

Design of a Conceptual Model to evaluate Urban Energy-Water Resilience (UEW-CRI)

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IIASA-INSF Workshop

Urban Resilience through Applied Systems Analysis

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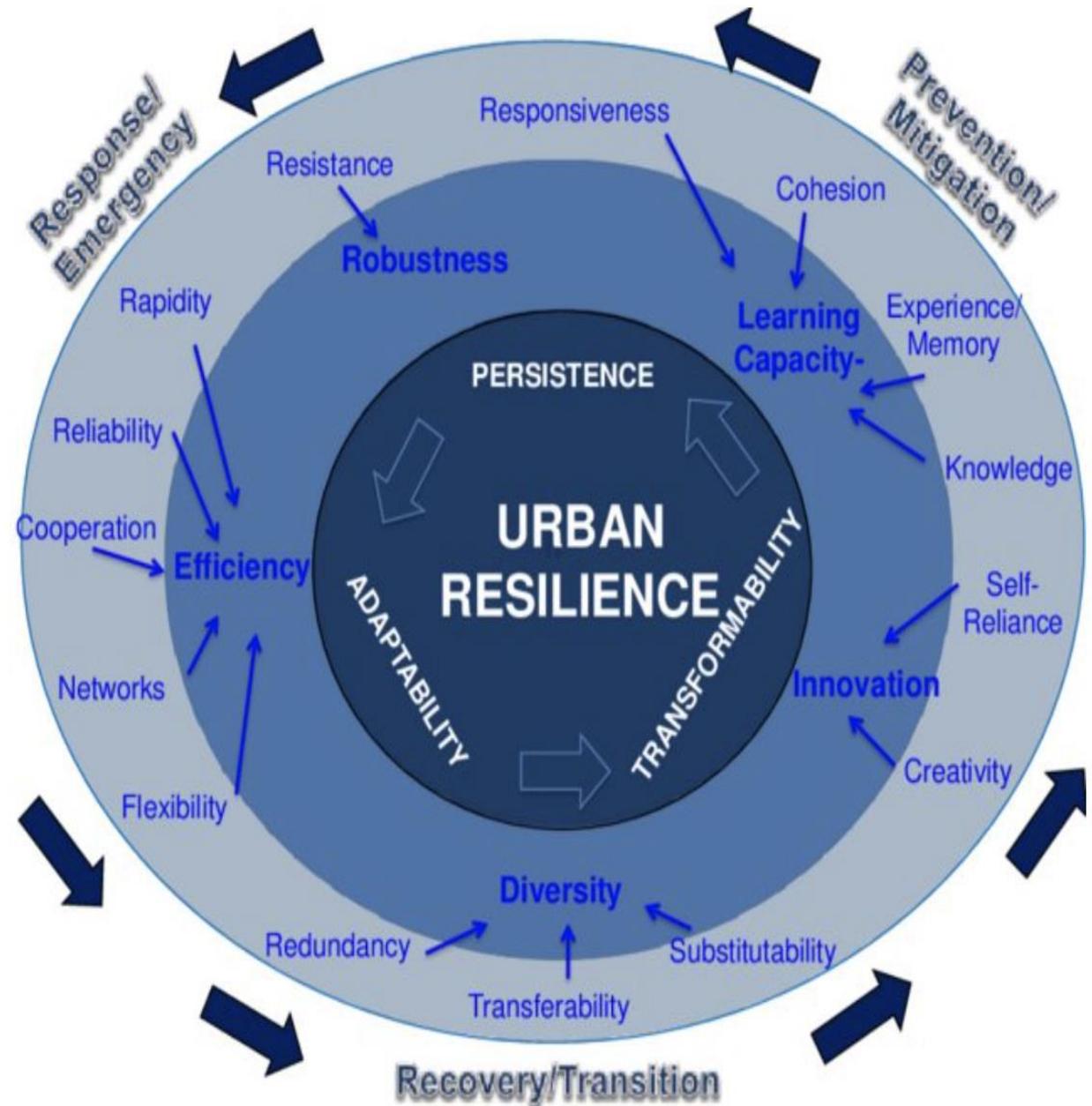
UN Sustainable Development Goal 11: Make cities inclusive, safe, resilient and sustainable



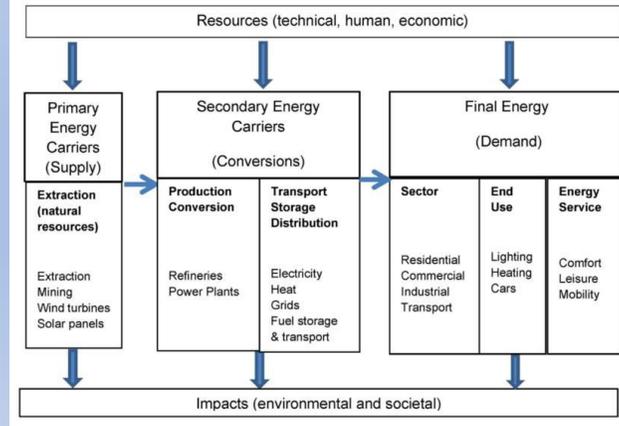
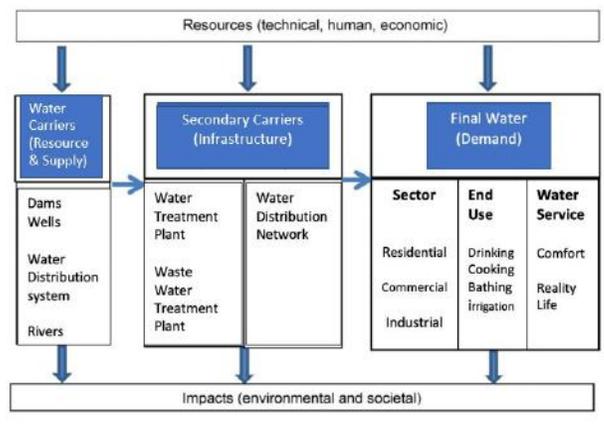
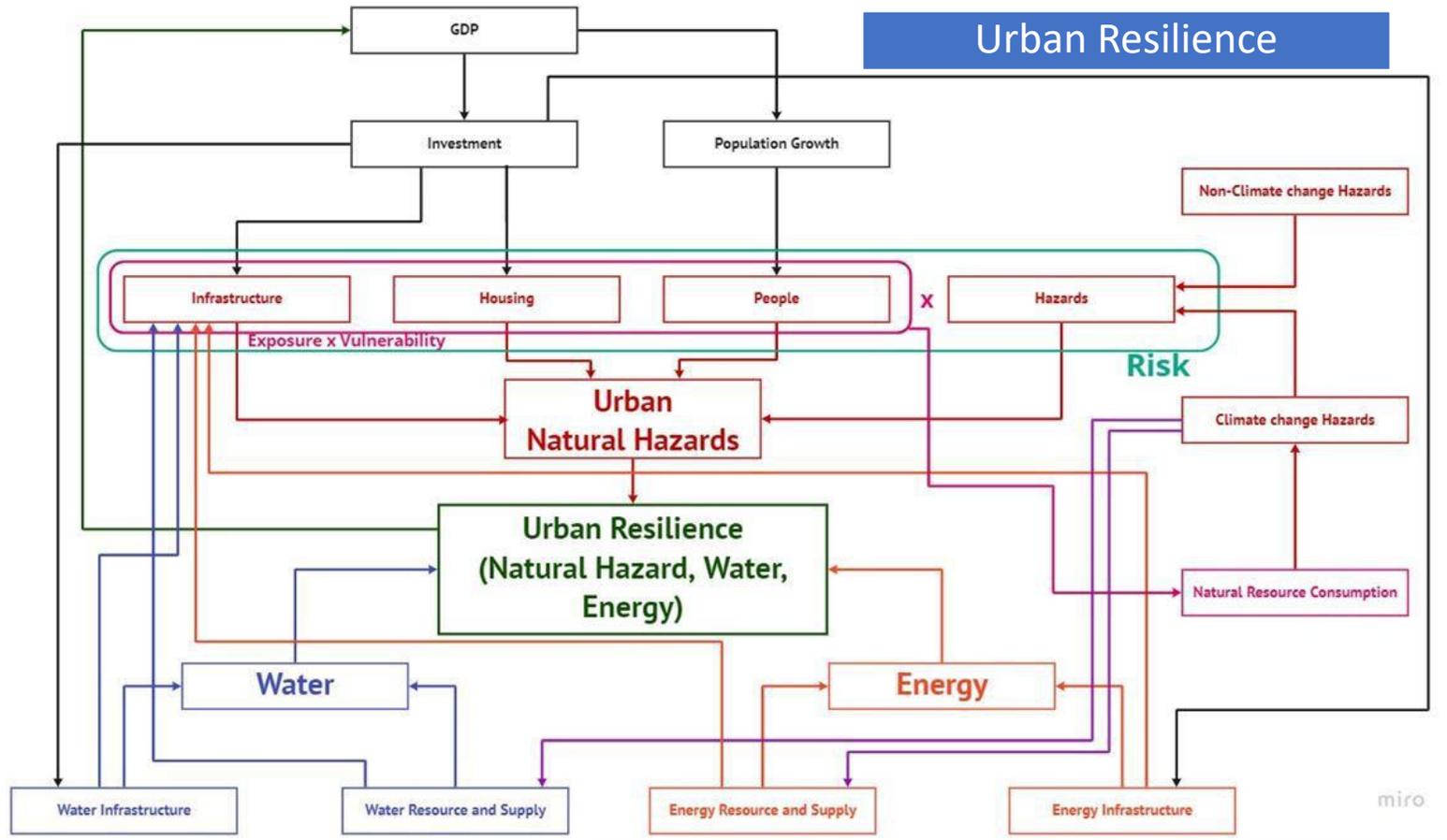
Resiliency Characteristics

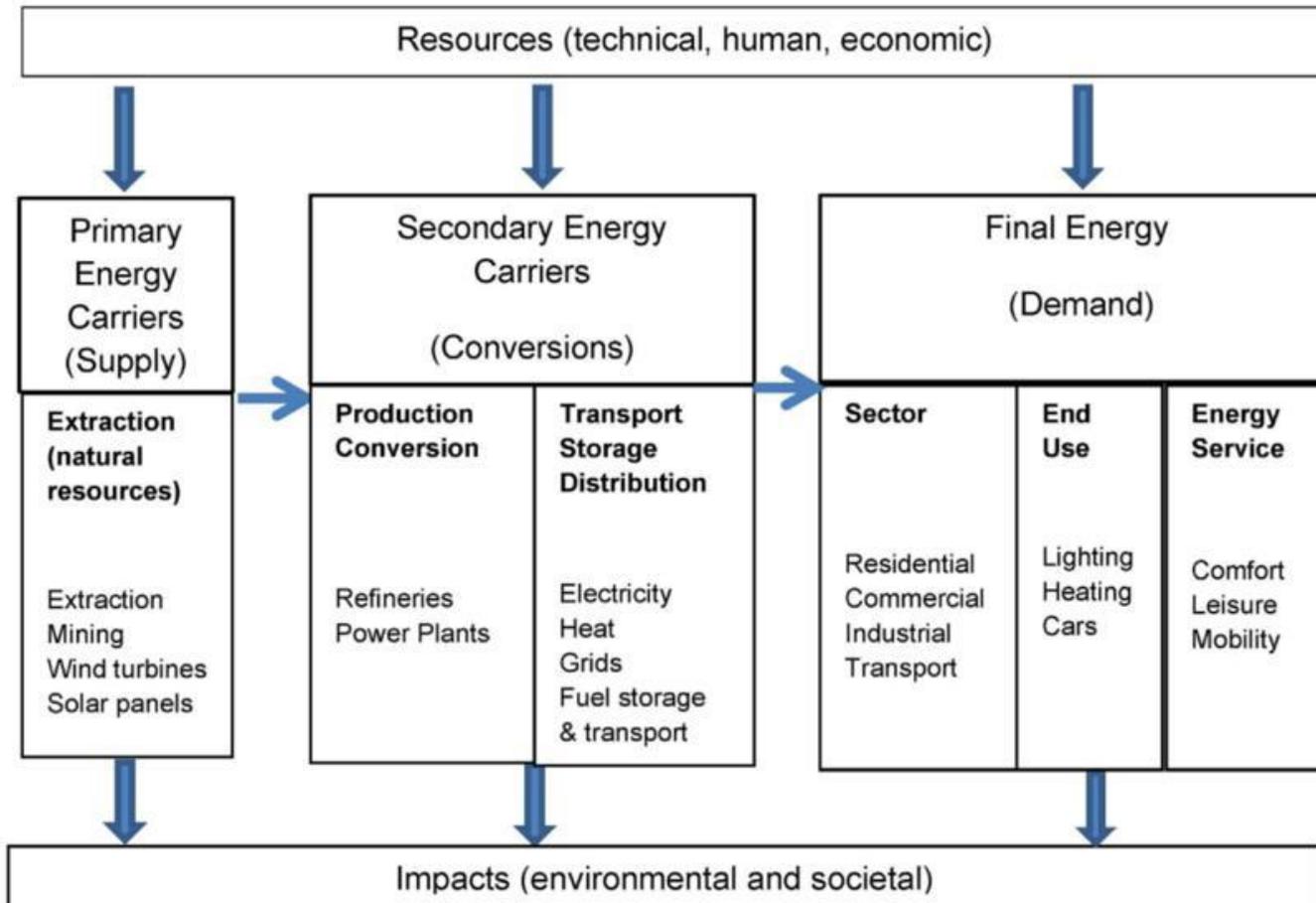


Integrated model for urban resiliency



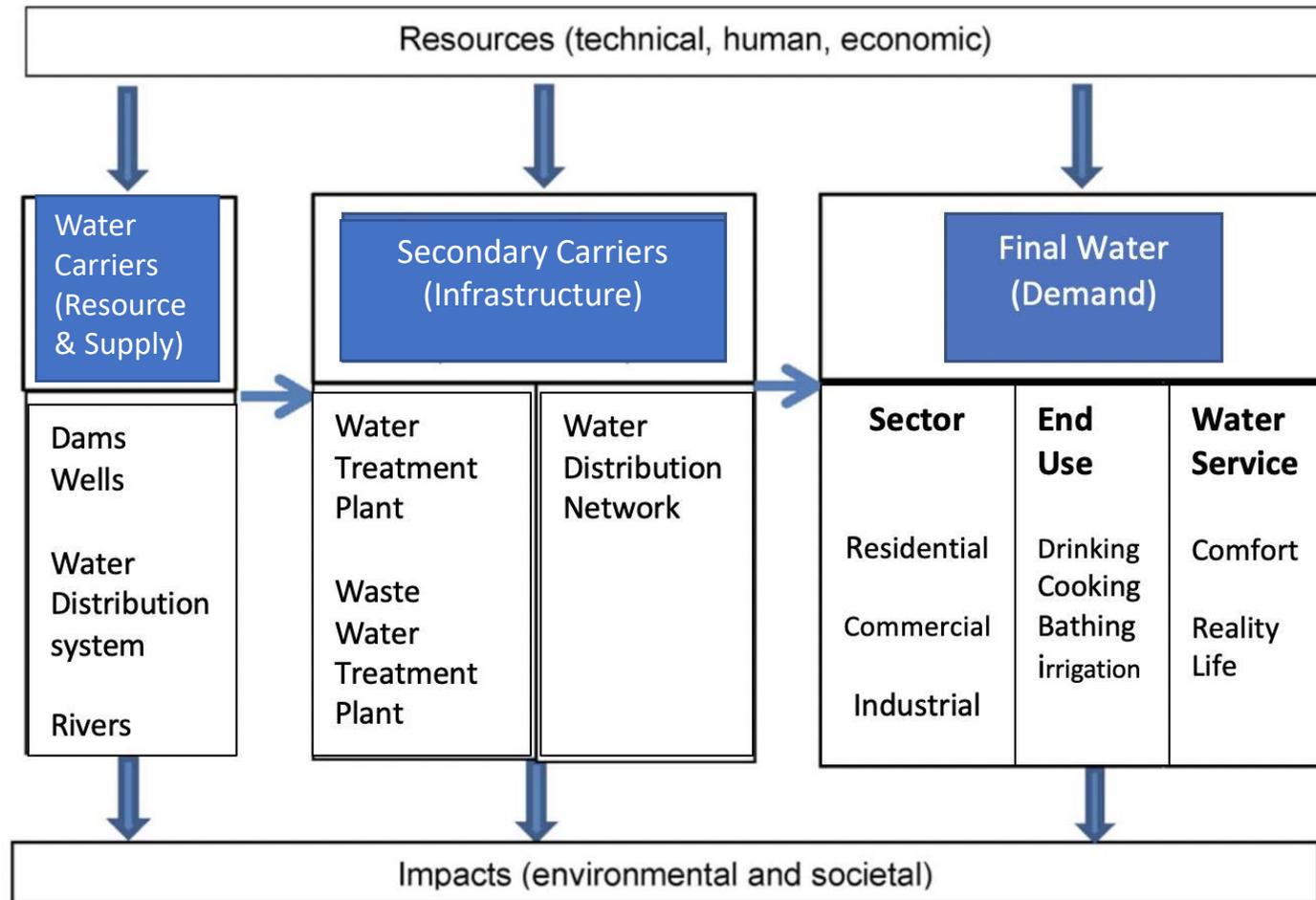
Urban Resilience





The Urban Energy System (Carréon, 2018)

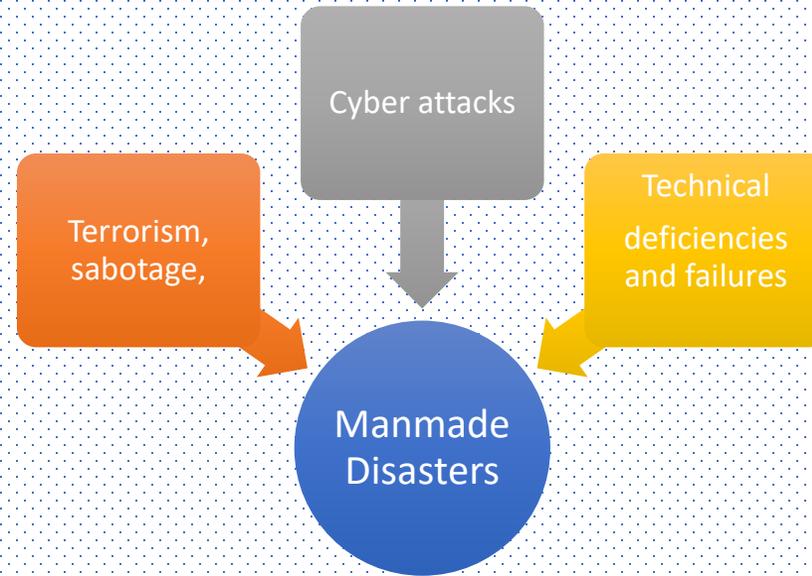
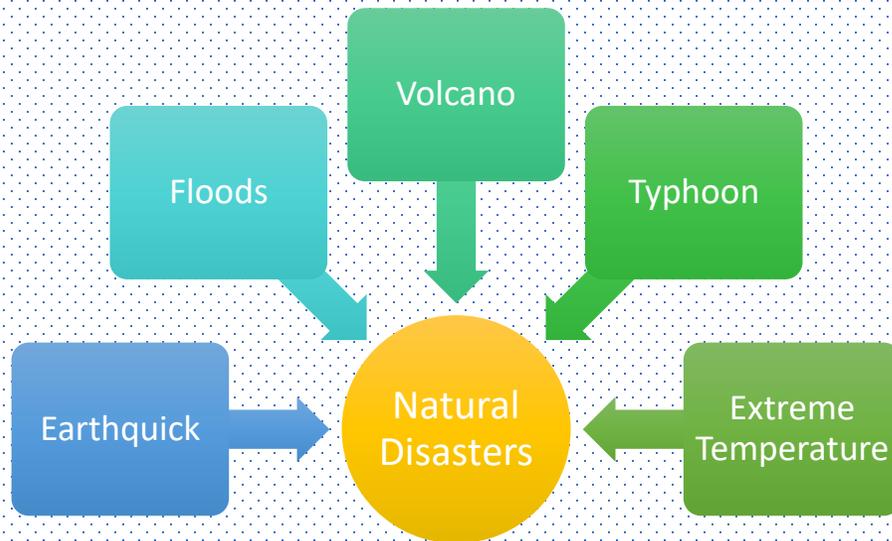


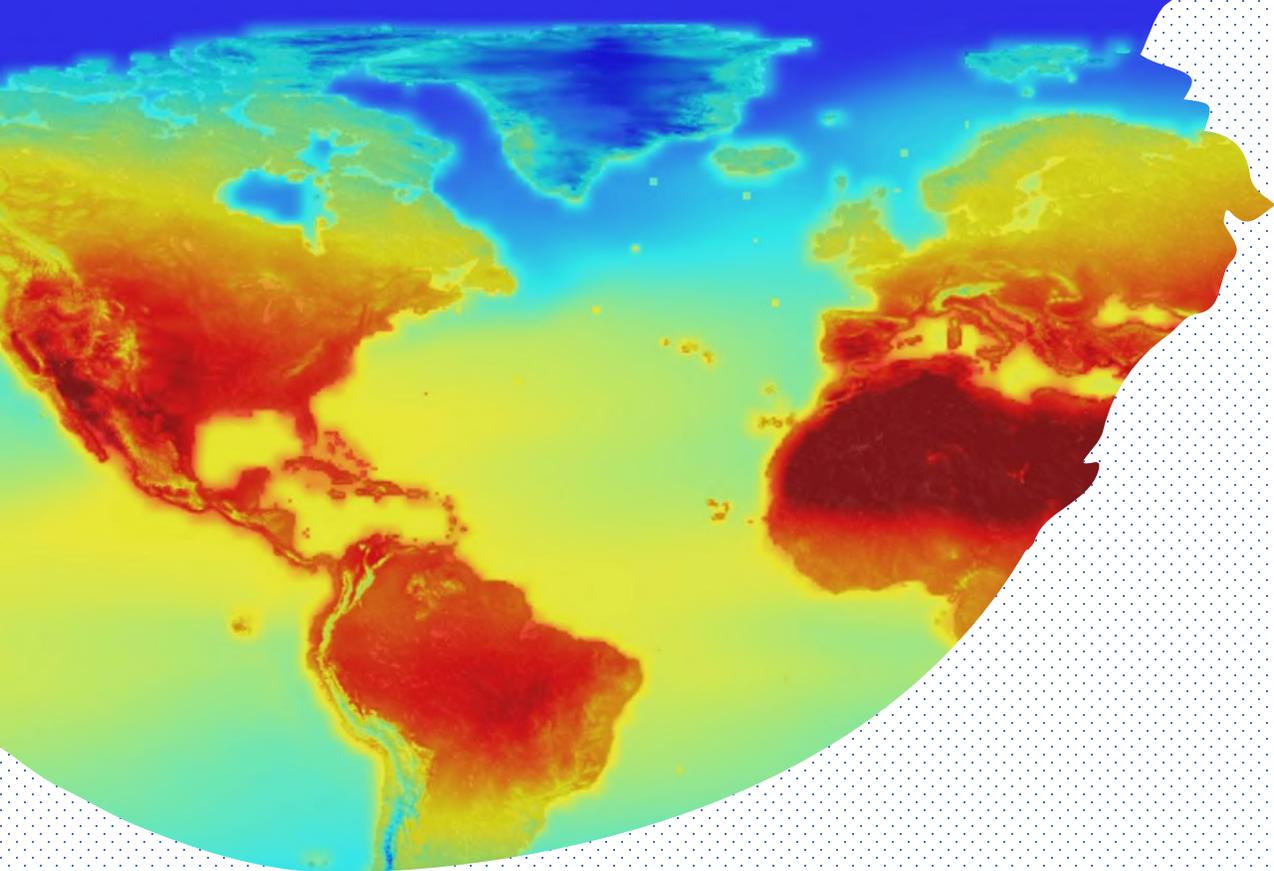


The Urban Water System

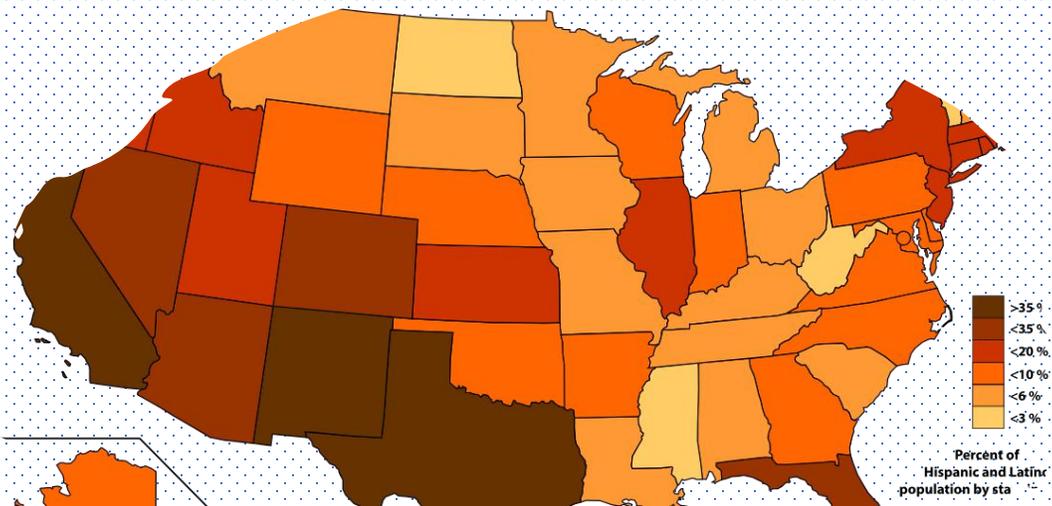
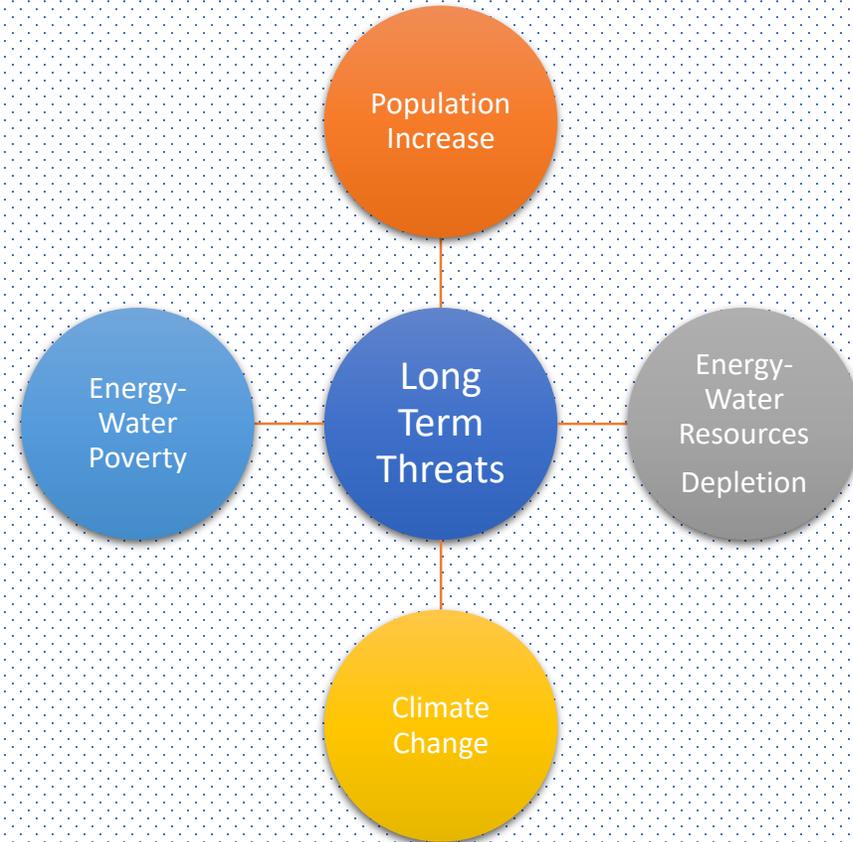


Short Term Threats

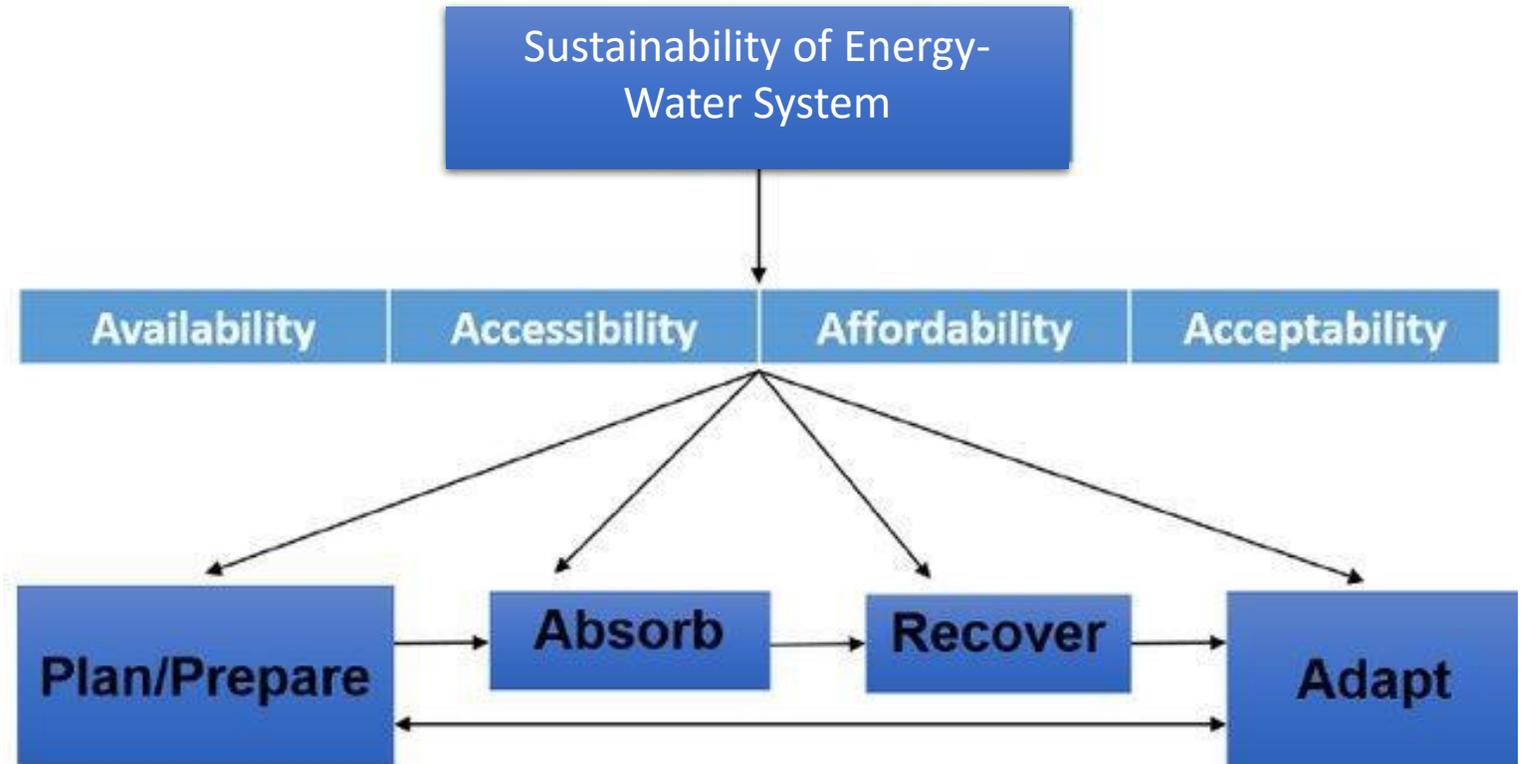


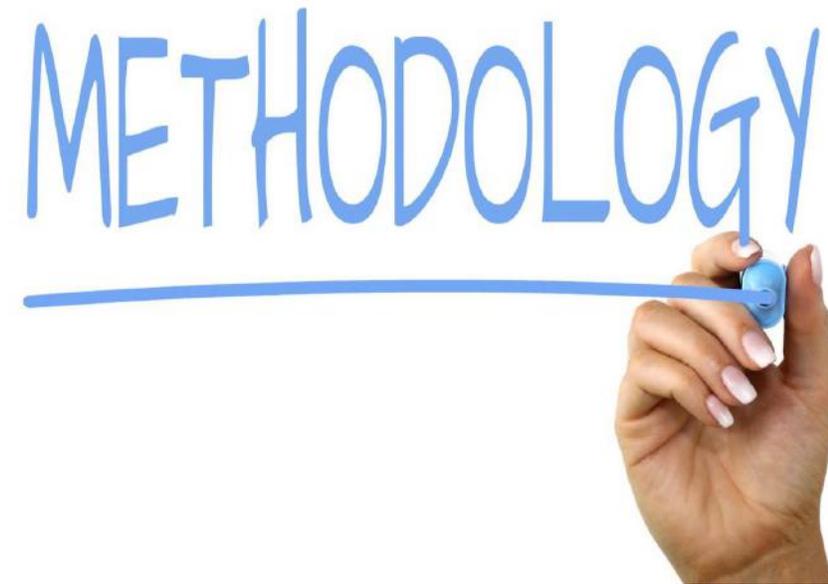
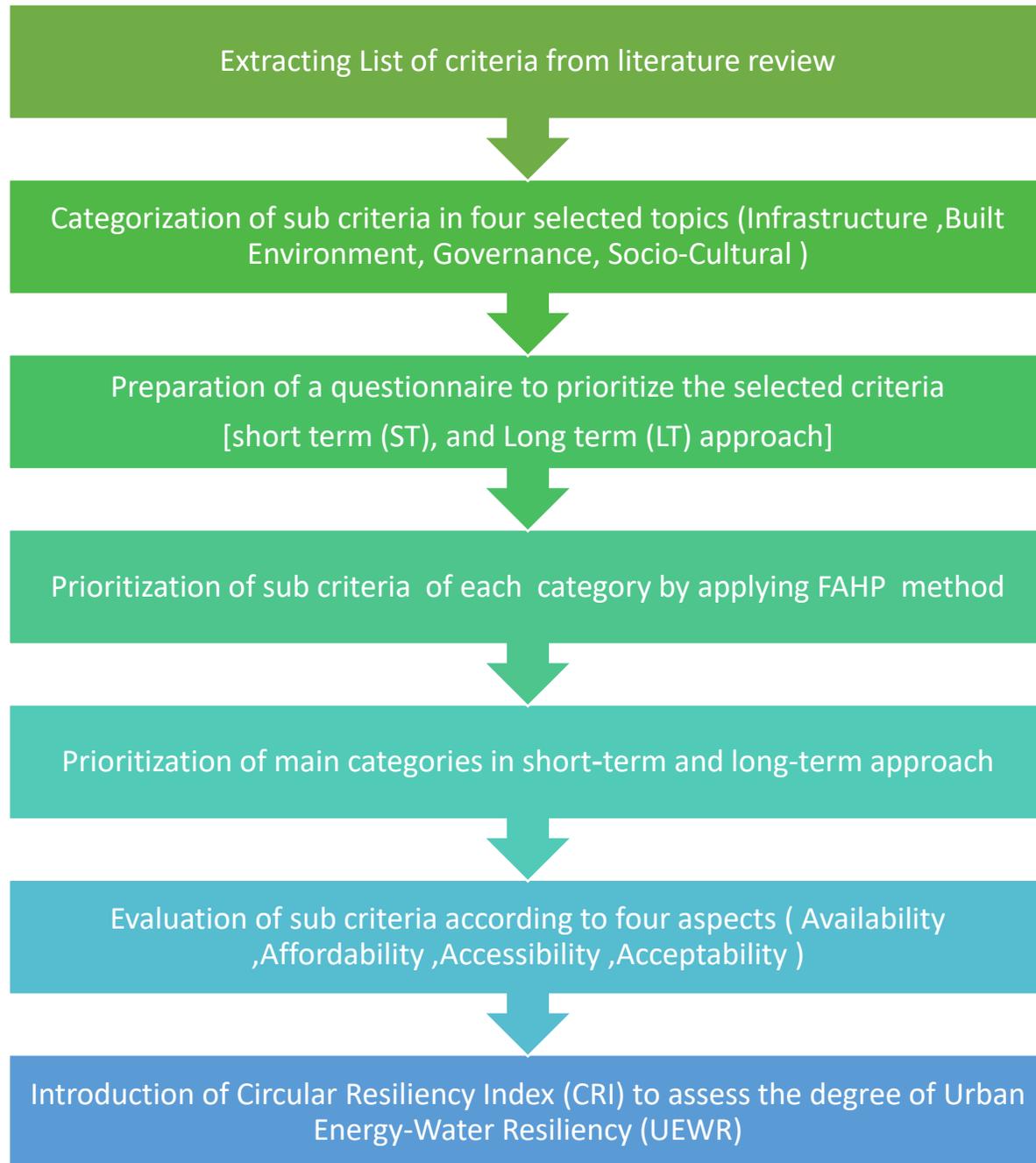


Long Term Threats



Conceptual Framework







Analysis and Results



List of criteria extracted from literature review



Criteria Related to Urban Infrastructure & Built Environment (Energy)

Supply, transmission, distribution

Diversification of energy supply

Spatially distributed generation and Energy production near point of use

generation of energy from renewable sources

Intelligent ICT infrastructure and its cyber security

Interdependency and interconnection of infrastructures and their networks

planning for Regular maintenance

Generation, transmission, and distribution efficiency

Fortification and robustness (physical security)

Criteria Related to Urban Infrastructure & Built Environment (Energy) (Cont.)

Backup and storage

Energy storage facilities

Green infrastructure

open spaces, green wall, green roof

Buildings

Mitigation Approach

Adaptation Approach

Criteria Related to Urban Infrastructure & Built Environment (Energy) (Cont.)

Transportation
Modal split
Resources
Energy intensity
Carbon Intensity
Diversification of energy carriers
Water–energy nexus
Reducing energy footprint of water production, treatment and distribution
Land use
Development pattern (sprawl, compact, suburbanization, infill, brownfield, greenfield, etc.)
Density (housing, population)
Innovation
Enhancing energy efficiency through innovation and technology

Criteria Related to Urban Governance (Energy) (Cont.)

Monitoring and assessment

Surveillance , evaluation and monitoring

Certificates, labeling, and rating tools

Planning and management

Long-term vision

Scenario-based energy planning and risk management

Training and communication planning for raising awareness

Participatory governance

Reliance on imports

Regulatory basis

Regulatory basis and executive requirements (Building code (development, Land-use and zoning bylaws, technological development , ...)

Pricing (Carbon Pricing, Time-varying Electricity Rates, Road pricing,...)

Governance support and incentives

Funding for research and technology development

Financial & non-financial mechanisms and Attracting private sector's investment in low carbon development

Socio-Cultural

Public access to energy resources and Social-class equality

Communal solutions for social cohesion and energy saving

Energy consciousness of the public and consumption behavior

Criteria Related to Urban Infrastructure & Built Environment (Water)

Supply, transmission, distribution

Diversification of water supply

Spatially distributed water supply

Desalinated water from salty water or sea water

Intelligent ICT infrastructure and its cyber security

Interdependency and interconnection of infrastructures
and their networks

planning for Regular monitoring and maintenance

Generation, transmission, and distribution efficiency

Fortification and robustness (physical security)

Criteria Related to Urban Infrastructure & Built Environment (Water) (Cont.)

Backup and storage

Water storage facilities

Green infrastructure

Open spaces, Green wall, Green roof

Buildings

Mitigation Approach

Criteria Related to Urban Infrastructure & Built Environment (Water) (Cont.)

Water–energy nexus

Reducing water footprint of energy production and supply

Land use

Development pattern (sprawl, compact, suburbanization, infill, brownfield, greenfield, etc.)

Density (housing, population)

Innovation

Enhancing water efficiency through innovation and technology

Criteria Related to Urban Governance (Water)

(Cont.)

Monitoring and assessment

Surveillance , evaluation and monitoring

Planning and management

Long-term vision

Scenario-based water planning and risk management

Training and communication planning for raising awareness

Participatory governance

Criteria Related to Urban Governance (Water) (Cont.)

Regulatory basis

Regulatory basis and executive requirements

Pricing

Governance support and incentives

Funding for research and technology development

Financial and non-financial mechanisms and Attracting private sector to invest in sustainable water supply

Criteria Related to Socio-Cultural (Water)

Socio-Cultural

Public access to water resources and Social-class equality

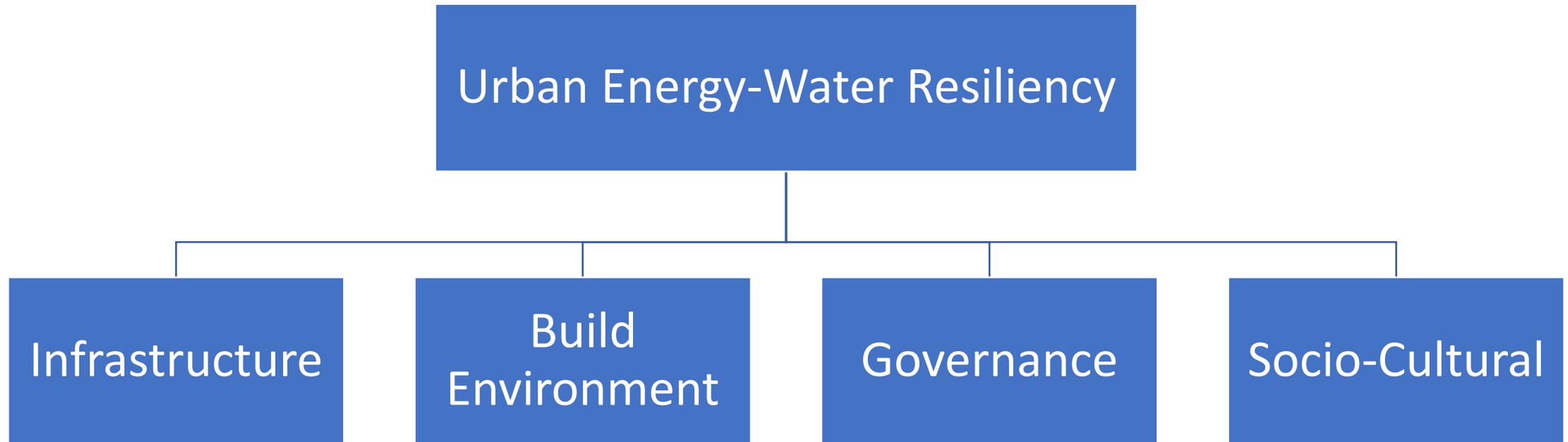
Communal solutions for social cohesion

Water consciousness of the public and consumption behavior



Categorization of
sub-criteria for
Energy & Water
(Extracted from documents)

Main Criteria of Urban Energy-Water Resiliency



Infrastructure (Energy)

- Diversification of energy supply
- Spatially distributed generation
- Generation of energy from renewable sources
- Intelligent ICT infrastructure and its cyber security
- Interdependency and interconnection of infrastructures and their networks
- planning for Regular maintenance
- Generation, transmission, and distribution efficiency
- Fortification and robustness
- Energy storage facilities
- Energy intensity
- Carbon Intensity
- Diversification of energy carriers
- Enhancing energy efficiency through innovation and technology

Built Environment (Energy)

- Green infrastructure
- Mitigation Approach in Buildings
- Adaptation Approach in Buildings
- Modal split
- Reducing energy footprint of water production, treatment and distribution
- Urban development pattern
- Population Density

Governance (Energy)

- Surveillance , evaluation and monitoring
- Certificates, labeling, and rating tools
- Long-term vision
- Scenario-based energy planning and risk management
- Training and communication planning for raising awareness
- Participatory governance
- Reliance on imports
- Regulatory basis and executive requirements
- Pricing
- Funding for research and technology development
- Financial & Non-financial mechanisms and attracting private sector's investment in low carbon development

Socio-Cultural (Energy)

- Public access to energy resources
- Participatory and communal solutions
- Public access to energy resources

Infrastructure (Water)

- Diversification of water supply
- Spatially distributed water supply
- Desalinated water from salty water or sea water
- Intelligent ICT infrastructure and its cyber security
- Interdependency and interconnection of infrastructures and their networks
- Planning for Regular monitoring and maintenance
- Generation, transmission, and distribution efficiency
- Fortification and robustness
- Water storage facilities
- Enhancing water efficiency through innovation and technology

Built Environment (Water)

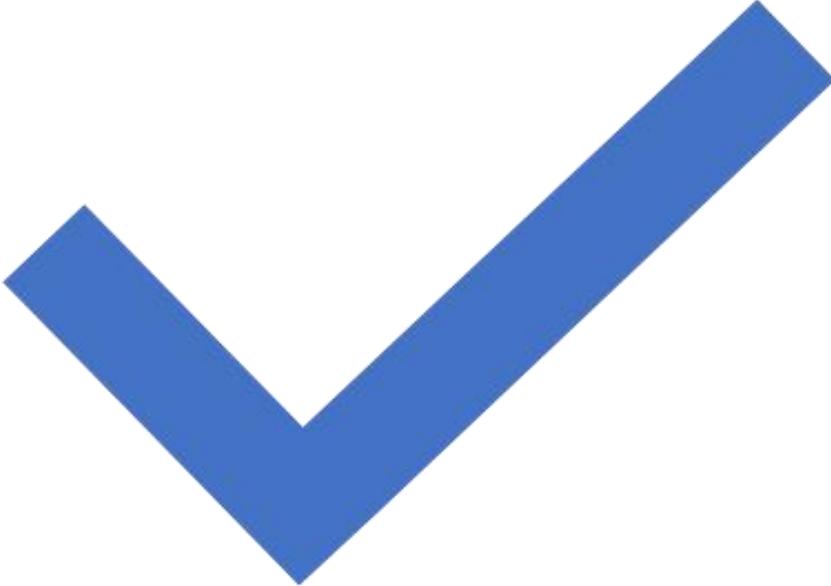
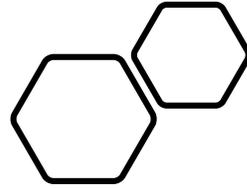
- Open spaces, Green wall, Green roof
- Mitigation Approach
- Reducing water footprint of energy production and supply
- Urban development pattern
- Population Density

Governance (Water)

- Surveillance , evaluation and monitoring
- Long-term vision
- Scenario-based water planning and risk management
- Training and communication planning for raising awareness
- Participatory governance
- Regulatory basis and executive requirements
- Pricing
- Funding for research and technology development
- Financial, Non-financial mechanisms and attracting private sector's investment in low carbon urban water development

Socio-Cultural (Water)

- Public access to water resources
- Participatory and communal solutions
- Public perception of water consumption



Prioritization of Categories (Energy and Water)

Pairwise questionnaire for FAHP assessment of Criteria

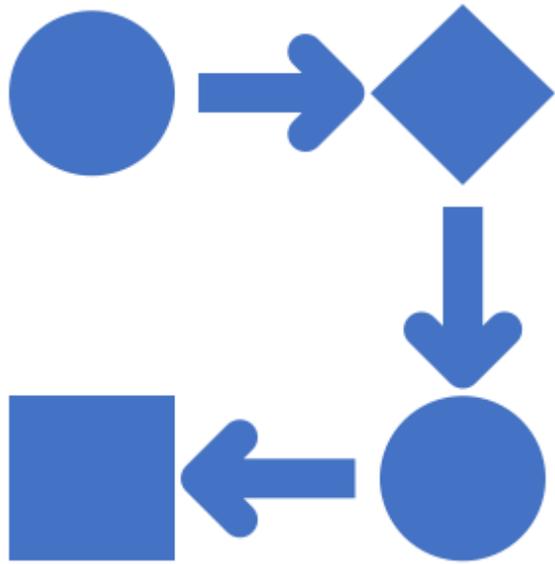
Criteria	what are the priorities of each of the following main factors in terms of increasing Urban Energy/Water resiliency in the short-term approach?																	Criteria
Infrastructure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Built Environment
Infrastructure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Governance
Infrastructure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Socio-Cultural
Built Environment	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Governance
Built Environment	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Socio-Cultural
Governance	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Socio-Cultural

Evaluation of sub-criteria

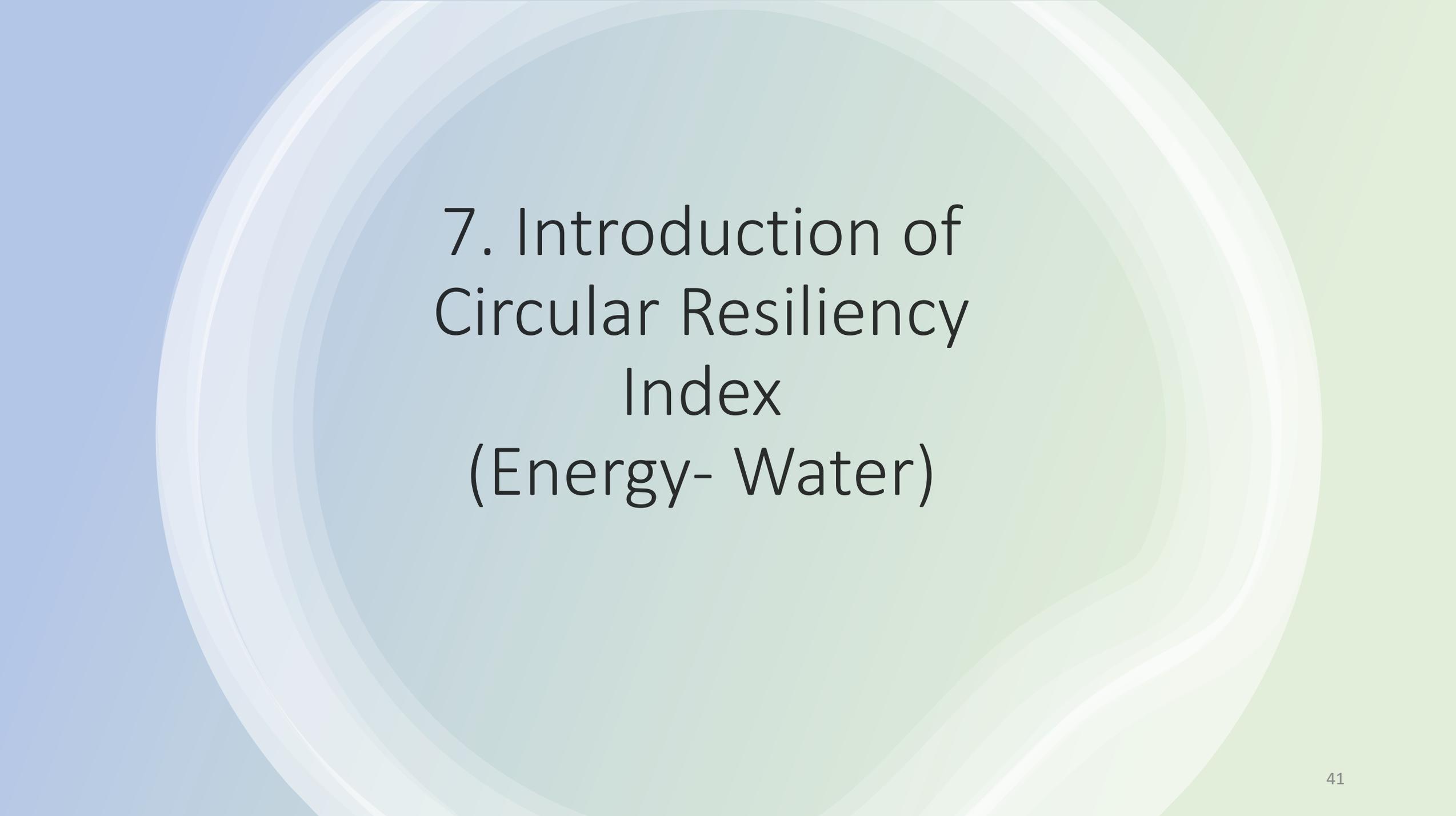


Feasibility evaluation of Infrastructure sub-criteria

Code	Description	Score	
1T	Diversification of energy supply	LT:0.49	ST:0.45
Evaluation Factors:			
Availability	Existence of potential for using various types of energy (fossil energy fuels such as oil, gas, renewable energy, electricity and fuel carriers such as gasoline, etc)	If there is potential in each of the mentioned energy categories, a percentage of the total 1 is awarded.	
Affordability	Is the use of available energy, economically justified?	Depending on the government's policy on cost-effective energy supply, a score of 0 .to 1 is given	
Accessibility	Are there necessary technologies, or the possibility of importing equipment to use the mentioned types of energy?	Depending on the technology and facilities available, the score would be . (It will get a score of 1 .between 0 and 1 for the availability of the mentioned .(energies	
Acceptability	Is the use of all kinds of energy acceptable to the public in terms of security and culture?	Yes: 1 No:0	



The same procedure will be done for the other main Criteria....



7. Introduction of Circular Resiliency Index (Energy- Water)

Governance (ST)

rank	Sub-Criteria name	Normalized Weight
1	Training and communication planning for raising awareness	1.00
2	Participatory governance	0.95
3	Scenario-based energy planning and risk management	0.76
4	Regulatory basis and executive requirements	0.62
5	Funding for research and technology development	0.59
6	Reliance on imports	0.42
7	Pricing	0.33
8	Financial & non-financial mechanisms to attract private sector's investment in low carbon development	0.31
9	Certificates, labeling, and rating tools	0.27
10	Surveillance, evaluation and monitoring	0.25

Infrastructure (ST)

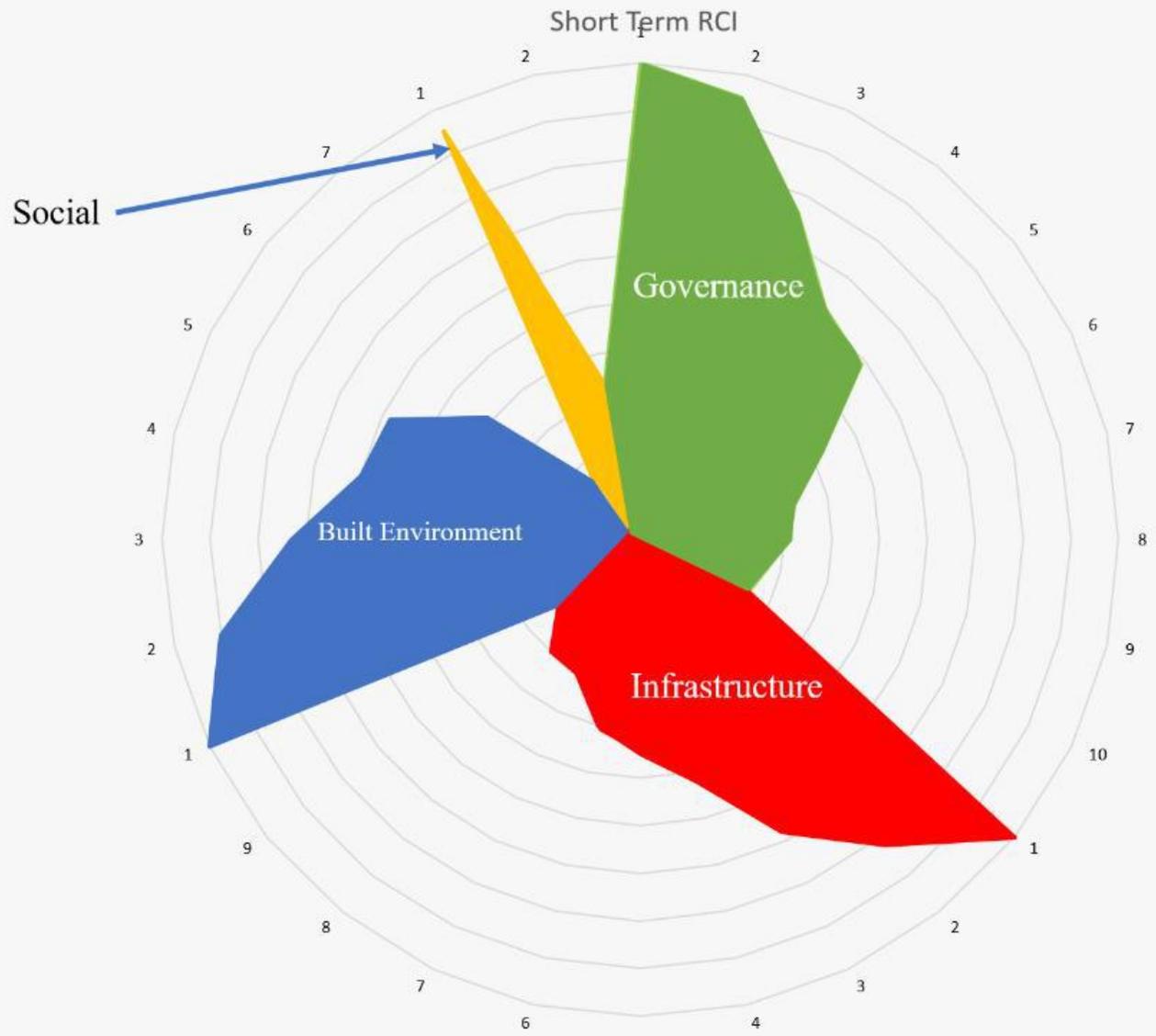
rank	Sub-Criteria name	Normalized Weight
1	Energy storage facilities	1
2	Fortification and robustness	0.82
3	Diversification of energy carriers	0.68
4	Distributed generation of Energy	0.52
5	Diversification of energy supply	0.45
6	Generation of energy from renewable sources	0.40
7	Interconnection of infrastructures and their networks	0.31
8	Intelligent ICT infrastructure and its cyber security	0.30
9	planning for Regular maintenance	0.22

Built Environment (ST)

rank	Sub-Criteria name	Normalized Weight
1	Urban Development Pattern	1.00
2	Population Density	0.90
3	Reducing energy footprint of water production ,treatment and distribution	0.73
4	Mitigation Approach in Buildings	0.60
5	Modal Split	0.58
6	Adaptation Approach in Buildings	0.41
7	Green Infrastructure	0.15

Socio-Cultural (ST)

rank	Sub-Criteria name	Normalized Weight
1	Culture building and educational awareness	1
2	Participatory and communal solutions	0.35



Short Term CRI

Governance (LT)

rank	Sub-Criteria name	Normalized Weight
1	Regulatory basis and executive requirements	1.00
2	Financial & non-financial mechanisms to attract private sector's investment in low carbon development	0.99
3	Funding for research and technology development	0.87
4	Pricing	0.87
5	Training and communication planning for raising awareness	0.40
6	Long-term vision	0.37
7	Certificates, labeling, and rating tools	0.35
8	Participatory governance	0.26
9	Scenario-based energy planning and risk management	0.13
10	Surveillance , evaluation and monitoring	0.13

Infrastructure (LT)

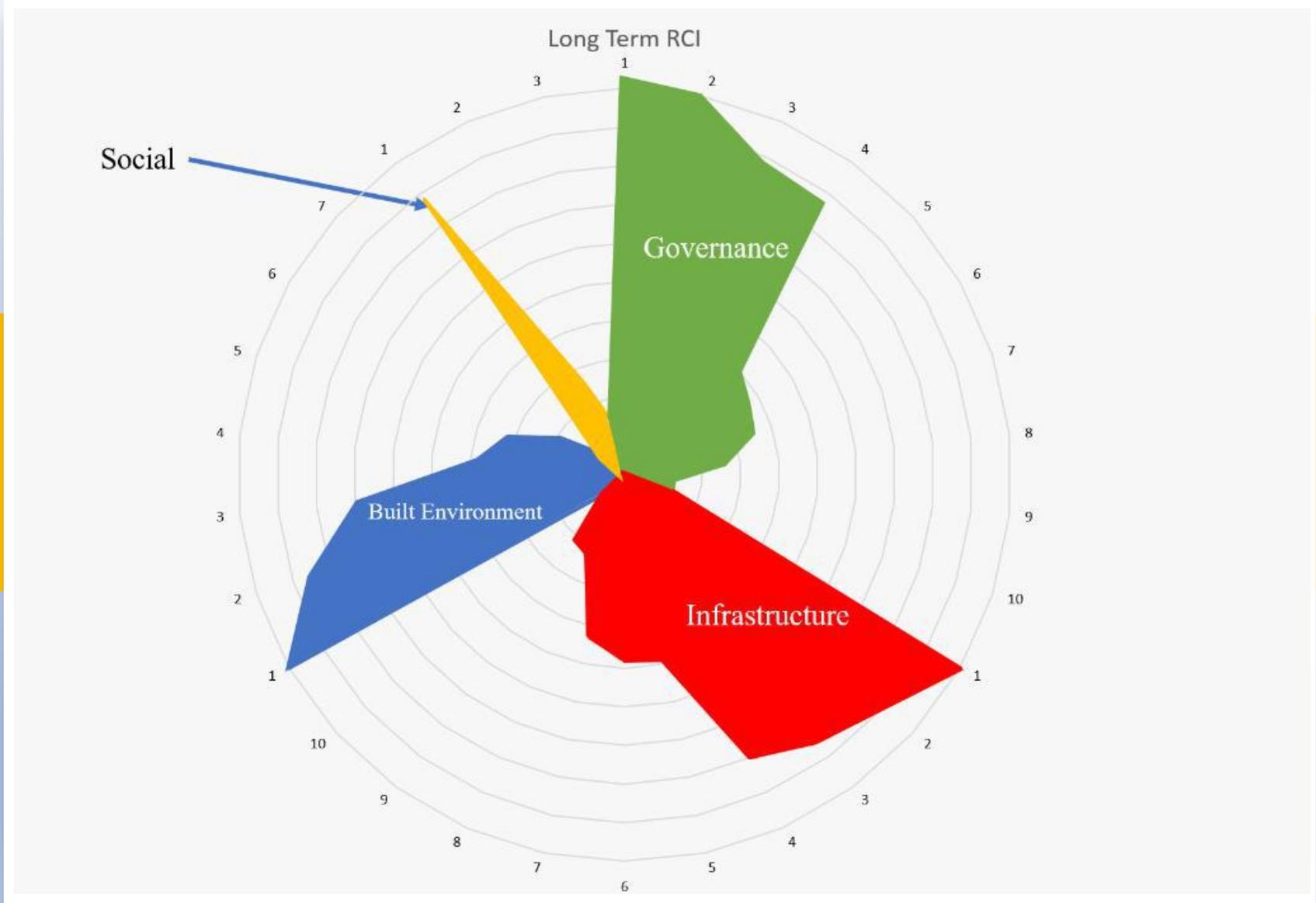
rank	Sub-Criteria name	Normalized Weight
1	Enhancing energy efficiency through innovation and technology	1.00
2	Generation of energy from renewable sources	0.89
3	Energy Intensity	0.85
4	Carbon Intensity	0.80
5	Diversification of energy supply	0.49
6	Diversification of energy carriers	0.48
7	Generation, transmission, and distribution efficiency	0.43
8	Distributed generation of Energy	0.23
9	Energy storage facilities	0.21
10	Intelligent ICT infrastructure and its cyber security	0.08

Built Environment (LT)

rank	Sub-Criteria name	Normalized Weight
1	Mitigation Approach in Building	1.00
2	Modal Split	0.85
3	Adaptation Approach in Buildings	0.69
4	Population Density	0.38
5	Reducing energy footprint of water production ,treatment and distribution	0.32
6	Urban Development Pattern	0.19
7	Green Infrastructure	0.08

Socio-Cultural (LT)

rank	Sub-Criteria name	Normalized Weight
1	Culture building and educational awareness	1
2	Participatory and communal solutions	0.30
3	Public access to energy resources	0.15



Long Term CRI

Formula:

The area S of the polygon is the sum of the areas of n triangles whose vertices are the center of the chart and two consecutive vertices of the polygon.

Each of them, according to the *law of sines*, has area :

$$S_i = \frac{v_i v_{i+1} \sin\left(\frac{2\pi}{n}\right)}{2}$$

Then you can compute S as following :

$$S = \sum_{i=1}^n S_i$$

For further information visit:

<https://doi.org/10.1007/s13762-022-03949-8>



The End

Thank you for your attention