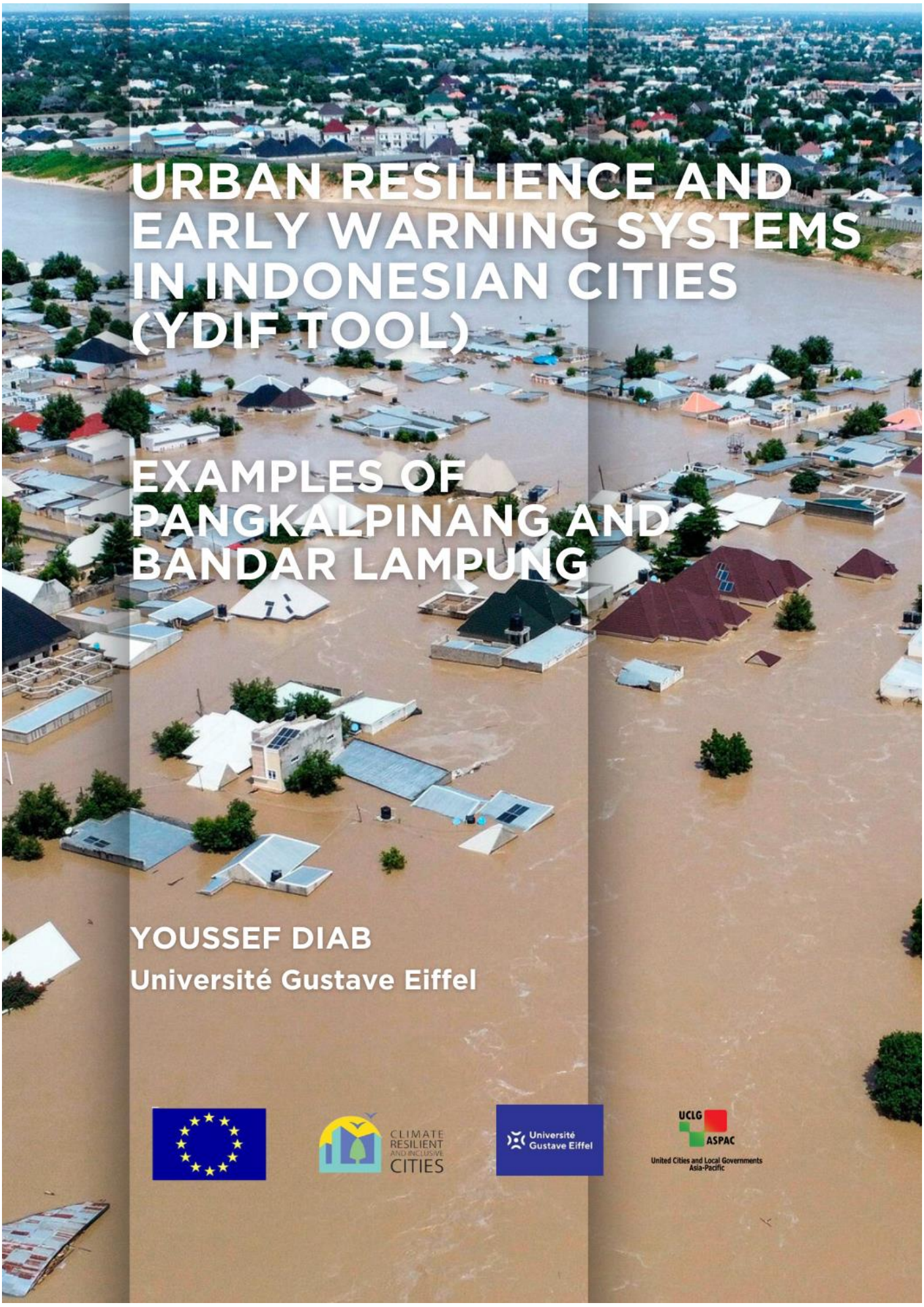


URBAN RESILIENCE AND EARLY WARNING SYSTEMS IN INDONESIAN CITIES (YDIF TOOL)

EXAMPLES OF PANGKALPINANG AND BANDAR LAMPUNG

YOUSSEF DIAB
Université Gustave Eiffel

CLIMATE RESILIENT AND INCLUSIVE CITIES

Université Gustave Eiffel

UCLG ASPAC
United Cities and Local Governments Asia-Pacific

Urban Resilience and Early Warning Systems

in Indonesian Cities (YDIF Tool)

Examples of Pangkalpinang and Bandar Lampung

Youssef DIAB [1]

Université Gustave Eiffel

5 boulevard Descartes
Champs-sur-Marne
77454 Marne-la-Vallée Cedex 2

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1. Key Concepts in Urban Resilience and Early Warning Systems

1.1. Urban Resilience and Its Importance

1.1.1. Definition and Dimensions of Urban Resilience

Urban resilience is the capacity of individuals, communities, institutions, and systems within a city to survive, adapt, and thrive in the face of chronic stresses and acute shocks. These stresses might include ongoing challenges like poverty, aging infrastructure, and climate change, while shocks could refer to disasters such as floods, heatwaves, or earthquakes.

Resilience is multidimensional, incorporating ecological, economic, social, and institutional aspects. It does not merely involve recovery from a crisis but emphasizes the ability to "bounce forward" by addressing vulnerabilities, fostering inclusivity, and ensuring long-term sustainability.

The modern understanding of resilience draws from multiple disciplines:

- **Ecology** emphasizes adaptability and system stability.
- **Engineering** highlights robustness and recovery from structural impacts.
- **Social Sciences** focus on human adaptability, social cohesion, and governance.

The transformative approach to resilience introduces the concept of "bouncing forward," which underscores not only recovery but also the reorganization and improvement of systems to prevent future crises.

1.1.2. Challenges Posed by Climate Change to Urban Areas

Climate change intensifies both the frequency and severity of stresses and shocks in urban environments. Cities are especially vulnerable due to their dense populations, extensive infrastructure, and reliance on interconnected systems. Key challenges include:

- Extreme Weather Events: Floods, hurricanes, and heatwaves increasingly threaten cities, disrupting lives and livelihoods.
- Rising Sea Levels: Coastal cities face existential risks due to flooding and storm surges.
- Resource Scarcity: Higher temperatures and erratic rainfall patterns lead to water and food shortages.
- Public Health Risks: Climate change exacerbates the spread of diseases like dengue fever and malaria.

Urban resilience strategies must integrate climate change adaptation by prioritizing green infrastructure, enhancing early warning systems, and promoting sustainable development.

- Since the start of the 21st century, the resilience concept evolved from adaptation, learning, prevention, dynamism, recovery to transition, modularity, inclusion, and ability to rebound.
- Approach based on system thinking, based on the understanding of the dynamic and relationships between the different systems involved to guarantee reliability, safety, business continuity and sustainability.
- Organizations keep improving their capacity to know when a shock is likely, which areas are exposed to disasters, to foresee economic changes that will affect society. The challenge now is how to understand potential events from a systemic perspective, to manage risks and ensuring the ability to act efficiently at different levels of the system / community.[2]

1.2. Essentials of Early Warning Systems (EWS)

5.1.1. Overview of Multi-Hazard Early Warning Systems (MHEWS)

Multi-Hazard Early Warning Systems (MHEWS) are integrated frameworks designed to detect, analyse, and provide warnings for a variety of hazards, enabling timely responses to minimize disaster impacts. Unlike single-hazard systems, MHEWS address the systemic nature of risks, recognizing that different hazards often occur simultaneously or sequentially, amplifying their effects.

MHEWS serve as a critical component of disaster risk reduction (DRR) strategies. They emphasize prevention and preparedness, rather than solely response, saving lives and reducing economic losses.

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[2] *Community (system's) focus: the National Institute of Standards and Technology (NIST) approach.*
Resilience is the ability of a community to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. Activities, such as disaster preparedness (including prevention, protection, mitigation, response, and recovery), and code adoption and enforcement, are key steps, and certainly help, but communities can do more to prepare for and improve their resilience to disasters.

5.1.2. Components: Monitoring, Forecasting, and Dissemination

MHEWS are built around four core components:

1. Risk Knowledge
    - Understanding and assessing the risks posed by various hazards is foundational to designing effective EWS. This involves mapping vulnerable areas, collecting historical data on hazards, and identifying critical infrastructure at risk.
2. Monitoring and Forecasting
3. Continuous observation of environmental and hazard conditions is crucial. Advanced technologies, such as seismic sensors, weather satellites, and AI-based predictive modelling, are used to detect early warning signs of potential disasters.
4. Communication and Dissemination
    - Timely and accurate communication of warnings is critical for enabling appropriate responses. Information must reach all sectors of the population, including vulnerable groups, through multiple channels such as text alerts, sirens, and community loudspeakers.



5. Preparedness and Response
    - The final component focuses on ensuring that emergency services, local governments, and communities are prepared to act. Regular training, drills, and updated response plans are essential for building the capacity to respond effectively to warnings.

The combination of these components creates a robust MHEWS capable of mitigating the impacts of a wide range of hazards.

1.3. Governance and Community Engagement

1.3.1. The role of local governments in resilience building

Local governments are pivotal in implementing urban resilience strategies and early warning systems. Their responsibilities include:

- Policy Development: Formulating policies that integrate resilience into urban planning and development.
- Coordination: Bringing together stakeholders, including public agencies, private entities, and civil society organizations, to ensure a cohesive response to hazards.
- Infrastructure Investment: Allocating resources to build and maintain resilient infrastructures such as stormwater systems, emergency shelters, and redundant power grids.

Strong governance frameworks also ensure that EWS components work cohesively. Clear institutional roles and responsibilities, coupled with public-private partnerships, enhance the effectiveness of early warning systems.

1.3.2 Community participation in EWS development

Community engagement is essential for the success of resilience initiatives and early warning systems. Residents often have firsthand knowledge of risks and vulnerabilities in their areas, which can inform better decision-making. Key elements of community participation include:

- Risk Awareness Campaigns: Educating communities about hazards and appropriate responses.
- Participatory Planning: Involving community members in the design and implementation of resilience projects and EWS.
- Empowerment through Low-Tech Solutions: Communities can use no-tech and low-tech tools, such as rain gauges, flags, and town criers, to complement high-tech systems, especially in resource-constrained settings.

Inclusive approaches ensure that marginalized groups, often most vulnerable to disasters, are not overlooked. By fostering trust and collaboration, community participation strengthens the overall resilience of urban systems.

From our vision in University Gustave Eiffel, building resilience consists in making people, communities and systems better prepared to withstand catastrophic events -both natural and manmade- and able to bounce back more quickly and emerge stronger from these shocks and stresses.(http://www.100resilientcities.org/#/-_/). In fact, Resilience against crises not only refers to reducing risks and damages from disasters (i.e. loss of lives and assets), but also the ability to quickly bounce back to a stable state. While typical risk reduction measures tend to focus on a specific hazard, leaving out risks and vulnerabilities due to other types of perils, the resilience approach adopts a multiple hazards approach,

considering resilience against all types of plausible hazards. We can differentiate Instantaneous and dynamic resilience.

As a summary: Indonesian urban resilience describes the capacity of cities to function, so that the people living and working in cities – particularly the poor and vulnerable – survive and thrive no matter what stresses or shocks they encounter.

This multidisciplinary approach applied to Indonesian cities is presented on this figure.



2. Overview of the YDIF Tool Methodology

The YDIF Tool methodology is an approach designed to enhance urban resilience by identifying interdependencies among critical services, analysing vulnerabilities, and preparing Indonesian cities for cascading risks. It is based on a **systematic and participatory** framework, enabling stakeholders to collaboratively address urban challenges. In this section, we develop the main principles, and application framework of the methodology.

Resilience: new challenges and new standards

European public authorities are starting to take into account these new challenges, as evidenced by the update of the EU Civil Protection Mechanism which refers to the Sendai Framework for Action for Disaster Risk Reduction (2015-2030), the Paris Agreement and the United Nations 2030 Agenda for Sustainable Development. In parallel, national and international standardization bodies (DIN, BSI, ISO) have launched initiatives to create reference standards on city resilience.

YDIF Tool, a collaborative tool to manage service interconnections and resilience in cities

For city leaders and experts who must continue to effectively manage their services, solutions are developed that enable an operational approach to resilience management. Among them, YDIF offered in the past q support for the engagement of various urban actors, the formalization of information related to their interconnections and the modelling of cascade effects leading to a global vision of the various services and infrastructures of the territory.

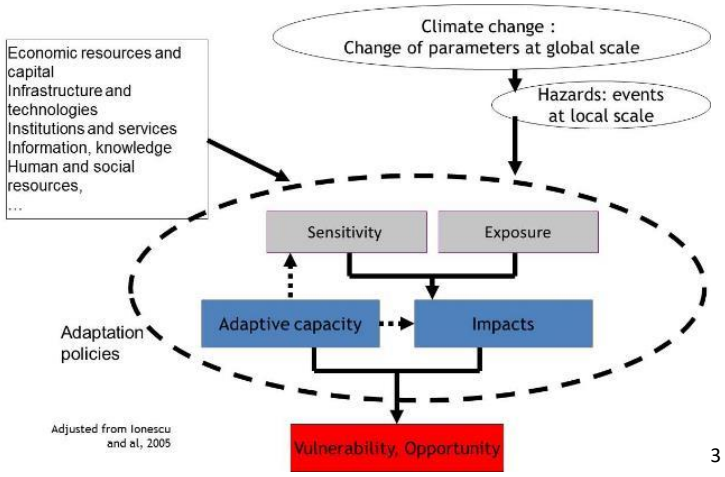
Unlike urban service operator tools or global resilience programs, that are sometimes difficult to adapt to specific territories YDIF was designed to create and implement a resilience strategy inspired by industrial safety methodologies, business continuity, strategic analysis and urban management. YDIF includes engagement and online training functionalities of city stakeholders (*Players*), exercises on “What If" and interconnections between services at different levels. The tool also proposes participatory modelling, simulation of domino effects, and analysis of the effects of climate change adaptation measures on urban service operations.

By gathering and organising information currently distributed among different stakeholders, the tool aims at supporting the prioritization of investments in resilience. Its use by experts can help the public authorities and all the operators of the territory to make decisions about the urban operations in case of a hazard (Decision Support System), and to reduce the material and human losses thanks to a better cooperation.



Partnerships and operational implementation

Research teams in Barcelona, Paris (University Gustave Eiffel) and Virginia (Virginia Tech) with local leadership have launched the idea of an urban resilience platform. YDIF has been implemented in different types of cities and projects. In CRIC the testing and the development for Indonesian cities was specific and based on the theories developed by the University Gustave Eiffel team regarding resilience and EWS.



3

- ✓ The semantic definition of resilience in relation to the principles of elasticity, ductility and plasticity is not stabilized in the scientific literature. The concept of resilience has been picked up in several disciplines, particularly in ecology and urban planning.

[3] Vulnerability is the degree to which a system is susceptible to, and unable to cope with adverse effects. Vulnerability is a function of the character, magnitude, and rate of potential events to which a system is exposed, its sensitivity, and its adaptive capacity.

- ✓ It now refers to the capacity of a system to adapt and organize in order to best cope with disruptions, whether ecosystems, social systems, economic systems or spatial systems, etc.

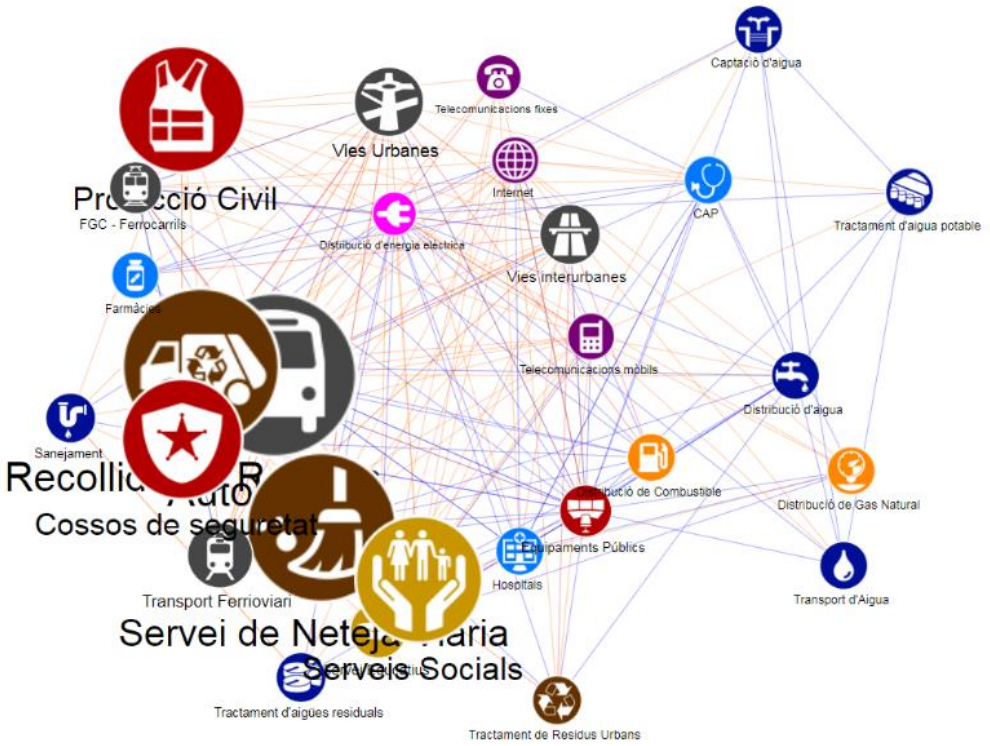
The systemic approach of resilience fosters multidisciplinary approaches. The concept of resilience has gradually taken on importance at major UN conferences. In Yokohama in 1994, the notion of vulnerability thus, replaced that of hazards before being itself replaced by resilience in Hyogo in 2005 and Sundai in 2015. These frameworks are crucial for a better implementation of EWS.

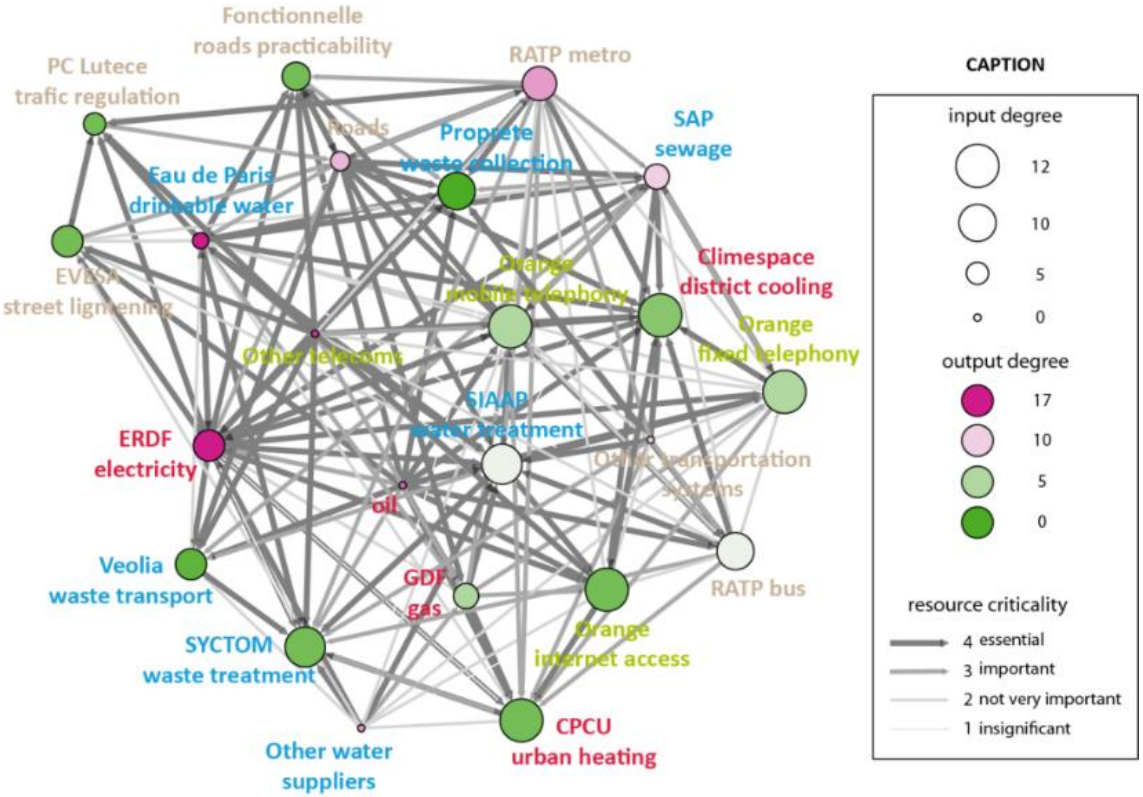
Service interconnections analysis tool and decision support tool for a resilience strategy

In the framework of a major European projects funded by the H2020 program, the tool YDIF is tested in the major cities of Barcelona, Bristol and Lisbon with the participation of UN Habitat. Moreover, and thanks to the direct financing of intermediate cities or other local authorities, YDIF has also been implemented in Italy and Spain, i.e. La Garrotxa-Girona (56k inh.), Terrassa (216k inh.) and Sant Cugat (80k inh.) in the metropolitan area of Barcelona, Vicenza (122k inh.) in the Veneto region, Benidorm (68k inh. in winter, eightfold in summer) in the Valencia region.

In Terrassa, where a violent wind had caused casualties and major damage in 2014, YDIF has allowed city departments to become aware of their interdependencies and the analysis of the cascade effects to be integrated into various improvement projects and a Resilience Plan. In parallel, the Smart Cities module aims at developing a complete and dynamic dashboard with the key indicators of resilience of the city. Terrassa plans to use YDIF Simulator in its "smart" urban platform, which will also allow anticipating unwanted cascade effects on municipal services and consequently on the quality of life of its citizens.

These two figures show an example of initial visualization of interconnections between services, which, with the support of the stakeholders and working groups gathered in an online Forum, will help us to build up a resilience strategy.


Captació d'aigua
Telecomunicacions fixes
Vies Urbanes
Internet
CAP
Tractament d'aigua potable
FGC - Ferrocarrils
Distribució d'energia elèctrica
Vies interurbanes
Farmàcies
Telecomunicacions mòbils
Distribució d'aigua
Sanejament
Distribució de Combustible
Distribució de Gas Natural
Cossos de seguretat
Equipaments Públics
Hospitals
Transport Ferroviari
Transport d'Aigua
Servei de Neteja Viaria
Serveis Socials
Tractament d'aigües residuals
Tractament de Residus Urbans


Fonctionnelle
roads practicability
RATP metro
PC Lutece
trafic regulation
SAP
sewage
Eau de Paris
drinkable water
Climespace
district cooling
Orange
fixed telephony
Other telecoms
SIAAP
water treatment
ERDF
electricity
oil
Veolia
waste transport
GDF
gas
RATP bus
SYCTOM
waste treatment
Orange
internet access
CPCU
urban heating
Other water
suppliers
CAPTION
input degree
12
10
5
0
output degree
17
10
5
0
resource criticality
4 essential
3 important
2 not very important
1 insignificant

Development of the YDIF Methodology

2.1.1. Background and Key Principles

The YDIF methodology was originally developed as a response to the increasing complexity and interconnectedness of urban systems, which are becoming more vulnerable to cascading disruptions caused by climate change, natural hazards, and technological failures.

At its core, YDIF views cities as **systems of systems**, where each service (such as energy, water, transportation, and healthcare) is deeply interconnected. This systemic approach enables cities to better understand how disruptions in one sector may cascade into others. For example, a power outage might disrupt water supply, halt public transportation, and hinder emergency services.

Key principles of the methodology include:

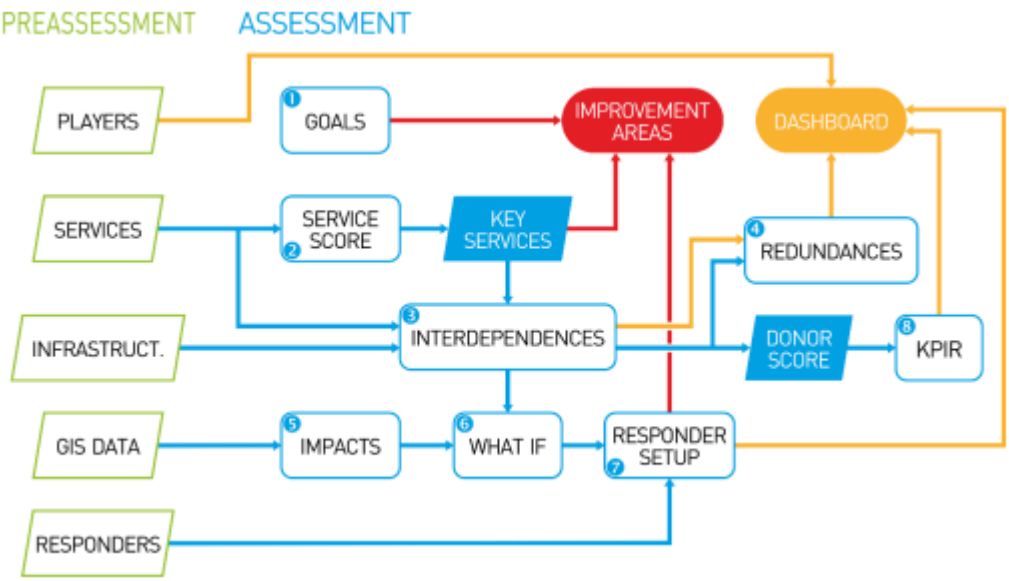
- **Systemic Thinking**: Understanding and mapping interdependencies among urban services and infrastructures.
- **Stakeholder Collaboration**: Engaging a diverse range of stakeholders, including municipal governments, service providers, emergency responders, and community representatives, to ensure inclusiveness and comprehensiveness.
- **Scalability**: The methodology is adaptable to urban areas of varying sizes, from intermediate cities to major metropolitan regions.
- **Resilience-Driven Planning**: Focuses on identifying vulnerabilities, proposing targeted interventions, and fostering redundancy in critical systems.
- **Data-Driven Decision-Making**: Utilizes real-time data, scenario modeling, and tools like Kumu for visualization and risk analysis.

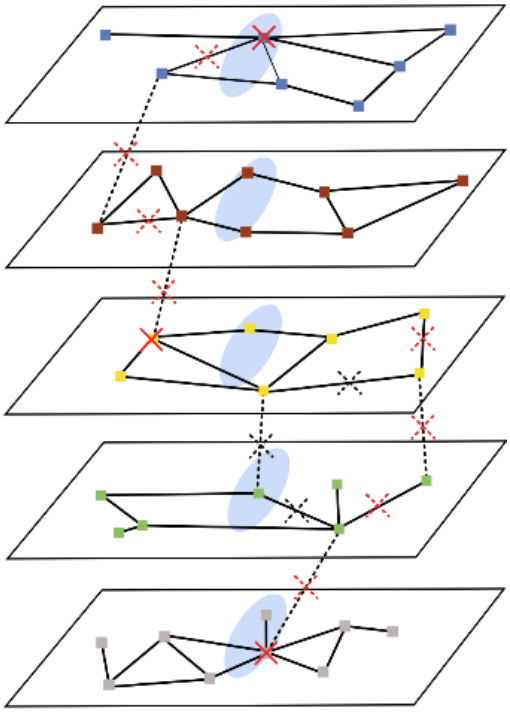
Integration with Urban Resilience Strategies

YDIF is aligned with global urban resilience frameworks, such as:

- **Sendai Framework for Disaster Risk Reduction (2015-2030)**: Provides guidance on reducing disaster risk through systemic resilience planning.
- **Paris Agreement**: Addresses climate adaptation and mitigation, ensuring that resilience measures account for climate-related risks.
- **United Nations Sustainable Development Goals (SDGs)**: Particularly SDG 11, which focuses on creating sustainable, resilient, and inclusive cities.

The methodology helps cities operationalize these frameworks by providing tools and techniques to assess risks, prioritize actions, and implement resilience strategies. For instance, cities can integrate YDIF insights into urban planning, smart city initiatives, and emergency response systems, ensuring a holistic approach to resilience.

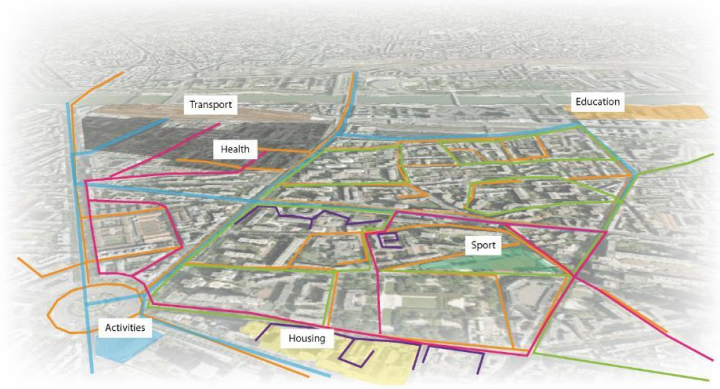


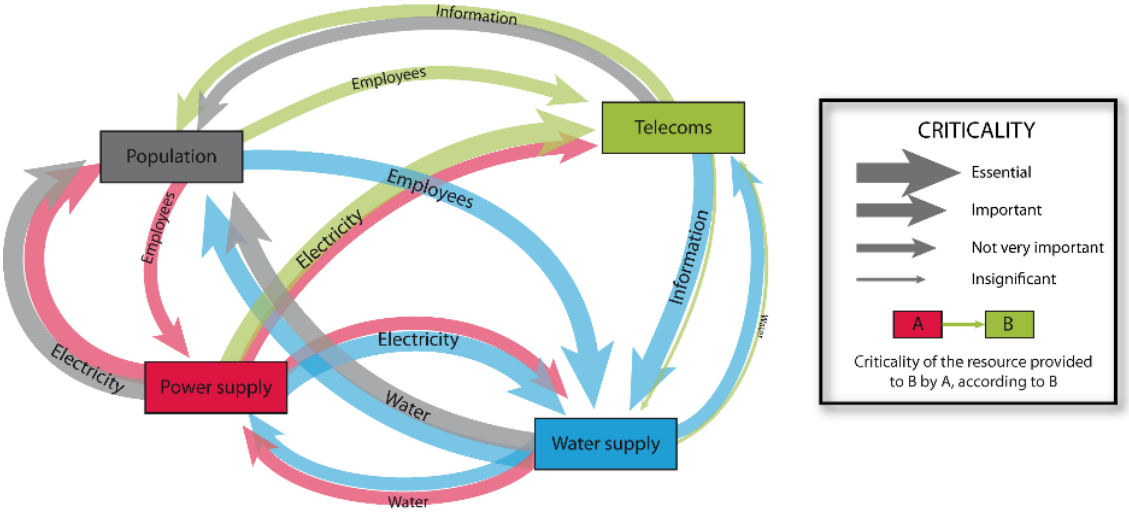


2.2. Application Framework

The YDIF methodology follows a structured framework comprising three primary stages: Pre-Assessment, Assessment, and Management. Each stage builds upon the previous,

creating a comprehensive and iterative process that enables cities to continuously refine their resilience strategies.





Pre-Assessment Stage

The Pre-Assessment stage serves as the foundation for resilience planning, focusing on understanding the current state of urban systems and their vulnerabilities. It involves:

- **Engaging Stakeholders**: Key players, including municipal leaders, service providers, and community representatives, are brought together to define goals and establish priorities.
- **Mapping Services and Infrastructures**: Critical services (e.g., water supply, energy, transport) and their supporting infrastructures are identified and mapped.
- **Baseline Analysis**: Data is collected to assess existing vulnerabilities, interdependencies, and previous disruptions. Geospatial data (GIS) is often used to visualize service zones and hazard exposure.

The Pre-Assessment stage culminates in the definition of resilience goals and the identification of key services that will be the focus of subsequent analysis.

Assessment Stage

The Assessment stage is the analytical core of the YDIF methodology. It involves a detailed evaluation of interdependencies, cascading risks, and system vulnerabilities.

Key activities include:

- **Interdependency Mapping**: Relationships between services are analyzed to identify "giver-receiver" dynamics. For example, energy supply (a giver) may support multiple services such as water distribution and healthcare.
- **Scenario Modelling**: Hazards such as floods, power outages, or heatwaves are simulated to understand their cascading effects across urban systems.
- **Redundancy Analysis**: The presence or absence of redundancies in critical infrastructures is evaluated, highlighting areas where backup systems or alternative service providers are necessary.
- **What-If Scenarios**: These exercises explore potential failures and test how the city's systems would respond, providing insights into the adequacy of existing measures.
- **Key Performance Indicators for Resilience (KPIRs)**: Metrics are established to measure the robustness, adaptability, and recovery capacity of services and infrastructures.

The outcomes of the Assessment stage include a detailed resilience report, interdependency maps, and prioritized areas for improvement.

Management Stage

The Management stage focuses on operationalizing resilience strategies and integrating them into urban management practices. It emphasizes implementation, monitoring, and continuous improvement. These activities include:

- Action Plan Development: Strategies to address identified vulnerabilities are developed and aligned with broader urban planning objectives.
- Real-Time Monitoring: Tools like KPIR dashboards and GIS-based platforms are used to track the performance of services and infrastructures in real time.
- Simulation Exercises: Resilience strategies are tested under simulated scenarios to validate their effectiveness and identify areas for refinement.
- Continuous Improvement: The resilience framework is updated regularly based on new data, lessons learned, and changing urban dynamics.

The iterative nature of the Management stage ensures that cities remain prepared for evolving risks and challenges.

2.3. Use of Collaborative Workshops and Simulation Tools

A defining feature of the YDIF methodology is its emphasis on stakeholder collaboration and the use of advanced tools to support decision-making:

- **Collaborative Workshops**: These workshops bring together diverse stakeholders to:
    - Build a shared understanding of vulnerabilities and priorities.
    - Validate interdependency maps and KPIRs.
    - Test and refine resilience strategies.
- **Simulation Tools**: Tools like Kumu are used to visualize interdependencies, simulate cascading effects, and evaluate the impacts of proposed interventions.

The shift to open-source tools like Kumu, following the discontinuation of the original YDIF platform in 2020, has enhanced the accessibility and flexibility of the methodology. Kumu enables cities to create detailed visualizations of service interdependencies and test resilience strategies in a cost-effective manner.[4] Our tool is adapted to all the hazards indicated in this table.

Type of Hazard	High-Tech Solution	Low-Tech Solution	Combined Solution
Air Pollution	Air quality sensors and monitoring networks	Community-led air quality observation and reporting	Integration of sensor data with community observations
Coastal Surges	Advanced tidal gauges and satellite imaging	Community-based coastal watch groups	Combining tidal data with local observation reports
Earthquakes & Tsunamis	Seismic sensors and international data exchange	Community training and DIY seismographs	Use of both seismic data and community observations for early warnings

[4] *In addition to technology-driven communication, there are also no-tech and low-tech solutions. Examples of no-tech solutions include posters, murals, town criers and runners; low-tech communication solutions include flags, whistles and megaphones. These additional channels play an important part in reinforcing messages carried through other mediums and are especially important in less affluent areas where access to technology is limited yet communities are often exposed to the greatest risk. No-tech and low-tech solutions are also robust as they can function even if power and communication lines are down. They also play an important role in communities where literacy rates are low or multiple languages are spoken.*

Urban Flooding	AI-based rainfall prediction and flood modelling	Manual rain gauges and community monitoring	AI predictions combined with community-collected rainfall data
River Flooding	Satellite imagery and hydrological modelling	River watchers with marked poles for water level	Satellite data combined with local river level observations
Forest Fires	Satellite-based fire detection systems	Local training in early fire detection signs	Satellite alerts supported by local observations
Volcanic Activity	Seismic networks and ash tracking technology	Traditional knowledge and simple seismographs	Integrating scientific and traditional methods of monitoring
Drought	Climate modelling and water resource management systems	Traditional rainwater harvesting and conservation practices	Climate forecasts guiding traditional water management
Landslides	Geological surveys and land movement sensors	Community teams for landslide risk observation	Sensor data supplemented with community observations
Tsunami	Tsunami detection buoys and seismic data analysis	Tsunami watch groups and natural sign observation	Combining detection system data with community watch efforts

The proposed methodology for the 2 cities is indicated in this figure. Four steps are proposed: the knowledge, the preparedness, the observations and the EWS communication.


Disaster risk knowledge
Systematically collect data and undertake risk assessments
• Are the hazards and the vulnerabilities well known by the communities?
• What are the patterns and trends in these factors?
• Are risk maps and data widely available?
Detection, observations, monitoring, analysis and forecasting of hazards
Develop hazard monitoring and early warning services
• Are the right parameters being monitored?
• Is there a sound scientific basis for making forecasts?
• Can accurate and timely warnings be generated?
Preparedness and response capabilities
Build national and community response capabilities
• Are response plans up to date and tested?
• Are local capacities and knowledge made use of?
• Are people preapred and ready to react to warnings?
Warning dissemination and communication
Communicate risk information and early warnings
• Do warnings reach all of those at risk?
• Are the risks and warnings understood?
• Is the warning information clear and usable?

3. Practical exercise on interdependencies analyses and cascading effects for Indonesian cities

Based on our visits to the Cities, the understanding of the Indonesian context, the effectiveness of MHEWS in Bandar Lampung and Pangkalpinang lies in the synergy of its four core components.

We identified the following topics:

Disaster Risk Knowledge, which focuses on the systematic collection of data and risk assessments; Monitoring and Forecasting, which outlines methods for hazard detection and forecasting; Communication, which entails strategies for effective dissemination and communication of warnings; and Preparedness and Response, which discusses strategies to prepare for and respond to emergencies. Understanding these components is crucial for the development of a robust early warning system.

Governance and Institutional Framework
Governance is the glue that holds the MHEWS components together. In this section, we'll discuss the need for an overarching governance framework that outlines clear roles and responsibilities within institutional arrangements. This framework ensures that all parts of the MHEWS work cohesively to achieve a common goal.

Financing MHEWS
Financing is a critical aspect of establishing and maintaining MHEWS. We will explore the various financing mechanisms available, emphasizing the importance of public-private partnerships and the role of international funding in supporting these systems.

Early Action and Anticipatory Approaches
Early action is pivotal in the context of MHEWS, mitigating the impact of disasters. We'll define impact-based forecasting and explain how early actions, based on accurate forecasts, can protect lives and livelihoods.
Monitoring and Evaluation
To ensure the MHEWS remains effective, continuous monitoring and evaluation are essential. This section will outline the importance of these processes and how they contribute to the system's improvement over time

3.1. Phase 1: Selection of Critical Services and Infrastructures

Summary:

Goal: Define the scope by selecting services and infrastructures for analysis.

1. **Activity**: Begin with a brainstorming session to identify critical services in the city. Examples include electricity, water supply, transportation, healthcare, and telecommunications.
2. **Perception Assessment**:
    - Rank each service based on perceived importance by different stakeholders:
        - Citizens (impact on daily life)
        - Policymakers (alignment with urban goals)
        - Economic agents (dependency for economic continuity)
    - Use a scale (1 = low, 3 = medium, 5 = high, 9 = very high) to evaluate criticality, exposure, and frequency of service usage.
3. **Output**:
    - A prioritized list of services to focus on for interdependency analysis.

SERVICE	PERCEPTION						
	CIT.	POL.	ECON.	VISIT.	CRITIC.	EXPOS.	FREQ.

Prioritizing critical infrastructures is a foundational step in the YDIF methodology, ensuring that resilience planning targets the most impactful services and systems within a city. This phase establishes a clear scope for subsequent interdependency analysis and cascading effect simulations. Drawing from the lessons learned in cities like Barcelona, Lisbon, and Bristol during the RESCCUE project, the process emphasizes strategic selection to maximize effectiveness while managing complexity.

The Necessity of Prioritization

Urban systems are inherently complex, with hundreds of services and infrastructures interacting in intricate ways. Attempting to address all systems simultaneously can overwhelm resources, dilute focus, and make actionable insights difficult to extract. Prioritization:

1. Identifies **key services** essential for city functionality (e.g., energy, water, healthcare).
2. Ensures that analysis is **manageable** within resource constraints.
3. Aligns resilience planning with **strategic goals** such as mitigating climate-related risks or addressing vulnerable populations.

Steps in the Prioritization Process

1. **Defining Goals and Scope**
    - Begin with a **strategic analysis** to determine the city's resilience objectives.
    - Consult stakeholders, including municipal leaders, service operators, and community representatives, to align on critical priorities.
    - Examples of goals:
        - Reducing flood risks in high-density areas.
        - Ensuring continuity of power supply during extreme weather events.
2. **Evaluating Service Criticality**
    - Rank services and infrastructures based on their importance to urban functionality using predefined criteria:
        - **Criticality**: Services that are essential for other systems (e.g., power supply as a donor service).
        - **Exposure**: Vulnerability to hazards such as floods or heatwaves.
        - **Impact**: Consequences of service disruption on public safety, economy, and social well-being.
    - Barcelona's assessment highlighted power distribution, telecommunications, and water services as critical donor systems.
3. **Scoring and Filtering**
    - Assign numerical scores to services and infrastructures based on stakeholder input and available data.
    - Use tools like dependency matrices to identify "giver-receiver" relationships and refine the selection process.
    - Focus on 20–30 key services to keep the analysis detailed yet manageable.
4. **Validating with Stakeholders**
    - Conduct workshops to validate selected services and infrastructures with stakeholders.
    - This ensures inclusivity, builds consensus, and integrates local expertise into the prioritization process.

Benefits of Prioritization

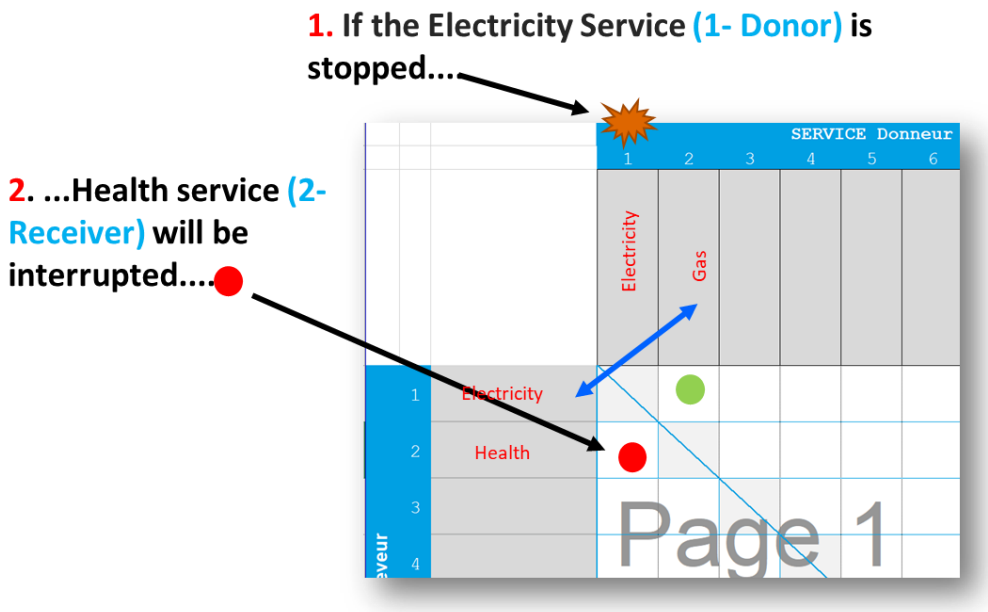
- **Efficiency**: Directs resources and efforts toward the most impactful areas.
- **Actionability**: Produces targeted recommendations that are easier to implement.
- **Scalability**: Facilitates expansion to include additional services or infrastructures in future phases.

For instance, in Lisbon, the focus on specific drainage catchment basins enabled a detailed interdependency analysis that could later be scaled citywide.

3.2. Phase 2: Mapping Interdependencies and Cascade Effects

The target of this phase is to understand relationships between selected services and visualize their interdependencies.

1. **Dependency Analysis**:
    - Define "donor" and "receiver" roles:
        - **Donors**: Services that provide critical support (e.g., electricity powers water pumps).
        - **Receivers**: Services dependent on donors.
    - Record dependencies in a matrix format:
        - **NA**: Not affected by donor disruption.
        - **Min**: Partially functional without the donor.
        - **Int**: Completely interrupted if the donor fails.
2. **Visualization with Kumu**:
    - **Preparation**:
        - Import the dependency matrix into Kumu following Kumu's import guide.
        - Organize the data into "Elements" (services) and "Connections" (dependencies).
    - **Visualization**:
        - Generate a map highlighting interdependencies and identifying critical nodes vulnerable to cascading failures.
        - Adjust parameters to show high-risk relationships.
3. **Output**:
    - A comprehensive visual representation of interdependencies using Kumu, showing potential cascade effects and critical areas for intervention.



Phase 2: Mapping Interdependencies and Cascade Effects

The second phase of the YDIF methodology focuses on mapping interdependencies among urban services and infrastructures to understand how disruptions can cascade through systems. This step is critical for creating a comprehensive resilience strategy, as it identifies vulnerabilities and potential failure pathways within urban systems. The RESCCUE project demonstrated the implementation of this phase in pilot cities such as Barcelona, Lisbon, and Bristol, emphasizing the need for precise data collection, collaboration, and advanced visualization techniques.

Goals of Phase 2

1. **Identify Interdependencies**: Analyze the relationships between critical urban services and infrastructures, distinguishing donor (provider) and receiver (dependent) roles.
2. **Simulate Cascade Effects**: Evaluate how disruptions propagate through interconnected systems.
3. **Enhance Resilience Planning**: Provide actionable insights for mitigating cascading risks and improving urban resilience.

Steps in Phase 2

1. **Data Collection and Matrix Development**
    - Data on urban services and infrastructures is collected, including their interdependencies, geographic distribution, and vulnerability to specific hazards.
    - A dependency matrix is created to categorize and quantify the relationships between services, using terms such as:
        - **Not Affected (NA)**: No dependency on a donor service.
        - **Minimal (Min)**: Limited impact from donor service disruption.
        - **Intermediate (Int)**: Significant impact on functionality without the donor service.
        - **Total (Tot)**: Complete failure of the service without donor support.
2. **Mapping Interdependencies**
    - Services are represented visually, using tools like GIS systems or open-source platforms like Kumu, to create interdependency maps.
    - These maps highlight critical nodes (services with numerous dependencies) and vulnerable pathways where disruptions may propagate.
3. **Scenario Analysis**
    - Specific hazards (e.g., floods, power outages) are simulated to observe their cascading effects on interconnected systems.
    - These simulations help in quantifying the impacts of potential failures and identifying bottlenecks.
4. **Stakeholder Workshops**
    - Collaborative workshops engage municipal authorities, service providers, and community representatives to validate the dependency matrix and interdependency maps.
    - Stakeholder input ensures that the analysis reflects local realities and priorities.

Outputs of Phase 2

1. **Interdependency Maps**: Graphical representations of service relationships and cascading effects, highlighting critical vulnerabilities.
2. **Scenario Reports**: Documentation of potential impacts under simulated hazard scenarios, providing a foundation for strategy development.
3. **Validated Data Sets**: Refined dependency matrices and interdependency models, ready for integration into resilience planning.

Role of Kumu in Phase 2

With the disruption of the original YDIF platform in 2020, tools like Kumu have been adopted to perform key functions of Phase 2. Kumu enables users to:

- **Import Dependency Matrices**: Create visual maps of interdependencies.
- **Simulate Cascade Effects**: Test scenarios by disabling critical nodes and observing impacts on connected services.
- **Facilitate Collaboration**: Share visualizations with stakeholders for validation and refinement.

By providing dynamic and interactive visualizations, Kumu enhances the ability of cities to understand complex systems and prioritize interventions effectively.

3.3. Phase 3: Strategy Development

Goal: Propose strategies to reduce vulnerabilities and integrate them into resilience planning.

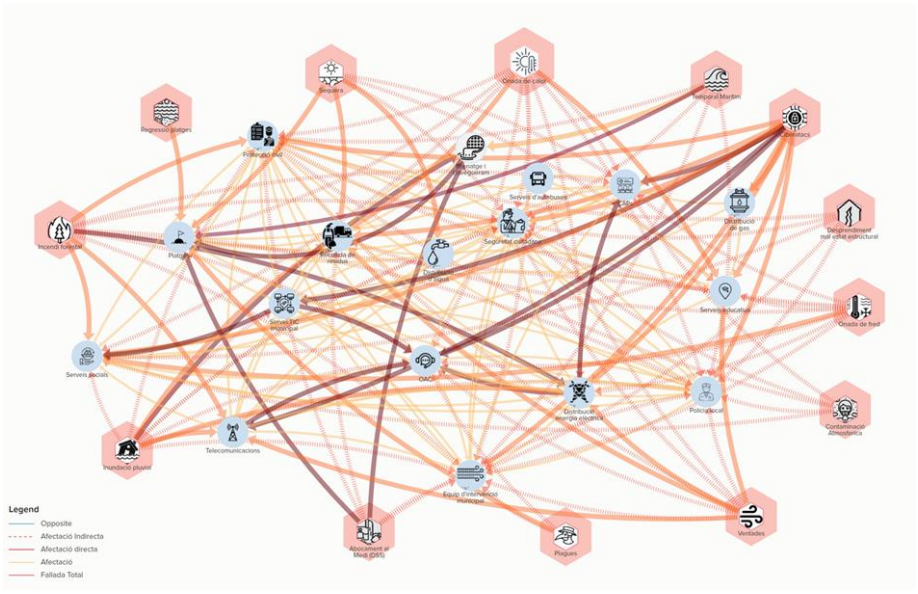
1. **Scenario Analysis**:
    - Use the interdependency map to simulate a specific disruption, such as a 48-hour power outage, and evaluate cascading impacts across services.
2. **Group Reflection**:
    - Discuss the following:
        - What cascade effects were observed?
        - Which services were most impacted?
        - Where are the critical vulnerabilities in the system?
3. **Actionable Strategies**:
    - Propose 3-4 improvement actions to mitigate identified vulnerabilities, such as:
        - Establishing redundancies (e.g., backup power sources).
        - Strengthening communication between service providers.
        - Upgrading infrastructure to withstand hazards.
    - Align strategies with broader urban resilience goals.
4. **Integration into Resilience Plans**:
    - Frame proposed actions within a general resilience strategy for the city.
    - Define how these strategies align with long-term urban planning and disaster risk reduction frameworks like the Sendai Framework.
5. **Output**:
    - A draft resilience strategy outlining proposed actions and their integration into the city's urban management plan.

3.4. Using Kumu for Visualization and Analysis

Why Use Kumu? Kumu is a powerful tool for mapping and analysing relationships, ideal for visualizing interdependencies among services and their cascading effects.

How to Use Kumu for This Exercise:

1. **Setup**:
    - Create a free account on Kumu.io.
    - Prepare an Excel file with two tabs:
        - **Elements**: List all services and their descriptions.
        - **Connections**: Define dependencies between services (donor-receiver relationships).
2. **Import Data**:
    - Upload the Excel file into Kumu, ensuring the format matches their import requirements.
3. **Visualize Relationships**:
    - Generate a map displaying services as nodes and dependencies as connections.
    - Use colour coding to highlight critical nodes and high-risk dependencies.
4. **Scenario Testing**:
    - Simulate disruptions by adjusting parameters for a node (e.g., disabling a service) and observing the cascade effects on connected nodes.



Expected Outcomes

Participants will:

- Gain practical experience with the YDIF methodology.
- Understand the importance of analyzing interdependencies for urban resilience.
- Learn to use Kumu for visualizing complex relationships.

- Propose actionable strategies that address cascading risks and align with broader resilience goals.

This exercise serves as a foundational activity for implementing the YDIF methodology, equipping participants with essential skills and tools for urban resilience planning.

4. Recommendations for Scaling EWS and resilience tools in two pilot cities : Pangkalpinang and Bandar Lampung

Indonesia, an archipelagic nation situated on the Pacific Ring of Fire, is highly vulnerable to a wide range of natural hazards, including earthquakes, tsunamis, volcanic eruptions, and extreme weather events. Early Warning Systems (EWS) are integral to disaster risk reduction, offering advanced mechanisms for detecting and responding to imminent threats. This document delves into the scientific and technical intricacies of Indonesia's EWS, emphasizing its critical role and identifying opportunities for improvement.

In CRIC project, we are concerned by two cities Bandar Lampung and Pangkalpinang.

4.1 Brief presentation of the Indonesian situation

The Role of Early Warning Systems in Indonesia

EWS are designed to detect, forecast, and disseminate information about potential hazards before they occur, allowing individuals, communities, and authorities to take preventive measures. An effective EWS comprises four interconnected components:

1. **Risk Knowledge**: Hazard identification and risk assessment form the foundation of an EWS. This involves geological, hydrological, and meteorological studies to map hazard zones and quantify vulnerabilities. For example, seismic hazard models integrate fault line activity data, while climate risk maps use historical rainfall and temperature patterns to predict extreme weather events.
2. **Monitoring and Detection**: Advanced monitoring systems include:
    - **Seismic Networks**: Arrays of broadband seismometers and accelerometers measure ground motion to determine earthquake parameters.
    - **Ocean Buoy Systems**: Deep-ocean tsunami detection buoys, such as those used in the Indonesian Tsunami Early Warning System (InaTEWS), measure changes in sea level and wave propagation.
    - **Radar and Satellite Imaging**: Weather radars and remote-sensing satellites monitor atmospheric conditions and volcanic activity, providing near-real-time data for early forecasts.
3. **Communication and Dissemination**: Multiple channels, including radio, SMS, internet, and siren systems, ensure timely dissemination of warnings. Data interoperability standards like CAP (Common Alerting Protocol) enhance coordination between agencies and systems.
4. **Response Capability**: This involves translating warnings into actionable plans through:

- Evacuation route optimization using Geographic Information Systems (GIS).
- Training programs that simulate disaster scenarios to prepare response teams and communities.

Early Warning Systems for Tsunamis in Indonesia

Tsunamis pose one of the gravest threats to Indonesia due to its tectonic setting. InaTEWS was developed post-2004 with advanced technologies:

- **Seismic Detection**: Using the Indonesian Seismic Network, earthquakes are analysed for magnitude, depth, and epicentre to assess tsunami potential.
- **Deep-ocean Assessment and Reporting of Tsunamis (DART) Buoys**: These devices measure pressure changes on the ocean floor to detect undersea activity that could trigger tsunamis.
- **Tide Gauges**: Deployed along coastlines to validate tsunami arrival predictions and refine models.
- **Numerical Modelling**: Computational models simulate tsunami wave propagation, predicting impact times and inundation areas based on bathymetry and coastal topography.

Despite these advancements, InaTEWS faces limitations such as funding constraints, delayed maintenance cycles, and disruptions in telemetry systems. Efforts are underway to modernize detection algorithms and deploy next-generation sensors that enhance precision and reliability.

Community-Centric Approaches

Technological sophistication alone cannot guarantee effective disaster mitigation. Indonesia's geographic and cultural diversity necessitates community-centric approaches:

- **Education and Awareness Programs**: Training workshops, public campaigns, and school curriculums on hazard recognition and response.
- **Participatory Risk Mapping**: Engaging local communities in creating hazard maps to foster ownership and enhance situational awareness.
- **Indigenous Knowledge Integration**: Leveraging traditional warning systems, such as ecological cues (e.g., unusual animal behaviour) observed by indigenous communities, complements scientific data.
- **Drill and Simulation Exercises**: Regular evacuation drills and mock disaster responses strengthen preparedness and reduce panic during actual events.

Challenges and Scientific Considerations

Indonesia's EWS is constrained by various technical and operational factors:

- **Geophysical and Climatic Complexity**: High seismicity and variable climatic patterns make accurate forecasting challenging.

- **Infrastructure Gaps**: Remote regions lack the robust telemetry systems required for real-time data collection and dissemination.
- **Data Integration and Sharing**: Fragmentation among monitoring networks hinders holistic hazard analysis. Standardized data sharing protocols are essential.
- **Trust in Science**: Public scepticism about warnings can undermine compliance. Transparent communication and community involvement are crucial to building trust.

Innovations and Future Directions

To address these challenges, Indonesia is adopting innovative technologies and strategies:

- **Artificial Intelligence (AI) and Machine Learning**: AI-driven algorithms analyse large datasets from seismic, hydrological, and meteorological sources to enhance prediction accuracy and reduce false alarms.
- **Internet of Things (IoT) for Remote Monitoring**: IoT-enabled sensors deployed in remote and high-risk areas provide continuous, low-maintenance monitoring solutions.
- **Blockchain for Data Security**: Ensuring the integrity and traceability of hazard data improves stakeholder confidence and interoperability.
- **Hydrodynamic Models for Tsunami Simulations**: Enhanced models incorporate finer-scale coastal features, providing detailed impact assessments.

Moreover, Indonesia's participation in international collaborations, such as the Indian Ocean Tsunami Warning and Mitigation System (IOTWS), strengthens its capacity through shared knowledge and resources.

4.2 Infrastructure in Bandar Lampung and Pangkalpinang

Bandar Lampung	**Pangkalpinang**
Population 1.051.500 inhabitants (2019) **• 169,2 km² divided into 20 sub-districts** **• Density: 5.332 inhabitants per km²** **• Population growth: 1,71% in 2019** **• Unemployment rate: 7.12 %** **• Poverty rate: 8.71% in 2019 (10.85 in 2013)** **• 12,4% of the population lives in informal settlements**	**Population 212.727 inhabitants (2019)** **• 118,41 km² divided into 7 districts** **• Density: 1.819 inhabitants per km²** **• Population growth: 1,98% in 2019** **• Unemployment rate: 5,01 % (BPS Pangkalpinang, 2020)** **• Poverty rate: 4.25%**

Bandar Lampung is supported by various critical infrastructures that are essential for its economic activities and public services. Bandar has serves as the capital of Lampung Province. It is the native home of my ethnic group, the Lampung's people. It is also a home for many ethnicities coming from different regions, such as the Javanese, Sundanese, Chinese, Malay and Batak. This makes the city also known for its vibrant culture with a rich cultural blend. Key attractions include Way Kambas National Park, Pahawang Island for snorkelling, and the Krakatoa volcano, which erupted in the late 19th century.

The city grapples with the impacts of climate change, including flooding, coastal erosion, and sea-level rise. By 2070, annual mean precipitation is projected to increase by 22% compared to 2010 averages, and annual mean water discharge by 52%.

The city's been seeing more frequent floods lately. People living near the coast are exposed to coastal floods called *'robs*,' which happen when high tides cause flooding and erosion. Pluvial flooding is also commonplace yearly. Poor drainage and waste management have also made flooding worse. 86% of the city's waste never even makes it to the landfill.

12% of the population lives in informal areas, who do not see waste as a problem; they use it to build more homes. This has led to community-based coastal reclamation in Bandar Lampung over the past 25-30 years, as this reclaimed land is extremely exposed to rising sea level and pluvial and riverine flooding. This makes vulnerable groups, including children, the elderly, and those with limited resources, are most at risk from these climate hazards.









Crédit Photos: Y. Diab, August 2024

For the first time, flooding hit my neighbourhood in Rajabasa District, northern Bandar Lampung, in April 2024. Although my house was saved, the water stood 10-30 cm high on the road in front of it. A mosque and houses in my neighbourhood were flooded by 20-100 cm. Our local community worked together to rebuild and clean the mosque and houses after the destruction caused by the flooding.

The city is implementing several measures to address climate issues and developing a Climate Action Plan to reduce climate impacts in its most vulnerable districts across different areas, including ecosystems and infrastructure, and including improving drainage systems. However, efforts have been insufficient due to limited funding, inadequate infrastructure, and the need for more comprehensive climate adaptation strategies.

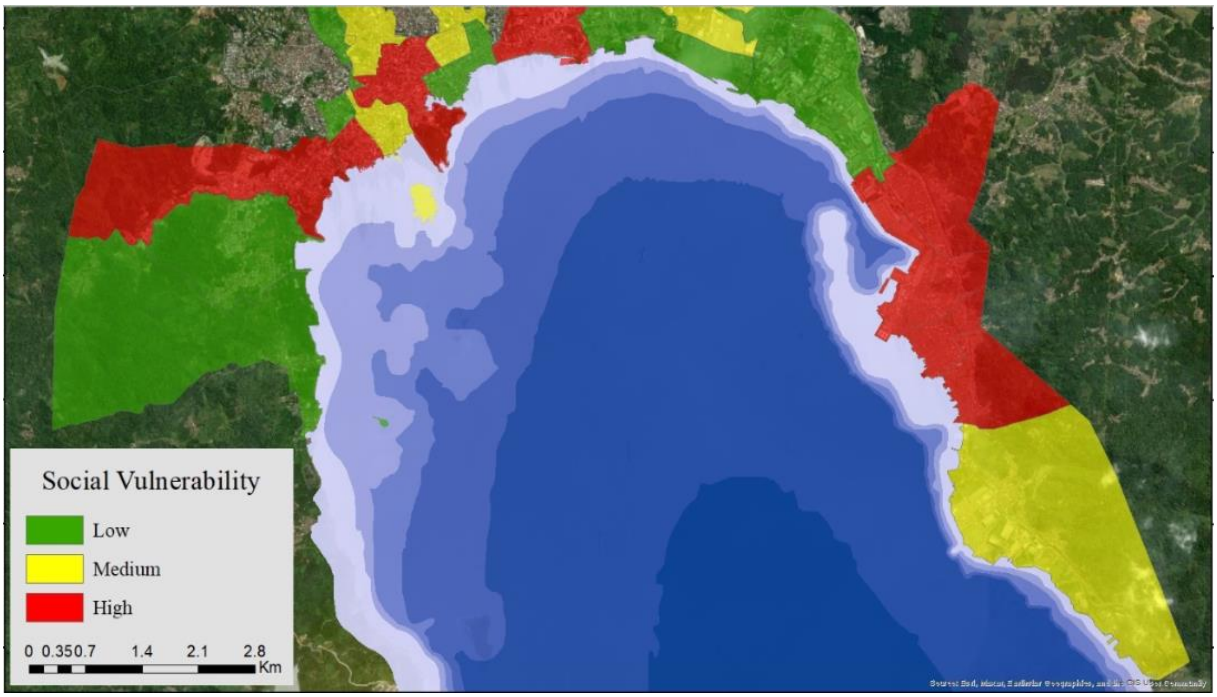


Source: Ecoltdgroup



Photos showing the presence of urban services are progressing in informal areas in Bandar Lampung (meters for water and electricity)

Many studies were realized to assess the social vulnerability to climate change by Indonesian searchers. They are resumed on this figure.



Distribution of Social Vulnerability Levels in Coastal Areas of Bandar Lampung City
Source: Iopscience

The infrastructures vulnerability isn't well analysed. No specific mapping of critical infrastructures is available. Below is a detailed overview with quantitative information related to the infrastructure's situation. This assessment is a preliminary approach towards a resilience strategy for Bandar Lampung.

Transportation Infrastructure:

- Rail Transport: In November 2023, trains were the predominant mode of transportation in Bandar Lampung, accounting for 45.41% of passenger usage. Tanjung Karang Railway Station serves as the main hub, connecting the city to Palembang and facilitating both passenger and freight services.
- Air Transport: Radin Inten II Airport, located in South Lampung Regency, serves as the primary air gateway for the region. In November 2023, the airport handled 42,994 departing passengers, reflecting a 2.02% increase from the previous month.
- Maritime Transport: The Port of Panjang is a significant maritime facility in Bandar Lampung, handling substantial cargo volumes. In November 2023, the port managed 2,706,360 tons of loaded goods, although this represented a 12.77% decrease compared to October 2023.

Water Supply Infrastructure: The Bandar Lampung Drinking Water Supply System (SPAM) project aims to enhance access to clean water for residents. This initiative is crucial in addressing previous limitations in service coverage and ensuring a reliable water supply for the city's growing population.

Digital Infrastructure: Regarding the Data Centre, Telkom Indonesia has established a data centre in Bandar Lampung to support the city's increasing demand for reliable internet and telecommunications services. This facility plays a vital role in enhancing digital connectivity and supporting various sectors, including business, education, and government services.

Environmental Considerations: Recent studies have identified environmental challenges in Bandar Lampung, including land subsidence and flood risks:

- Land Subsidence: Between 2015 and 2023, certain areas in the eastern part of the city, such as Sukabumi, Sukarame, Tanjung Senang, Kedamaian, and Wayhalim, experienced subsidence rates ranging from approximately -2 mm/year to -6.9 mm/year. This phenomenon is primarily attributed to industrial activities and extensive groundwater extraction.
- Flood Risk: Over a decade (2010-2019), Bandar Lampung experienced 26 disasters, 14 of which were floods. Approximately 20.58% of the city's area (3,781.12 hectares) is classified as high flood risk. Factors contributing to this risk include hazard exposure, vulnerability, and capacity challenges.

Bandar Lampung has experienced significant flooding events, particularly in January 2025, affecting numerous districts across the city. According to the Lampung Disaster Mitigation Agency (BPBD), only four out of the city's twenty districts remained unaffected during these events. The most severely impacted areas include:

- Way Lunik in Panjang District: This area suffered extensive flooding, leading to property damage and displacement of residents.
- Pakuwon in South Teluk Betung District: This district also faced severe flooding, with significant impacts on the local community.

Additionally, coastal villages such as Bumi Waras, Pesawahan, and Keteguhan have been identified as having high levels of social vulnerability, making them particularly susceptible to flood-related impacts. These events underscore the need for comprehensive flood mitigation strategies and infrastructure improvements to enhance the city's resilience against future flooding incidents. The Flooding happened on the 17 of January 2025 caused many damages on infrastructures, housings especially in informal areas.

1. Flash flood hit Bandar Lampung: https://www.youtube.com/watch?v=iSUyu7DX-VY)
2. Unprecedented flooding in Bandar Lampung, Sumatra, Indonesia: https://www.youtube.com/watch?v=Hk7b8qO78Gs

These infrastructures and environmental considerations are pivotal in supporting Bandar Lampung's development and addressing the challenges associated with urban growth.

The Bandar Lampung City has taken several steps in planning and building resilience to climate change. This paper investigates the evolution of institutional transformation and policy change in the City of Bandar Lampung. It highlights the experience on how the city

adapting to climate change through modified urban development policy. Overall, the city demonstrates a new and unique form of urban climate governance within Indonesia context. A collective decision-making body namely City Team (comprises of city departments, university-based experts and academia and civil society organizations) has been formed to temporarily function as mandated body that assesses climate risks and vulnerability, sets and prioritizes problems and programs, pilots small scale adaptation projects, plans for city-scale adaptation intervention and functions as climate advocates within the city. This paper highlights how Bandar Lampung evolves as climate change ignorant city to be a climate change sensitive city as indicated by the shifts in planning.

In Pangkalpinang:

Pangkalpinang is the capital city of Bangka Belitung Islands Province in Indonesia, geographically located between 2°4'-2°10' South Latitude and 106°4'-106°7' East Longitude.

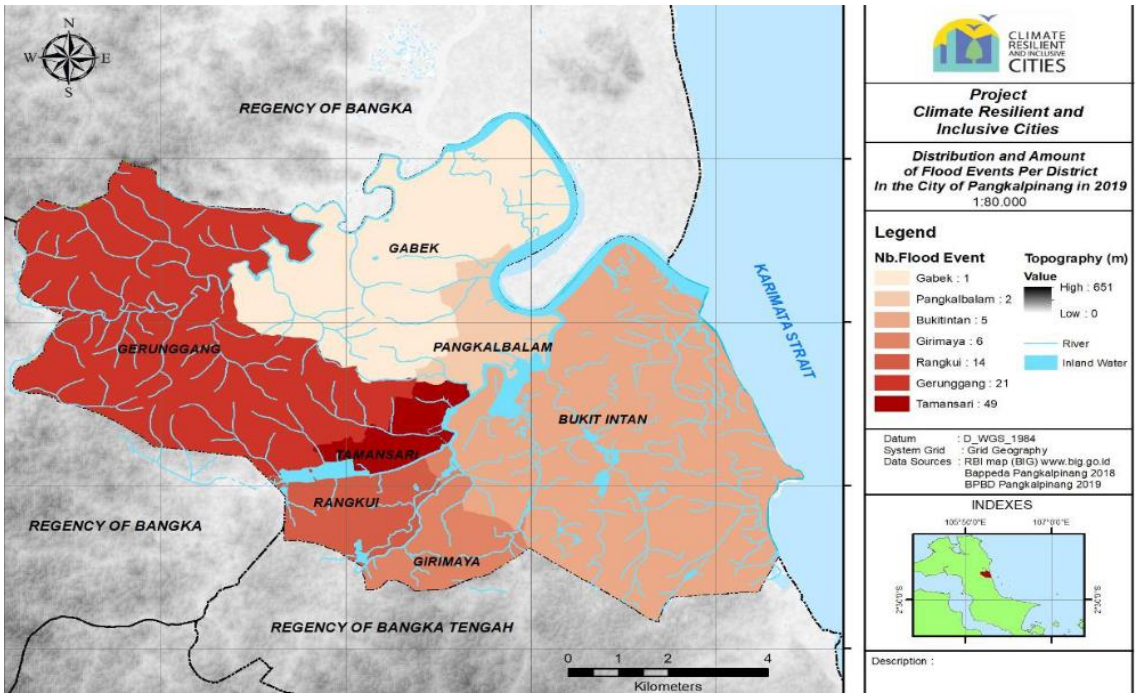
The city has a total area of 118,41 km2 which is administratively divided into seven districts, namely, Rangkui, Bukit Intan, Girimaya, Pangkalbalam, Gabek, Tamansari, and Gerunggang with a total population of 212,727 inhabitants. The city of Pangkalpinang is a trading city in the province.

The local governmental policy on mining businesses has had an impact on the economy along with the rubber and palm oil plantations in the islands. A total of 1,562ha area is used to cultivate food crops, smallholder plantations, fisheries and forests.

The low topography of Pangkalpinang and the high sedimentation of the river are associated with the frequent floods. Indeed, the riverbed is located higher than some of its flow areas, causing frequent inundations, which can be worsened by the malfunctioning drainage network. In addition, floods occur not only in residential areas but also in the central trade/city centre area.

The highest number of floods occurred in Tamansari district with a total of 49 events during 2019. Flood incidents that were considered high occurred in Tamansari, Gerunggang and Rangkui districts. Specifically, in Gerunggang district, the location of the flood is on the border with Tamansari district. Flood events generally occur in districts that are located on riverbanks. Districts that experienced high flooding events (Tamansari, Gerunggang and Rangkui) were flowed by the Rangkui River and the Pedindang River.

During the rainy season, large volumes of water from upstream eventually can't be accommodated by river bodies. This is one of the main factors that cause Pangkalpinang to experience frequent flooding. Number of damaged houses due to floods reached 1,497 houses in 2019 with light damage.



As one of the most vulnerable coastal cities in Indonesia, the city of Pangkalpinang is facing environmental problems such as flooding, extreme weather events, and the quality of water. All this contributes to infrastructure damage, vector-borne disease, and natural resource degradation. Thus, the city holds challenges associated with the implementation of appropriate policies in Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR).

The most dominant climate change issue is the impact of high rainfall during the rainy season which leads to flood disasters. The city has been actively working to enhance the resilience of its infrastructure, particularly in response to recurrent flooding challenges. The city has experienced significant flood events, notably in 2016, which have been exacerbated by factors such as extreme rainfall, high tides, and environmental degradation due to upstream tin mining activities.

Flood Control Strategies

To mitigate flood risks, Pangkalpinang has implemented a comprehensive flood control program based on a Multi-Criteria Assessment (MCA) approach. This strategy integrates technical aspects, including hydraulic modelling, with non-technical considerations such as risk assessments and socio-economic factors. Key initiatives under this program include:

- **Detention and Retention Ponds:** Construction of detention ponds, such as the PDAM-Jelana Detention Pond, aims to manage water flow from the Pedindang River during peak rainfall periods. Plans include the development of the Perak Retention Pond to further enhance water storage capacity.
- **River Training and Tidal Gates:** Efforts to improve river channel capacity and the installation of tidal gates, like the proposed Rangkui Tidal Gates, are designed to regulate water flow and prevent tidal backflow into the city.

- **Sea Walls:** The planned Pasir Padi Sea Wall is intended to protect coastal areas from sea-level rise and storm surges, contributing to the city's coastal defence mechanisms.

Environmental Rehabilitation

Recognizing the environmental impact of extensive tin mining, which has led to deforestation and land degradation, the city is focusing on rehabilitating mined areas. This includes reforestation efforts and the restoration of natural waterways to improve the hydrological balance and reduce surface runoff, thereby mitigating flood risks.

Community and Economic Resilience

Beyond physical infrastructure, Pangkalpinang is fostering resilience through economic diversification. The promotion of Micro, Small, and Medium Enterprises (MSMEs) in the creative economy sector is a strategic move to reduce dependence on mining and build a more sustainable economic base. These enterprises are pivotal in driving sustainable tourism and regional development, enhancing the city's overall resilience.

Issues surrounding vulnerability caused by climate change and natural disasters tend to only be partially tackled. Consequently, most local inhabitants aren't prepared for the impacts of climate change that will bear consequences on both individual and urban development. The use of appropriate data and tools is necessary, especially in employing technology and information systems. The social networks through multi-stakeholders' processes beyond administrative boundaries are also crucial. This suggests that environmental issues and climate change adaptation cannot be managed solely by the city of Pangkalpinang.



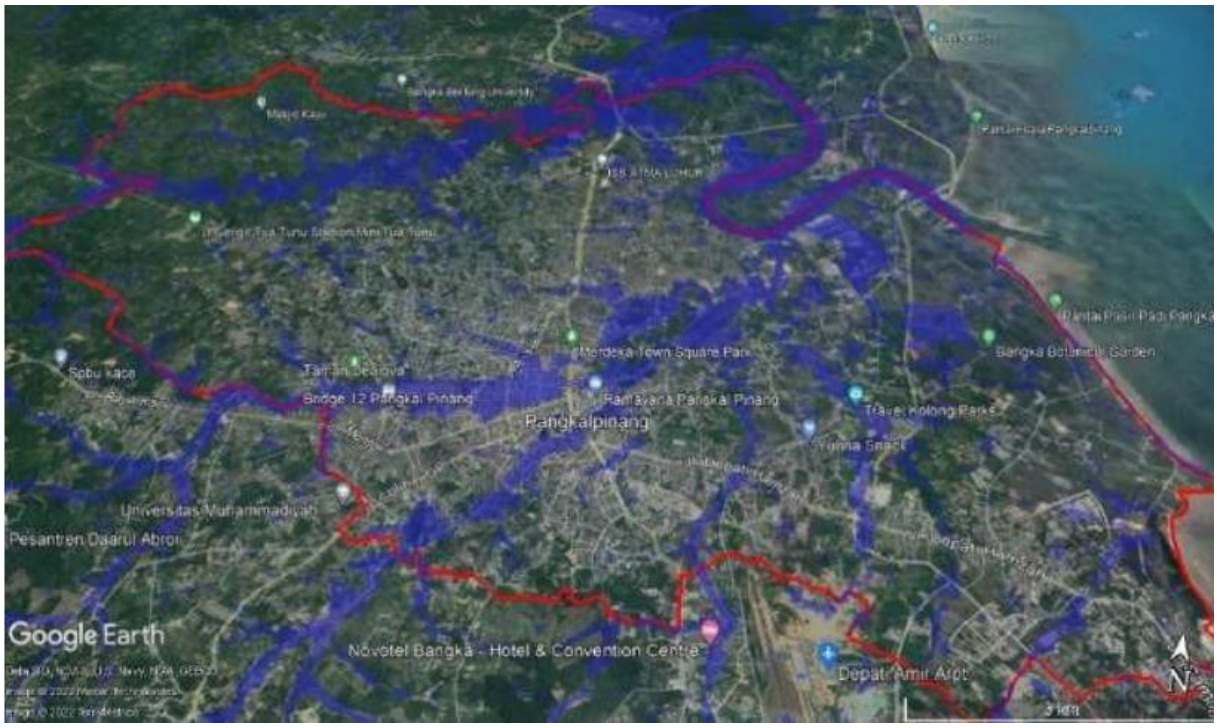
Pangkalpinang Delta City Area (H Bachtiar et al 2024) *IOP Conf. Ser.: Earth Environ. Sci. 1343 01201. Source: Iopscience*

Flood event has occurred almost every year in Pangkalpinang city with the most devastating flood event occurred in 2016. The 2016 flood had similar phenomenon to 1986 but with a larger magnitude. On the 8th of February, it rained evenly in Pangkalpinang City with a depth of 114.9 mm and continued the 9th of February at 183.9 mm (BMKG Pangkalpinang City).

On the other hand, high tides occur at the same time, resulting in a backwater phenomenon in the river which causes the flow from upstream to be blocked, so that the water level in the river increases. The figure shows the flood inundation depth at several points around Pangkalpinang City during the February 2016 extreme flood. There has been no official report on the February 2016 flood losses in Pangkalpinang City. Pangkalpinang City Government has implemented various flood mitigation strategies, including:

- Structural Measures: Dredging of rivers, construction of retention basins, and mangrove planting to enhance water absorption and reduce runoff.
- Non-Structural Measures**:** Community engagement initiatives, public awareness campaigns, and the establishment of rapid response teams to improve disaster preparedness and response.

1. **Detention and Retention Ponds:**
    - **PDAM-Jelana Detention Pond Flow Diversion:** This project involves diverting flow from the Pedindang River to the PDAM-Jelana Detention Pond in the upstream area. As of 2023, this construction is prioritized to manage upstream water flow effectively.
    - **Perak Retention Pond:** Planned for future implementation, this retention pond aims to temporarily store excess runoff, thereby reducing peak discharge and mitigating downstream flooding.
2. **River Training and Normalization:**
    - Regular dredging activities are conducted to maintain river capacity and flow efficiency. This includes reshaping and stabilizing riverbanks to prevent erosion and improve water conveyance.
3. **Tidal Gates and Sea Walls:**
    - **Rangkui Tidal Gates:** These structures are designed to control tidal influences, preventing seawater from flowing back into the river systems during high tides, which can exacerbate flooding.
    - **Pasir Padi Sea Wall:** A proposed sea wall to protect coastal areas from storm surges and tidal flooding, thereby safeguarding low-lying regions.



Map of Flood Modelling Results for Pangkalpinang City (February 2016)



Current Condition for PDAM-Jelana Detention Pond Construction

Non-Structural mitigation measures:

1. **Policy and administrative actions:**
    - The establishment of the Regional Disaster Management Agency in 2016 marked a significant step toward organized disaster response and mitigation. Regular coordination meetings with provincial and national

agencies have been institutionalized to ensure cohesive disaster management efforts.

2. **Community engagement and environmental Conservation:**
    - Initiatives to raise public awareness about the importance of maintaining waterways and proper waste disposal have been implemented. Programs encouraging community participation in river cleaning and mangrove planting are aimed at enhancing natural water absorption and reducing runoff.

Challenges:

Despite these comprehensive strategies, Pangkalpinang faces several challenges in effective flood management:

- **Funding Constraints:** Limited financial resources hinder the timely implementation and maintenance of both structural and non-structural measures.

  Environmental Degradation: Illegal tin mining activities in upstream areas have led to watershed degradation, increasing sedimentation and reducing the effectiveness of existing flood control infrastructures.

- **Community Engagement:** Achieving sustained public participation in environmental conservation efforts remains a challenge, necessitating continuous education and involvement initiatives.

Addressing these challenges requires a multifaceted approach, combining technical solutions with policy reforms and community-driven initiatives to enhance the city's resilience against flooding.

Flood event has occurred almost every year in this Pangkalpinang City with the most devastating flood event has occurred in 2016 historically. Irrespective of being caused by extreme rainfall and high tides, the flooding occurred due to a decrease in the hydrological condition of the watershed due to illegal tin mining activities in the upstream area. This paper discusses the flood control strategies in Pangkalpinang City which is based on hydrological-oceanographic modelling and a spatial risk analysis approach. The hydraulic model is employed to identify the water flow behaviour by reconstructing the extreme flood event in 2016. Simulation results show that there is an indication of the bottle neck affect in these three main waters shed of Rangkui River, Pedindang River, and Lantai River. At the same time, the tidal fluctuation in the Bayur Bay is in high tide period.

The maximum inundation at some points of the city is around two meter and the simulation results are validated by field observation. In the implementation strategy of flood control program, the priority scale of physical construction is already identified based on the consideration of technical, economic, social, and environmental aspects. The first construction priority in 2023 was in PDAM-Jelana Detention Pond Flow Diversion from Pedindang River. For the future, it is planned to carry out the flood control construction according to the priority analysis namely Perak Retention Pond, River Training, Rangkui Tidal Gates and Pasir Padi Sea Wall.

Our detailed analysis showed the need for efficient EWS systems. In the next chapter, and based on our experience, we are suggesting an economic and efficient EWS system. They can be funded and installed by international donors after a detailed design studies.

The TORs for this implementation process can be done by the University Gustave Eiffel to support UCLG ASPAC and the two cities.

4.3 The Early Warning System to be implemented

Based on the American approach called the Flood Control District, allowing to install, operate and maintain a low-cost flood sensor network to add sensor coverage across the region.

The primary purpose of the sensors is to monitor storm water drainage performance in urban areas and add coverage to upstream rural and suburban areas and communities to provide early alerting when roadways or bridges are impassable because of flood waters. This idea came after our detailed observations of flooding in Bandar Lampung.

For sensor coverage and density to increase substantially across a region, smaller agencies and counties will need to operate and maintain their own systems. There is a need to show case historical successes and failures of operating and maintaining low-cost flood sensor systems to provide smaller agencies with the necessary information needed to successfully implement. To date, relatively little information is available on the operation and maintenance of a low-cost flood sensor network; more specifically, on how smaller county and municipal agencies (not flood control districts) can install, operate, and maintain such a network. Our suggestion try to find answers to the following questions:

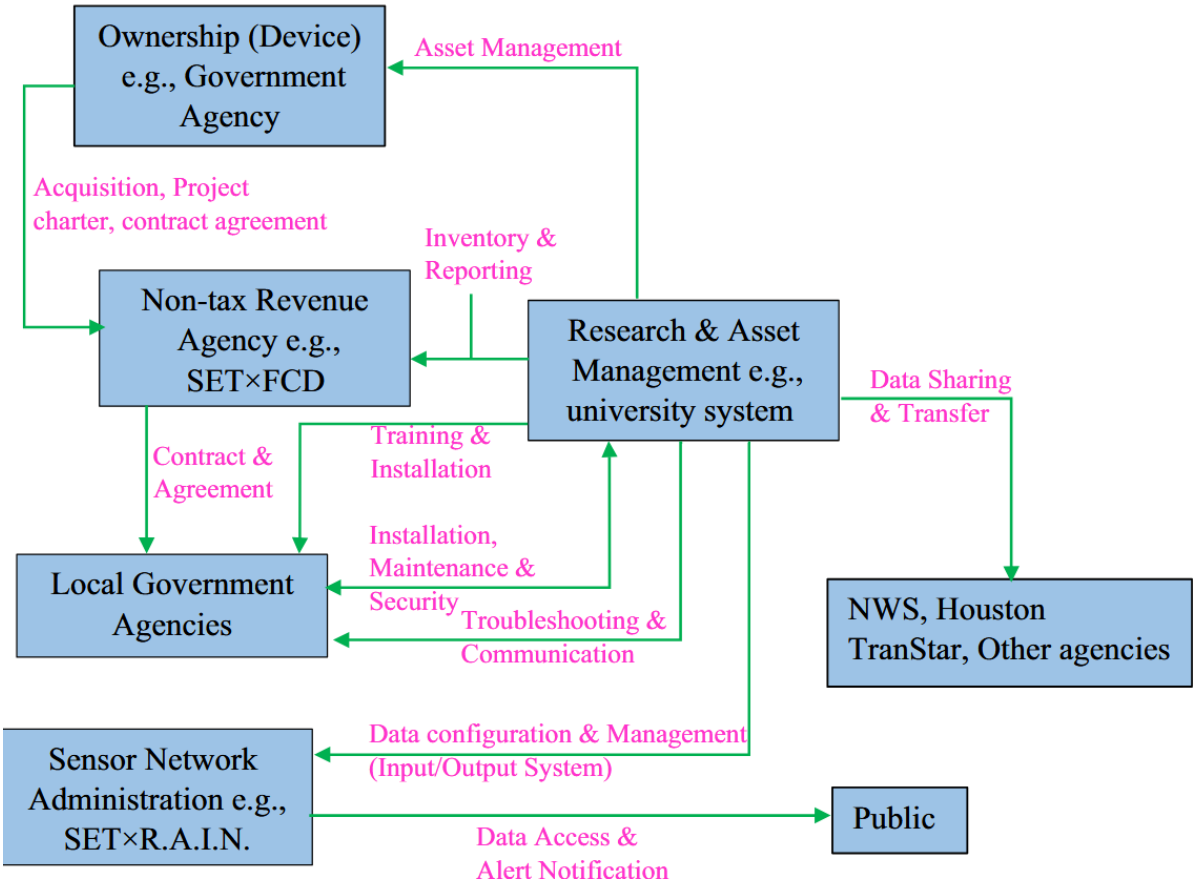
1. How can an interagency partnership be leveraged to install, operate, and maintain a low-cost flood sensor network?

2. In what ways can a university help in managing a flood sensor network?

3. What type of personnel is needed to manage a low-cost flood sensor network and what are the job responsibilities?

4. What are the advantages and disadvantages of a low-cost flood sensor network, and can it improve community resilience?

Over the course of this project, several stakeholder meetings were held regarding the availability of funds for flood monitoring system provision, installation, maintenance, and development of a public domain system for public access and emergency alert notification. The various stakeholders agreed on the need for the network and its data, but they recognized that there were many challenges such as the future maintenance and sustainability of such a system and availability of funds. The figure shows the approach adopted in USA for this kind of monitoring.



The organization of an integrated low cost and efficient EWS based on the American experience

The flood monitoring system provides a remote and autonomous flood warning system that can alert users and first responders to flooding. The camera module can transmit images of current flood conditions to users and first responders to aid in evacuation and road closure scenarios. The node can collect data within 60s of startup and connects through a cellular connection to an operation centre where the data are transmitted to the end users and first responders. An illustration of the installed system in Texas is showed on the figure.



Our two cities are crossed by numerous small rivers in heavily urbanized areas. Over time, the morphology of these waterways has evolved, as have development and land use planning. After recent flooding, when streams and waterways breached their banks, preventing floods has become a priority for the community and a challenge for prevention and for protection of the populace. Local authorities, along with local public safety authorities and the river guilds must be committed to improving knowledge and awareness of flood risks by providing prevention and warning tools.

The presented technology is based on analysis and image processing software that digitizes water surfaces to obtain hydrometric data. The system's nocturnal operation relies on infrared projectors connected to the cameras. But this system does more than that, offering concrete solutions — in fact the data obtained from image processing are accessible in real time through a web browser.

In this way, YDIF tool make it easy for metropolitan and community agents in charge of flood monitoring to understand the hydrological situation. Furthermore, within a Program for Action and Flood Prevention as mentioned earlier, the measurement data will be provided to the Flood Forecasting Commission in charge of monitoring and providing information on floods to allow alert maps to be created for the upcoming 24 hours.

Our tool is easy to access and read. It measures waterway data for water levels and flows and triggers an alert when the thresholds are exceeded. It is an excellent aid that allows us accurate surveillance of waterways in real time and allows public safety authorities to act when a risk is detected.

The proposed system allows:

- Measurement & Visual Monitoring in real time and remotely by the same device
- Non-contact for reliable data even under extreme conditions
- Speeds measured over the entire flow cross-section

- Continuously calculated flows for a rating curve consolidated from the first flood.
- Cam Flow & tapped flows for easy hydrometric operation









Photos from France of installing EWS in a context like Indonesian cities.





Photos from Bandar Lampung Protection System *(Credit: Youssef Diab)*






5. Conclusion

Early Warning Systems are indispensable for reducing disaster risks and safeguarding lives in Indonesia. Given the country's vulnerability due to its geographical location within the Pacific Ring of Fire and the presence of tropical monsoon climates, EWS has become a national priority. While Indonesia has made significant strides in technological and operational capacities, persistent challenges necessitate a multi-pronged approach. Integrating cutting-edge science with grassroots-level participation and robust pol.

In conclusion of this report, we can say that two elements are currently weak in Indonesian risk management approaches. The first is the management of the interdependence of networks between them an also the questions of setting up inexpensive and efficient EWS.

Interdependencies are managed through the YDIF tool which we can couple to EWS. At this stage and within the framework of CRIC, we are in a preliminary approach, but we will be able to solicit, if UCLG ASPAC wishes, the donors who are numerous to be interested in the subject. This question is fundamental to adapting Indonesian cities to the consequences of climate change.

The YDIF Tool is Built Upon Three Pillars

METHODOLOGY

YDIF methodology developed by UGE for many European cities

1. **Analysis**
2. **Response analysis**
3. **Improvement projects**

ORGANISATION

RESILIENCE

RESILIENCE

VERTICAL RESILIENCE BOARDS (SERVICES)

HORIZONTAL RESILIENCE BOARDS (RISKS)

PLATFORM

Tool supporting the YDIF methodology:

- **Managing the Community**
- **Analysing impacts, interdependences matrix, cascading effects, responders, simulations...**

