

PULSE-AI: Predicting National ICT Resilience in Disasters

An AI-Enabled Framework for Dynamic Assessment and Regional Vulnerability Analysis in Disaster Management

Ahmath Bamba MBACKE
(ahmathbamba.mbacke@esp.sn)
UCAD/ESP/LITA - SENEGAL



Why ICT Resilience Matters in Disaster Management

01

Dependence on Digital Infrastructure

Modern societies rely on digital networks for healthcare, emergency response, public administration, finance, and humanitarian coordination.

These systems are essential for daily functions and crisis management.

02

Consequences of Network Failure

When telecommunications fail during disasters, critical systems such as early warning alerts and telemedicine become inoperative.

Financial transactions and operational coordination halt, worsening the crisis.

03

Impact on Public Safety and Recovery

Loss of communications leads to degraded coordination among responders and increased risk to public safety.

Recovery efforts are delayed due to disrupted information flows and system breakdowns.

Country

Senegal

Select

Download latest IRI data as CSV

Print / Generate F

Africa

44 / 100

Infrastructure

36

Market Readiness

38

Performance

48

Security

55

Western Africa

43 / 100

Infrastructure

34

Market Readiness

34

Performance

51

Security

55

Senegal

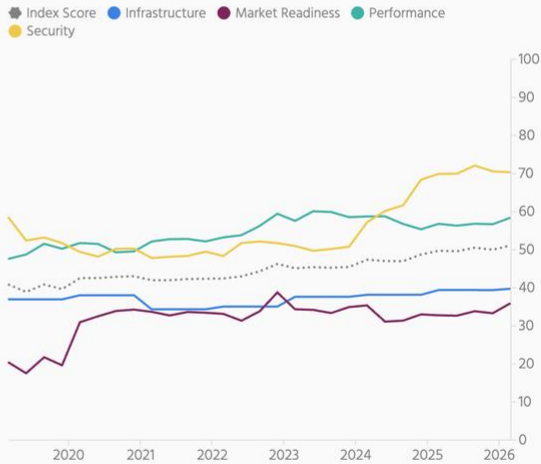
51 / 100

The Internet in Senegal is **more resilient on average than other countries in Western Africa**, and is **high for Africa**. It ranks **1st in Western Africa for security**, a category that evaluates the use of technologies and best practices that support a network's ability to resist disruptions. It ranks **29th in Africa for market readiness**, a category that evaluates the overall competitiveness of the market, and the ability to offer affordable prices to consumers.

[View country report for Senegal](#)

Infrastructure	40
Market Readiness	36
Performance	58
Security	70

IRI Score for Senegal



Infrastructure

40

Physical infrastructure for Internet connectivity exists, and is available.

Enabling infrastructure

2

Data center coverage

2

Score measured based on data centers per 10 million population. Source: PeeringDB

Internet Exchange Point (IXP) coverage

2

Shows how well large population centers (defined as more than 300,000 people) are served by IXPs. Source: PeeringDB

Mobile connectivity

77

Network coverage

86

Country has mobile network coverage (includes 2G, 3G, and 4G). Source: Composite score provided by GSMA

Spectrum allocation

55

Mobile operators have access to spectrum that allows them to offer sufficient services to customers. Source: Composite score provided by GSMA

Market readiness

36

The ability of the market to offer affordable prices to consumers by maintaining diversity and competition.

Market structure

54

Affordability

64

Measures the affordability of Internet connectivity for consumers. Source: ITU

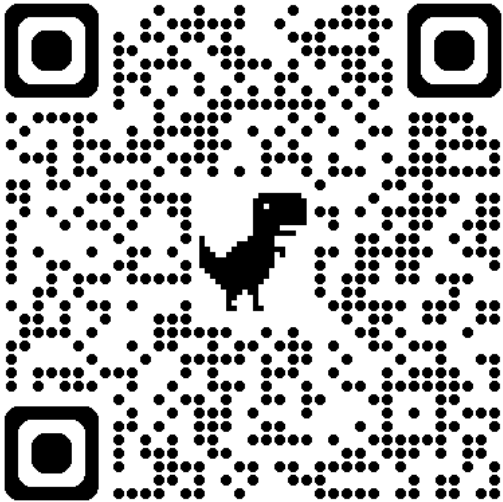
Upstream provider diversity

65

Uses the Herfindahl-Hirschman Index (HHI) to measure the market concentration of upstream Internet connections. Source: Internet Initiative Japan (IIJ)

Market competition

70



Infrastructure

<https://pulse.internetsociety.org/en/resilience/>

What Existing Indices Miss

01

Static Assessment

Current indices produce fixed scores without capturing how resilience degrades dynamically during crises.

02

Separate Dimensions

Digital infrastructure, cybersecurity, and disaster preparedness are evaluated independently, ignoring their interdependencies.

03

National Granularity

Existing tools assess resilience at the country level, overlooking critical regional differences within nations.

04

Lack of Real-Time Modeling

These frameworks do not incorporate real-time events or simulate cascading failures and degradation patterns during disasters.

PULSE-AI Framework: The Five Conceptual Pillars

1

Preparedness

Evaluates institutional and policy readiness to manage ICT disruptions during crises, including disaster management policies and coordination mechanisms.

2

Ubiquity

Measures the breadth and depth of telecommunications coverage, ensuring digital access for all communities including vulnerable groups.

3

Localization

Assesses national control over digital infrastructure and data assets, emphasizing local Internet infrastructure and domestic traffic routing.

4

Sustainability

Focuses on infrastructure redundancy, energy resilience, and long-term viability to maintain continuous digital operations.

5

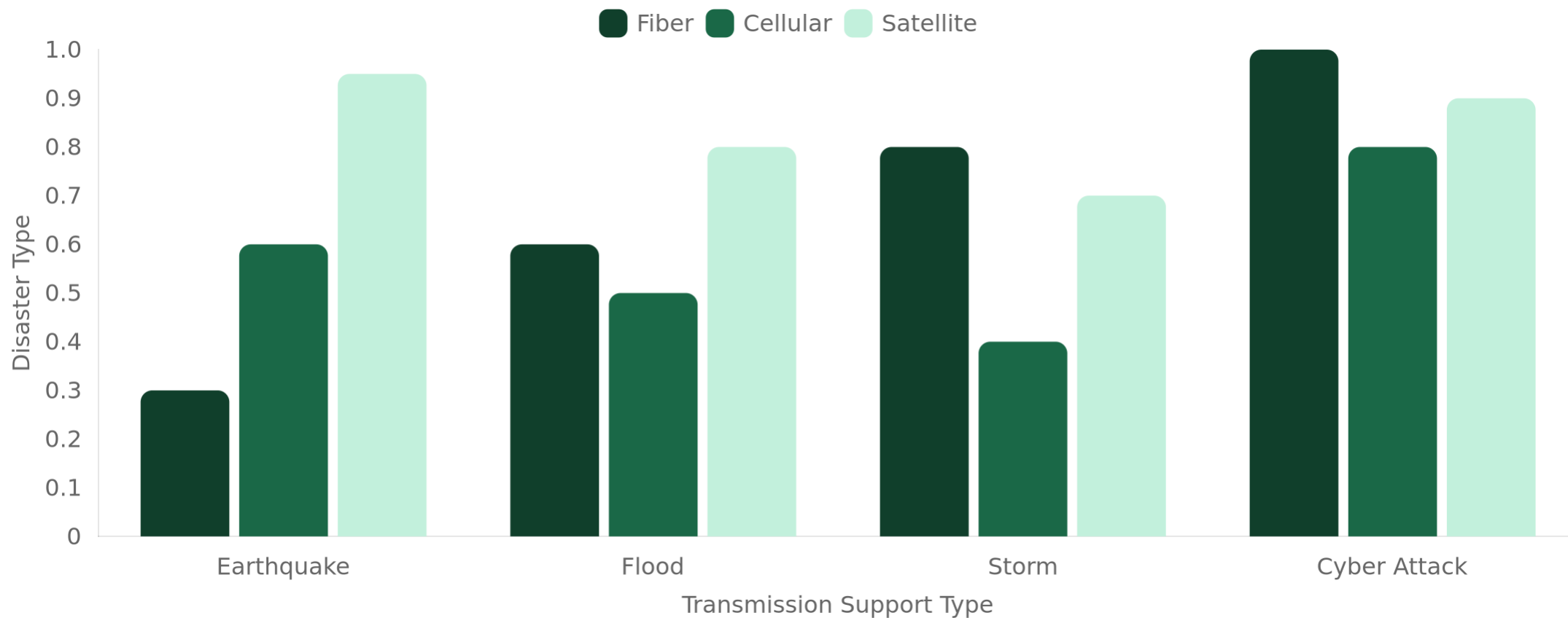
Emergency Intelligence

Incorporates AI and IoT technologies for crisis prediction, anomaly detection, and dynamic resilience scoring to support informed decision-making.

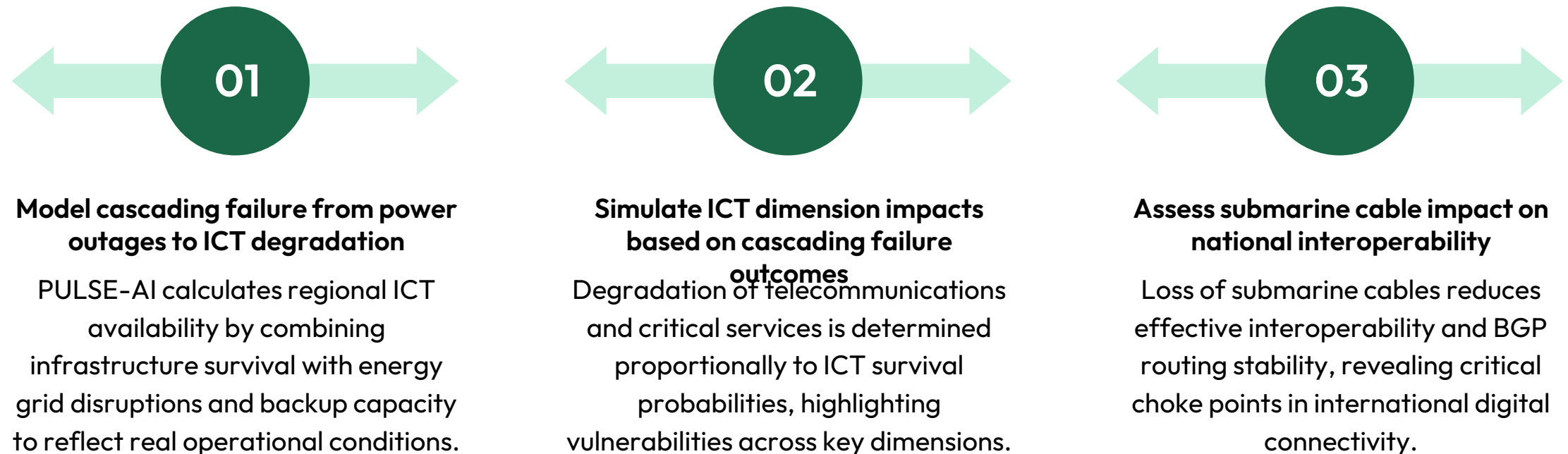
National Digital Resilience Score and Risk Bands

Risk Level	NDRS Range	Interpretation
Critical	0–299	Systemic failure likely under moderate stress
High	300–499	Significant vulnerabilities across multiple dimensions
Medium	500–749	Adequate baseline with identifiable weaknesses
Low	750–1000	Robust resilience with distributed redundancy

Infrastructure Fragility Model: Survival Probability of Transmission Supports Under Disaster Scenarios



Cascading Failures and Submarine Cable Stress



How the Platform Is Implemented

01

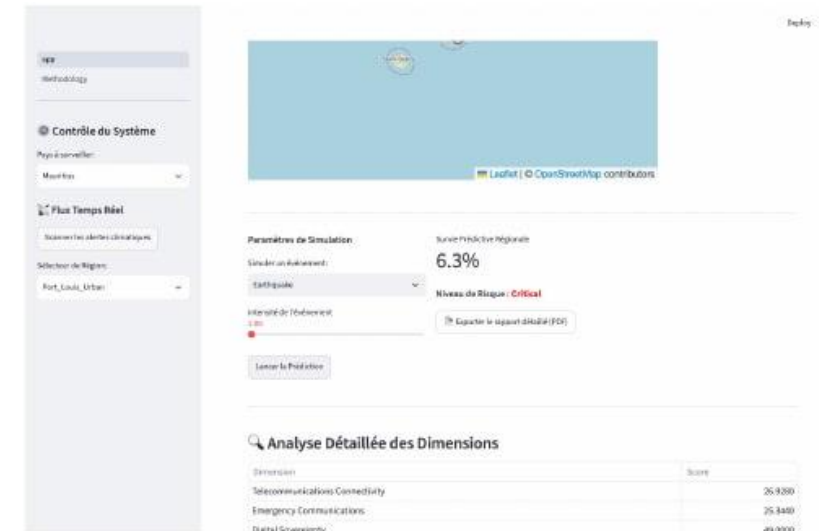
Modular Architecture

PULSE-AI is built as a modular decision-support platform using Python and Streamlit, organizing components into four layers for clarity and extensibility.

02

Interactive System Features

The platform integrates real-time disaster data, prediction engines, risk analysis, anomaly simulation, and interactive geospatial visualizations for live analytical insights.



app

Methodology

Contrôle du Système

Pays à surveiller:

Senegal

Flux Temps Réel

Scanner les alertes climatiques

Sélecteur de Région:

Casamance_Region

Paramètres de Simulation

Simuler un événement:

Flood

Intensité de l'événement



Lancer la Prédiction

Survie Prédictive Régionale

8.8%

Niveau de Risque : High

Exporter le rapport détaillé (PDF)

Analyse Détaillée des Dimensions

Dimension	Score
Telecommunications Connectivity	33.0332
Emergency Communications	26.4266
Digital Sovereignty	42.0000
Critical Services Continuity	26.4266
Cybersecurity	45.5000
Data Governance	42.0000
Inclusion and Accessibility	45.5000
AI and IoT Readiness	35.0000
Energy Resilience	26.4266
Interoperability	52.5000

app

Methodology

Contrôle du Système

Pays à surveiller:

Senegal

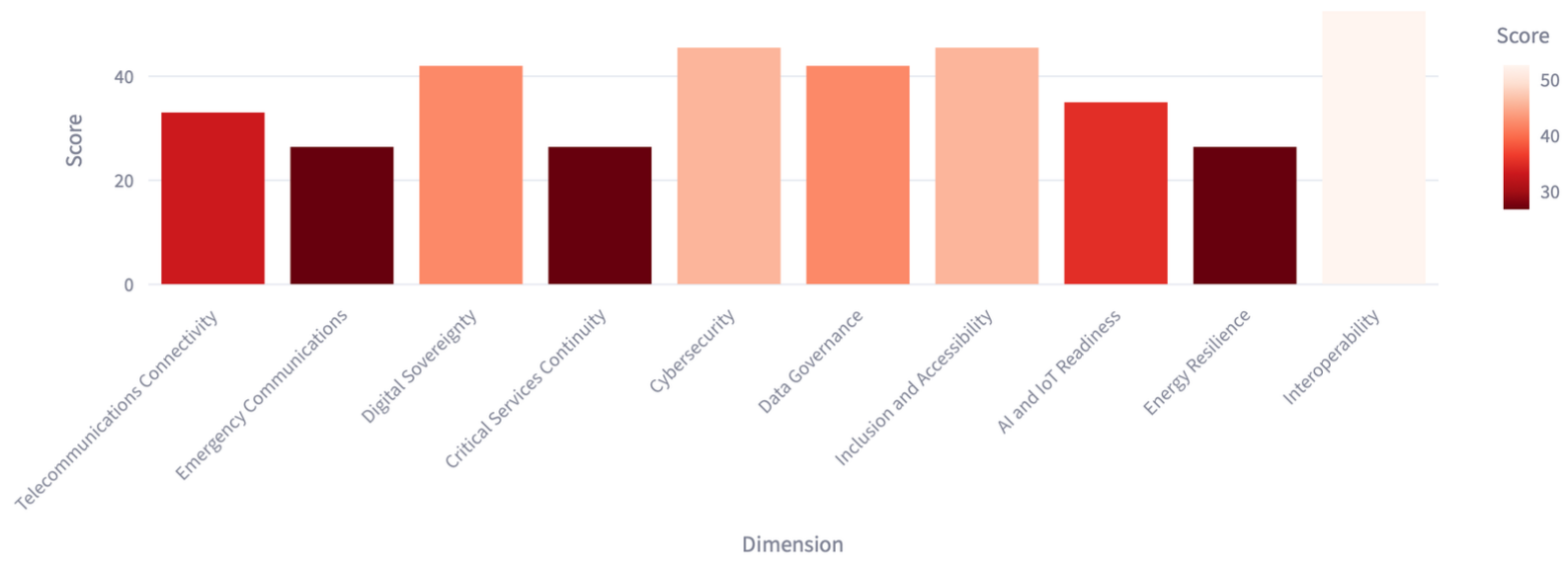
Flux Temps Réel

Scanner les alertes climatiques

Sélecteur de Région:

Casamance_Region

Deploy



Interprétation des Résultats

Cliquez sur une dimension pour voir le détail :

Digital Sovereignty

Digital Sovereignty

Niveau de contrôle national sur les données, le cloud et les infrastructures critiques pour éviter la dépendance étrangère.

Détail du calcul :

- Valeur de base : 60.00
- Impact de la catastrophe : -18.00

Validation Setup: Country Profiles and Baseline Scores

Country	Profile	NDRS	Risk
Singapore	Tech Powerhouse	896	Low
Iceland	Global Leader	838	Low
Mauritius	Indian Ocean Hub	773	Low
Senegal	Atlantic Hub	630	Medium
Rwanda	Digital Transformation	600	Medium
Nigeria	Mixed Resilience	575	Medium
Ethiopia	Emerging Market	490	High
Central African Republic	High Risk	205	Critical

Key Findings from Regional and Disaster-Specific Analysis



Regional Variability

Substantial differences exist within countries, with urban and rural regions showing different resilience due to technology mixes and energy backup.



Disaster Vulnerability Patterns

Earthquake scenarios severely impact fiber-dominant urban areas while storms disproportionately affect cellular-dependent regions, influencing regional risk profiles.



Infrastructure Choke Points and Energy Backup

Single points of failure emerge from submarine cable dependence, and low energy backup capacity critically decreases ICT survival during disasters.

Conclusion and Future Work

Framework Contribution

PULSE-AI enhances national ICT resilience assessment by integrating dynamic simulation with composite scoring, infrastructure fragility curves, cascading failure models, and submarine cable analysis. This provides a more detailed and spatially explicit prediction capability.

Next Steps

Future work includes incorporating real-time telemetry data, empirically calibrating fragility curves, applying machine-learning forecasting methods, and extending the framework to address challenges faced by Small Island Developing States.