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The Office of President
Vice Presidency for Science and Technology
Iran National Science Foundation

System Thinking, a Need for Urban Resiliency

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Why Systems Thinking is Needed for Urban Resilience?

Existing Situation of our Urban Area:

- ✓ High level of hazard, vulnerability and risk in existing cities and people are living in vulnerable environment;
- ✓ Rapid non-risk-informed and risk-based economic growth of urban areas;
- ✓ People still lack adequate access to safe housing, healthcare facilities, clean water, energy, etc.;
- ✓ Stress on natural resources is critical in developing cities;
- ✓ Increasing demand for safe housing, safe school, safe hospital;
- ✓ With a redundancy of know-how (science, technology, standards, guidelines, etc.), strategies, policies, and resources, the overall well-being of people and social equality and sustainable development is not acceptable;
- ✓ Existing process of our Urban Development is not Urban Resilience oriented

Why Systems Thinking is Needed for Urban Resilience?

Why the Existing Situation?

1. Lack of comprehensive look and systematic thinking and approach for urban development,
2. Lack of systematic approach to DRR and urban resiliency (prevention, preparedness, response and recovery process and actions),
3. Lack of appropriate urban governance system.
4. Poor cooperation and integration of stakeholders and beneficiaries,

Key Players in Urban Resilience and Sustainable Development

(Present Situation: Lack of Integration, Cooperation, Compatibility, etc.)

All Players are Not Satisfied!!
and
Results is Unsustainable Development and Disaster

Reasons:

Existing governance on urban development due to lack of integrated look and Cooperation;
Due Lack of integrated approach, the development process is suffering from a disease which can be cured only by implementation of System Thinking, Nexus approach with Strong Governance.

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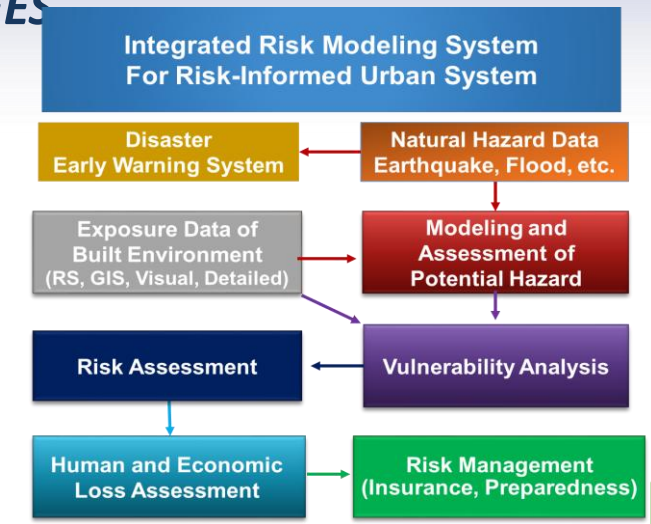
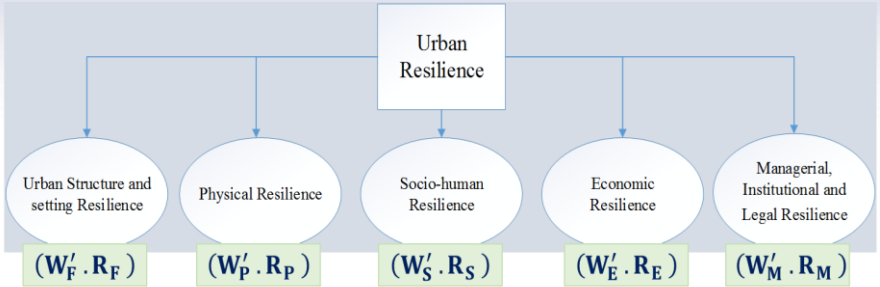
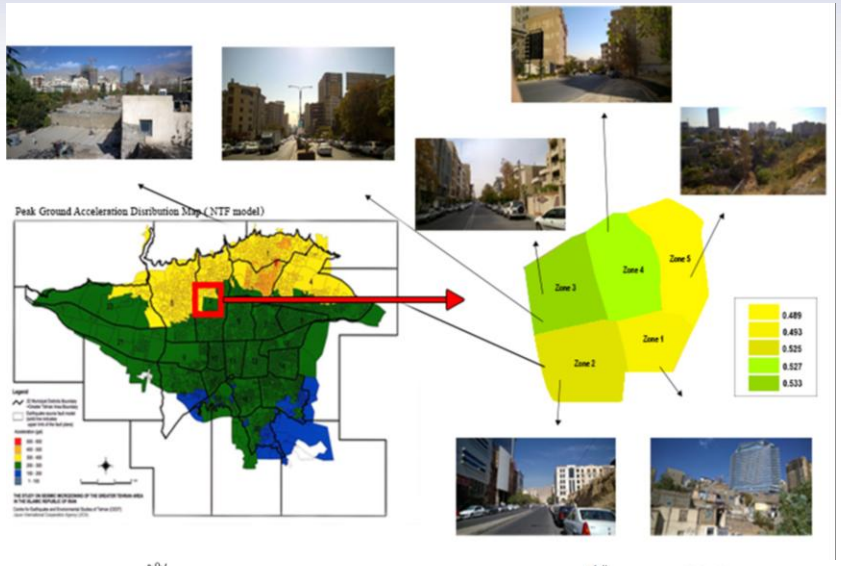
3. Lack of appropriate urban governance system.
4. Poor cooperation and integration of stakeholders and beneficiaries,
5. Lack of integrated look at Nexus of Energy, Water, Climate, Food, etc.
6. Presence of a gap between know-how, and policy and Implementation;
7. Lack of System look at our Complex Urban Areas as a “SYSTEM of SYTEMS”

Sample of Existing Modeling of Urban Resilience, Natural Hazard

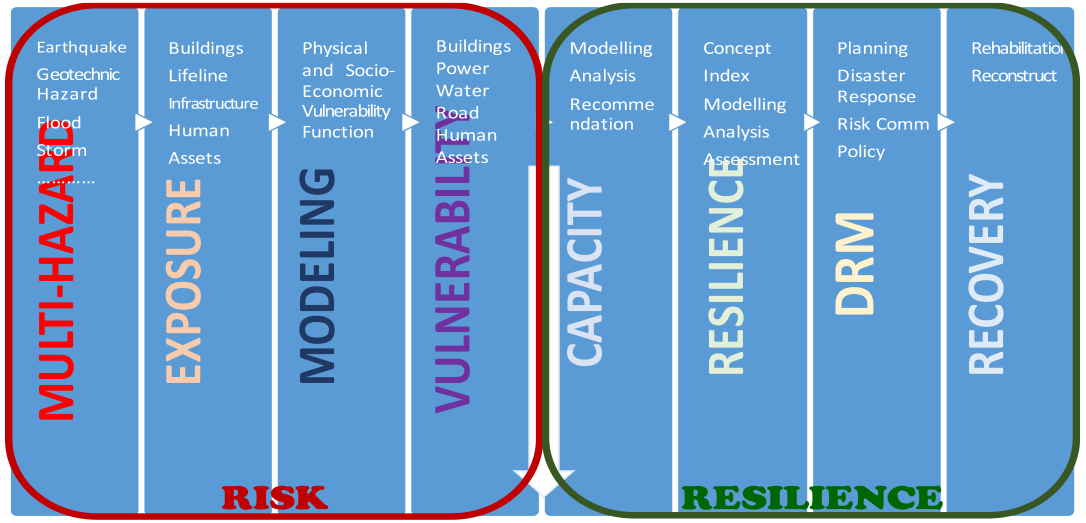




$$\text{Total Resilience} = (W'_F . R_F) + (W'_P . R_P) + (W'_S . R_S) + (W'_E . R_E) + (W'_M . R_M)$$

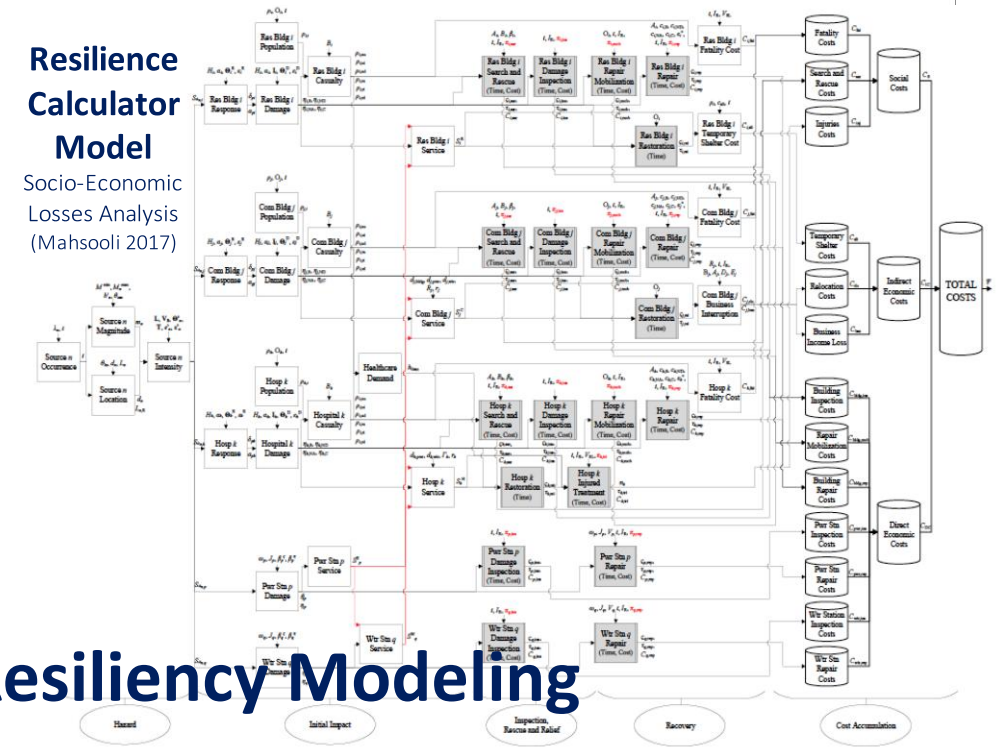


Integrated Resilience Modeling



Resilience Calculator Model

Socio-Economic Losses Analysis (Mahsooli 2017)



System Thinking, a Need for Urban Resiliency Modeling

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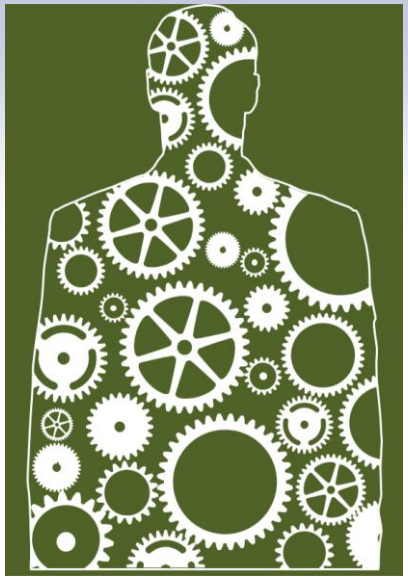


Cities are complex system composed of main sub-systems of:

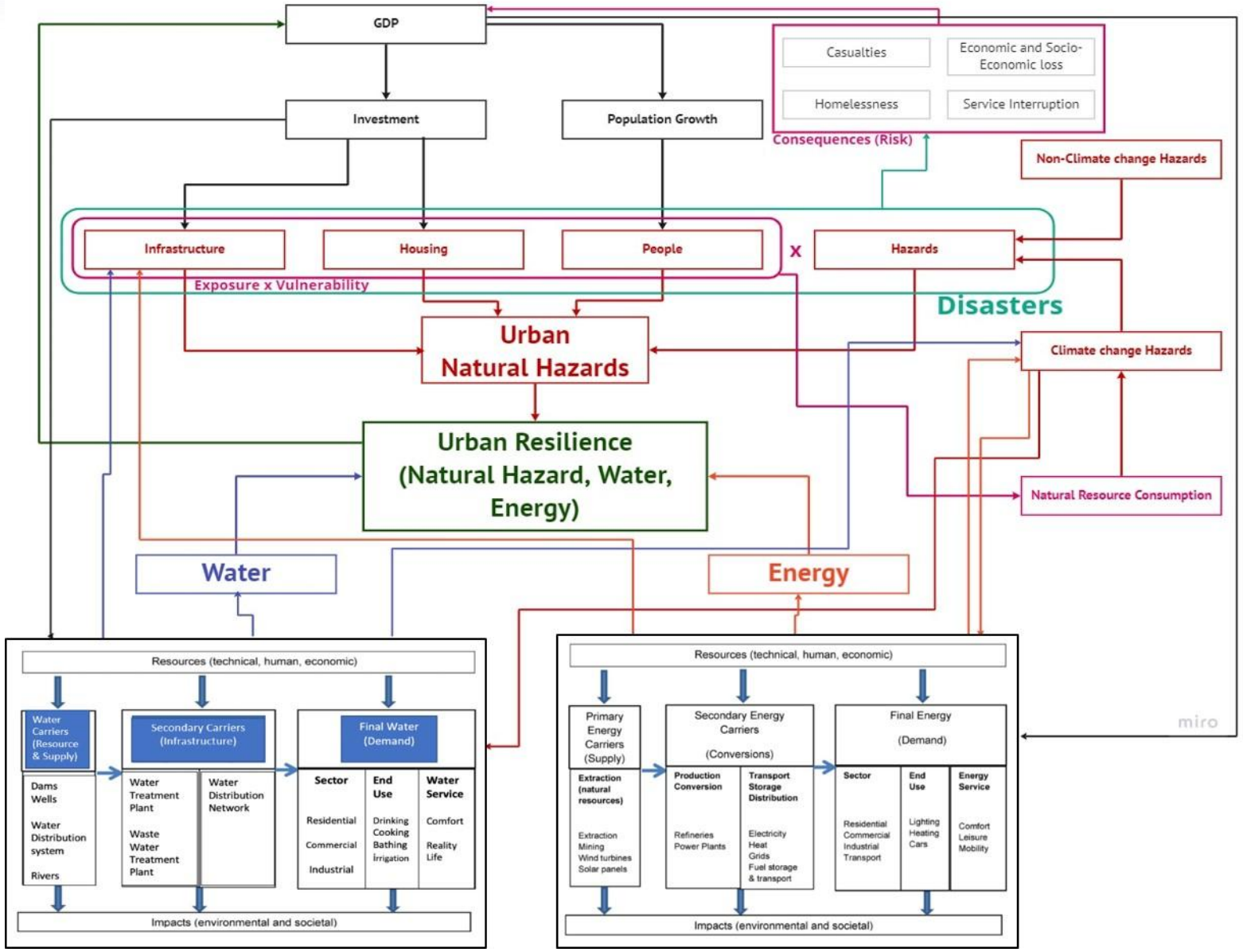
- ✓ People, Society, Economy, Governance, ..with many Stakeholders
- ✓ Built environment that are exposed to Natural Hazard
- ✓ Water System
- ✓ Energy System
- ✓ Other Lifelines
- ✓ ….

There are practical links between Disaster Risk, Water, Energy, etc.; and sustainable development leading to disaster risk reduction with aim of re-enforcing resilience as a new development paradigm of our cities.

To understand the behavior of this complex systems (system of systems), and ensure the resiliency of our cities by changing existing process of our urban development, we need systems thinking to create a balance between human and urban means.

Question: Can we couple existing models with various aspects of the urban system to better understand resilience?

Conceptual System Model of Urban Resiliency to Natural Hazard, Water and Energy and Water



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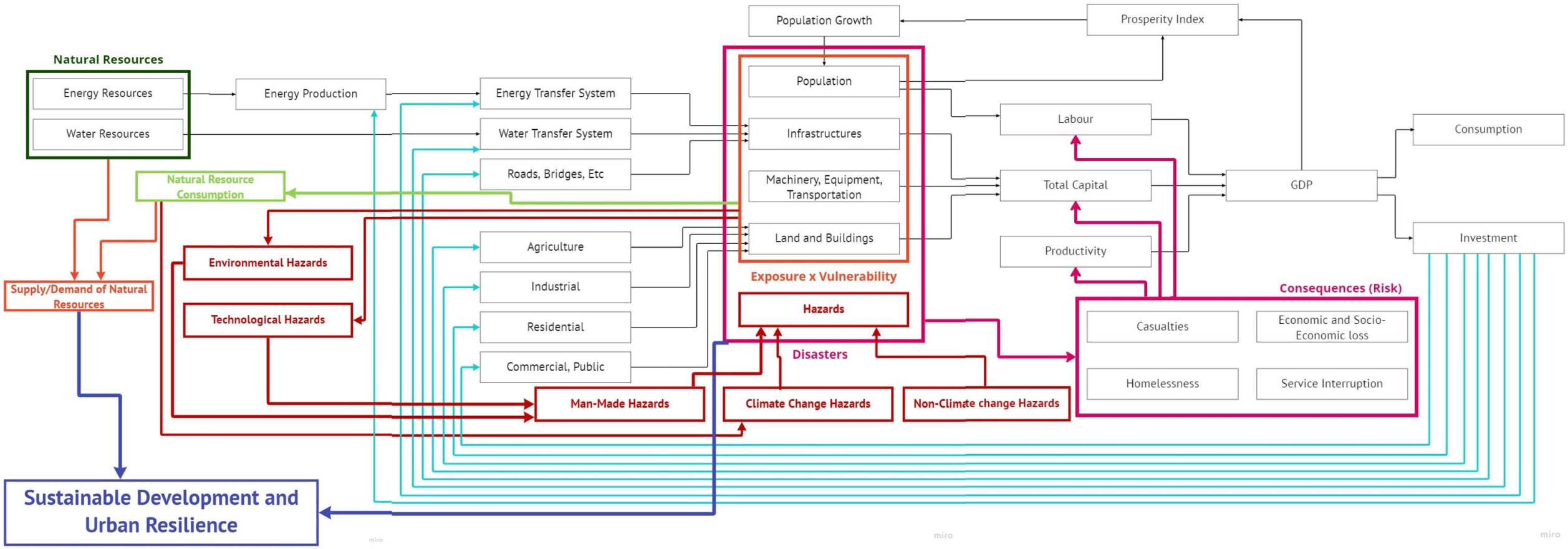

Systems Model to quantify Urban Resilience allows:

- ✓ Better understanding of factors contributing to multi-dimensional resiliency
- ✓ More systematic assessment of various measures can be done to increase resiliency.

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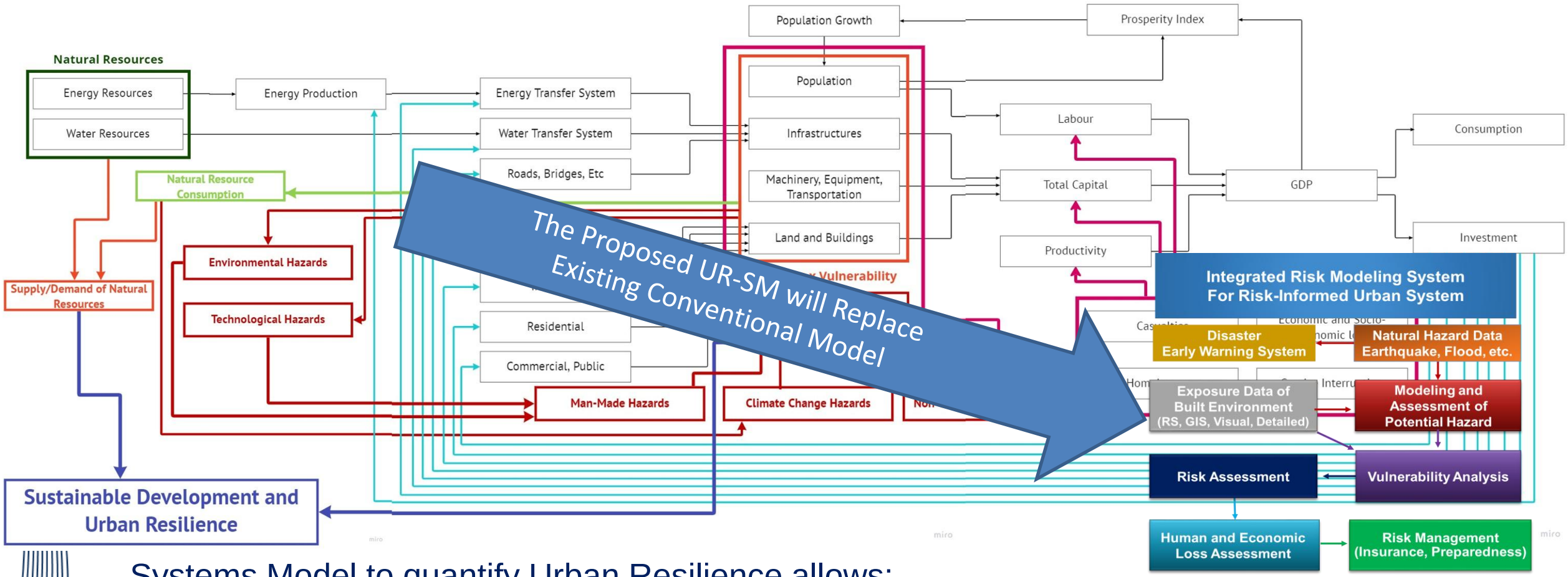

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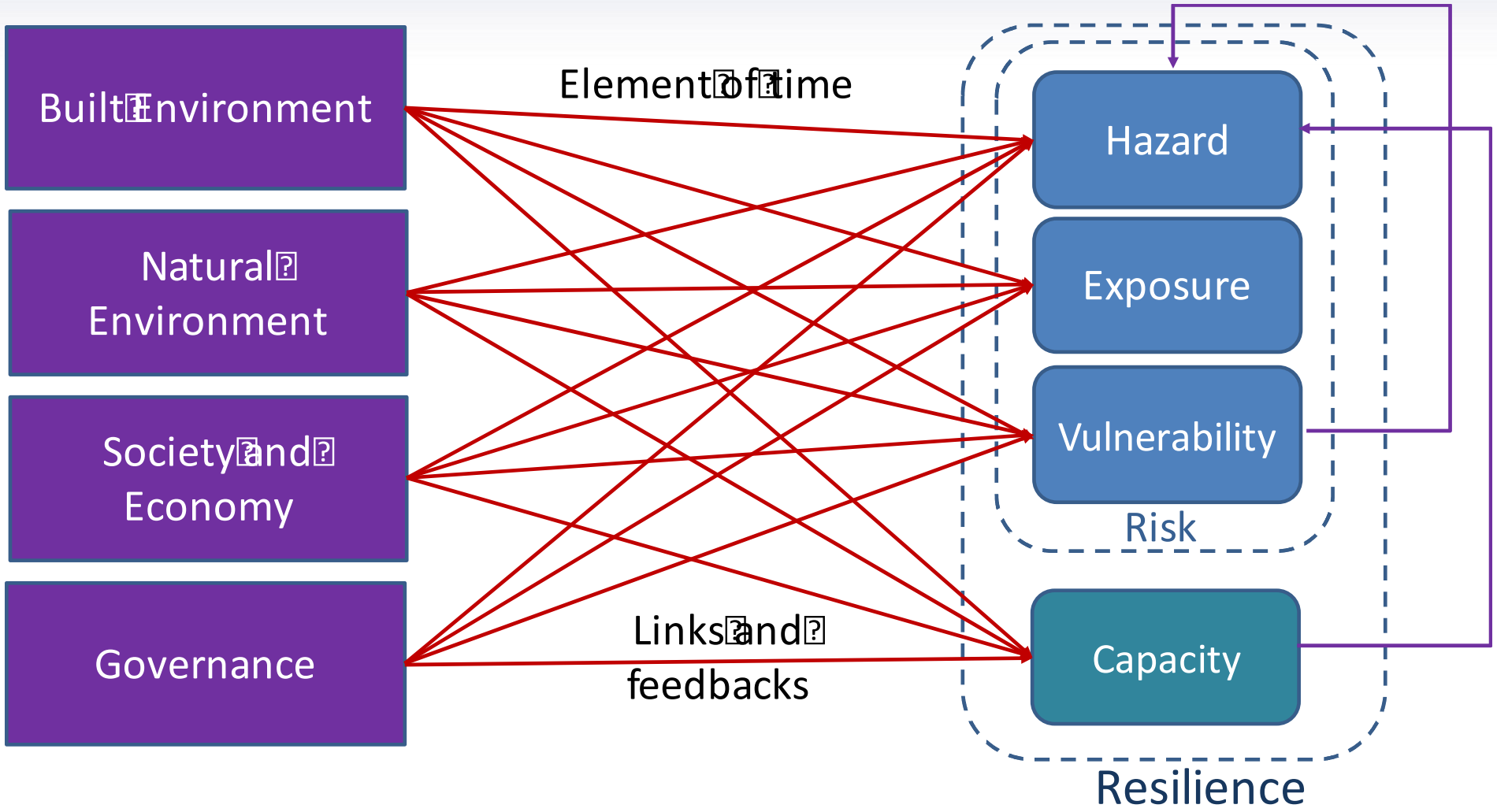
Urban Resilience through Applied Systems Analysis

- ✓ **Application of system modelling for solving Urban and Rural Development Sustainability and Resiliency**
  - Multi-Hazard impacts, specially Earthquake, Flood, Pandemic
  - Water Resources, Water Governance, Water sustainability
  - Population, Pollution, Poverty, etc.
  - Keeping right and sustainable balance between urban-rural areas
- ✓ **"System Thinking" for Urban Resilience or Urban Risk-Sensitive-Landuse-Planning (RSLUP).**
- ✓ **System Approach for providing Solution for Systematic Risk due to Multi-hazard and Multi-Objective**
- ✓ **Application of system modelling for solving the complex problem of energy and water demand and governance**

Example 1: System Model for Urban Disaster Resilience



- Interconnectedness and dynamism (cities are extremely complex systems!)
- Modelling suggestion: each urban sub-system resilience could be defined by a bundle of Risk (Hazard, Exposure, and Vulnerability) + Capacity

Ref.: Dr. Hooman Motamed

Example 2: System Approach for Desirable Housing

Desirable Housing Criteria:

Safe and Sustainable

- Safety against natural hazards (earthquakes, flood, …) with Sustainability and Energy Efficiency

Affordable and Economical

- Affordable in terms of purchasing power, housing prices relative to the average household income

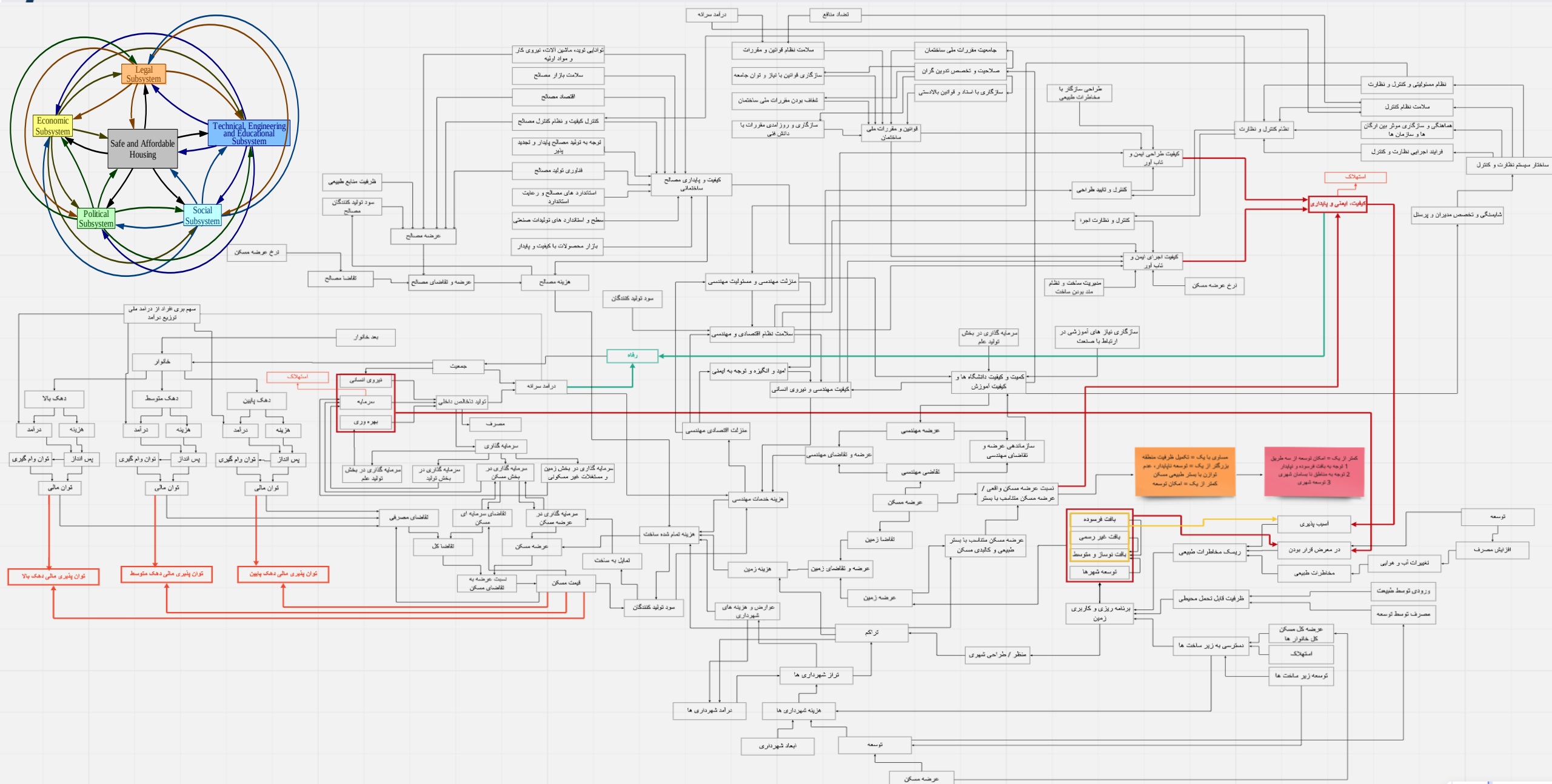
Comfortable and Secure

- Comfort in terms of providing a place for comfort and nature friendly and being away from noise and environmental pollution.

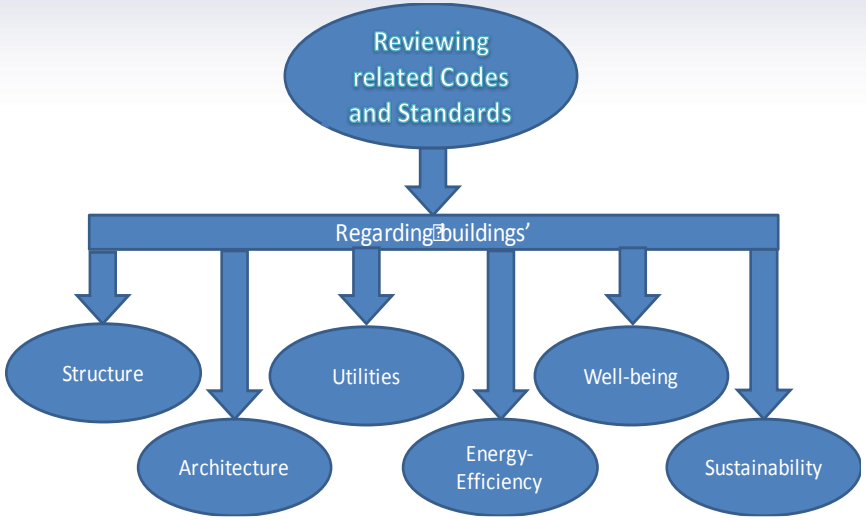
Safe and Affordable Housing as a complex challenge:

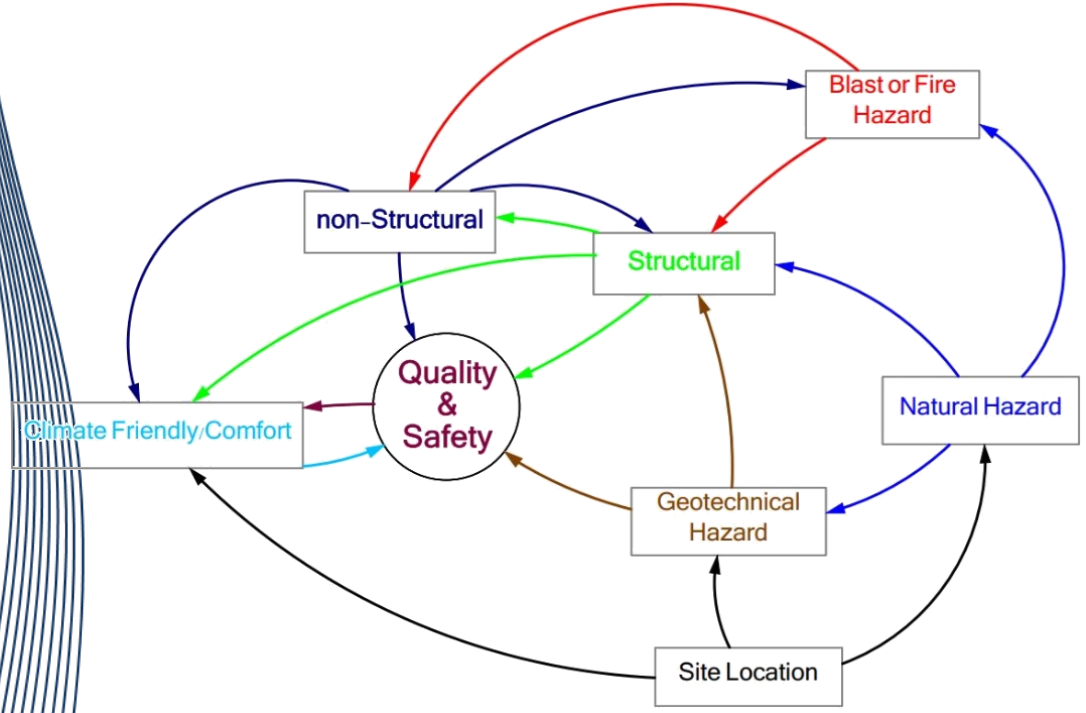
- Housing has many interactive and correlated dimension or aspects, such as: Economic, Political, Legal, Cultural, Technical and Engineering
- Each aspects has a large number of correlated variable and parameters.
- Housing has many stakeholders with different interest, objective and mentality.
- Difference between their goals leads to distance from the main goal.
- The extravagance of each of the stakeholders causes the lack of access to desirable housing.

Example 2: System Model for Desirable Housing



Example 3: Quality and Safety of Buildings





MS: Residential Buildings Quality and Safety Index (BQSI) Evaluation Checklist and C

:2:262:29E32:262:312:27

Section 0: Basic/Genral Information Regarding the Building

0.1. Introduction of the building and the evaluation team	Comments
Name of the occupant who briefs the evaluation team	
Building address	
Postal-code	
Name of the evaluator(s) and their responsibilities	

Section.4: Structural Quality and Safety

Tot. weight 36%	Rel. weight 100%	Symbol	Section.4	4. Structural Elements	Level of Quality / Safety (V.L / Low / Avg / High / V.H)	Observations / Comments	Cindition Multiplier	Rel. Index 0%	Fnl. Index 0%
7%	19.3%	Sign	Crrit.4	2.1. Prior events effecting the building safety	Determine the Level of Quality / Safety	If the answer is No, leave the next 3 questions Blank	Co.QS	0.0%	0.0%
6.85%	19.25%	IF	9	Have the building been exposed to hazards?	Yes or No?	No / Explain if applicable	0	0.00%	0.00%
1.60%	4.50%	I_{S1}	10	How do you evaluate the buildings safety after the damage?	N.A = 0		0	0.00%	0.00%
3.87%	10.88%	I_{S2}	11	Have the building been repaired after the damage? How?	N.A = 0		0	0.00%	0.00%
1.38%	3.87%	I_{S3}	12	Have the effects of remodelling on the structure been prevented?	N.A = 0		0	0.00%	0.00%
9%	25.9%	Sign	Crrit.5	2.2. Based on Visual Inspection	Determine the Level of Quality / Safety		Co.QS	0.0%	0.0%
2.14%	6.01%	I_{S4}	13	Overall construction quality based on visul inspection (material and so on)			0	0.00%	0.00%
2.12%	5.97%	I_{S5}	14	Regularity in plan (in terms of rigidity, mass and resistance)			0	0.00%	0.00%
1.77%	4.98%	I_{S6}	15	Regularity in elevation			0	0.00%	0.00%
1.93%	5.43%	I_{S7}	16	Structural redundancy			0	0.00%	0.00%
1.24%	3.48%	I_{S8}	17	Prevention of interaction between structural and non-structural elements			0	0.00%	0.00%
11%	31.6%	Sign	Crrit.6	2.3. Based on Auditing Documents and Plans	Determine the Level of Quality / Safety		Co.QS	0.0%	0.0%
2.12%	5.96%	I_{S9}	18	Overall design quality based on available documents			0	0.00%	0.00%
2.93%	8.24%	I_{S10}	19	Structural detailing including connections			0	0.00%	0.00%
1.47%	4.14%	I_{S11}	20	Structural integrity of roofs			0	0.00%	0.00%
3.47%	9.74%	I_{S12}	21	Prevention of short-story, weak-story and short-column			0	0.00%	0.00%
1.24%	3.48%	I_{S13}	22	Standard seperation of the building with the adjacent ones			0	0.00%	0.00%
		I_{S14}	23	Material sustainability					
		I_{S15}	24	As-built plans					
8%	23.3%	Sign	Crrit.7	2.4. Quality and Safety of the Foundation	Determine the Level of Quality / Safety		Co.QS	0.0%	0.0%
3.54%	9.94%	I_{S16}	25	Overal quality of the foundation design based on available documents	N.A = 0		0	0.00%	0.00%
4.76%	13.37%	I_{S17}	26	Performance of the foundation based on visual inspection (cracks and so on)			0	0.00%	0.00%

Section.5: Non-Structural Quality and Safety

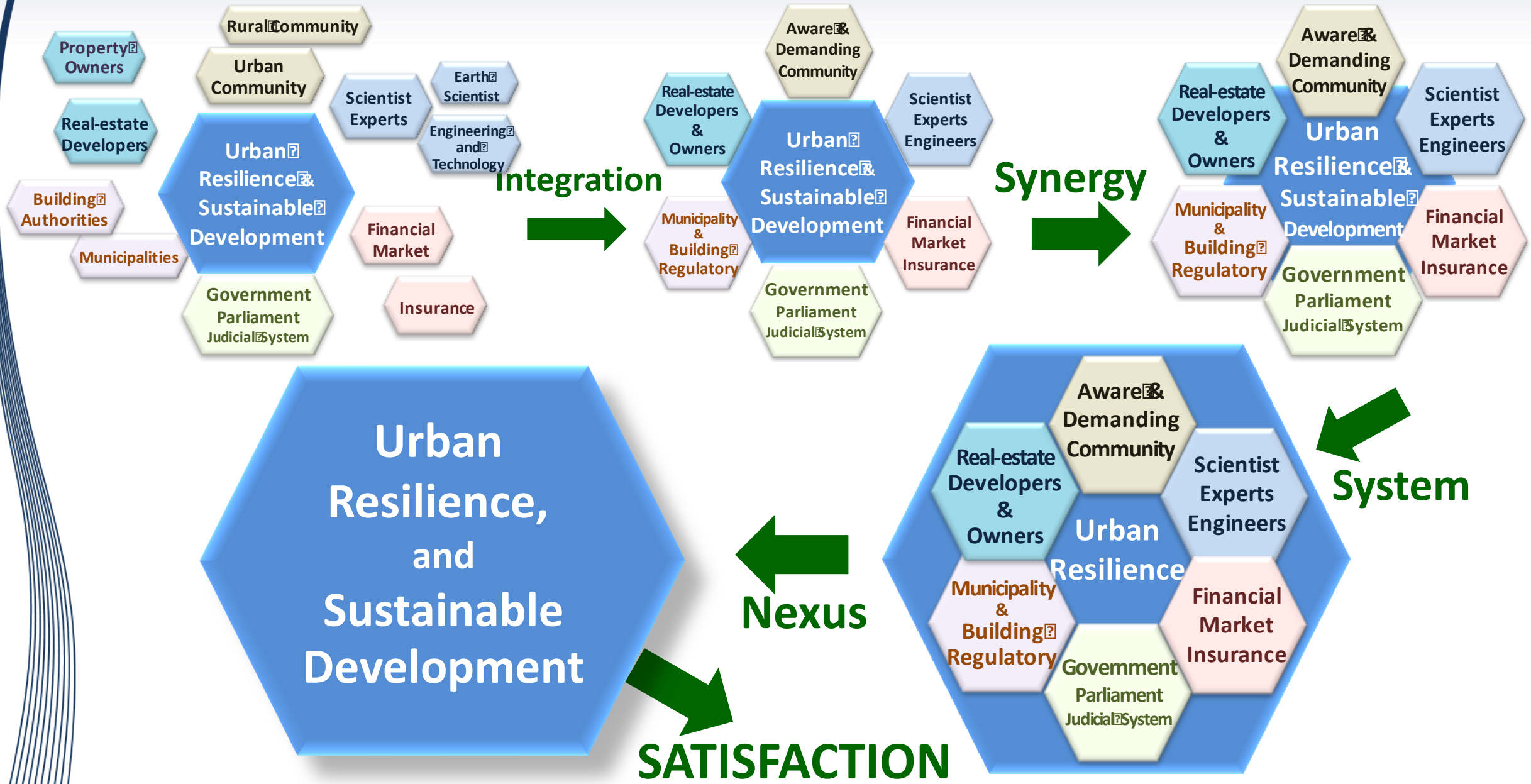
Tot. weight 11%	Rel. weight #REF!	Symbol	Section.5	5. Non-structural Elements	Level of Quality / Safety (V.L / Low / Avg / High / V.H)	Observations / Comments	Cindition Multiplier	Rel. Index #REF!	Fnl. Index #REF!
2%	38.7%	Sign	Crrit.8	3.1. Architectural Condition of the Building	Determine the Level of Quality / Safety		Co.QS	0.0%	0.0%
0.52%	4.89%	I_{A1}	27	Quality and safety of doors, exits and entrances			0	0.00%	0.00%
0.34%	3.19%	I_{A2}	28	Quality and safety of windows and shutters			0	0.00%	0.00%

How to Implement the "System Thinking" for Urban Resilience ??

With holistic integration process to be implemented gradually in 4 steps:

- ✓ Paradigm shift with system thinking toward enhancing synergy between sectors involved in DRS/DRR (people, scientists, socio-economist, and policymakers);
- ✓ Integration of all sectors in one system with inter- and transdisciplinary cooperation and implementation, since the emerging risks are too complicated to be overcome by a single entity or discipline;
- ✓ Use of system thinking to Identifying problems related to natural hazard, energy, water, climate change to be used for system dynamic modelling of all contributing parameters;
- ✓ Creation of nexus and integration among all sectors for effective implementation. This is the principal to good governance, where the elements of a system should work together in order to solve the complex problems of being safe against natural disasters.

System and Nexus Approach for Achieving "Urban Resilience"



Concluding Remarks:

- ✓ Urban dimensions have their own resilience (built environment, environment, society and economy, governance, energy, water, etc)
- ✓ Resilience of each dimension has its own 'Risk + Capacity' component which changes over time (deteriorates or enhanced)
- ✓ Urban dimensions and resilience components are interconnected in a dynamic manner (the size, type of feedback ,and linkage could change over time)
- ✓ To devise or achieve "Urban Resilience" strategies, we should develop its "System Dynamics Models" along with 'Risk + Capacity' components.
- ✓ INSF to establish System Analysis program, mini IIASA.