urbanization. He started a new impact enterprise in 2020 - District Development Unit - to scale initiatives designed to change how developing regions grow. He has written three books, Becoming Urban: The Mongolian City of Nomads, 2023, Border Ecologies: Hong Kong's Mainland Frontier, 2017, and Rural Urban Framework: Transforming the Chinese Countryside, 2014.

Risk Resilient Housing Prototypes for Informal Settlements in the Philippines

Joshua Bolchover

concentrated in high-risk and hazard-prone urban locations, including Metro Manila (UN-Habitat, 2023; Senate Policy Brief, 2025). Informal dwellings are predominantly self-built from temporary materials, lack essential infrastructure (drainage, sanitation, secure water supply, reliable electric service), and are often sited on floodplains, riverbanks, steep slopes or coastal margins—conditions which exacerbate hazard events into frequent, catastrophic loss of shelter, livelihood and life (ACASH, 2024).

This paper presents two prototypes for Risk Resilient Housing designed for informal settlements—one situated in Caloocan (Metro Manila) and another on the outskirts of the Metro in Naic, Cavite. The prototypes propose an in-situ upgrading model that enhances physical, environmental and social resilience without necessitating displacement to remote resettlement sites. The following interrelated objectives underpin the design: enhancement of structural resilience to both seismic and typhoon loads; upgrading of public spaces and organisation of these spaces from private to the public realm; capacity to build in situ using light-weight prefabricated systems for construction; affordability through community participation in building (sweat equity) and seeking other financial sources to scale the operation. By embedding resilience at both the dwelling and community scales, the prototypes seek to transform vulnerability into adaptive capacity.

Methodologically, the research adopts a multi-scalar approach combining site analysis, structural evaluations, and socio-economic assessment based on resident interviews conducted on site. The design process integrates local materials and vernacular construction knowledge with contemporary engineering principles. Structural models assess wind and seismic resistance, while environmental simulations evaluate passive-cooling and optimised daylighting.

These Risk-Resilient Housing prototypes are currently being designed by District Development Unit in partnership with local Philippine engineering specialist Base Bahay Foundation Inc. The prototypes employ a lightweight prefabricated bamboo structural system, ensuring typhoon and earthquake resilience while delivering high-quality living spaces characterized by natural ventilation, ample lighting, thermal comfort, and integrated rain-water collection. The prototypes demonstrate the capacity to build on sites with accessibility issues with a system that empowers local residents to construct their own homes with minimal training and supports incremental expansion over time—thereby adapting to evolving needs.

Beyond physical safety, the prototypes emphasise socio-spatial inclusion. Relocation to peri-urban resettlement sites often severs social networks and economic ties, resulting in "back-migration" to high-risk informal settlements (Vera Files, 2023). In contrast, in-situ upgrading sustains community cohesion and supports local economic activity while embedding disaster-risk reduction and climate adaptation into the urban fabric.

By addressing the structural causes of vulnerability—poor construction quality, insecure tenure and infrastructural deficits—the model contributes to the realisation of Sustainable Development Goal 11 (Sustainable Cities and Communities) and the Sendai Framework for Disaster Risk Reduction 2015–2030. Furthermore, it supports the Philippine government's ongoing Pambansang Pabahay para sa Pilipino (4PH) Program, which targets one million housing units annually but remains challenged by affordability and site-selection issues (UN-Habitat, 2023; ACASH, 2024). Embedding resilience into informal-settlement upgrading thus represents a strategic opportunity to integrate national housing policy, disaster-risk management and urban sustainability agendas.

EXTENDED ABSTRACTS

Risk Resilient Housing Prototypes for Informal Settlements in the Philippines

Joshua Bolchover

In conclusion, Risk Resilient Housing: A Prototype for Informal Settlements in the Philippines demonstrates that safe, adaptive and affordable housing can be achieved within existing urban communities when resilience principles are embedded from the outset. As climate and disaster risks intensify, particularly in hazard-exposed nations such as the Philippines, the transformation of the most vulnerable settlements through in-situ, community-driven upgrading offers not only a pathway toward physical safety but also toward inclusive and sustainable urban futures.

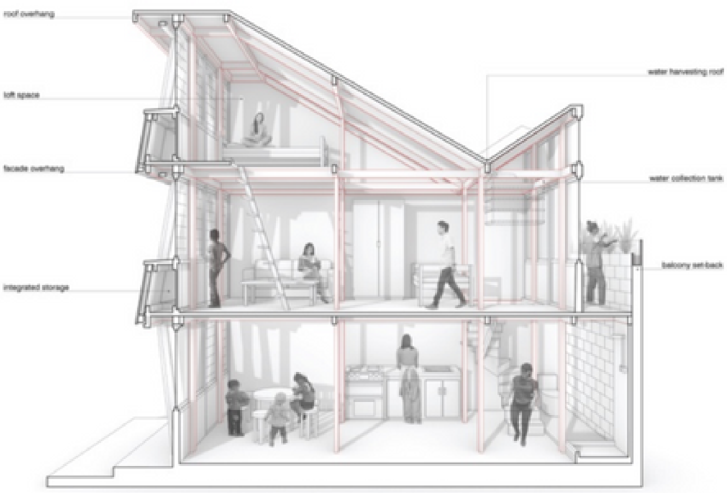

Figure 1. Perspective Section, Risk Resilient Prototype
Source: Image created by District Development Unit

Figure 2. In-situ Rendering of two-and-a-half storey housing prototype
Source: Image created by District Development Unit

Risk Resilient Housing Prototypes for Informal Settlements in the Philippines
Joshua Bolchover

Figure 3. Rendering illustrating further development with an additional one-and-a-half-storey prototype
Source: Image created by District Development Unit

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An Analysis of Prison Cell Design Through Computational Fluid Dynamics (CFD): Analyzing Thermal Perception and Optimal Airflow for Occupant Comfort in Compliance with ASHRAE Standards

Stephen Allen B. de Guzman[1]**,** John Ernest F. Jose[2]

ABSTRACT

This study investigates the role of Computational Fluid Dynamics (CFD) in optimizing prison cell design to enhance thermal comfort and airflow efficiency in accordance with ASHRAE Standards 55 and 62.1. The study focuses on Calamba City Jail, which addresses environmental stressors such as excessive heat, stagnant air, and inadequate ventilation that compromise the well-being and rehabilitation of inmates. Utilizing a mixed-methods approach, the study combined field data from site visits and interviews with inmates and facility personnel with quantitative CFD simulations to evaluate airflow and thermal distribution under eight wind orientations. The CFD simulations were conducted in Autodesk CFD, incorporating specific heat flux settings for each model to replicate real-world thermal conditions. Two cell models were analyzed: one reflecting the actual overcrowded condition (40 occupants in 30m²) and another conforming to ASHRAE recommendations (6 occupants in 24 m²). Results indicate that wind direction from northeast to southwest (NE→SW) provided the most effective airflow and thermal uniformity in both configurations, significantly reducing heat accumulation and improving comfort indices. Conversely, the east to west (E→W) orientation demonstrated poor ventilation and stratification, failing to meet the required airflow rates. The findings highlight the inadequacy of current prison designs and demonstrate the value of CFD as a planning tool for evidence-based architectural interventions. The study advocates for design improvements that promote humane living conditions, reduce the risk of airborne disease transmission, and align with global indoor environmental quality standards contributing to inmate rehabilitation.

Keywords: Computational Fluid Dynamics (CFD); Prison Cell Design; Thermal Comfort; Ventilation; ASHRAE Standards; Indoor Environmental Quality

I. INTRODUCTION

This study responds by applying Computational Fluid Dynamics (CFD) to simulate and assess airflow and thermal distribution within confined prison spaces. CFD offers a data-driven approach to identify ventilation inefficiencies and test design solutions such as optimal vent placement, ceiling height, and material selection (ANSYS Inc., 2023; Dokgöz, 2002). Aligned with ASHRAE standards for indoor comfort and air quality (ASHRAE 55, 2020; ASHRAE 62.1, 2022), this research aims to promote humane, sustainable, and cost-effective improvements to prison cell environments. It seeks to contribute to correctional reform by integrating engineering and architectural insights that support the health and well-being of Person Deprive of Liberty (PDL).

This study employs a mixed-methods approach, combining Computational Fluid Dynamics

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[2] John Ernest F. Jose is a faculty member at National University, Philippines, specializing in engineering research, computational modeling, and the development of sustainable built environments.

An Analysis of Prison Cell Design Through Computational Fluid Dynamics (CFD): Analyzing Thermal Perception and Optimal Airflow for Occupant Comfort in Compliance with ASHRAE Standards

Stephen Allen B. de Guzman, John Ernest F. Jose

(CFD) with site data from Calamba City Jail to assess airflow and thermal distribution in prison cells. The research analyzes two models: an existing overcrowded configuration and an ASHRAE-compliant standard, aligned with industry benchmarks for indoor comfort and air quality (ASHRAE 55, 2020; ASHRAE 62.1, 2022). The CFD simulations provide a data-driven method to identify ventilation inefficiencies and test design solutions for vent placement and cell geometry. A key finding reveals that wind orientation is a pivotal design factor. The Northeast to Southwest (NE→SW) direction promotes optimal airflow and thermal uniformity, whereas the East to West (E→W) orientation causes dangerous stagnation and heat buildup. These evidence-based, architectural interventions, guided by engineering insights, are therefore not merely technical improvements but are essential for creating more humane, health-compliant, and rehabilitative environments for Persons Deprived of Liberty (PDL), contributing directly to sustainable correctional reform.

II. METHODOLOGY

To evaluate thermal comfort and airflow performance, two separate prison cell models were generated: one representing the maximum number of inmates recorded during the site visit (40 individuals in a 30 m² cell), and another complying with ASHRAE's recommended space allocation of 4 m² per person. Both models were analyzed using an inlet velocity of 2.5 m/s, derived from the 2025 average wind speed in Calamba City, (approximately 5.3 miles per hour or 3.5 meters per second as reported by Weatherspark, 2025). The prison cell were conducted under eight different wind orientations—N→S, NE→SW, E→W, SE→NW, S→N, SW→NE, W→E, and NW→SE—to reflect varying environmental conditions.

A. Computational Domain and Geometry

Two distinct 3D prison cell models were created in Autodesk Revit based on precise site measurements from Calamba City Jail. The first model replicated the actual, overcrowded condition, measuring 6m x 5m x 2.5m and housing 40 inmates. The second was an ASHRAE-compliant standard model (6m x 4m x 2.5m) for 6 occupants. Key openings—a window and cell bars—were modeled as primary and secondary ventilation inlets/outlets. These geometries formed the basis for all simulations.

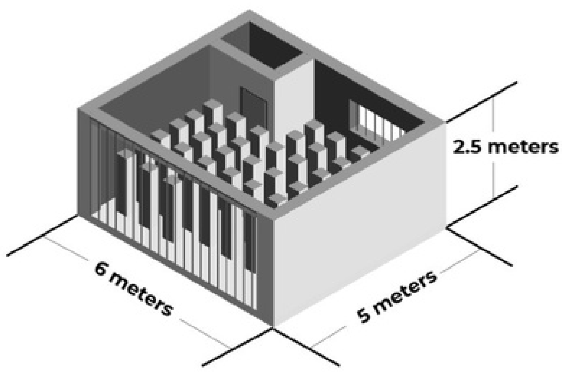

Figure 1. Calamba City with 40 occupants

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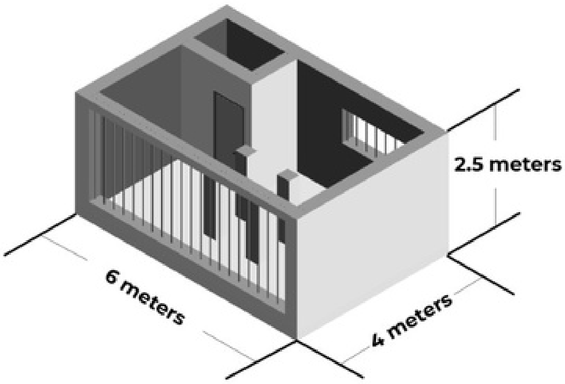

Figure 2. ASHRAE 62.1 with 6 occupants

B. Mesh Generation and Simulation Setup

g A critical step involved generating a structured computational mesh for each model using Autodesk CFD Workbench. The Calamba model contained 430,000 grid nodes, while the more spatially constrained ASHRAE model required a finer mesh of 540,000 nodes for accuracy. Local refinement ensured precise modeling near ventilation openings and walls. Boundary conditions were set to reflect realistic scenarios: a velocity inlet of 2.5 m/s (based on local wind data), pressure outlets, and wall surfaces with applied heat flux to simulate internal and solar heat gains.

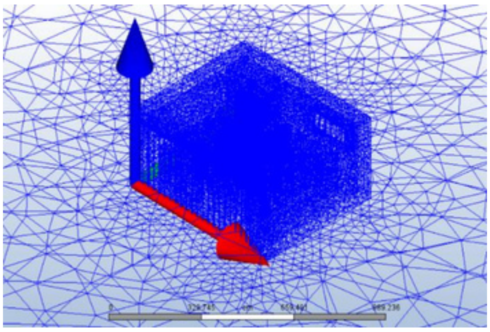

Figure 3. Mesh Generation Calamba City (430,000 grid nodes)

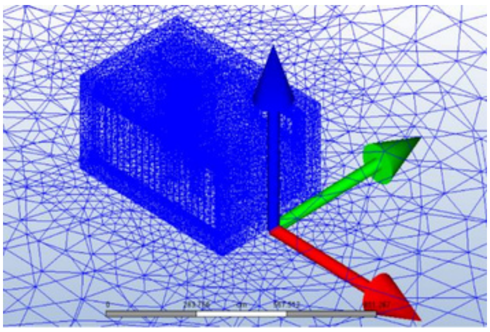

Figure 4. Mesh Generation ASHRAE 62.1 (540,000 grid nodes)

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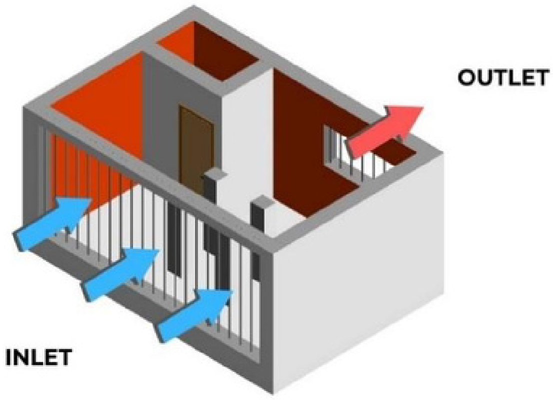

Figure 5. ASHRAE 62.1

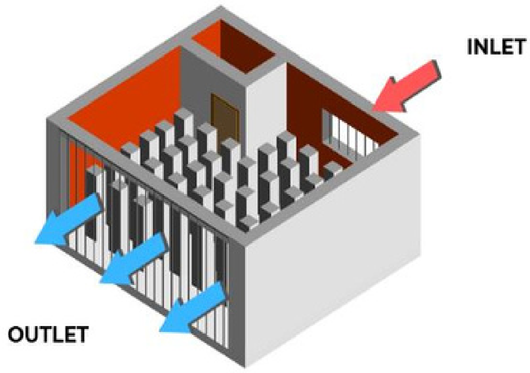

Figure 6. Calamba City

C. Equations and Turbulence Analysis.

The core analysis involved running simulations for eight different wind orientations (e.g., N→S, NE→SW) for each cell model. The Reynolds-Averaged Navier-Stokes (RANS) equations were solved to simulate turbulent airflow and heat transfer. Post-simulation, results were analyzed by examining generated streamlines and temperature contours to identify stagnation zones, recirculation, and thermal stratification. The performance of each configuration was evaluated through comparative visual analysis and validated against the benchmark criteria established in ASHRAE Standards 55 and 62.1 for thermal comfort and ventilation.

Continuity-Equation:

$$\frac{\partial u_i}{\partial x_i} = 0 \qquad (1)$$

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Incompressible Momentum Equation:

$$\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = f_i - \frac{1}{\rho}\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_j}\left(v \frac{\partial u_i}{\partial x_j} \right) \qquad (2)$$

the Reynolds time average method is mainly the ensemble average of the physical parameters in the flow field, expressed as the sum of the time mean and the pulsation value:

$$f = \overline{f} + f' \qquad (3)$$

where u_i represents the velocity components, ρ is the air density, is ρ the pressure, and Fi includes body forces such as buoyancy effects.

The parameters in the flow field are expressed as the representation of equation (3) above, and then brought into the flow control equation system represented by (1) and (2), and the average Reynolds time equation for the average motion of the incompressible fluid is simplified by simplifying the time-averaging characteristics:

$$\frac{\partial \overline{u}_i}{\partial x_i} = 0 \qquad (4)$$

$$\frac{\partial \overline{u}_i}{\partial t} + \overline{u}_j \frac{\partial \overline{u}_i}{\partial x_j} = \overline{f}_i - \frac{1}{\rho}\frac{\partial \overline{p}}{\partial x_i} + v\frac{\partial^2 \overline{u}_i}{\partial x_j \partial x_j} + \frac{1}{\rho}\frac{\partial(-\rho \overline{u'_i u'_j})}{\partial x_j} \qquad (5)$$

Based on the preceding equation, Reynolds stress varies with pulse-value velocity and is nonlinear. The number of control equations remains at four after ensemble averaging, but the unknown quantity is raised to five owing to Reynolds stress. To solve the system of equations numerically, the Reynolds stress must be expressed in a known number, and a new equation must be added to the system of equations to make it closed and solvable.

III. DATA GATHERED

The site visit provided foundational geometric data, confirming cell dimensions of 6 meters in length, 5 meters in width, and 2.5 meters in height, with a primary window opening of 1.7m by 1.2m. The qualitative interviews yielded compelling testimonies from inmates, who described the cell environment as "like being in an oven" and reported widespread respiratory issues and sleep disruption due to the heat. Jail officer testimony corroborated these observations, confirming frequent inmate complaints regarding heat and poor ventilation, alongside reports of heat-related illnesses. The most extensive dataset came from the CFD simulations, which produced quantitative metrics for each wind orientation. This dataset included air velocity vectors and streamline plots for visualizing airflow paths, temperature distribution contours for assessing thermal stratification, and specific inlet airflow parameters.

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Figures 7-9. Entrance of Dormitories and Head Office of Calamba City Jail, Laguna

IV. RESULT AND ANALYSIS

The analysis of the CFD simulation results yielded definitive and significant findings. A critical determinant of performance was the wind orientation.

Table 1. Wind Direction Performance Analysis Table- comparison table for wind direction performance in both the Calamba City Jail (overcrowded model) and the ASHRAE-compliant-setup

Wind Direction	Calamba City Jail (Overcrowded)	ASHRAE-Compliant (6 Occupants)
North to South (N→S)	Air inflow at 3.5 m/s but uneven; **velocities drop to <0.8 m**/s; rear stagnation; moderate comfort.	Airflow **1.8–2.2 m**/s; minimal turbulence; corner stagnation reduced; stable comfort.
Northeast to Southwest (NE→SW)	Optimal flow; **velocities 1.5–2.0 m**/s; minimal stratification; excellent thermal and air quality.	Most optimal; **2.0–2.8 m**/s flow; excellent uniformity; meets ASHRAE standards.
East to West (E→W)	Weak performance; **airflow <0.5 m**/s; poor cross-ventilation; thermal hotspots.	Flow **1.0–1.5 m**/s; limited distribution; minor stagnation; acceptable but not ideal.
Southeast to Northwest (SE→NW)	**Upper zones 1.0–1.3 m**/s, **floor** <0.7 **m**/s; thermal stratification present; moderate comfort.	Airflow **1.7–2.3** m/s; improved floor ventilation; slight stratification.
South to North (S→N)	**Average 1.2 m**/s; airflow lacks penetration; localized heat buildup; moderate performance.	Stable **1.5–2.0 m**/s; minimal recirculation; meets basic comfort needs.
Southwest to Northeast (SW→NE)	Strong **flow 1.5–2.0 m**/s; minimal gradients; good pollutant control; second best orientation.	Strong flow **2.0–2.5** m/s; effective cooling and pollutant removal.
West to East (W→E)	Poor flow <**0.4 m**/s; airflow limited to inlet area; high thermal discomfort.	Still poor at ~**1.0 m**/s; thermal gradients and air stagnation persist.
Northwest to Southeast (NW→SE)	Decent coverage at **1.0–1.4 m**/s; minor turbulence; reasonable performance.	Good flow **1.8–2.4** m/s; minimal turbulence; good thermal distribution.

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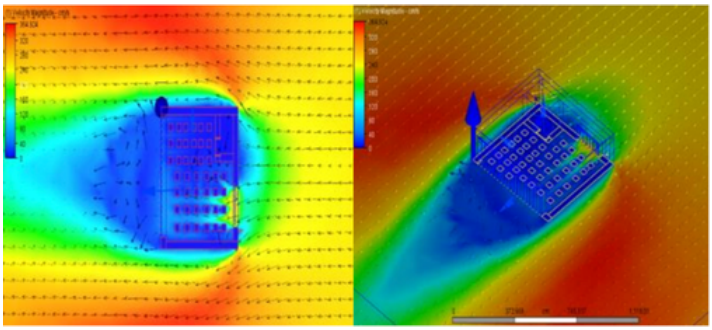
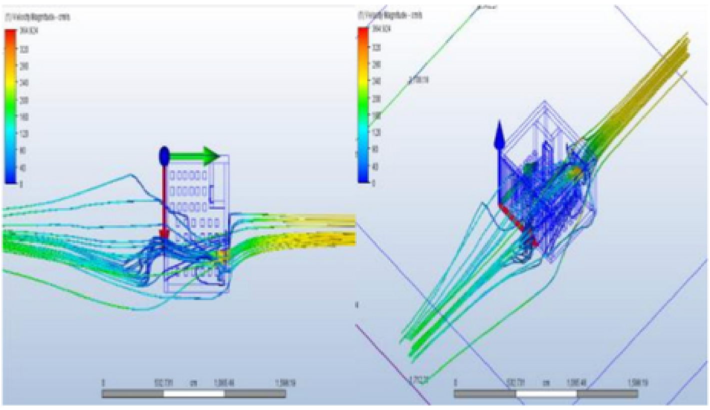
The Northeast to Southwest (NE→SW) orientation was consistently identified as the most effective across both prison cell models. In this orientation, air velocities remained high, between 1.5–2.8 m/s, with streamline visualizations showing smooth, uninterrupted flow that penetrated deep into the cell, minimizing stagnant-zones.

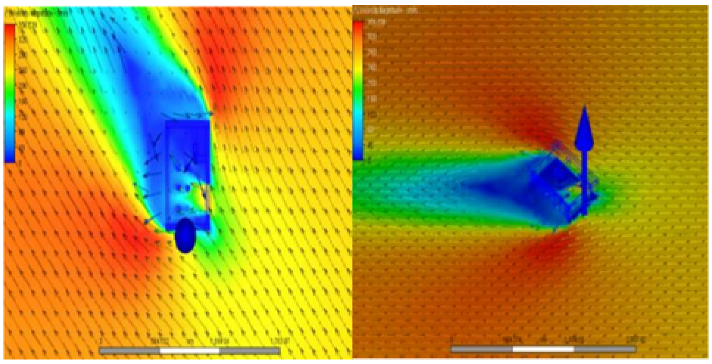


Figures 10-11. NE→SW Air Velocity Vectors-Calamba City Jail with 3D view.



Figures 12-13. NE→SW Streamline Visualization-Calamba City Jail with 3D.

The East to West (E→W) and West to East (W→E) orientations demonstrated the poorest performance, with airflow velocities plummeting below 0.5 m/s shortly after entry, resulting in significant air stagnation and severe heat accumulation in the cell's core and rear zones. The analysis of thermal conditions revealed alarming results.



Figures 14-15. (E→W) Air Velocity Vectors- Calamba City Jail with 3D.

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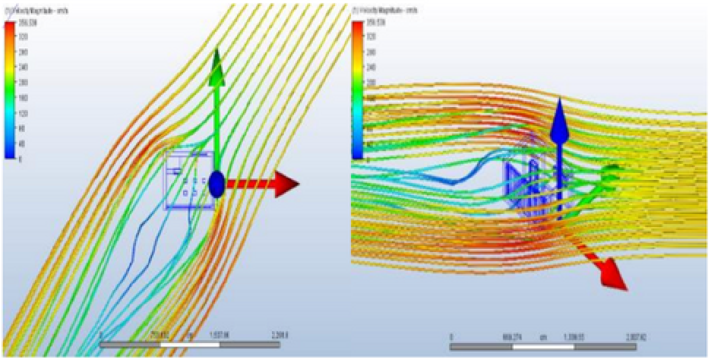

Figures 16-17. (E→W) Streamline Visualization with 3D.

The overcrowded Calamba City Jail model exhibited internal temperatures ranging from 38.5°C to a peak of 47.1°C, drastically exceeding the ASHRAE Standard 55 comfort range of 23–26°C. A formal compliance check against ASHRAE standards confirmed systemic failure.

Table 2. Temperature Assessment by Wind Direction Table- showing the comparative thermal ranges recorded across different airflow orientations in both the Calamba City Jail (overcrowded) and the ASHRAE-compliant prison cell models.

Wind Direction	Calamba City Jail (Overcrowded) Temp (°C)	ASHRAE-Compliant Temp (°C)
North to South (N→S)	Up to 44.2°C	40.5°C – 42°C
Northeast to Southwest (NE→SW)	38.5°C – 40.2°C	38°C – 39.5°C
East to West (E→W)	Up to 46.3°C	43°C – 44.7°C
Southeast to Northwest (SE→NW)	42.6°C – 45.1°C	41.3°C – 42.5°C
South to North (S→N)	41.5°C – 44.8°C	40.5°C – 42°C
Southwest to Northeast (SW→NE)	39°C – 41.7°C	39.8°C – 41.2°C
West to East (W→E)	Up to 47.1°C	43°C – 44.7°C
Northwest to Southeast (NW→SE)	39.4°C – 45.5°C	39.5°C – 42.5°C

The required ventilation rate for the overcrowded cell was calculated to be 118 L/s, but the effective usable airflow, hampered by poor distribution, was only 85.7 L/s, resulting in a deficit of 32.3 L/s. Psychrometric analysis further solidified this non-compliance.

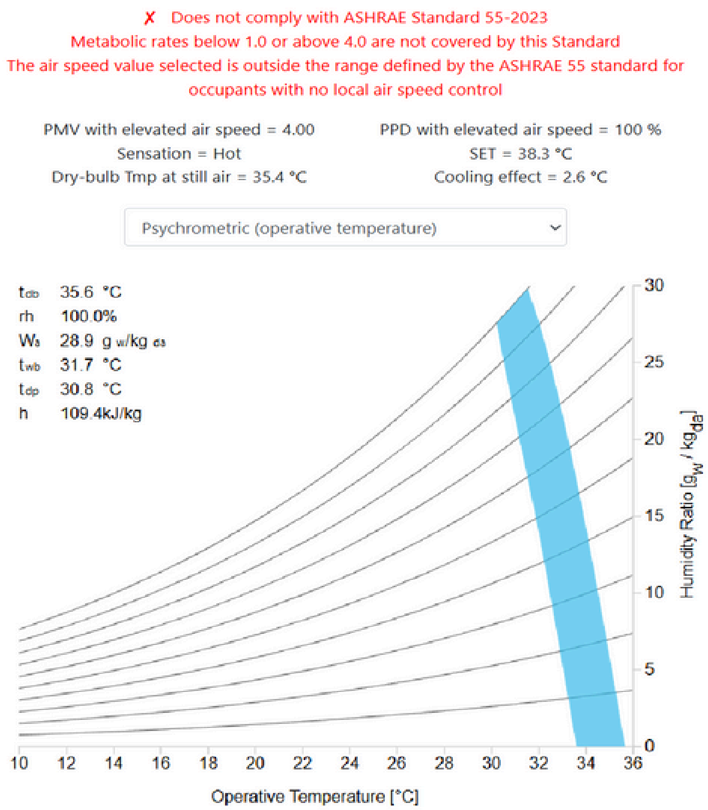

Figure 18. Psychrometric Chart Analysis in Compliance with ASHRAE 55 – Calamba City Jail (Based on Simulation).

V. CONCLUSIONS AND RECOMMENDATIONS

This study conclusively establishes that Computational Fluid Dynamics (CFD) is an indispensable diagnostic and optimization tool for evidence-based architectural design in correctional facilities. The research validates that the current conditions in severely overcrowded prisons like the Calamba City Jail are not only inhumane but also fundamentally non-compliant with international health and comfort standards. The findings demonstrate a direct causal relationship between architectural configuration, specifically building orientation and occupancy density, and the resulting indoor environmental quality. To translate these findings into practical action, the study proposes the following recommendations:

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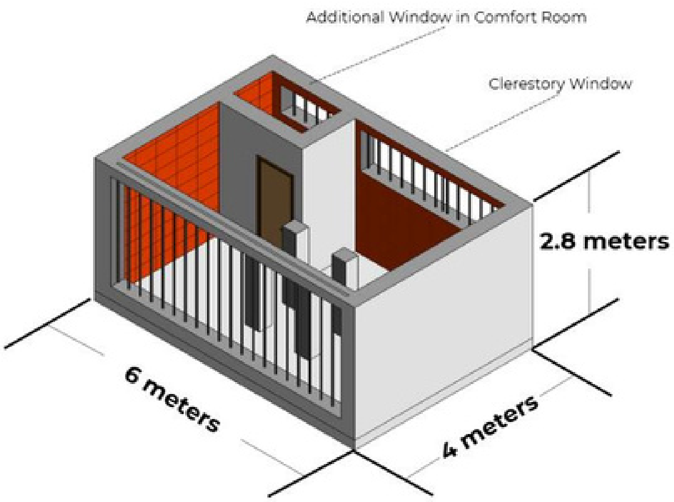

Figure 19. Revised Model Layout of Prison Cell in Calamba City, Laguna, in enhancing thermal stratification

First, all new prison structures or retrofits should be strategically aligned to capitalize on the Northeast to Southwest (NE→SW) wind direction to maximize natural cross-ventilation. Second, it is imperative to enforce a minimum spatial allocation of 4 m^2 per inmate to mitigate excessive heat load and allow for effective air circulation. Third, architectural designs should incorporate enhanced ventilation strategies, including raising ceiling heights to a minimum of 2.8 meters and installing elevated exhaust vents to facilitate the removal of hot, stagnant air. Fourth, for orientations with inherently poor natural airflow, the integration of low-energy mechanical exhaust fans is necessary to maintain the minimum ventilation rates mandated by ASHRAE 62.1. Finally, future research and development should explore the integration of passive cooling technologies, such as Phase Change Materials (PCMs), which have demonstrated potential to significantly reduce indoor temperatures. By adopting these data-driven design solutions, stakeholders can redefine correctional facilities as environments that ensure not only security but also the fundamental health, dignity, and rehabilitative potential of every occupant.

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EXTENDED ABSTRACTS

Opportunities for Integrating Flood Resilience into Environmental Management of the Pansipit River System, Batangas, Philippines

Efren John B. Buno[1], Patricia Ann J. Sanchez[2], Loucel E. Cui[2], Janice B. Sevilla-Nastor[2]

ABSTRACT

The Pansipit River System, the sole natural outflow of Taal Lake to Balayan Bay, sustains biodiversity, fisheries, and livelihoods across four municipalities while regulating hydrology and linking inland waters to coastal ecosystems. These ecological and socio-economic functions are increasingly threatened by climate-driven extreme rainfall and land cover change, which amplify flood risks. While moderate floods can benefit river ecology, this study finds that severe floods contribute to downstream dissolved oxygen (DO) depletion, particularly in the Palanas River, a critical spawning ground for migratory fishes. An integrated assessment combined (1) nonlinear regression modeling of DO dynamics (adjusted $R^2 = 0.67$), incorporating interaction effects among spatial, temporal, pollutant, and flood parameters; (2) Rainfall–Runoff–Inundation simulation model applied to a 3,365-hectare watershed isolated from Taal Lake, which pinpointed deep flood-prone zones in the Palanas River during a 200-mm Typhoon Ulysses (2020) scenario and demonstrated its capacity to simulate flood extent and depth in low-relief, data-scarce environments; and (3) Fuzzy Analytical Hierarchy Process, conducted by local government representatives to identify the most suitable mitigation strategy using criteria aligned with national objectives and influenced by community preferences. This process revealed strong preference for rehabilitating the Palanas River into a mangrove sanctuary, supporting local goals for clean water access, damage mitigation, livelihood security, tourism asset protection, and riparian preservation. By integrating ecological assessment, hydrological modelling, and participatory planning, the study offers a replicable framework for embedding flood resilience measures into environmental management plans applicable to other river systems facing similar multi-hazard pressures.

Keywords: flood resilience, water quality, hydrological modeling, nature-based solutions, environmental management, Pansipit River

I. INTRODUCTION

Outside the Taal Volcano Protected Landscape (TVPL), the Pansipit River System (PRS, Figure 1) is the sole outlet of Taal Lake to Balayan Bay through a bifurcated channel. One branch, the Palanas River, is a spawning ground and refuge for native freshwater species, while the other is dredged to maintain navigation and drainage. Spanning San Nicolas, Agoncillo, Lemery, and Taal, the PRS faces ecological and planning challenges as urban expansion intensifies floodplain pressures. The Pansipit River Management Plan (PRMP 2016–2021) addressed these issues, yet pollution persists. Major floods can surge suspended solids and contaminants (Grinham et.al., 2024), with climate change potentially amplifying events, highlighting the need for sustainable flood management.

[1] Efren John Buno is an alumnus of the School of Environmental Science and Management, University of the Philippines Los Baños, under the Master of Science in Environmental Science program. This paper is derived from his master's thesis, "Integrating Flood Resilience into Environmental Management: Recommendations for the Pansipit River System in Batangas, Philippines," completed and presented in 2024.

[2] Patricia Ann Sanchez, Loucel Cui, and Janice Sevilla-Nastor are faculty researchers at the same institution whose collective expertise includes environmental hydrology, freshwater biodiversity and conservation, and water quality dynamics related to land use and organic pollutants.

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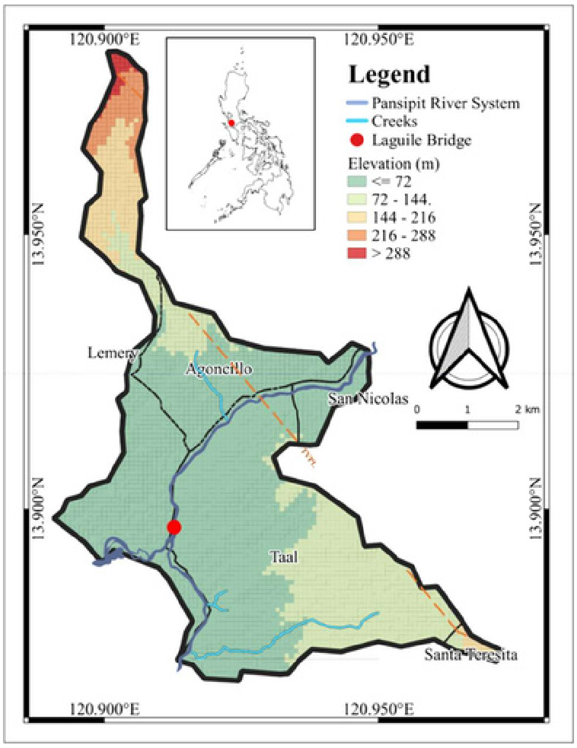

Figure 1. Delineated Watershed Map of the PRS.

Previous studies in the PRS, such as Paringit & Uy (2017), focused on fluvial flood estimation, with limited attention to environmental quality. Figure 2 presents the conceptual framework for integrating flood resilience. This study examines opportunities by integrating hydrology, ecology, and participatory planning to strengthen riverscape health.

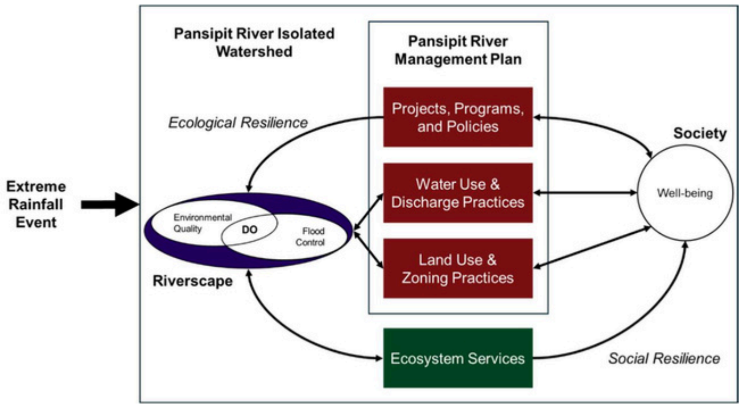

Figure 2. Conceptual Framework for Flood Resilience.

I. INTRODUCTION

The PRS was delineated as a 3,365-hectare watershed hydrologically isolated from the Taal Lake Basin, based on a 15-arc-second (~450 m) DEM. The area experiences a dry season from November to April and a wet season during the remaining months. A multi-method approach combined modeling with stakeholder evaluation for flood mitigation and ecological enhancement.

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First, nonlinear regression analyzed dissolved oxygen (DO) dynamics using quarterly monitoring data (2017–2021) from four stations (see Figure 3) set by Protected Area Management Office (PAMO-TVPL), considering interaction effects among critical pollutants (phosphate, fecal coliform) and flood-related variables (total suspended solids, temperature, pH).

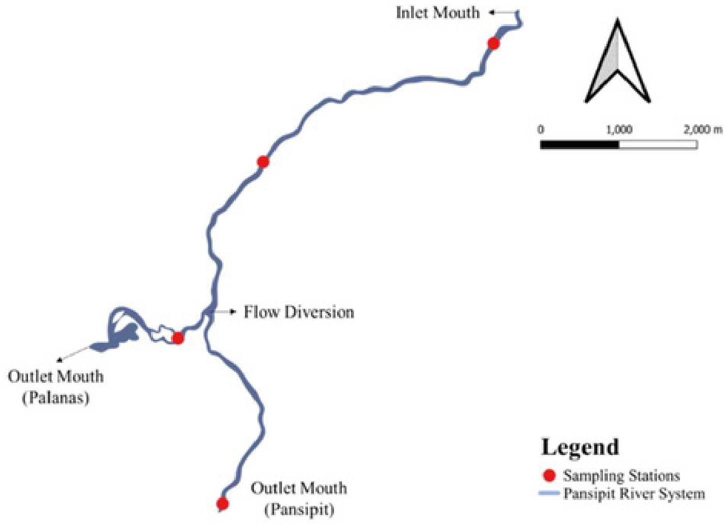

Figure 3. Location of Water Sampling Stations.

Second, a Rainfall–Runoff–Inundation (RRI) model (Sayama et.al., 2012) simulated flood behavior during the 48-hour rainfall of 2020 Typhoon Ulysses, using secondary data on rainfall, land cover, soil type, and elevation, calibrated with water-level measurements near the lake–river junction.

Finally, a Fuzzy Analytical Hierarchy Process (FAHP) (Kannan et.al., 2013) engaged four LGU representatives, one per municipality, to evaluate enhancement projects across five criteria aligned with PRMP priorities and the interests of national agencies and flood-affected establishments, with fuzzification applied to normalize judgments and reduce bias.

III. RESULTS AND ANALYSIS

The PRS faces compounding stresses—aggradation, nutrient loading, and fecal contamination beyond its intended beneficial use. Nonlinear regression (adjusted $R^2 = 0.67$) showed DO depletion below 5 mg/L was most critical downstream during the wet season, especially when fecal coliforms exceeded 80,000 MPN/100 mL at pH < 8.

The RRI model proved feasible for low-relief, data-scarce areas, delineating flood depths above 150 mm during the 200 mm rainfall of Typhoon Ulysses 2020. In Figure 4, flood-prone zones were observed close with low DO reaches, informing FAHP prioritization based on ecological vulnerability and flood exposure.

Sustainable options include sedimentation pond, constructed wetland, mangrove rehabilitation, and organic fertilizer facility. Selection criteria encompassed protection of livelihoods, assets, tourism, water resources, and ecosystem integrity. Table 1 shows that access to clean water received the highest prioritization.

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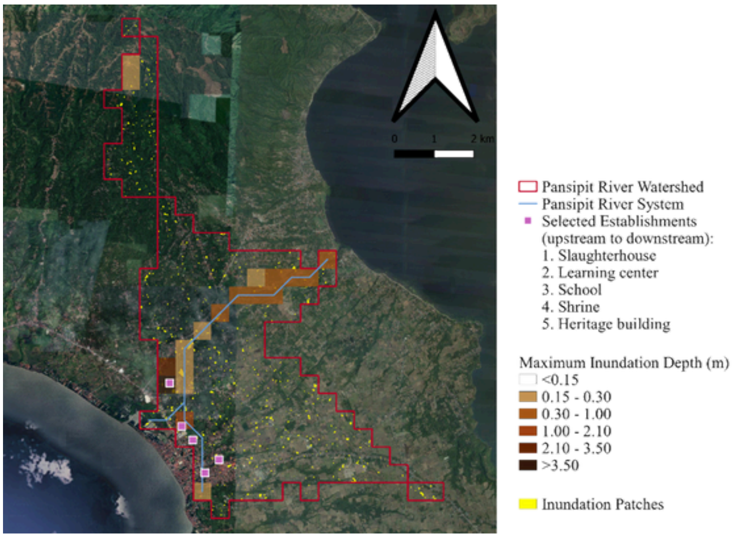

Figure 4. Simulated Maximum Floodwater Depths and Extent.

Table 1. Defuzzified Weights and Ranking of Criteria.

CRITERIA	$\bar{w}$	RANK
Secure the livelihoods of flood-affected communities	0.19	3
Minimize flood damage and lower recovery costs	0.20	2
Safeguard tourism infrastructure and roads during floods	0.14	4
Ensure access to clean water for communities after floods	0.39	1
Protect riverbanks and the benefits of floodplains	0.09	5

In Figure 5, FAHP results indicated the strongest preference for rehabilitating the PRS, particularly the Palanas River, as a mangrove–fish sanctuary, primarily for ecotourism. Meanwhile, the constructed wetland, intended to reduce fecal pollution, received the lowest score.

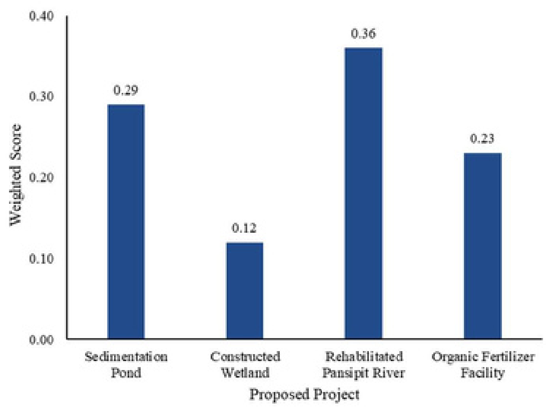

Figure 5. Weighted Scores of Proposed Enhancement Projects.

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IV. CONCLUSION

This study showed that integrating ecological assessment, hydrologic modeling, and multi-criteria analysis can identify opportunities to strengthen flood resilience in riverine management. FAHP favored nature-based solutions over engineered ones. Future work should refine models through continuous monitoring, particularly to validate dissolved oxygen as an indicator of environmental condition and flood resilience.

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PARALLEL SESSION 6

HERITAGE ENVIRONMENTS

Session Moderator: Caryn Paredes-Santillan PhD

Heritage Conservation as a Driver of Post-disaster Sustainable Resilience: Case of the 2022 Mw 7.0 Northwestern Luzon Earthquake at the World Heritage City of Vigan, Philippines

Cheek Fadriquela, *Kenneth Javier Tua, Maria Cristina P. Paterno, Anjelika A. Orui*

International Council on Monuments and Sites, Philippines, Inc.

Typhoon Odette: Post-Disaster Rapid Assessment

Joselito H. Corpus

ICORP Philippines / ICOMOS Philippines

Historical and Geographical Vulnerabilities: A Call for Documentation and Preparedness for the Colonial Churches of Cavite

Phillip Norbert Ahmad Medina

ICORP Philippines / ICOMOS Philippines / Cave Historical Society

Heritage Preservation in Conflict-Affected Areas: The Case of Lanao del Sur

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Heritage Conservation as a driver of post-disaster sustainable resilience: Case of the 2022 Mw 7.0 Northwestern Luzon Earthquake at the World Heritage City of Vigan, Philippines

Cheek S. Fadriquela[1], Cristina P. Paterno[2], Anjelika A. Orui[3], Kenneth K. Tua[4]

ABSTRACT

On July 27, 2022, a magnitude 7 earthquake struck Northern Luzon with the epicenter in Abra province. One of the sites heavily affected was the World Heritage Site (WHS) Historic City of Vigan inscribed in the UNESCO World Heritage List of Cultural Properties in December 1999. Subsequently, another strong earthquake with a magnitude of 6.4 struck the WHS city again on October 25, 2022. Many government agencies and civil service organisations came to the assistance of Vigan. However, despite efforts by local and national government agencies, the assistance was insufficient to address all damages of the historic zone, including limited funding and expertise for full analyses and restoration. The national government agencies have prioritized work on a few publicly owned structures, leaving most of the historic city of Vigan, composed of privately-owned structures, in dire need of assistance, several of which were rendered structurally unstable. UNESCO Jakarta accordingly supported the work of ICOMOS Philippines from August to November 2022 to assess and prioritize the needs of the vernacular houses in Vigan and thus a report was created which details ICOMOS Philippines' formulated valuation system in determining priority heritage structures for field survey immediately after disaster. This research provided a proven methodological and systematical way on how to address post-disaster in an immediate yet substantial and timely manner. This is the two-tier rapid valuation assessment approach, which utilized 'during' and 'after' heritage place specific valuation parameters for field surveys to assess and prioritize heritage assets. The assessment methodology can aid other heritage sites not only in Damage Assessment and Prioritization, but also in Knowledge Management and Synergy, and Funding and Resource Planning.

Keywords: Vigan, earthquake, valuation, rapid assessment, heritage, ICOMOS

I. INTRODUCTION

Vigan City is the capital of the Province of Ilocos Sur, a coastal province in the northwestern part of the Philippines. It is an island, detached from the mainland by three rivers - the great Abra River, the Mestizo River and the Govantes River. Inscribed as a World Heritage Site by United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1999, Vigan represents a unique fusion of Asian building design and construction with European architecture and planning. It is a well-preserved example of a European trading town in East and South-East Asia. 15 years later, the city has been selected as one of the "New 7 Wonder

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[4] Kenneth J. Tua is an architect with expertise in cultural landscapes, and environmental economics. He previously served as ICOMOS Philippines' Vice President and Country Director for the first UNESCO Heritage Emergency Fund project. He now serves as Kabilin Partnership Chief Project Officer at RAFI.

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Cities of the World", drawing an increasing number of tourists while presenting more challenges in its long term conservation and sustainability as a heritage site.

When the magnitude 7.0 Earthquake hit northwestern Luzon affecting Vigan City at exactly 8:43AM of July 27, 2022, infrastructure damages were visible in several buildings including the protected Ancestral Houses. Immediately, the CDRRM, with the assistance of Vigan Emergency Response Team and City Health Office, provided information and response measures accordingly. They conducted roving inspection to high risk and vulnerable areas and conducted Rapid Damage Assessment and Evaluation of the affected Infrastructures. They raised the city in Red Alert Status, eventually declaring a State of Calamity.

Despite efforts by local and national government agencies, the assistance was insufficient to address all damages of the historic zone, including limited funding and expertise to shoulder expenses for full analyses and restoration. The national government agencies were prioritizing work on a few publicly owned structures, leaving the majority of the historic town of Vigan, composed of privately owned structures, in dire need of assistance, several of which were rendered structurally unstable.

At this time, one of the most authentic and culturally significant heritage homes, the Syquia Mansion, reached out to ICOMOS Philippines for assistance. It was then that ICOMOS Philippines inquired to UNESCO Jakara about the Heritage Emergency Fund (HEF), and communicated the situation on the ground, based on the then haphazard information it was receiving.

ICOMOS Philippines was then assigned to fact find and consolidate all findings from various stakeholders to develop a situational analysis - past and current initiatives to study, stabilize and restore historic structures within the designated heritage zone of Vigan.

II. METHODOLOGY

A. Consolidation of Rapid Damage Assessment Reports

Rapid damage assessment reports from various public and private institutions were consolidated to gauge the severity of the situation after earthquake, understand the parameters used in the evaluation and create a valuation system for the priority structures for fieldwork investigation.

B. Valuation Parameters

A valuation system was created to determine the priority heritage structures for field survey by ICOMOS Philippines. Additional valuation parameters that would be determined during the fieldwork were established to determine priority heritage structures for further studies and/or intervention.

To facilitate the sorting of data for the priority listing, a three-tiered approach for each valuation parameter was adapted. Each level corresponds to a number which represents its level, with 3 corresponding to the classification or top level of utmost importance. A focused group discussion was conducted to evaluate the proposed valuation system.

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Table 1. Valuation Parameters for Priority Listing of Structures for Field Survey.

Severity of Damage to Structure				Cultural Significance							
Damage Classification		Exterior Damage		Age		Typology		With markers or declarations		Location	
Unsafe	+3	Heavy (fallen wall, major debris, etc.)	+3	< 1870	+3	Wood and Brick with Volada or Flush Façade	+3	WH, NCT, HNL, NHS, NHM (Grade 1)	+3	Along Crisologo St.	+3
Partially Safe/ Restricted	+2	Major(Minor to Major cracks; with falling debris)	+2	1871-1900	+2	All Brick	+2	Declared ICP (Grade 2)	+2	Core Zone	+2
Safe	+1	Minor (0-Minor cracks)	+1	From 1901	+1	American Colonial Period	+1	Presumed ICP (Grade 3) or with local marker	+1	Buffer Zone	+1

Table 2. Additional Valuation Parameters after Field Survey.

Accessibility and Public Service		Funding Availability for Restoration		Ownership		Sustainability	
Accessibility of site to public: open to the public all year round	+3	No source of funding/ has own initiative (based on action plan, with communication with related agencies)	+3	Privately owned with clear ownership	+3	Has technical, administrative and financial capability to maintain the structure	+3
By Appointment / seasonal accommodation	+2	No source of funding, rely on LGU assistance/other agencies	+2	Privately owned with multiple owners but without conflict of interest (ease of coordination)	+2	No technical and administrative capability but financially-abled to keep the structure privately owned	+2
Closed to public	+1	Has own source of funding	+1	Privately owned with multiple owners but with conflict of interest (high difficulty for coordination)	+1	For sale or owners are pondering of selling the structure	+1

C. Field Survey

A field survey was conducted from the 27th of September 27 (Tuesday) until the 1st of October (Saturday) 2022 to capture a general overview of the following:

1. Technical capacity and expertise with regards to conservation and restoration works in the World Heritage Site of Vigan whereby technical capacity refers to human resources (policy, coordination/operations, engineering, architectural, community members) and materials used for conducting conservation and restoration works;
2. Administrative concerns pertaining to conservation and restoration works in the World Heritage Site of Vigan whereby administrative concerns refer to:
   a. protocols and standards awareness
   b. stakeholder engagement and decision making or action planning;
3. Financing mechanisms towards World Heritage Site of Vigan conservation, restoration, and maintenance hereby finance mechanisms may be in the form of insurance, government support, or private donors.

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III. GATHERED DATA

A. Documents and Records Gathering

Figure 1. Formal turnover of requested documents and records (A0 09272022).

IV. RESULTS AND ANALYSIS

A. Technical Capacity Before, During and After Earthquake

B. Policies and Operations

C. Financing and Sustainability

V. CONCLUSION

There were other measures recommended to enhance the technical, administrative and financial capability of the World Heritage Site to respond in times of disaster. These can be classified into immediate, medium and long-term measures. Immediate-term measures are policies and activities with results within one year. Medium-term measures are those with results within three years while those beyond this period are classified as long term measures.

Short/Immediate-term:

1. The immediate retraining of Vigan LGU personnel in using the FARO laser scanner by Digiscript and the conduct of an on-the-job-training of students at the College of Architecture of UNP for scanning the ancestral houses;
2. A resolution on the use the heritage conservation fund with the heritage fee in the conservation of private ancestral houses;
3. An update on the PRECUP list towards the declaration of other heritage structures;
4. The efficient use of the private donations in understanding the structures through implementation of research;
5. The installation of a disaster alert system; and
6. Funding assistance request to UNESCO through the HEF for the technical and scientific studies at the Syquia Mansion and/or for the repair of Ruby Jars Factory dragon kiln towards the revival and sustainability of the burnay making industry.

Medium-term:

1. A revision of the 2010 Preservation Manual that will reflect the lessons in the earthquakes of 2022, an updated listing of accredited materials, technical and financial providers in the Resource Directory with contact details, and the need for its distribution to all homeowners and custodians as part of the awareness program for the long time maintenance of the heritage structures;
2. A review and an amendment of the Vigan Conservation Guidelines which include a. Setting of standards in structural retrofitting schemes that adheres to the tenets of international conservation guidelines;
   a. Streamlining of the processes for the building permit application;
   b. Right-sizing of the Heritage Conservation Division under the CEO with a competent structural engineer and heritage conservation architect;
   c. An increase in the Heritage Conservation Fund;
   d. Implementation of the heritage fee to augment the Heritage Conservation fund; and
   e. Thorough documentation with archival research of all heritage structures registered in the Directory of Homeowners.
3. The creation and adoption of Oplan Sarikedked for a cultural heritage focused disaster response;
4. The application of the priority listing for repair and restoration in other types of disaster situation;
5. A levelling-off with the national cultural agencies on the authority to conduct conservation works;
6. An update on the PRECUP list towards the declaration of other heritage structures;
7. The revitalization of the SVAHAI to attend to the concerns of ancestral house members; and
8. A funding assistance request to the DOT for undertaking vulnerability assessment studies.

Long-term:

1. A thorough implementation of the Vigan Charter that includes the identification of hazards and vulnerabilities in the natural, built, intangible and movable heritage, and the creation of the corresponding conservation management plans; and
2. The establishment of the Historic Forest Reserve system.

For the medium-term measures, the inclusion of external experts representing institutions on built heritage conservation in the VCC is also recommended.

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EXTENDED ABSTRACTS

Typhoon Odette: Post-Disaster Rapid Assessment

Joselito H. Corpus[1]

ABSTRACT

Typhoon Odette (Rai), which struck the Philippines in December 2021, devastated the Eastern and Central Visayas, severely affecting the Diocese of Maasin's historic churches, convents, and ecclesiastical structures. Many of these Spanish colonial-era buildings—symbols of religious and cultural continuity—suffered extensive damage that exposed both their physical fragility and the absence of Disaster Risk Management for Cultural Heritage (DRMCH) strategies. Roof failures, collapsed masonry walls, and weakened bell towers revealed how time, environmental exposure, and inadequate maintenance had compromised traditional construction systems once designed to withstand natural hazards. Post-disaster assessments led by a multidisciplinary team provided a comprehensive understanding of these vulnerabilities. Structural engineer Engr. Lessandro Garciano examined masonry performance under extreme wind and rain, recommending adjustments to engineering codes for heritage contexts. Architect Michael F. Manalo's condition surveys documented material deterioration and poor interventions, while historian Regalado Trota Jose's archival research uncovered historical records of resilience and community adaptation. Architect Cham Odam's photographic documentation further correlated architectural damage with environmental factors. Under the coordination of Dr. Eric Zerrudo, these efforts integrated technical, historical, and community-based perspectives in alignment with international conservation principles.

Findings revealed that the extent of damage stemmed as much from systemic neglect and lack of preparedness as from the typhoon's force. The Diocese of Maasin's experience underscores the urgent need to institutionalize DRMCH within local governance and heritage practice. Building resilience requires not only engineering and architectural solutions but also policy integration, education, and community participation to safeguard heritage in an era of escalating climate risk.

Keywords: Typhoon Rai, DRMCH, climate change

I. INTRODUCTION

Typhoon Odette (Rai), which struck the Philippines in December 2021, was one of the most destructive tropical cyclones in recent history, heavily impacting the Eastern and Central Visayas. Torrential rainfall, destructive winds, and widespread flooding caused significant loss of life, livelihood, and infrastructure. Cultural heritage was among the hardest-hit sectors, particularly the historic churches, convents, and ecclesiastical buildings under the Diocese of Maasin in Southern Leyte. Many of these structures, dating back to the Spanish colonial period, embody centuries of architectural, religious, and cultural continuity. The typhoon, however, exposed their material vulnerabilities and the gaps in preparedness and risk management for heritage conservation.

Post-disaster assessments revealed a consistent pattern of structural failures across several heritage buildings. Traditional stone masonry churches—long regarded as resilient due to their thick coral-stone walls, lime mortar bonds, and timber trusses—sustained extensive damage. Roofs were torn off, walls partially collapsed, and bell towers suffered major failures. Though these structures were historically adapted to local climatic and seismic conditions, decades of

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environmental exposure, insufficient maintenance, and cumulative deterioration had weakened them significantly. Moisture infiltration, biological growth, corrosion, and other agents of deterioration further compromised structural integrity. Without preventive conservation or pre-disaster planning, the buildings were highly vulnerable when Odette struck.

This situation underscores the urgent need to integrate Disaster Risk Management for Cultural Heritage (DRMCH) into local governance and heritage practice. DRMCH provides a strategic framework for identifying, assessing, and reducing risks to heritage, functioning across the entire disaster cycle—preparedness, response, recovery, and mitigation. When implemented effectively, it strengthens institutional capacity, promotes community engagement, and embeds heritage considerations within broader disaster risk reduction (DRR) systems.

This presentation examines the impact of Typhoon Odette on the Diocese of Maasin's built heritage and how the absence of a DRMCH plan contributed to the scale of destruction. It also highlights findings from multidisciplinary post-disaster studies conducted to understand structural and historical vulnerabilities in the affected sites.

Among the key contributors was Engr. Lessandro Garciano, AEP, who led structural engineering assessments based on the 2015 National Building Code of the Philippines. His research, grounded in climate change and contemporary risk analysis, clarified how historic masonry behaves under extreme wind and rain. He identified critical weaknesses such as deteriorated mortar joints, unanchored or weakened roofing systems, and stress concentrations in load-bearing walls. His findings emphasized that existing engineering codes—designed primarily for modern concrete and steel structures—must be adapted to better address the unique characteristics of heritage buildings.

Architectural condition assessments led by Architect Mico Manalo complemented these engineering studies. His documentation revealed recurring issues such as inadequate drainage, poor roof maintenance, and incompatible past repair materials that contributed to the structures' susceptibility to extreme weather. The detailed architectural documentation provided essential baseline data for future restoration, conservation interventions, and long-term maintenance planning.

A parallel historical investigation was conducted by Sir Regalado "Ricky" Jose, then archivist of the University of Santo Tomas. His review of diocesan and historical records traced earlier natural disasters and community responses. These findings revealed longstanding patterns of resilience, reconstruction, and adaptation. This historical dimension contextualized the technical assessments, demonstrating how traditional knowledge and past disaster experiences could inform contemporary risk management.

Architect Cham Odam contributed comprehensive visual documentation of the heritage sites through photography, mapping, and condition surveys. His work established a visual record of damage patterns and architectural features, aiding in correlating structural weaknesses with environmental exposure. These visual datasets became essential tools in understanding the extent of the disaster and planning appropriate conservation interventions.

The integration of all these efforts was facilitated by Dr. Eric Zerrudo, whose longstanding partnership with the Diocese of Maasin ensured smooth coordination among assessment teams. His leadership helped align the technical findings, archival perspectives, and community insights with international conservation standards and ecclesiastical protocols. This collaborative approach highlighted the importance of interdisciplinary work in post-disaster heritage assessment and recovery.

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Overall, the destruction caused by Typhoon Odette was not only a consequence of an extreme weather event but also the result of systemic gaps in preparedness, maintenance, and risk governance. The Diocese of Maasin's experience demonstrates the critical role of coordinated technical, historical, and community-based approaches in strengthening heritage resilience.

Ultimately, this case reinforces that DRMCH must be proactive rather than reactive. Safeguarding heritage in an era of intensifying climate risks requires institutional commitment, regular documentation, proper maintenance, community awareness, adaptive engineering, and culturally grounded strategies. By integrating heritage conservation within broader disaster management systems, communities can ensure that the tangible and intangible legacies of their faith and history endure—weathering both the storms of nature and the passage of time.

EXTENDED ABSTRACTS

Historical and Geographical Vulnerabilities: A Documentation and Preparedness Action for the Colonial Churches of Cavite

Phillip N.A.L. Medina[1]

ABSTRACT

The past should be the foundation for a responsive present. While the 2013 Bohol earthquake became an eye-opener for most heritage workers, learnings, initiatives, and sectoral alignment remain slow in the province. Locally known as Hazards to Heritage, the project aims to reignite the multi-sectoral initiatives focused on the documentation and risk assessment of the remaining Spanish colonial churches in Cavite. Cognizant of the locale's situation within proximity to volcanic and tectonic activities, other risk factors should be considered and coordinated with key community stakeholders for a more comprehensive action plan on provincial heritage structures. Recent scholarly works identify these various risks as geographical vulnerabilities (Alvarez, 2019 to 2024) in environmental history, while in heritage management, it is known as Agents of Deterioration and Loss (ICRROM, 2016). Following the core components of a risk management framework (RMF), the project pursues the identification, measurement, planning, monitoring, and governance using the joint perspectives of history and public administration as operative views for raising awareness and taking concrete action. Further, the project shall present the current initiatives as aligned with the international standards, such as the ISO 31000:2009 on Risk Management principles and the 6-step guidelines. This can be attested by its current developmental cooperation with the Cavite Provincial Disaster Reduction and Risk Management Office (PDRRMO). Lastly, the project shall pursue replication in other nearby provinces to include heritage structures in the methodological research, planning, and monitoring of other localities' DRRMO through collaboration with ICOMOS Philippines.

Keywords: Cavite, colonial churches, geographical hazards, heritage vulnerability, risk management.

I. INTRODUCTION

The Philippines has a long history of disasters. One can define the experience as perennial, and the Philippine nation has accepted it as its fate. The entire archipelago lies in a geographic hazard as it is located in the Pacific Ring of Fire, where active tectonic and volcanic activities occur daily. More so, the vast eastern ocean of the Pacific creates the deadliest of typhoons, causing great floods across the country. It is not surprising that the Philippines is listed "first" in the World Risk Report of 2024 and 2025. While we acknowledge these as facts of life, we should nonetheless learn from our history of disasters to address the burgeoning needs of disaster preparedness.

Part of the overarching study of heritage management tackles the varied studies of the social sciences. Here, history takes its role in defining and structuring past experiences and actions as a guide to understanding human interventions and decision-making. Apart from the dialectical contributions of archeology, anthropology, and the field of the arts, history engages with science as it deals with environmental history and climate change. These two fields of study are relevant in understanding the intersectionality of *geographical hazards, heritage vulnerability,* and *risk management.*

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EXTENDED ABSTRACTS

Historical and Geographical Vulnerabilities: A Documentation and Preparedness Action for the Colonial Churches of Cavite

Phillip N.A.L. Medina

Currently, there is a great need to elucidate the emergent discourses on hazards and calamities as themes in the review of historical and social sciences. Rather than just natural courses and accepted facts of life, this study offers a possible avenue for raising public awareness on the significance of viewing hazards and disasters as dynamic political, economic, social, and cultural phenomena that frequently endanger our nation's built structures.

Moreover, this study stems from earlier scholarly studies of merging history and science and grafting it to the local level in the last section of the study. Developing from Alvarez's (2019) extensive research on environmental history, early pioneers in 20th-century historical seismology have laid the groundwork for the study. He noted that in Europe, Jean Vogt (1993) contended that to be an expert in the field of earthquakes, one must have a good grasp of history to broaden its multidisciplinary approach and appreciation by having "a sense of scientific, technical, economic, social, and political responsibility requires the best possible all-round knowledge of historical seismicity and its background." In Asia, Katsuhiko Isihibashi (2004) discussed the approach of historical seismology as observation and analysis of historical materials beyond the technicalities of calculations and numeric data from seismograms, and that it is an integration of historiography and earthquake science.

In the Philippines, there are available studies on hazards, particularly on earthquakes that deal with the historical narrative and its complex consequential outcomes to policies, economics, and society. Here, the study noted two local scholars. Gealogo (2016) wrote a historical narrative teeming with scientific seismic data. Given this approach, the scholar identified and compared seismic phenomena in 1863 and 1880, achieving an initial study field of historical seismology in the Philippines. "Historical Seismology and the Documentation of Post-disaster Conditions: The 1863-1880 Luzon Earthquakes" responded to the growing interest in 21st-century modern history on the multi-focal approach of history, interwining science, social science, and history into a verdant study. Four years later, a young professor has specialized in the field of environmental history. Alvarez published "The June 1863 and the July 1880 Earthquakes in Luzon, Philippines: Interpretations and Disasters" in 2020 and the article "A Cultural Minority's Disaster Survival Experience: The August 1968 Luzon Earthquake, the Ruby Tower Tragedy, and the Chinese in Manila" in 2023. Both works tackle the historical hazard narrative of great earthquakes and how the colonial and modern governments responded to the natural hazards. Moreso, it provided a historical assessment of political ill-preparedness in times of disasters resulting in economic and social losses.

While earthquakes are just one of the natural hazards in the country, another scholar explored climate and its sub-themes of storms, floods, and droughts. Warren (2024) wrote comprehensively on the interplay of typhoons and Philippine society. Through the juxtaposition of hazards and history, he presented an innovative interpretation of past and future and provided an opportunity for a long-term perspective to address the recurring challenges in heritage management.

We appreciate these studies as they trailblazed a narrative on historical geographical hazards paralleled to heritage vulnerability, much so, the vulnerability of governance dealing with disasters. With natural hazards as key information, these scholars employed multi-disciplinary viewpoints to augment the available archival sources in the historicity of natural disasters and to address issues of heritage management beyond the Agents of Deterioration and Loss (ICRROM, 2016) and the standardized study of risk management of heritage in the country.

Historical and Geographical Vulnerabilities: A Documentation and Preparedness Action for the Colonial Churches of Cavite

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With Cavite as the focus of the study, we widen the expanse of environmental history to converge with the concerns of heritage risk management using PHILVOCS' hazard maps. While a multi-disciplinary study of history corresponds to risk identification and is valuable to risk analysis or assessment, the quest for public awareness will target other risk management principles and guidelines, such as implementation, allocation, mitigation, and reporting. This will necessitate not just the national agency's cooperation as claimed by Elayda and Tabuyo (2023) but will also require the full cooperation of the academe, the church, and local government (Medina, 2024).

Currently, the Cavite Provincial Disaster Reduction and Risk Management Office (PDRRMO) operates within the mandate and directives of the Department of Interior and Local Government. A new order issued this year explicitly instructs local governments and local DRRMOs to inspect "national cultural relics" every year. While this is a welcome progress, the study promotes an advocacy to monitor the tangible cultural heritage after every occurrence of disaster, especially those with documented risk occurrence and recurring damages. It is with great hope that through the usage of the historical past, we can document the present heritage and preserve these as future inheritance through a progressive stance on awareness, policy making, and preparedness.

Initial Figures

The entire province lies west of the West Valley faultline that runs from Montalban near the Las Mesa Watershed in the north and down to a residential area between Binan, Laguna, and Silang, Cavite. Given this fault system in the province, nearest to the faultline are the churches of Carmona, Silang, and Dasmarinas. Farthest are the churches of Cavite City, Tanza, Naic, Ternate, and Maragondon. However, distance may be insignificant as earth movement or shaking covers the entire province as seen in the following maps.

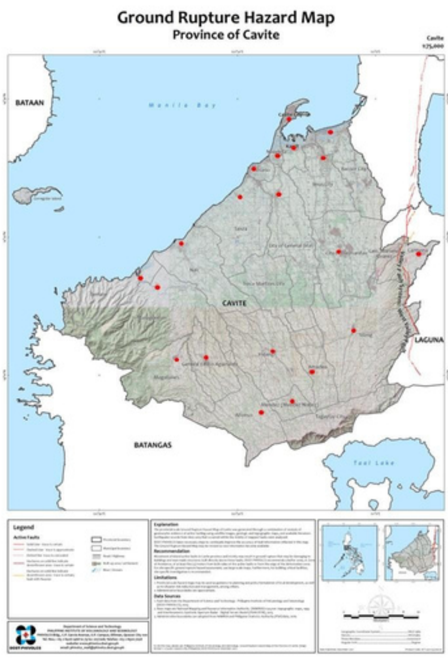

Figure 1. Ground Rupture Hazard Map with coordinates of heritage churches.
Source: https://www.phivolcs.dost.gov.ph/gis-web-hazard-maps/

Historical and Geographical Vulnerabilities: A Documentation and Preparedness Action for the Colonial Churches of Cavite

Phillip N.A.L. Medina

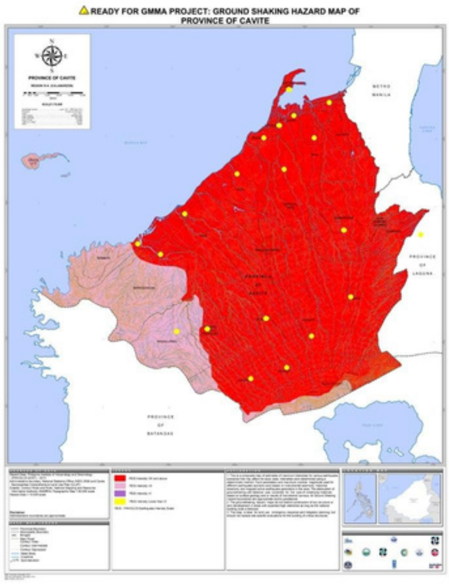

Figure 2. Ground Shaking Hazard Map with coordinates of heritage churches.
Source: https://www.phivolcs.dost.gov.ph/gis-web-hazard-maps/

Note that all churches with an exclusion of one (Magallanes) are mapped within the ground-shaking hazard of PHILVOCS. However, the frequent tectonic activity of Batangas may also affect upland Cavite's heritage churches given the proximity. These are the churches of Magallanes, Bailen, Alfonso, Mendez, Indang, Amadeo, and Silang.

For tsunami-prone areas, the coastal towns are at risk primarily the churches of Cavite City and Kawit. Tanza, Naic, and Ternate Churches may also be at risk given the proximity to the body of water.

Lastly, several coastal areas are also prone to liquefaction and even flooding as evident during the monsoon season. This hazard may greatly affect the churches of Cavite City, Bacoor, Kawit, and Rosario. A lesser degree of risk is posed in the areas of Imus, General Trias, Tanza, Naic, and Maragondon. These are located mostly in the north and north-western locations. Carmona solely on the eastern side is also prone to liquefaction and flooding based on the map.

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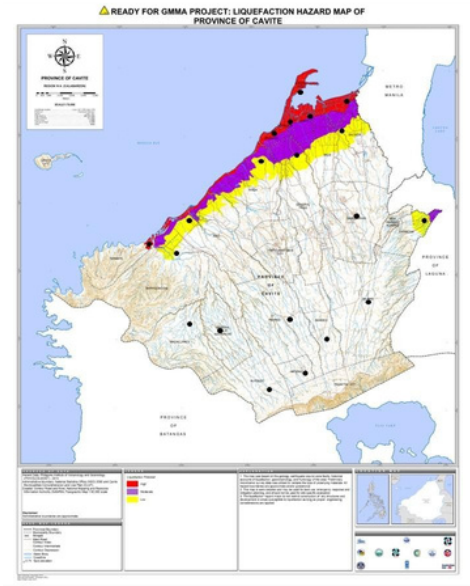

Figure 3. Liquefaction Hazard Map with coordinates of heritage churches.
Source: https://www.phivolcs.dost.gov.ph/gis-web-hazard-maps/

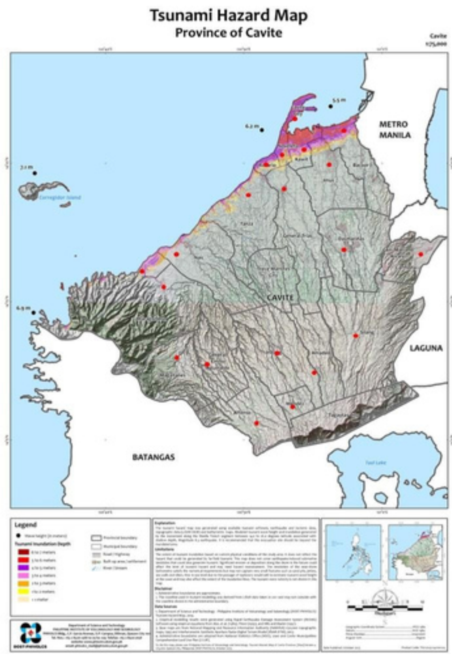

Figure 4. Tsunami Hazard Map with coordinates of heritage churches.
Source: https://www.phivolcs.dost.gov.ph/gis-web-hazard-maps/

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EXTENDED ABSTRACTS

Heritage Preservation in Conflict-Affected Areas: The Case of Lanao del Sur

Ruhollah Al-Husseini J. Alonto[1]**,** Sittie Ayena H. Caye[2]

ABSTRACT

Lanao del Sur, one of the component provinces of the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), is a sanctuary of Mindanao's rich heritage where Islamic traditions intertwine with indigenous culture. From the intricate okir motifs that are prominently featured in woodcrafts, brassware, textiles, and indigenous architecture (e.g., torogan), to the profound wisdom preserved in the centuries-old UNESCO-listed Darangen epic, cultural legacies are a testament to the time-tested resilience of the Meranaw ('people of the lake') and their collective desire to preserve their traditions and identity despite encountering centuries of conflict, such as the Spanish-Moro Wars, American Pacification Campaign, the Second World War, the contemporary Bangsamoro Struggle for Self-Determination, and the most recent 2017 Marawi Siege. This particular study aims to explore the complex relationship between conflict and culture. Specifically, it examines how violence alters the cultural landscape while simultaneously catalyzing resilience. Drawing data from archival sources, field research, and oral history, the case of Lanao del Sur is a testament to the long-enduring desire of Meranaws to preserve their distinct cultural identity. However, centuries of conflict and violence have significantly eroded the very fabric of Meranaw culture. This would explain the state of deterioration and neglect of both tangible and intangible heritage in the province despite their popularization through trade, tourism, and other forms of representation. As a way forward, this study underscores the need for deliberate efforts in the preservation, revitalization, and recognition of heritage as a foundation for building a just and lasting peace in the province.

Keywords: Lanao del Sur, Meranaw, heritage, conflict, post-conflict recovery

I. INTRODUCTION

Lanao del Sur, a predominantly Meranaw ('people of the lake') community, represents a geo-cultural space wherein indigenous agencies amalgamated with Islamic culture and traditions. The synthesis of this historical process has resulted in the development of a distinctly Meranaw culture that is popularly known for its sophistication and timeless beauty. From the intricate okir motifs that are featured in their material culture to the indigenous knowledge and worldview contained in the oral traditions, such as the Darangen Epic, Lanao del Sur can arguably be the sanctuary of Mindanao's rich heritage.

Unfortunately, this frontier of heritage and tradition is constantly threatened by the vicious cycle of violence and conflict. In 2017, the world witnessed a five-month brutal conflict between the Armed Forces of the Philippines and radical extremist groups that led to the destruction of the Islamic City of Marawi and the displacement of thousands of its residents. According to the Asian Development Bank (2018), around Php. 51.7 billion is required to finance the full recovery of the city. It must be stressed, however, that a significant portion of the city's cultural assets has been forever lost in the battle.

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EXTENDED ABSTRACTS

Heritage Preservation in Conflict-Affected Areas: The Case of Lanao del Sur

Ruhollah Al-Husseini J. Alonto, Sittie Ayena H. Caye

The cultural landscape of Lanao del Sur has long been shaped – and continues to be so - by conflict. Horizontal conflicts, such as the Spanish-Moro Wars, the American Pacification Campaign, the Second World War, the contemporary Bangsamoro Struggle for Self-Determination, and the most recent Marawi Siege in 2017, have resulted in the destruction of lives and property and the diaspora of Meranaw communities across the archipelago. This is further exacerbated by the constant threat of vertical conflict, such as clan feuds (rido) and election-related violence, that continue to disrupt local peace and order.

In this study, we explore the complex relationship between conflict and culture. Specifically, we examine how violence can alter the cultural landscape while simultaneously catalyzing resilience. In essence, this study aims to address two important objects of inquiry:

- To what extent has conflict affected the cultural development of Lanao del Sur?
- In what way can heritage preservation contribute to facilitating social cohesion, healing, and the promotion peace and justice in Lanao del Sur?

II. METHODOLOGY

A. Locale of the Study

The Province of Lanao del Sur is a component province of the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) and is located in the hinterland of Mindanao with an elevation of approximately 700 meters above sea level. The component municipalities of the province surround the basin of Lake Lanao, with an extension to the south occupying some of the coastal towns of Ilana Bay. Furthermore, the province is bounded by Bukidnon on the east, Maguindanao del Norte and North Cotabato on the south, and Lanao del Norte on the northwest.

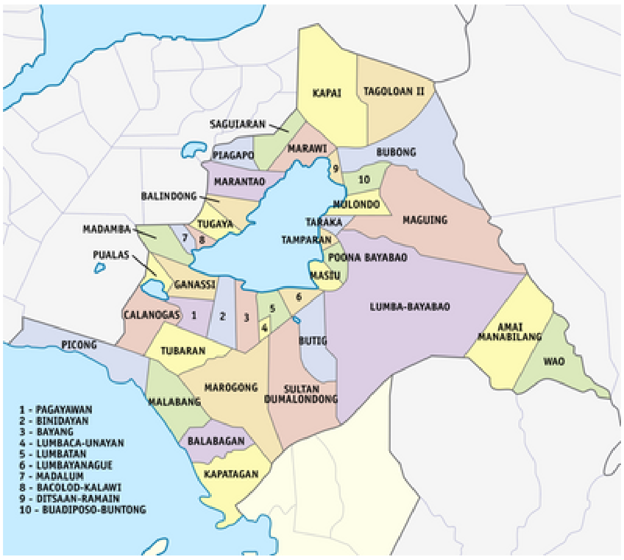

Figure 1. Political map of Lanao del Sur.
Source: https://www.phivolcs.dost.gov.ph/gis-web-hazard-maps/

B. Research Design

This research utilizes a qualitative historical methodology integrating three historical sources: archival records, fieldwork records, and oral traditions.

The analysis of data derived from these materials shall be clustered into three case studies.

Each cluster shall illuminate a distinct aspect of Meranaw society:

- Case Study 1: Built Heritage
- Case Study 2: Meranaw-Islamic Traditions
- Case Study 3: Intangible Cultural Heritage

III. DISCUSSION OF FINDINGS

The data reveal that there are two effects of conflict in Lanao del Sur, with respect to cultural development: 1) cultural erosion, and 2) cultural resilience.

The vicious cycle of conflict has consequently led to the destruction, displacement, and militarization of certain areas in the province. As a result, this in turn contributed to the gradual loss of traditional knowledge systems, heritage structures, and the transmission of intangible knowledge. Furthermore, it is also important to underscore that external factors – such as modernization, globalization, and the increasing infusion of Arab culture – have also accelerated this erosion.

Figure 2. Picture of the Grand Mosque in Marawi City after a five-month-long battle.
Source: Photo c/o Ruhollah Al-Husseini J. Alonto (2017).

Figure 3. Traditional Meranaw mosque. Circa, early 1900s.
Source: Filipinas Heritage Library.

On the other hand, conflict has also catalyzed cultural resilience and revival in Lanao del Sur. In a way, the prevailing state of insecurity have left most of the heritage sites untouched. Furthermore, the idea of revitalizing Meranaw culture has gained increasing traction, albeit often superficially, as government agencies seek to integrate culture and heritage development into post-conflict rehabilitation and peacebuilding initiatives.

IV. CONCLUSION

The case of Lanao del Sur is demonstrative of the paradoxical nature of conflict vis-à-vis cultural life. Meranaws have lost both tangible and intangible cultural assets over the centuries of violence. This consequently led to the present state of cultural erosion that is prevalent in the province.

Nevertheless, the Meranaws remain cognizant of the predicament of their culture. It is the very idea of losing their identity that became the driving force behind that desire to preserve and revive. Thus, all initiatives are anchored on this very framework.

This study also finds that commercialization and tourism-driven frameworks, while increasingly becoming a trend in the present discourse, do not necessarily equate to meaningful preservation and conservation of cultural assets. Instead, they are but band-aid remedies to deeply rooted problems. What is necessary is that peacebuilding and post-conflict rehabilitation should address the factors leading to cultural erosion and become the very foundation of cultural revival.

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Nature-based Solutions for Urban Resilience in the Anthropocene (NATURA)

Erich Wolff, Pamela Cajilig, Prof. Yeowon Kim, Annemie Rose Janssen
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From Interactions to Integrations: Innovations and Multi-Hazard Assessment and Management

Likha Minimo, Richard Ybanez, Jerico Mendoza
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Yağızalp Okur[1], Yo Fukushima[1], Kuo-En Ching[2], Yogendra Sharma[2]
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Frances Jan Marie P. Manlagaylay, John Burtkenley T. Ong
Environmental Science Department, School of Arts and Sciences, Ateneo de Davao University

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Cheek S. Fadriquela
International Council on Monuments and Sites

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***Mei Kimura*[1]*, Saki Yotsui*[2]*, Kensuke Otsuyama*[2]*, U Hiroi*[2]**

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Sébastien Penmellen Boret, Hyejeong Park

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09 Development of Disaster Education in China: From Policy Context to Regional Practice

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13 Enhancing Resilience in Coastal Ecosystem: Integrating Technology and Conservation for Sustainable Turtle Protection Amid Multi-Hazard Threats

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14 The Development of the Adaptive Basic Resource Recognition and Allocation Model (ABRRAM): Initial Basic Resource Detection Methods

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