ENGINEERING RESILIENT RISK DNA:
A PARTICIPATORY SIMULATION APPROACH

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INTEGRATING DATA SCIENCE, SIMULATION, AND LOCAL WISDOM FOR PUBLIC VALUE.

CHAINARONG KESAMOON & PRACHYA BOONPRASURT

THAMMASAT RESEARCH UNIT IN STRATEGIC SCIENCE, SIMULATION AND DECISION MAKING

Our Team

Chainarong Kesamoon, Ph.D.
Agent-based Simulation, Data Science, Machine Learning

Prachya Boonprasurt, Ph.D.
Optimization, Process Design, Logistics and Supply Chain

Partner Researcher

Wichai Witayakiattilerd, Ph.D.
Fuzzy Logic, Quantitative Finance and Decision Making

THAMMASAT UNIVERSITY
FACULTY OF SCIENCE & TECHNOLOGY

THAMMASAT RESEARCH UNIT

STRATEGIC SCIENCE
SIMULATION AND DECISION MAKING

External partners

- **Thai Water Partnership (TWP)**

- **The National Science and Technology Development Agency (NSTDA)**

- **Defense Technology Institute (DTI), Ministry of Defense**

- **Advanced Computational Research On Sustainability Science (ACROSS)**
  - International Joint Laboratory established by the French Institute for Sustainable Development (IRD)

EXECUTIVE SUMMARY

The Challenge:

- Top-down disaster plans fail to account for local complexity and human behavior.

The Solution:

- An interactive "Serious Game" simulation that puts local responders (VHVs) in the driver's seat.

The Impact:

- Proven to increase rescue efficiency for vulnerable groups by 147% in pilot areas.

>> https://world.thaipbs.or.th/detail/malaysians-urged-to-stay-alert-as-floods-hit-southern-thailand/59619

Climate Volatility Index (2014-2025)

Southern Oscillation Index (SOI) vs. Pacific Decadal Oscillation (PDO)

○ SOI (Southern Oscillation Index) ○ PDO (Pacific Decadal Oscillation)
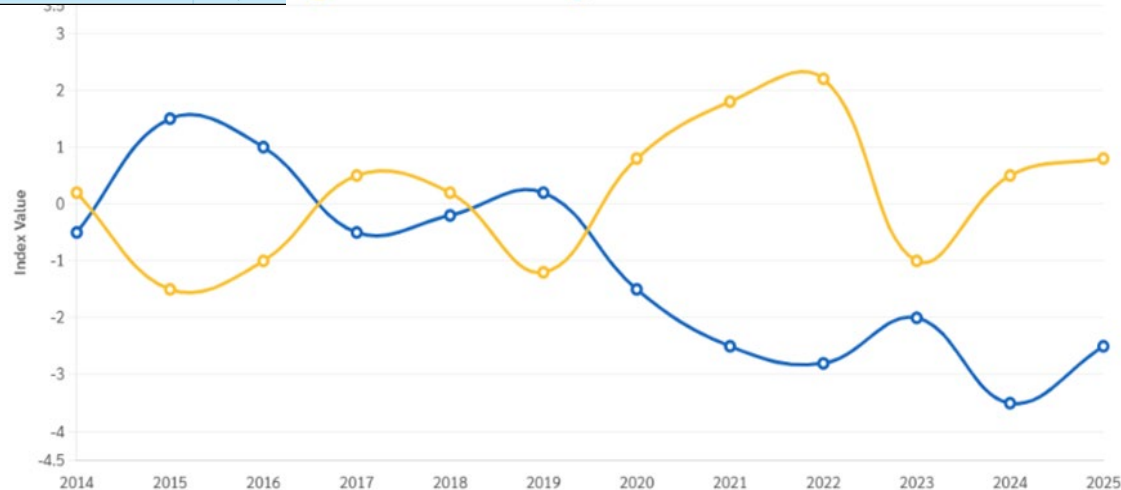
The graph illustrates extreme climate volatility. Notice the inverse relationship: when SOI (El Niño/La Niña) spikes, PDO often dips. The recent period (2020-2025) shows significant fluctuations, reinforcing the need for dynamic disaster planning over static historical models.

THE NEW RISK LANDSCAPE

Climate Volatility:
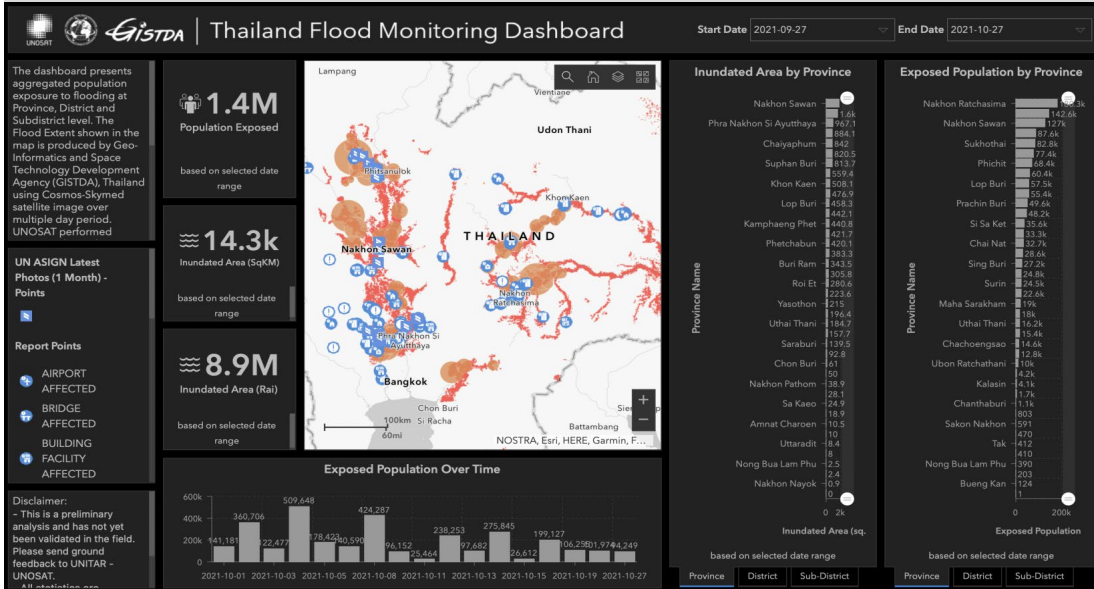
- Unpredictable patterns (e.g., Typhoon Noru).

Urban Complexity:

- Denser populations, complex infrastructure.

The Need:

- From "Static Response" to "Dynamic Agility."

>> https://world.thaipbs.or.th/detail/chiang-mai-downtown-now-under-water-emergency-response-in-full-swing/54859

THE OPERATIONAL GAP

The "Last Mile" Problem:

- Sophisticated data exists but doesn't reach the frontline.
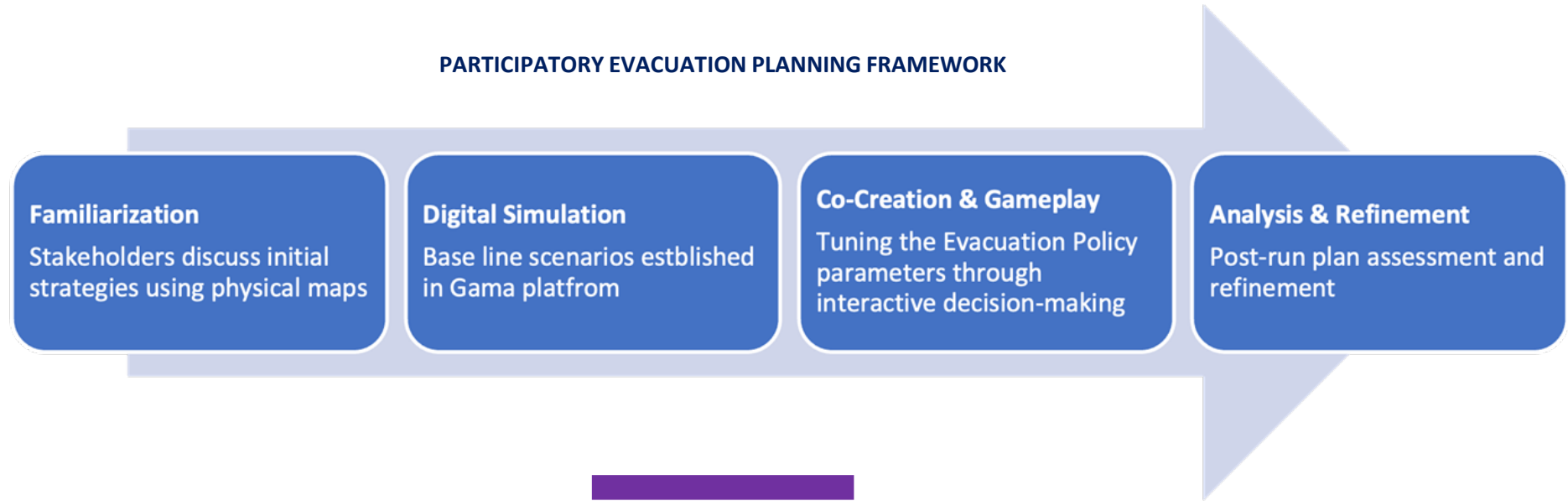
Siloed Decisions:

- Hydraulic data disconnected from demographic data.

Behavioral Blindspot:

- Plans assume logical behavior; reality involves panic and hesitation.

PARTICIPATORY EVACUATION PLANNING FRAMEWORK

Familiarization
Stakeholders discuss initial strategies using physical maps

Digital Simulation
Base line scenarios estblished in Gama platfrom

Co-Creation & Gameplay
Tuning the Evacuation Policy parameters through interactive decision-making

Analysis & Refinement
Post-run plan assessment and refinement

INTRODUCING CO-SAFE

Co-created Simulation and Action Framework for Evacuation

- **Concept:** A "Safe-to-Fail" environment for strategic testing.

- **Goal:** Bridging technical modeling with practical decision-making.

THE "HUMAN-IN-THE-LOOP" STRATEGY
FLOOD-PRONE AREAS WIANG SA (NAN PROVINCE)

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- **Focus**: Co-designing collective response strategies through participatory flood simulation.

- **TWP (Thai Water Partnership):** Having been working closely with local communities for over 10 years.

- **Goal**: to strengthen community resilience by developing flood early warning systems and engaging <u>locals in risk assessments</u>.

COLLABORATION: TWP & RESEARCH UNIT
BRIDGING SCIENCE, POLICY & COMMUNITY

Engagement & Visualization

- Community Visualization: Engaging locals via flood simulations.
- Trade-off Analysis: Visualizing expectations vs. reality.

Policy & Governance

- Policy Alignment: Matching models with local needs.
- Inclusive Governance: Involving politicians in decision loops.

Process & Communication

- Participatory Planning: Active engagement of all stakeholders.
- Transparent Comms: Timely updates & clear messaging.
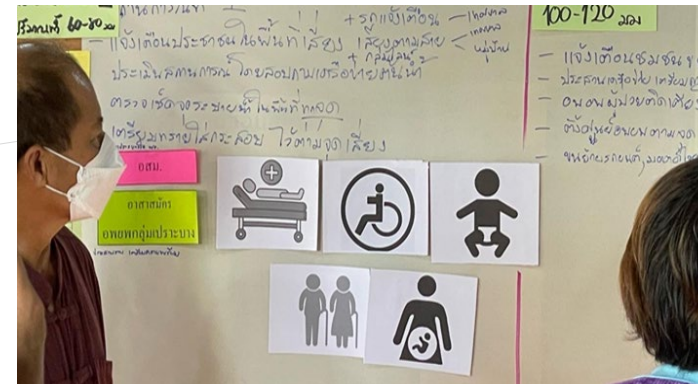
SPOTLIGHT ON VHVs
(VILLAGE HEALTH VOLUNTEERS)

TRANSFORMING "LOCAL WISDOM" INTO STRATEGIC RESILIENCE

- **The Local Strategic Asset.**
  - More than just volunteers—they are the operational backbone of community resilience.

- **The "Social Sensor":**
  - Providing deep, real-time knowledge of vulnerable groups (Bed-ridden, Elderly) that official data often misses.

- **Empowerment:**
  - Transforming VHVs from passive **executors** into active **Strategists** using participatory simulation tools.

https://chwcentral.org/wp-content/uploads/2020/12/Thailand-Dec-2020-Feature-Main-Pic.png

TECHNOLOGY STACK

Hazard Layer:

- High-fidelity hydraulic models (Flood Modeller).

Environment Layer:

- Real-world GIS & OpenStreetMap (Roads, Buildings).

Agent Layer:

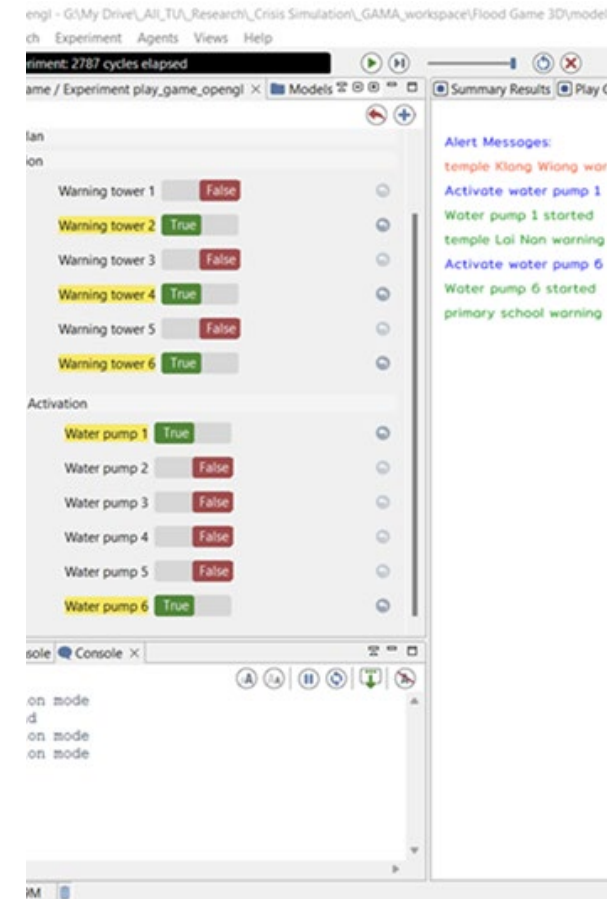- Synthetic population (Behavior, Mobility, Vulnerability).

THE PARTICIPATORY PROCESS

Step 1: Familiarization (Physical Maps).

Step 2: Digital Simulation (Testing Baseline).

Step 3: Co-Creation (Refining Strategy).

Outcome: A vetted, operational plan understood by all.

CASE STUDY: WIANG SA RESULTS

Case Study:

- Wiang Sa Subdistrict, Nan Province.

Bed-ridden Patients Rescued:

- Increased from 2 to 14 (7x improvement).

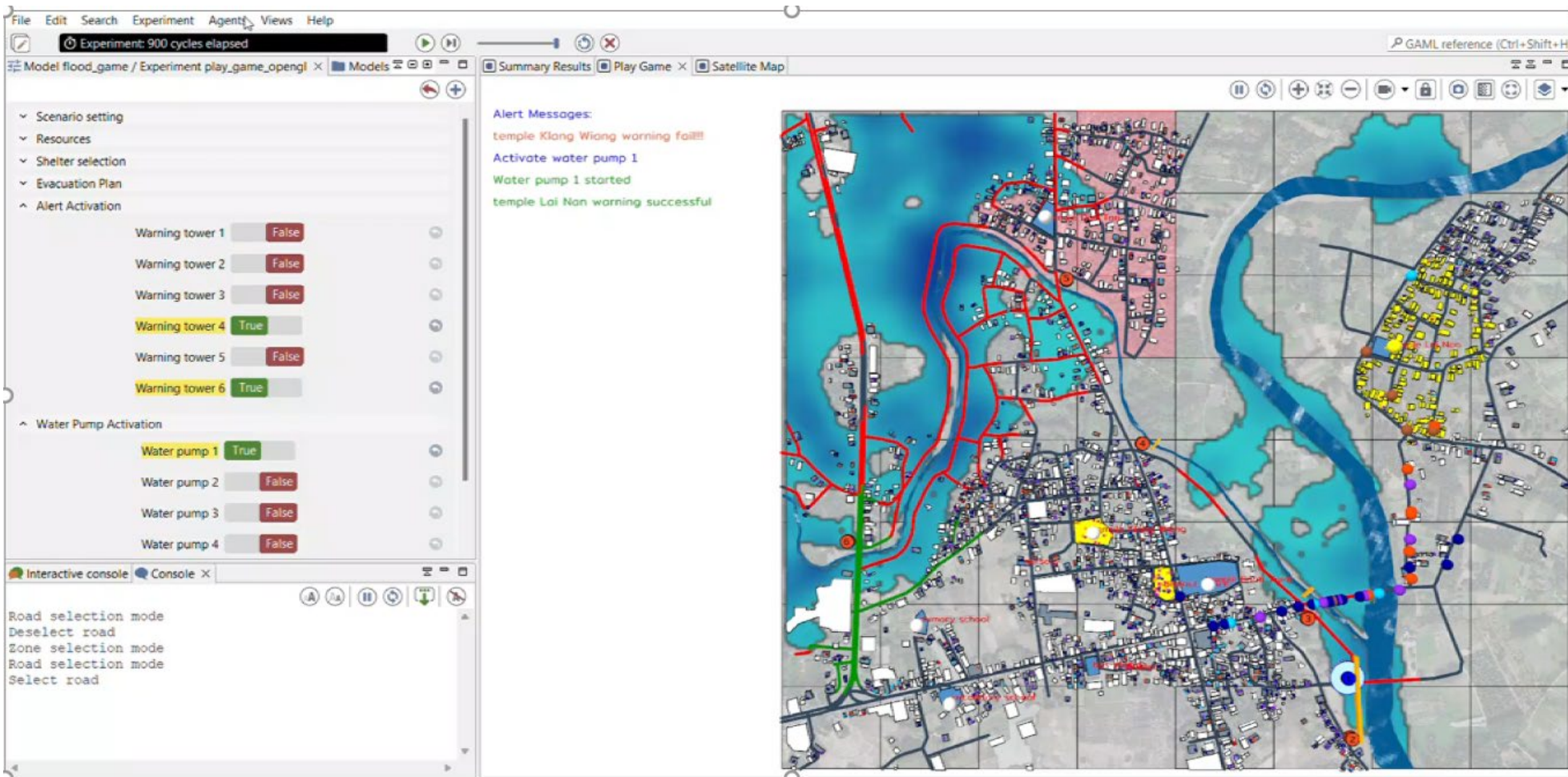**Total Vulnerable Rescued:**

- Increased by 147%.

Shelter Efficiency:

- Optimized Shelter 1 occupancy from 130% (Dangerous) to 68% (Safe).

VIDEO CLIP

Results

Outcome Metric	Wiang Sa	
	Baseline (Scenario 1)	Co-Created (Scenario 2)
Total Population	2500	2500
Total Vulnerable Population	715	715
Total Vulnerable Rescued	15	37
-- Bed-ridden Patients Rescued	2	14
-- Patients Rescued	4	18
-- Elderly Rescued	5	5
-- Pregnant Women Rescued	4	0
-- Children Rescued	0	0
Shelter Occupancy		
-- Shelter 1 (Capacity 600)	130% (Over Capacity)	68% (Within Capacity)
-- Shelter 2 (Capacity 500)	24% (Underutilized)	93% (Utilized)
-- Shelter 3 (Capacity 500)	-	-

Comparison of Vulnerable Rescued (Specific Groups)
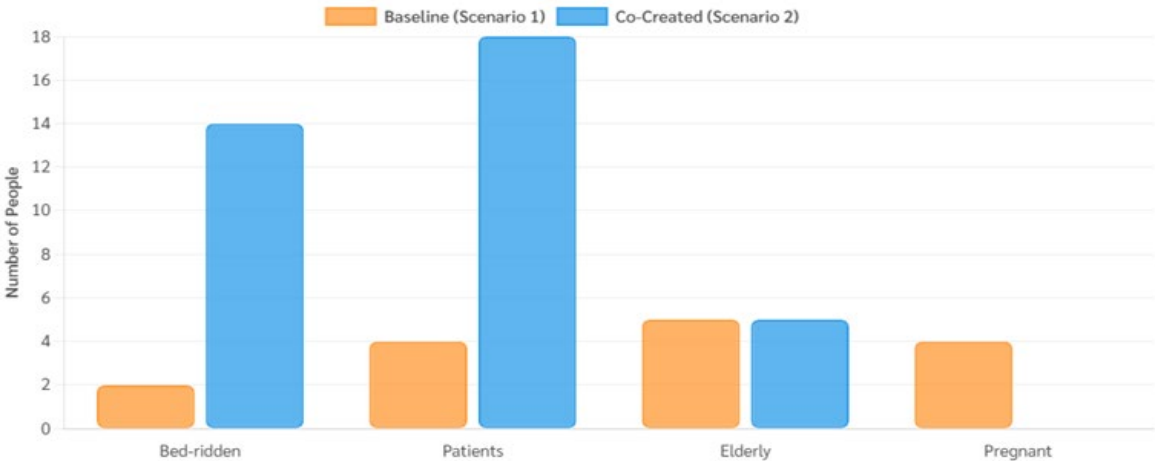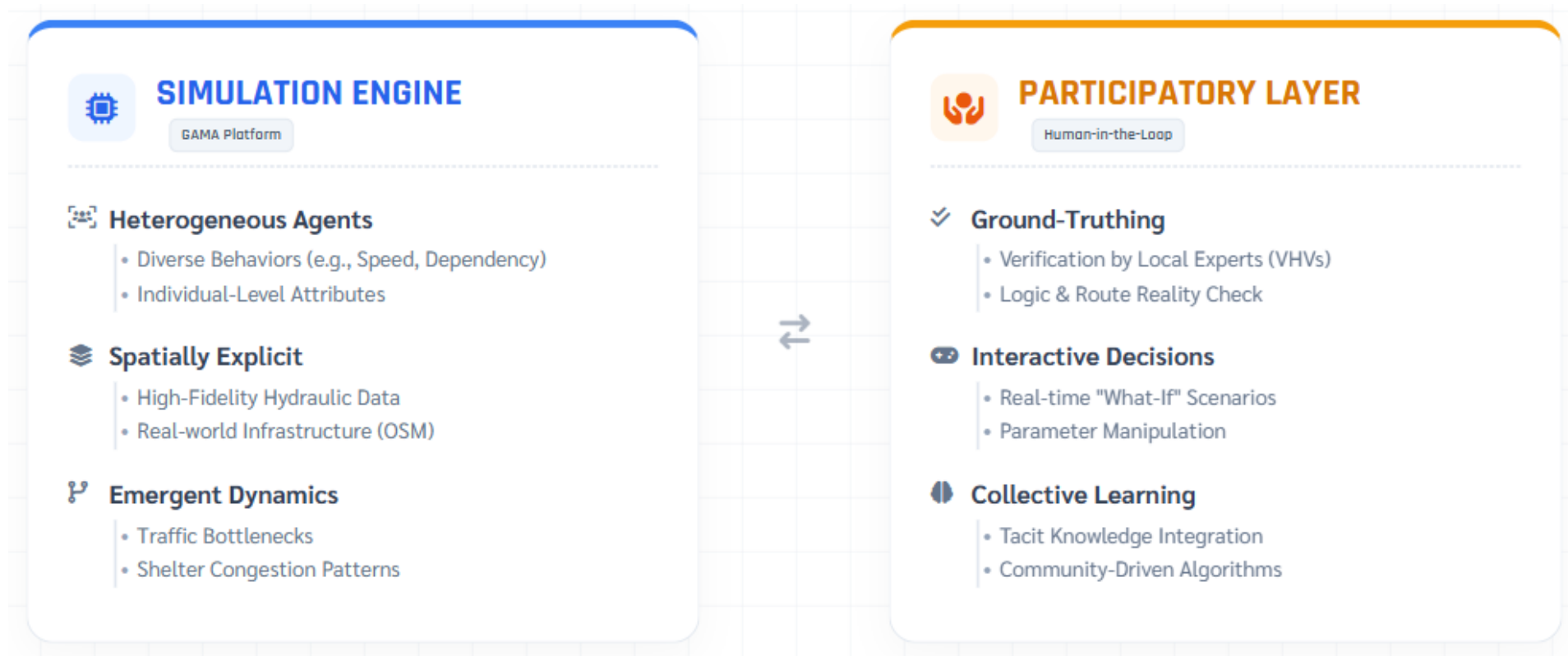

In Scenario 2 (Co-Created), the rescue of bed-ridden patients increased significantly from 2 to 14 . While pregnant women appear as 0, resources were reallocated to prioritize the most critical cases effectively.

TECHNICAL SYNERGY:

ABM & PARTICIPATION

SIMULATION ENGINE
GAMA Platform

Heterogeneous Agents
- Diverse Behaviors (e.g., Speed, Dependency)
- Individual-Level Attributes

Spatially Explicit
- High-Fidelity Hydraulic Data
- Real-world Infrastructure (OSM)

Emergent Dynamics
- Traffic Bottlenecks
- Shelter Congestion Patterns

PARTICIPATORY LAYER
Human-in-the-Loop

Ground-Truthing
- Verification by Local Experts (VHVs)
- Logic & Route Reality Check

Interactive Decisions
- Real-time "What-If" Scenarios
- Parameter Manipulation

Collective Learning
- Tacit Knowledge Integration
- Community-Driven Algorithms

Strategic Management Implications

A Holistic Framework for Resilience

Operational Resilience

Shift from reactive response to proactive **Business Continuity Planning (BCP)**. Simulate supply chain disruptions and workforce safety scenarios.

EFFICIENCY & AGILITY

Financial Risk Management

Utilize micro-level data for accurate **asset valuation** and insurance underwriting. Invest precisely in preventative infrastructure.

COST & PROTECTION

Stakeholder & Reputation (ESG)

Transform CSR to **"Capacity Building."** Strengthen your "Social License to Operate" by empowering communities with tangible safety tools.

TRUST & SHARED VALUE

Conclusion & Future Roadmap
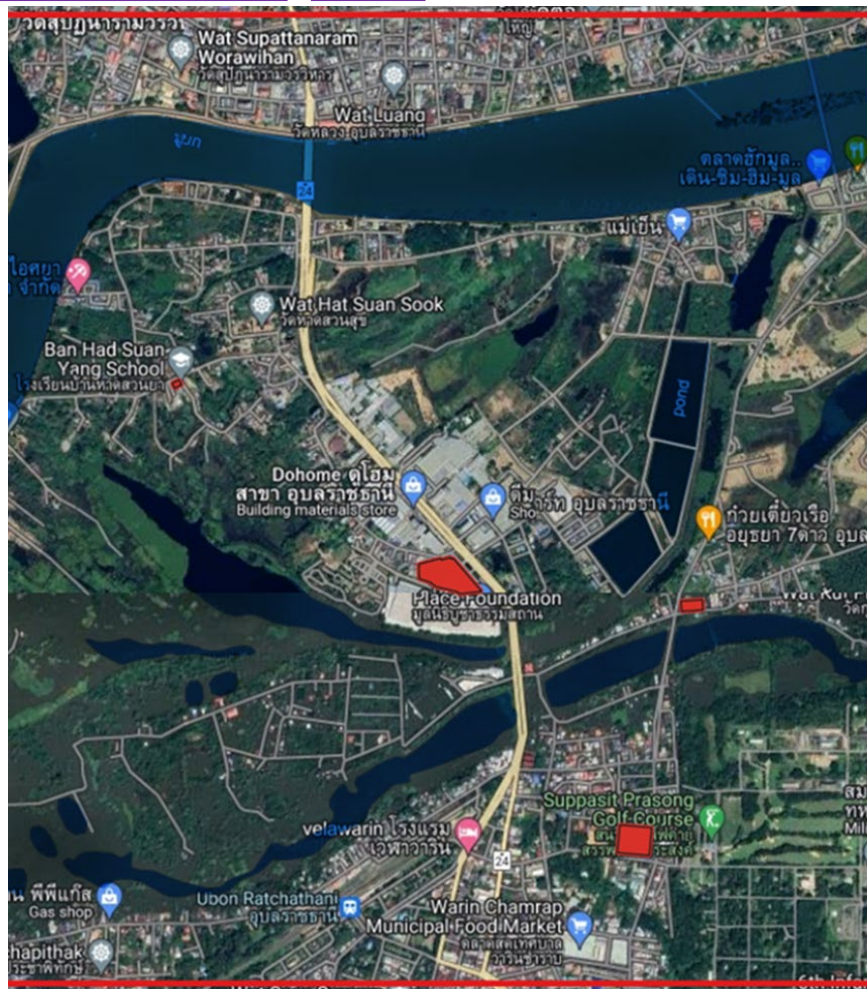
Building a Resilient Risk DNA
Core Achievements & Future Roadmap

Core Achievements

1. **Realistic Integration**
   Hydraulic Scenarios + Agent-Based Models

2. **Strategic Environment**
   Powerful platform for Training & Planning

3. **Scalable Resilience**
   Bottom-up model (CO-SAFE Framework)

Next Steps

Economic Scaling
Expand to key economic zones & integrate Real-time Data.

Inclusive Access
Develop interactive tools for ALL stakeholders.

THANK YOU

References:

- Kesamoon, C., & Boonprasurt, P. (2025). Enhancing local flood resilience: A participatory simulation-game framework for evacuation planning in Thailand. *International Journal of Disaster Risk Reduction*, *130*, 105848. https://doi.org/10.1016/J.IJDRR.2025.105848

Contacts:

- Chainarong Kesamoon, Ph.D. chainarong@mathstat.sci.tu.ac.th
- Prachya Boonprasurt, Ph.D. prachya@mathstat.sci.tu.ac.th

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มหาวิทยาลัยธรรมศาสตร์
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