Principles and Criteria for Urban Energy Resilience

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Background

- Frequency and enormity of damages caused by climate-related disasters
- A large volume of research on urban resilience
- Existing research on urban resilience is mainly discipline based
- Adaptation aspects have not received enough attention
- No appropriate metrics and indices for assessing the resilience of cities
- Such indices can play the role of decision support system and facilitate a more informed decision making process
- Here the focus in on both adaptation and mitigation issues

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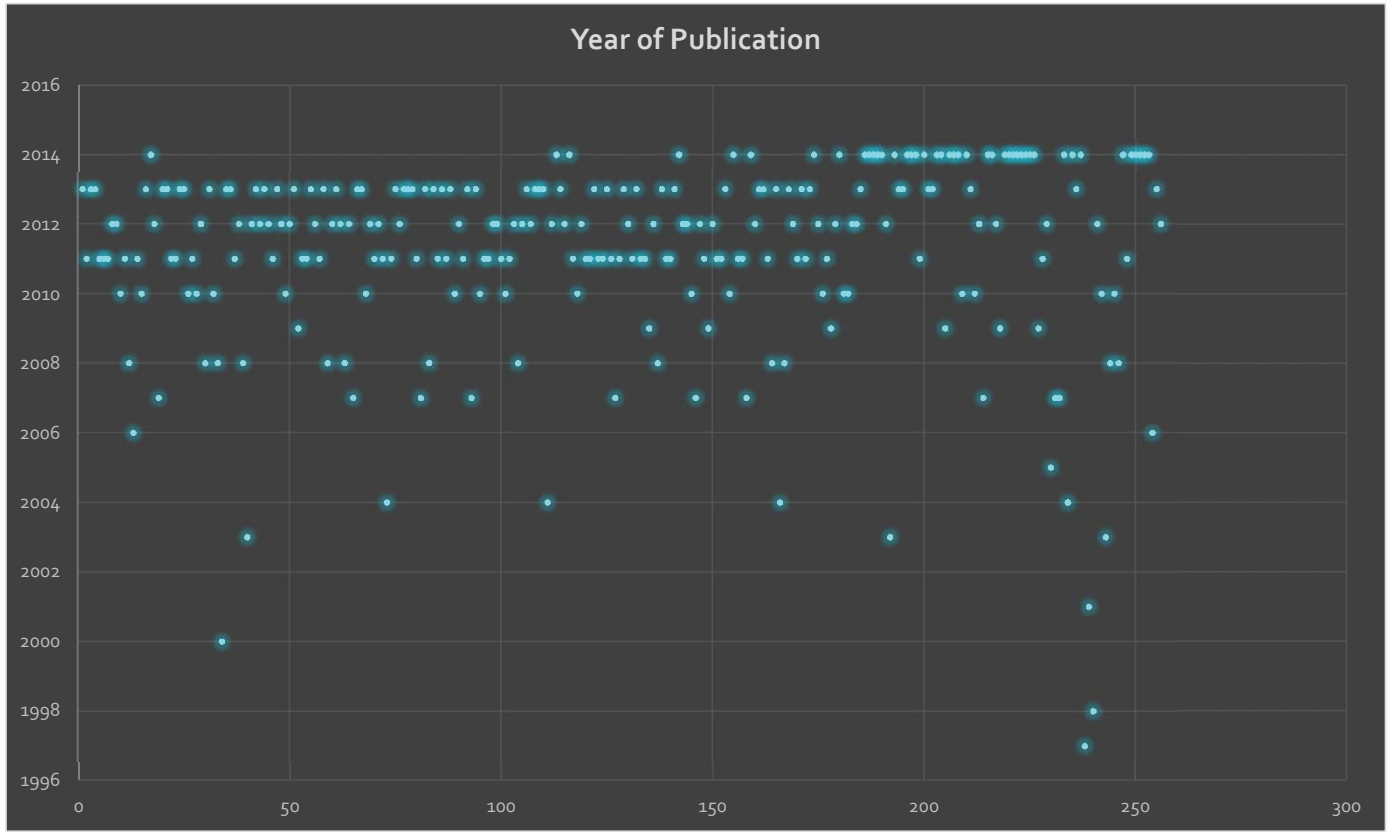
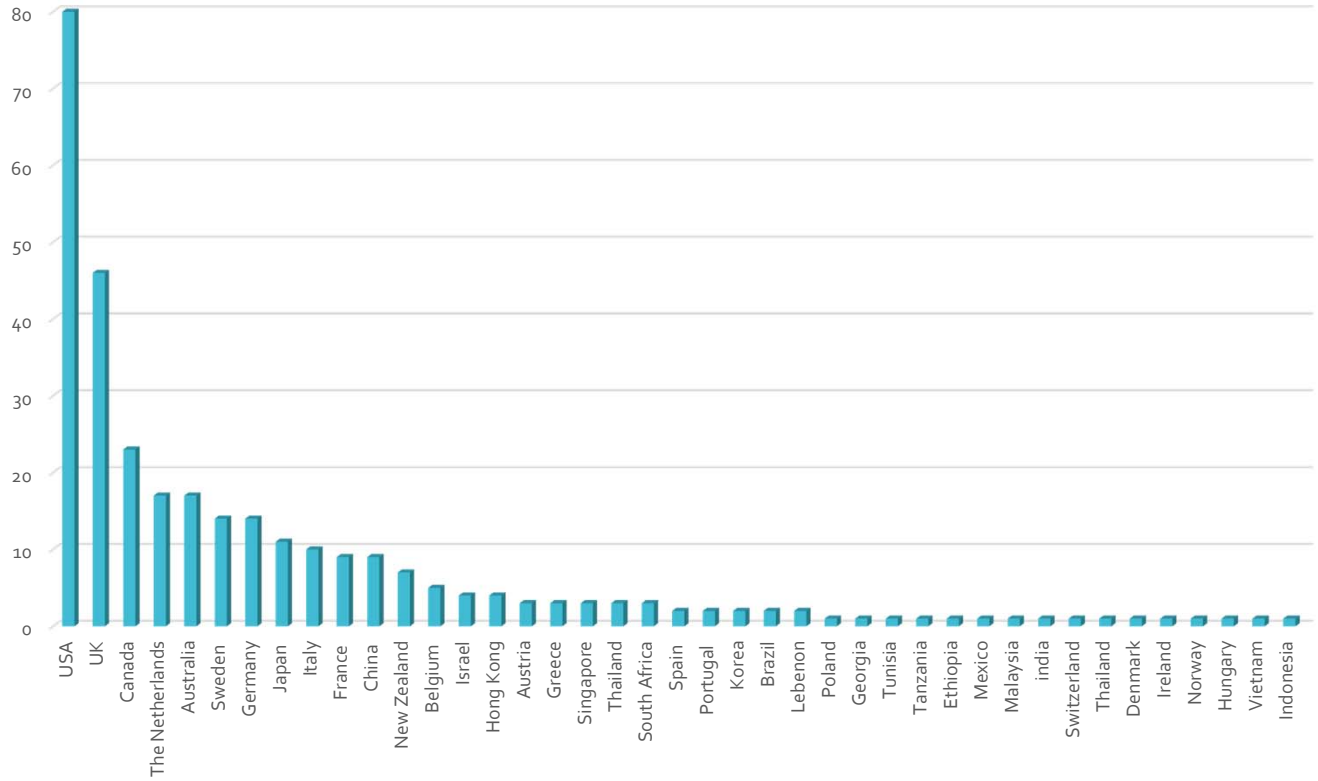
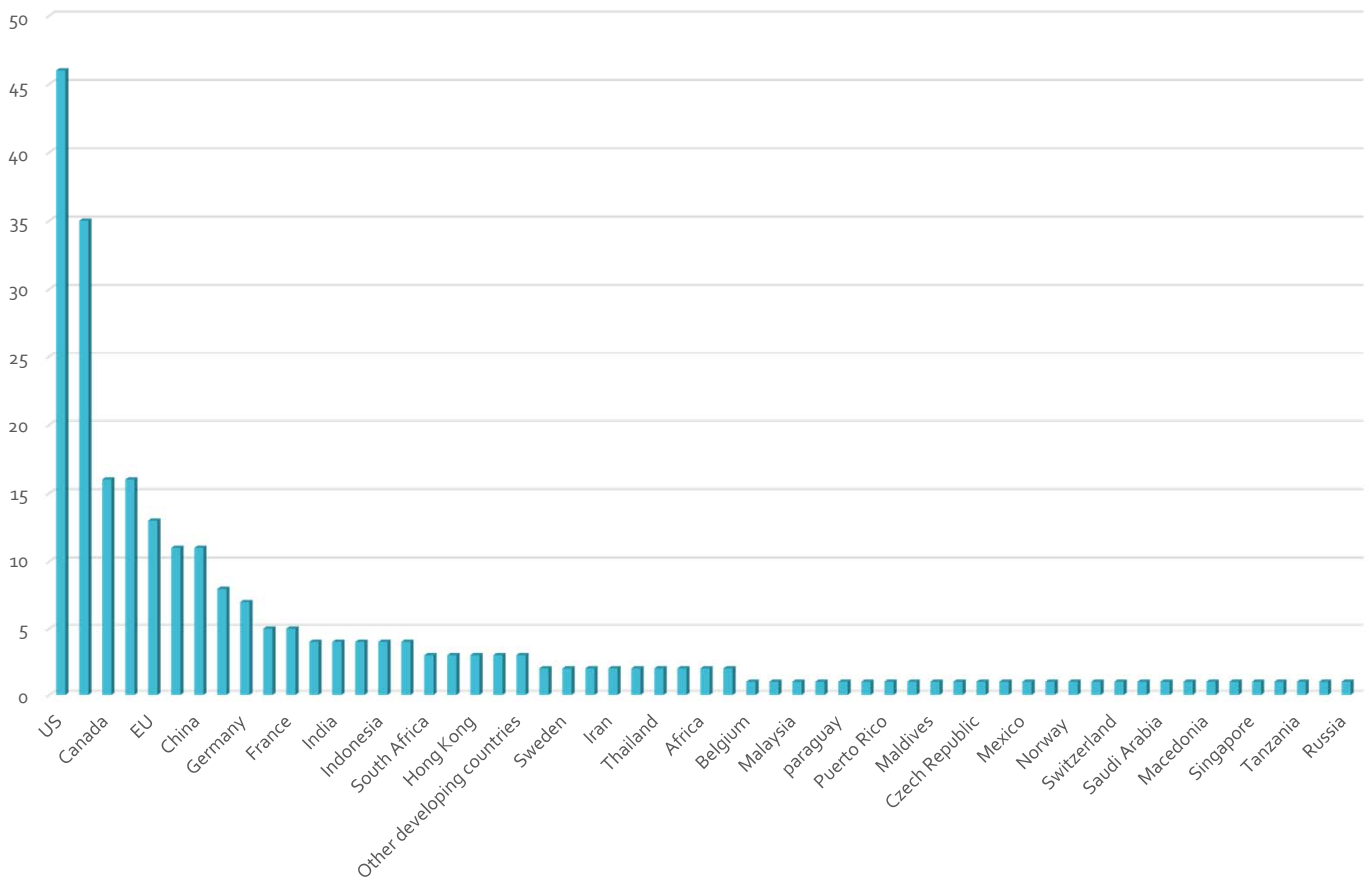
New to the Urban Literature



Geographical Distribution of the Authors



Geographical Focus



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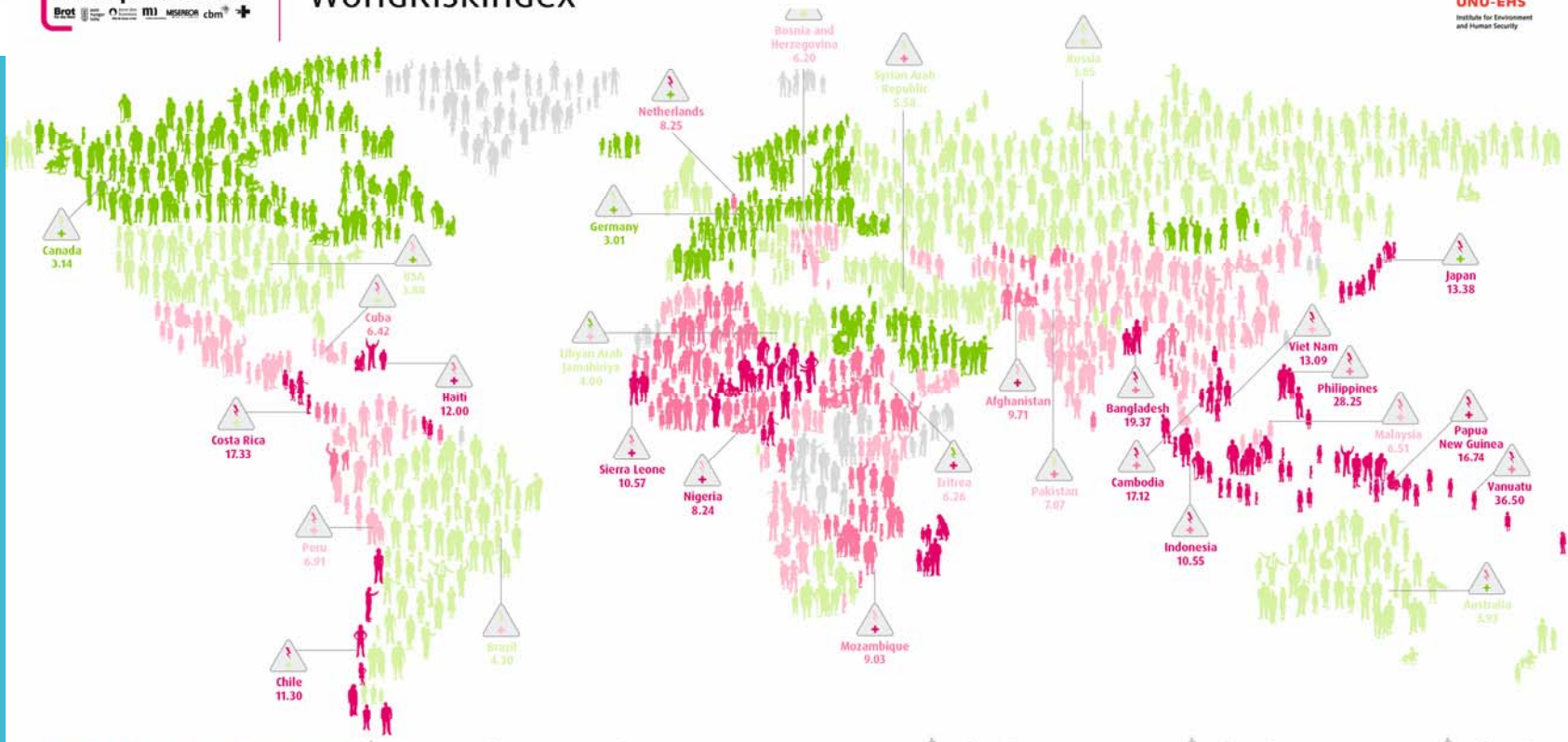
Alliance Development Works

WorldRiskIndex

UNITED NATIONS UNIVERSITY
UNU-EHS
Institute for Environment and Human Security



	WorldRiskIndex (WRI)	Exposure	Vulnerability
very low	0.04 – 3.46	0.28 – 9.25	25.98 – 34.96
low	3.47 – 5.47	9.26 – 11.53	34.97 – 44.55
medium	5.48 – 7.30	11.54 – 13.85	44.56 – 51.64
high	7.31 – 10.47	13.86 – 17.45	51.65 – 63.76
very high	10.48 – 36.50	17.46 – 63.66	63.77 – 75.72
no data available		no data available	no data available

Data: Source UNU-EHS, based on the PREVIEW Global Risk Data Platform, CReSIS, CIESIN and global databases; detailed information at www.WorldRiskReport.org

Country	WRI	Exposure	Vulnerability
Afghanistan	9.71	13.17	[illegible]
Australia	3.93	15.66	24.10
Bangladesh	[illegible]	[illegible]	63.90
Bosnia a. Herzegovina	6.20	14.02	44.26
Brazil	4.30	9.53	45.09
Cambodia	[illegible]	[illegible]	63.90
Canada	3.14	10.25	30.63
Chile	[illegible]	[illegible]	36.53
Costa Rica	[illegible]	[illegible]	40.68
Cuba	6.42	17.45	36.79

Country	WRI	Exposure	Vulnerability
Eritrea	6.26	8.55	[illegible]
Germany	3.01	11.41	26.37
Haiti	[illegible]	16.26	[illegible]
Indonesia	[illegible]	[illegible]	54.44
Japan	[illegible]	[illegible]	29.14
Libyan Arab Jamahiriya	4.00	7.80	51.27
Malaysia	6.51	14.60	44.60
Mozambique	9.03	12.73	[illegible]
Netherlands	8.25	[illegible]	25.98
Nigeria	8.24	12.06	[illegible]

Country	WRI	Exposure	Vulnerability
Pakistan	7.07	11.36	62.24
Papua New Guinea	[illegible]	[illegible]	[illegible]
Peru	6.91	14.40	48.00
Philippines	[illegible]	[illegible]	53.85
Russia	3.85	9.38	41.05
Sierra Leone	[illegible]	18.65	[illegible]
Syrian Arab Republic	5.58	10.56	52.82
United States	3.88	12.25	31.67
Vanuatu	[illegible]	[illegible]	57.34
Viet Nam	[illegible]	[illegible]	51.64

Exposure = Vulnerability

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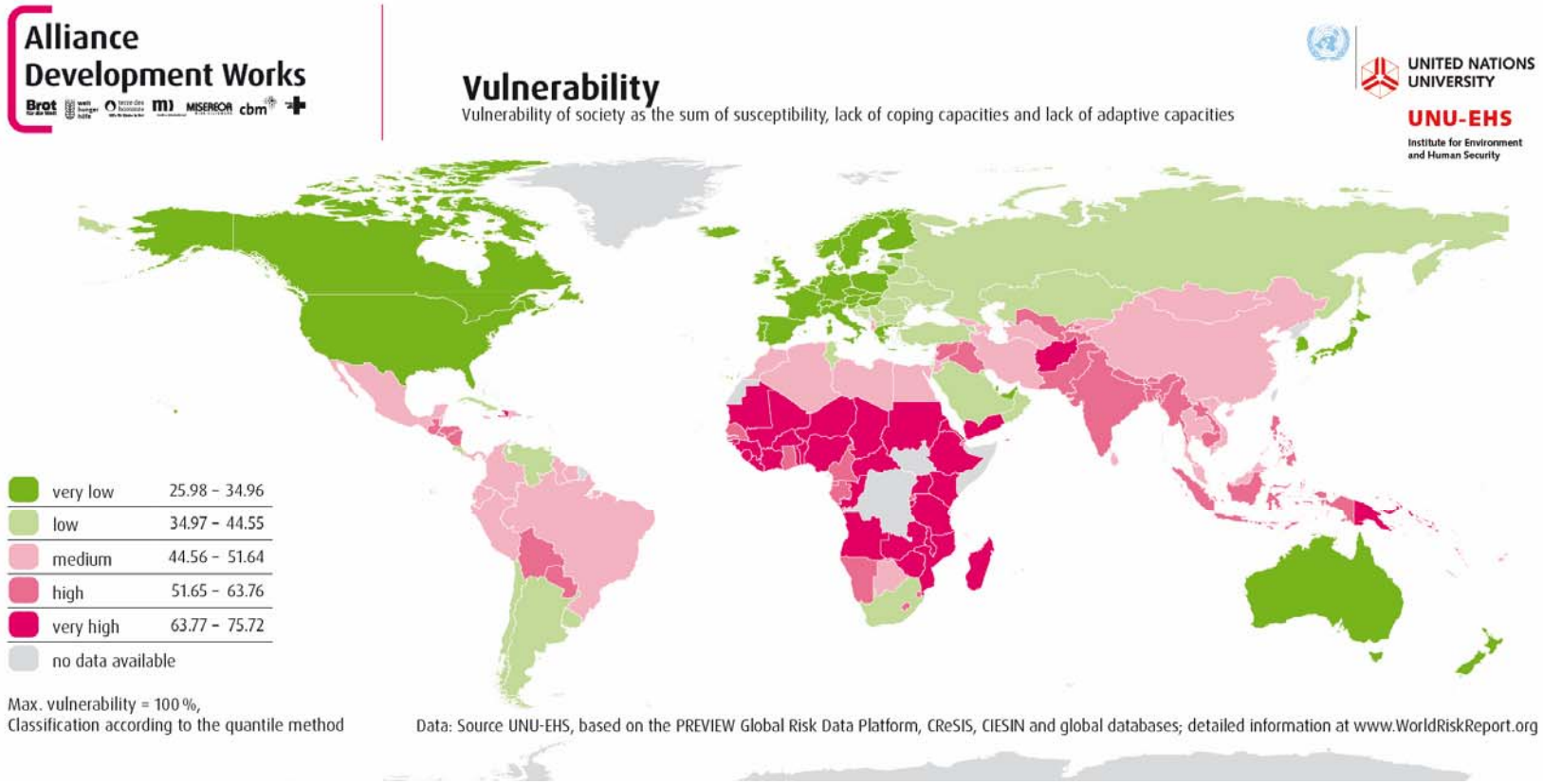
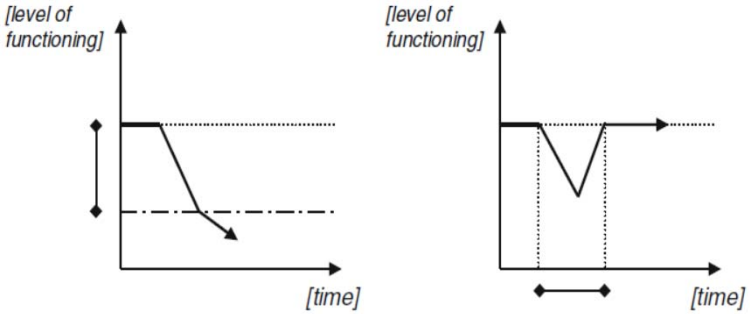


Major Approaches Towards Resilience

- Engineering Resilience
  - Resistance to change and return to the equilibrium after receiving a shock
- Ecological Resilience
  - Persistence of a system and its ability to absorb the disturbance and sustain its structure or function. The system may return to the old or a new equilibrium(s)
- Adaptive (socio-ecological) Resilience
  - The latest approach toward resilience which suggests that complex, dynamic, and adaptive systems (e.g. cities) would not necessarily return to an equilibrium state. This approach advocates the concept of living with risk

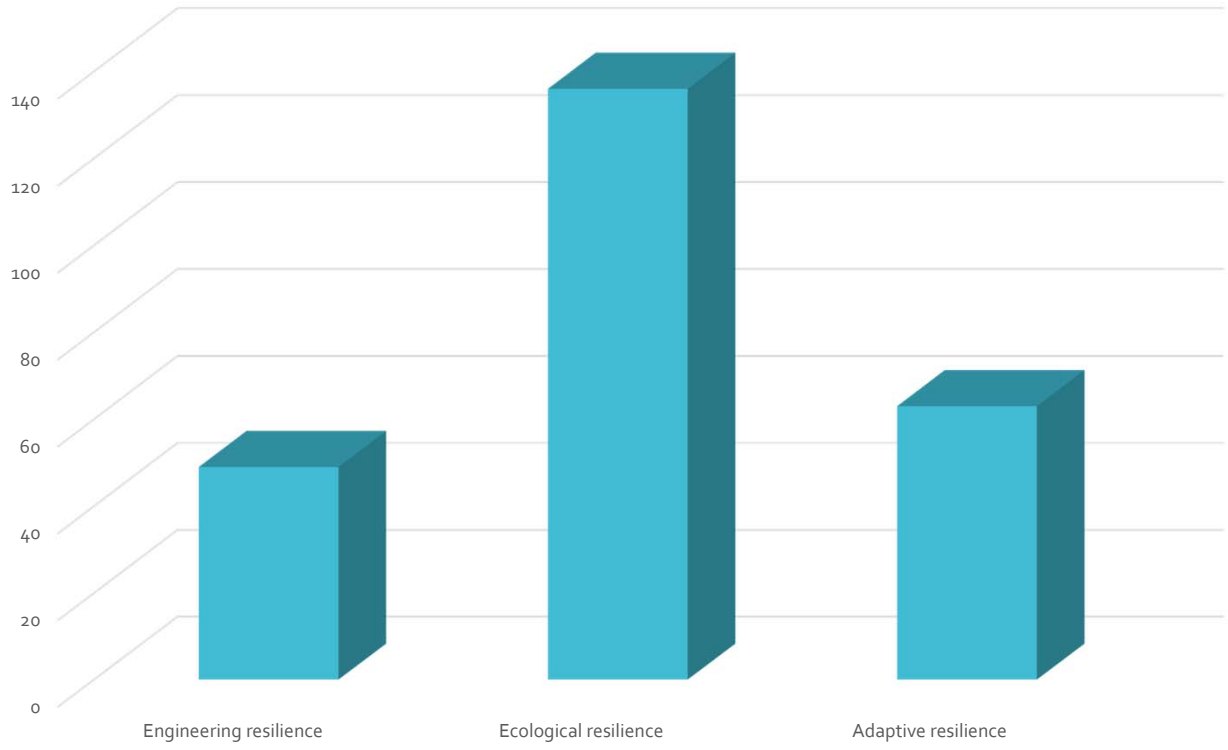
Fundamental Shifts in the Approach

www.aguanomics.com



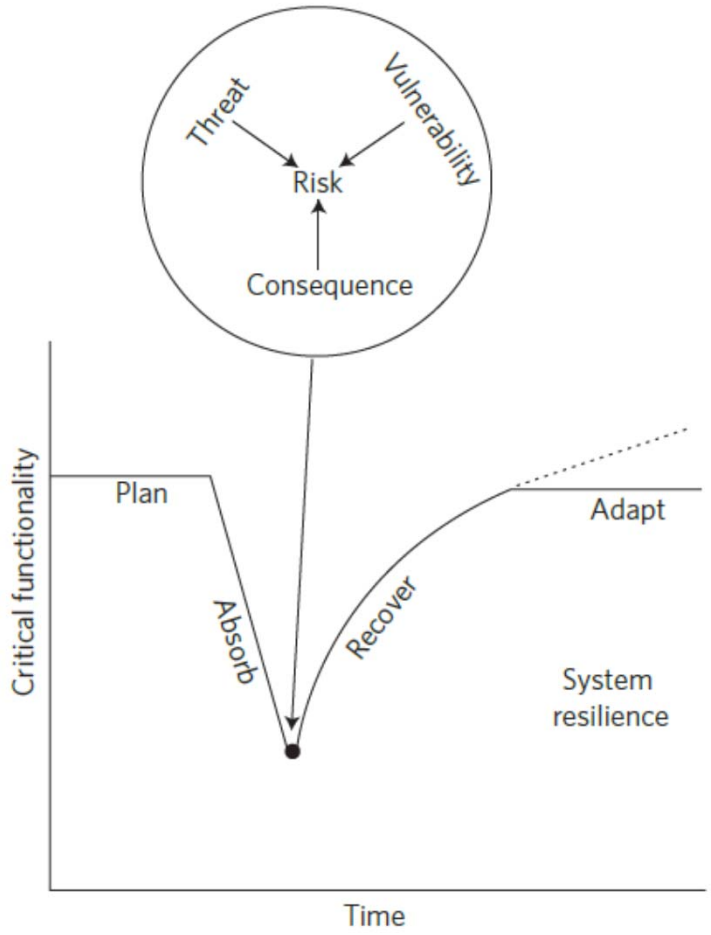
(Frommer, 2013)

http://floatbase.nl/


140
120
100
80
60
40
20
0
Engineering resilience
Ecological resilience
Adaptive resilience

Characteristics of a Resilient System

- ***Plan/Prepare***
  - ***Availability***
  - ***Accessibility***
  - ***Affordability***
  - ***Acceptability***
- ***Absorb***
- ***Recover***
  - ***Immediate***
  - ***Intermediate***
  - ***Long term***
- ***Adapt***



(Linkov et al, 2014)

Major Principles

- Some major principles drawn from the ongoing research:
  - Redundancy
  - Diversity
  - Independence
  - Interdependence
  - Robustness
  - Resourcefulness
  - Adaptability
  - Creativity
  - Collaboration
  - Self-organization
  - Efficiency
  - Rapidity

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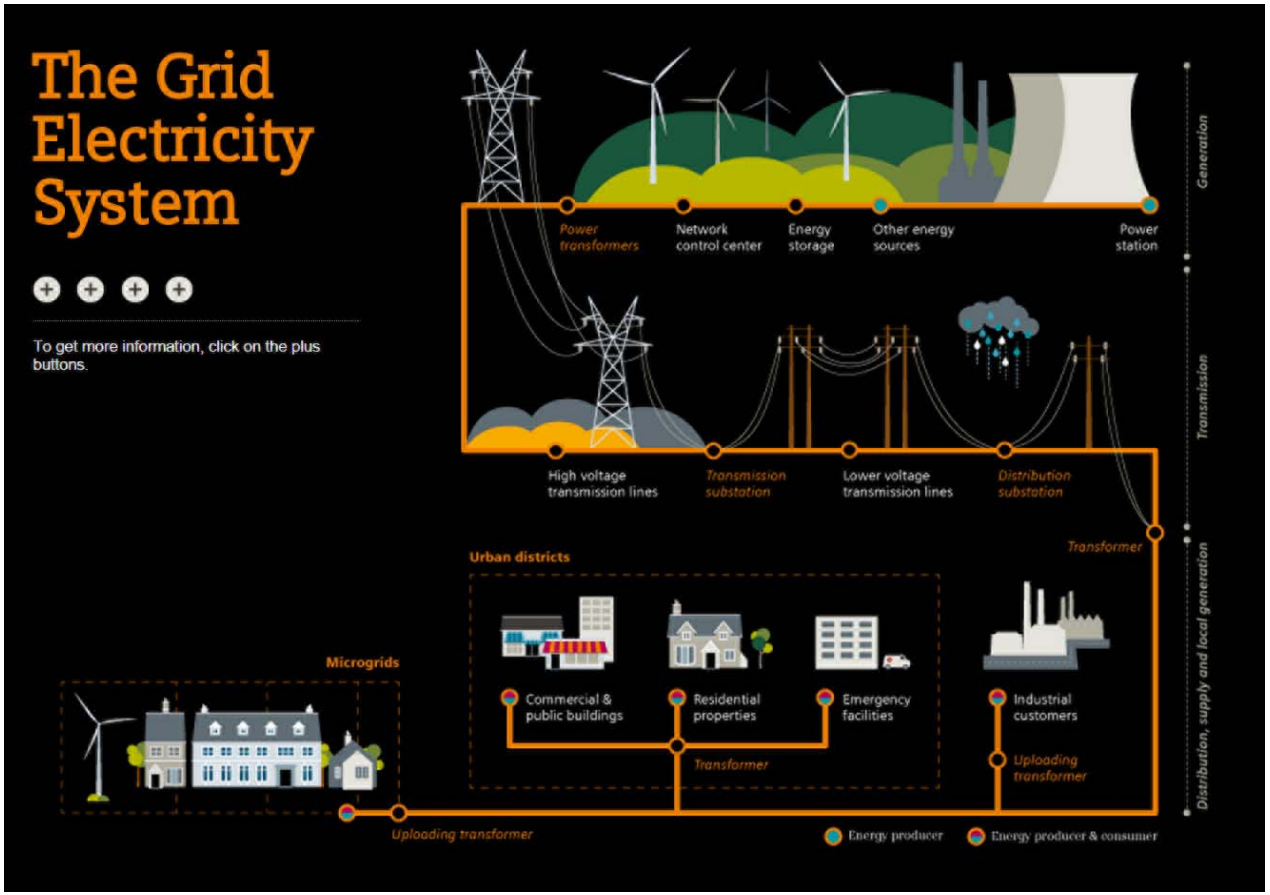
Generation, Transmission, Distribution,



http://www.siemens.com/

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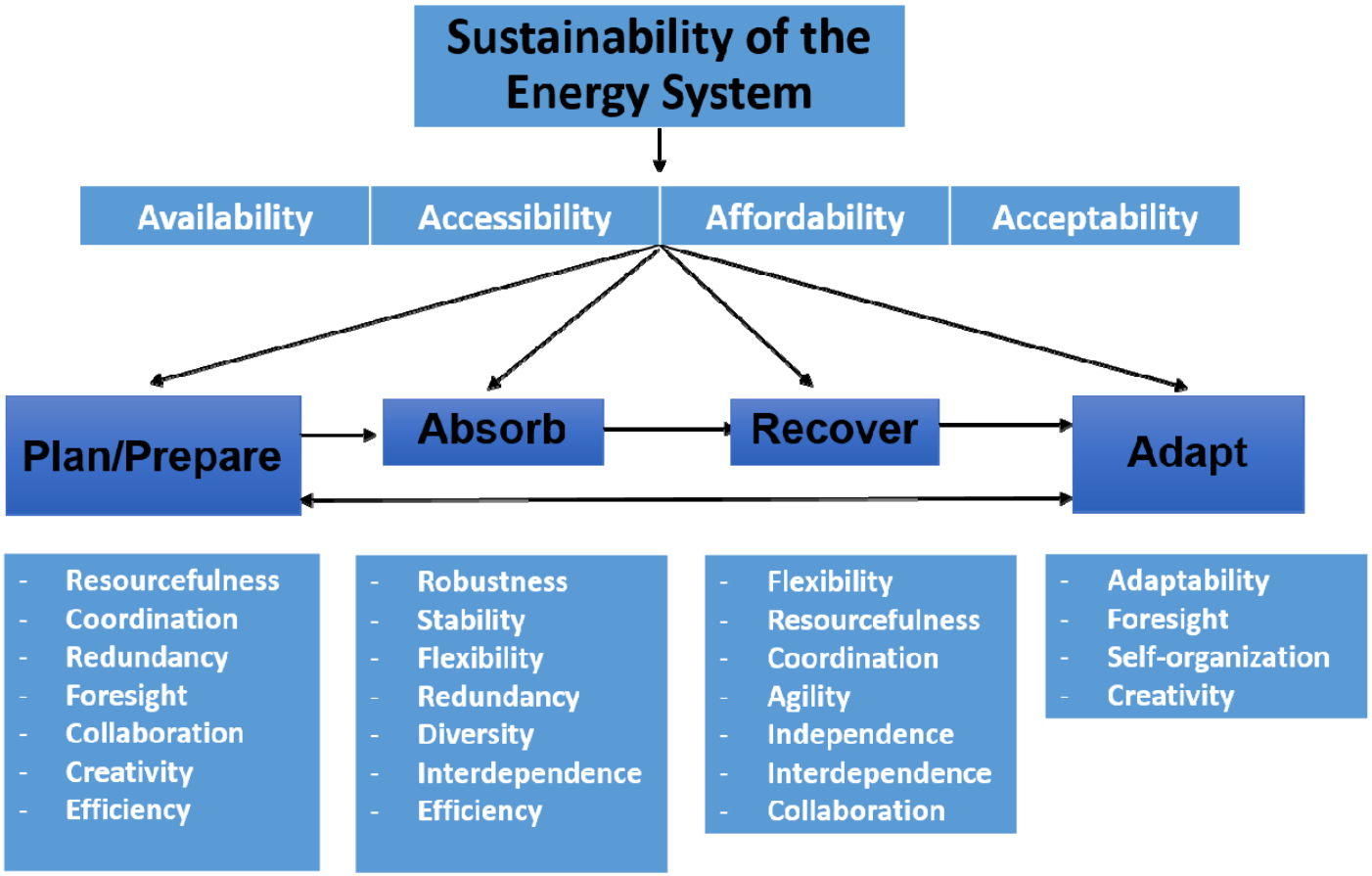

Threat facing urban energy

- Resource depletion
- Ex-events disrupting energy supply, transmission and distribution
- Increased occurrence and duration of hot spells
- Increase of very cold winters and heating demand
- Political conflicts disrupting energy production and distribution
- Price fluctuation
- Unplanned surge in demand
- Social acceptance of the production method

Infrastructure

- Production
  - Distributed generation
  - Harvesting local renewable sources
  - Small-scale renewable energy
  - CCHP, tri-generation
  - Waste incineration
  - Use of bio-fuel in district energy
  - Energy cycling
- Distribution
  - Type of feeder line: Overhead vs buried
  - Design margin (future expansion)
  - Connectivity (transmission infra)
  - Inter-regional collaboration
  - Geographic dispersion of energy facilities

(http://en.wikipedia.org/wiki/Undergrounding)

Infrastructure

- Consumption
  - Energy-efficient appliances
  - Redesign and refurbishment
  - Net- Zero energy buildings
  - Pooling of the built-envelope (shared walls)
  - Glazing, insulation
  - Fuel efficiency of cars
  - Use alternative and safer energy sources for critical infra such as traffic lights
- Maintenance and security
  - Physical security (reliability and robustness)
  - Regular maintenance of infrastructure
  - Cyber security of IT infra used in the energy sector
  - Early discovery of intervention (preventing cascading effects)
- Storage
  - Back-up power
  - Vehicle to grid
  - Vehicle to community

Infrastructure (Green- Blue Infrastructure)

- Urban greenery (Parks, Green roofs, Green walls, …
  - Facilitates evapotranspiration and provides cooling benefits
  - Heat island effect
  - Indoor cooling and heating demand
  - Indigenous species
  - Deciduous trees for cold climates
  - Urban agriculture
- Blue
  - Roofs
  - Waterscape
  - Rainwater harvesting
  - Wastewater management

http://en.wikipedia.org/wiki/Green_roof

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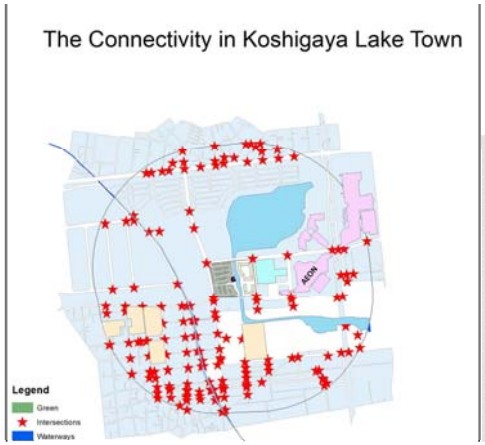
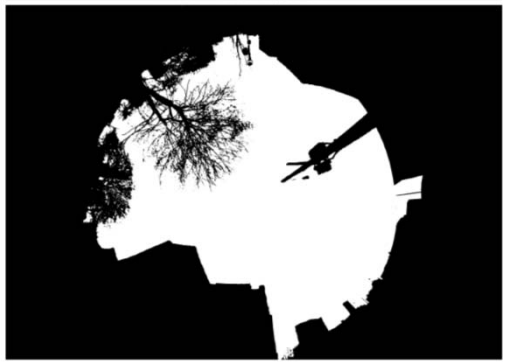
Transportation and Urban Form

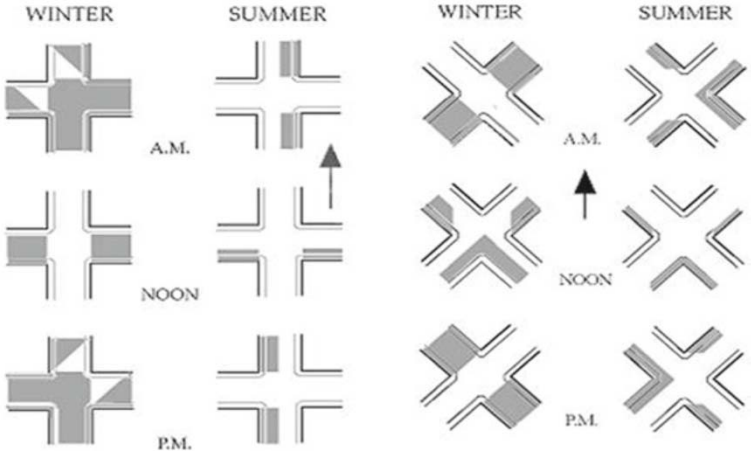
- Active Transportation modes
- Housing-job proximity
- Compactness vs Sprawl
- Connectivity
  - Grid vs Winding streets
  - No. of intersections
- Mixed use
- Density
- Block size
- Household and unit size
- Obstruction angle (obstruction from lateral building)
- Sky view factor
- Surface to volume ratio
- Urban horizon angle (H/W)





Passive Design

- Daylighting
  - Orientation and shape of buildings
  - Size and orientation of buildings
  - Rooflights
- Construction material
- Natural vs Mechanical ventilation
- Solar absorption (Albedo)
- Cool paving materials



(Raven, 2011)

Social and Behavioral Issues

- Income and equality
- Demand minimization (behavior change)
- Shared or communal solutions (e.g. sharing a heating or air conditioning system)
- Driving behavior
- Doing activities in the living room
- Social acceptance of technology
- Cultural change vs individual behavior change

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Urban Governance and management

- Flexible governance (to changes)
- Participatory governance
- Ability to prioritize tasks at the time of disaster
- Availability of trained personnel
- Support for renewable energy (Subsidies, incentives, Feed in Tariffs, Tax deduction, …)
- Market liberalization: Regulatory framework to address market barriers for decentralized generation
- Pricing Strategies (time-varying rates, pre-payment electricity, taxation on fuel)

Urban Governance and management

- Density bonus for densification for energy efficiency goals
- Regular maintenance
- Effective communication (periodic publication of energy planning documents)
- Legislation and regulation system:
  - Building regulations
  - Changing land-use bylaws to allow for in-fill
- Monitoring system
  - Monitor achievement of targets
  - Feedback and real-time monitoring (by households), enhances communication
- DSS systems such as rating tools

Different Issues Related to Each Criterion

Criteria	Mitigation/ Adaptation	Ex-ante/ Ex-post	Contributor/ Detractor	Co-benefits	Principle(s) related
Attachment	Both	Both	Dual	Health, collective action	Adaptability, collaboration, self-organization
Urban agriculture	Both	Ex-ante	Dual	Poverty, health, open space, energy consumption, cutting carbon emissions	Redundancy, diversity, resourcefulness, independence,

Trade offs

Criteria	+	_
High density, compact	Reduce energy consumption	UHI effect; Urban agriculture
Hard defense	Exclusive to failure	Complacency
Centrality	Prompt decision making	Community participation
Net Zero Energy Buildings	Energy bills, health effects, workplace productivity	Rebound effects; urban density
Food storage	Resourcefulness	Energy consumption
City size	Resources and adaptive capacity	Aggregate risk

Future research

- Scale to which is principle (criteria) is related
- Need to identify complementing criteria
- Also the possible synergies and conflicts should be assessed
- Temporal scale as a major component of dynamic and adaptive systems should be considered
- These all enables us of thinking about trade-offs
- Developing an energy resilience assessment system would be data intensive
- Urban energy resilience is a multi-dimensional phenomenon
- No set of specific measures will fit all contexts

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Thanks for your attention