Introduction to Earthquake Engineering

Urban Seismic Challenges

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Stand: September 2013

2 steps to urban seismic safety

1. Assessment:

- Earthquake hazard
- Vulnerability
- Human impact

2. Mitigation:

- Improve urban seismic robustness and resilience
- Improve response of society

Example: Istanbul metropolitan area

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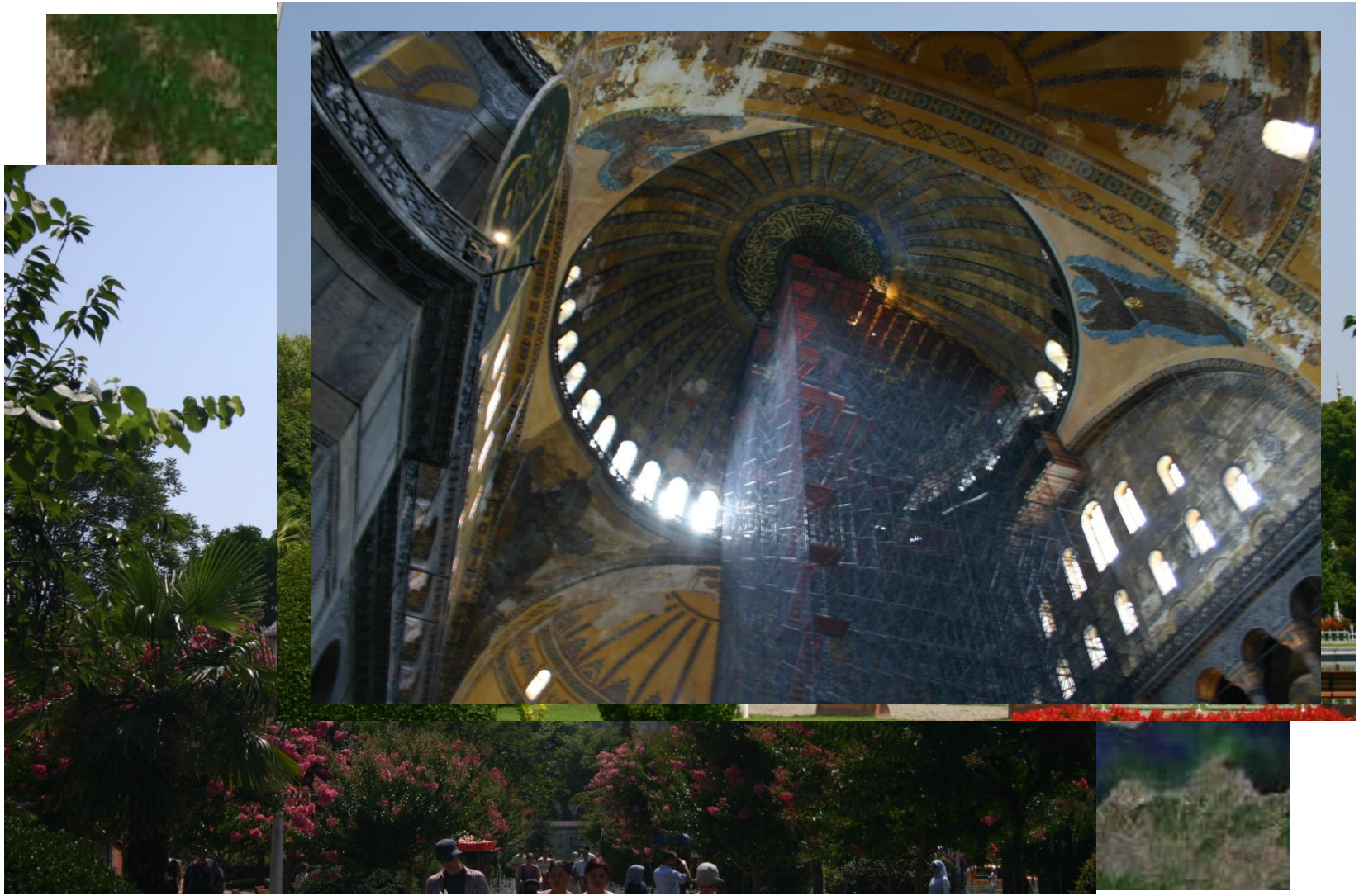
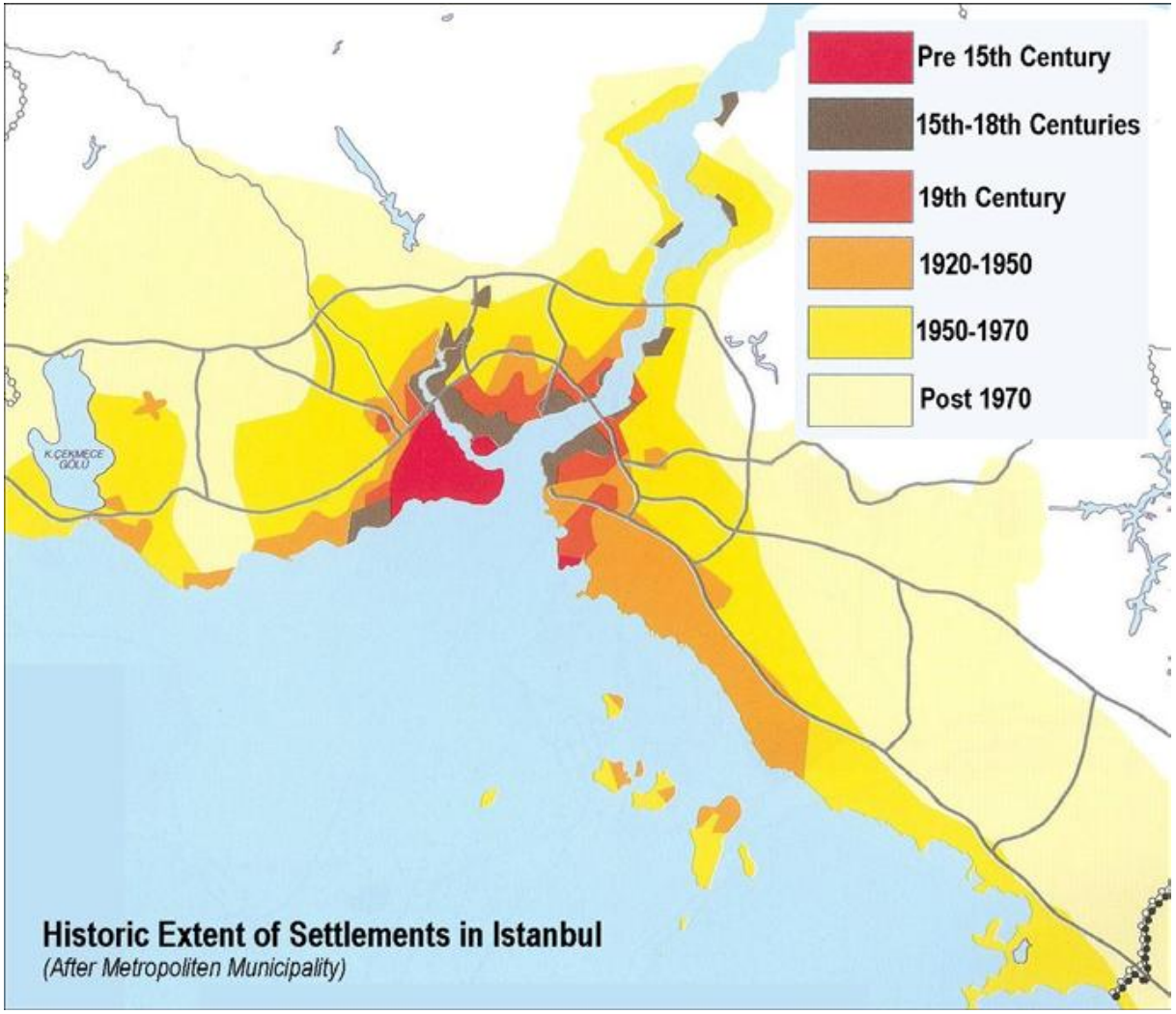


Example: Istanbul metropolitan area

Urban growth of Istanbul

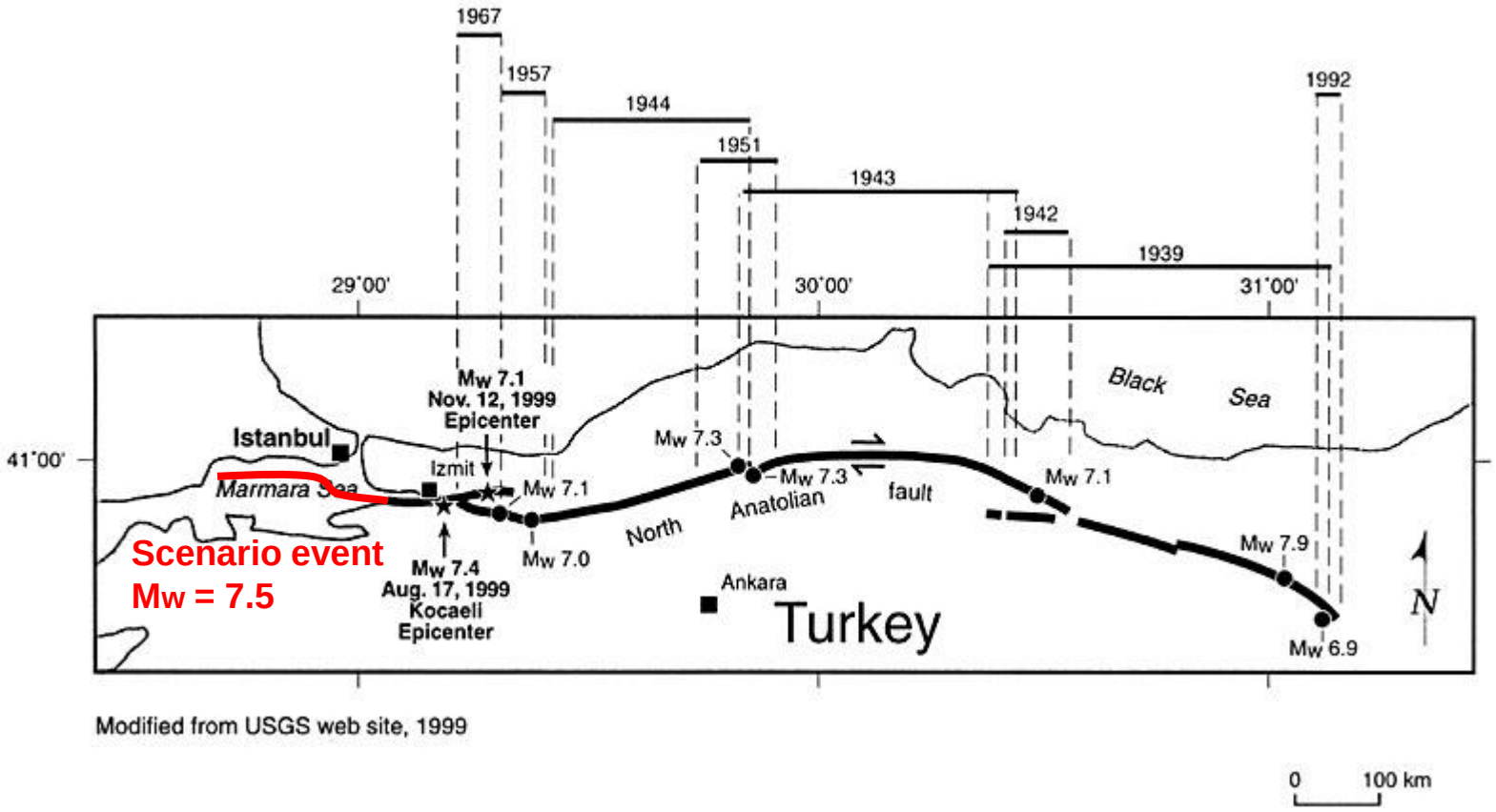


Assessment

- Earthquake Hazard:
  - Tectonics (regional system of fault lines, possible and probable movements)
  - Seismic history (locations, magnitude and frequency of past earthquakes)
  - Soil conditions (local magnification effects, liquefaction potential)
  - Topography (land slide potential, tsunamis, coastal subsidence)

Tectonics and seismic history

- North Anatolian fault line with recent earthquake history
- Possible and probable movements



Modified from USGS web site, 1999

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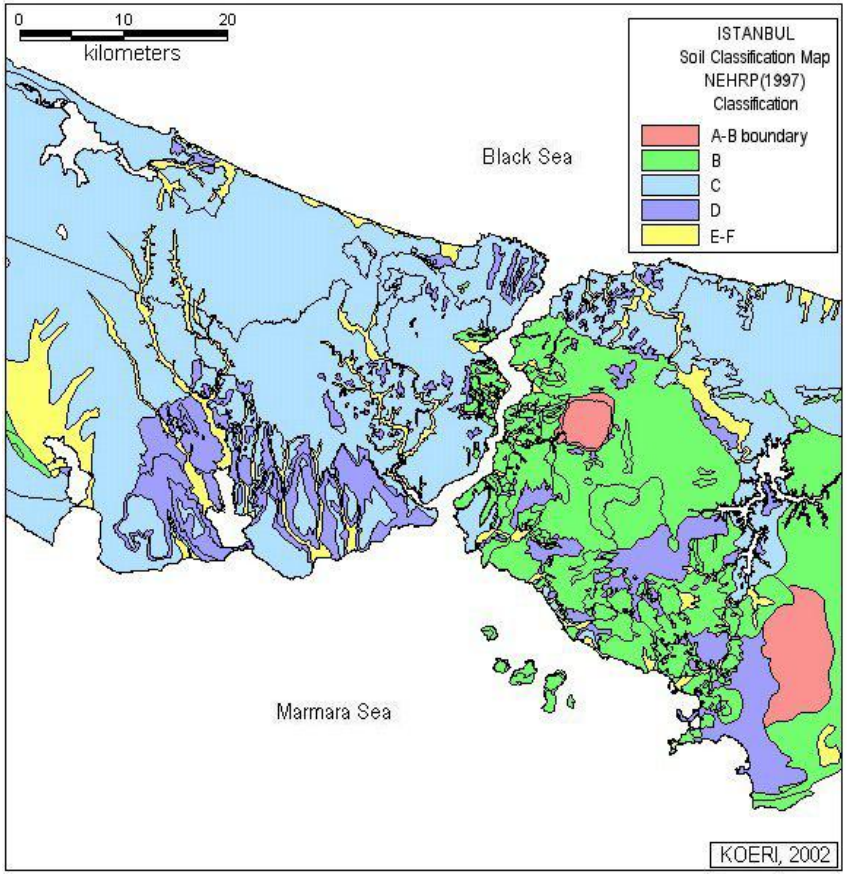
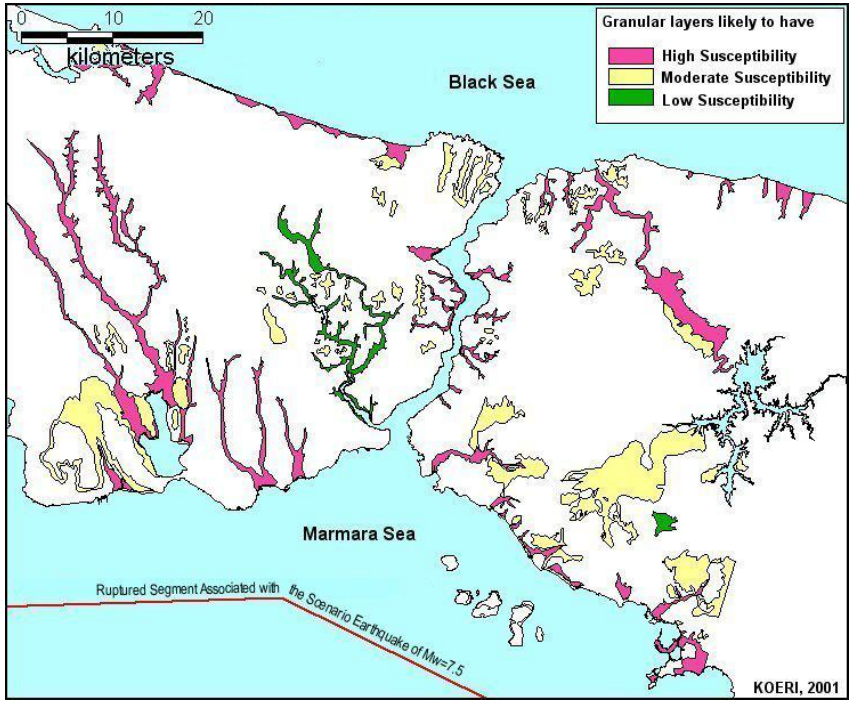
Soil Conditions

- local magnification effects
- liquefaction potential





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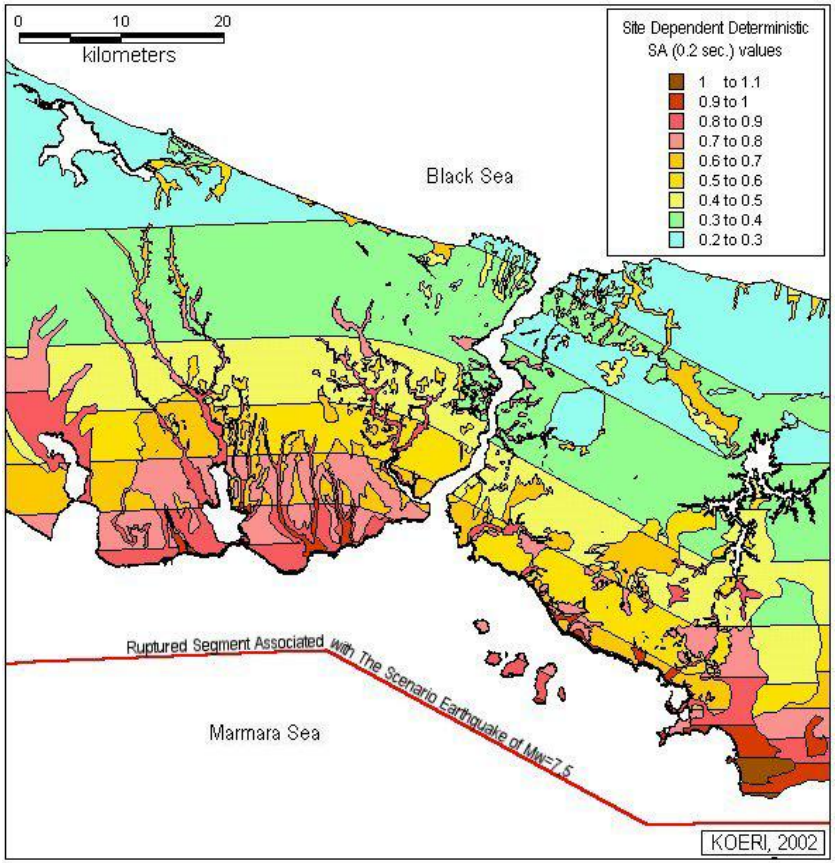
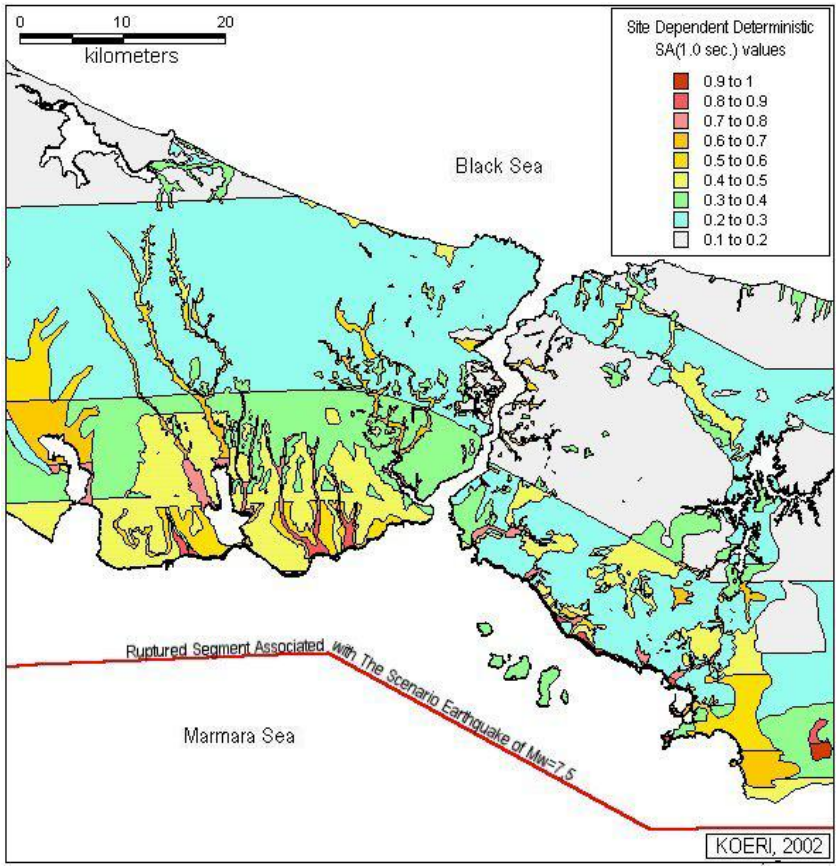
Topography

- Limited land slides
- Coastal subsidence may be a bigger problem!

Earthquake Hazard Assessment

- Leads to spectral acceleration maps for different return periods of anticipated seismic events
- Allows the construction of site specific response spectra for an event





Assessment

- Vulnerability:
  - Buildings (residential, administrative, educational, commercial, health, historical)
  - Transportation infrastructure (roads, railroads, bridges, waterways and harbors, airports)
  - Other life lines (water, waste water, electricity, gas)
  - Regular industry (SMEs, large manufactures)
  - Industry with large hazard potential (chemical, petrochemical, nuclear)
  - Economy (business interruptions, short and long-term market impact, financial market reaction)
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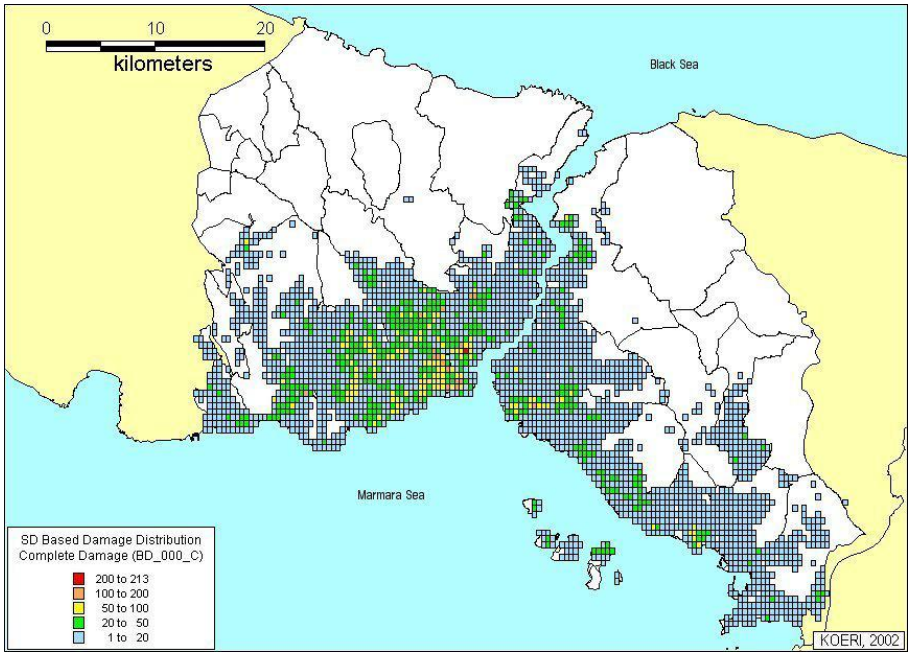
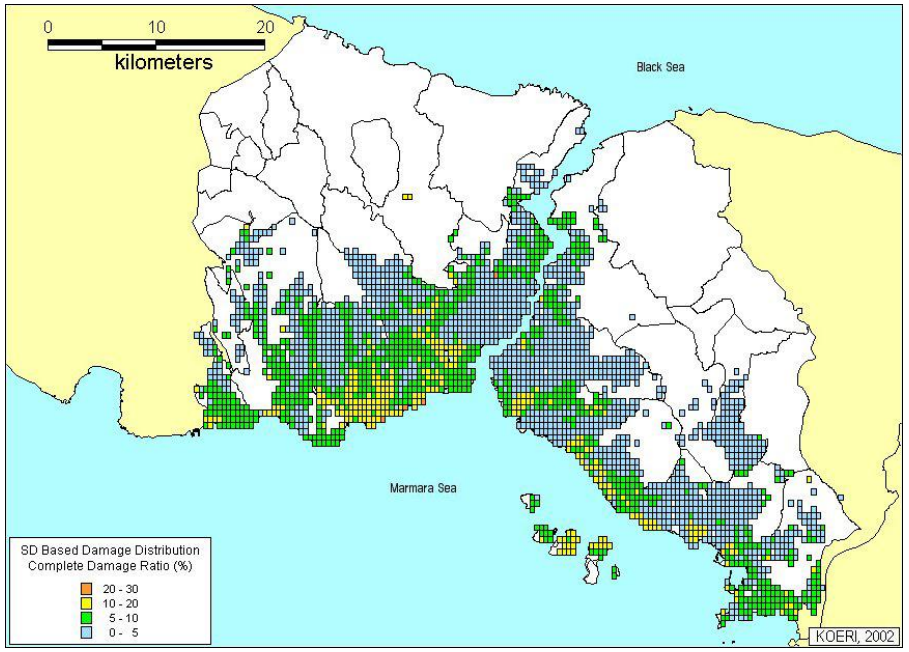
  - Post-quake fires

Buildings

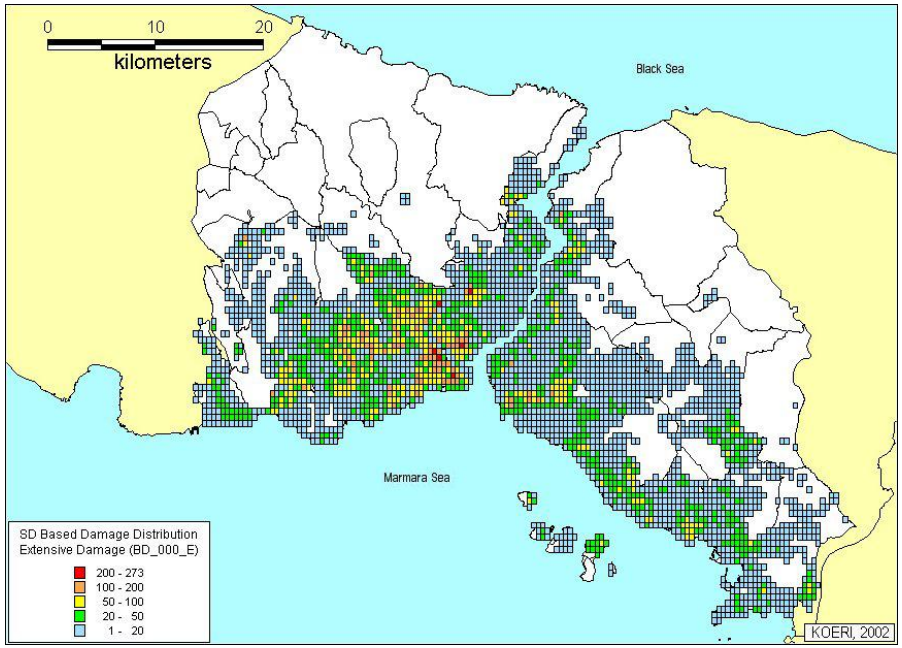
- Multi-stage vulnerability assessment
- Collapses

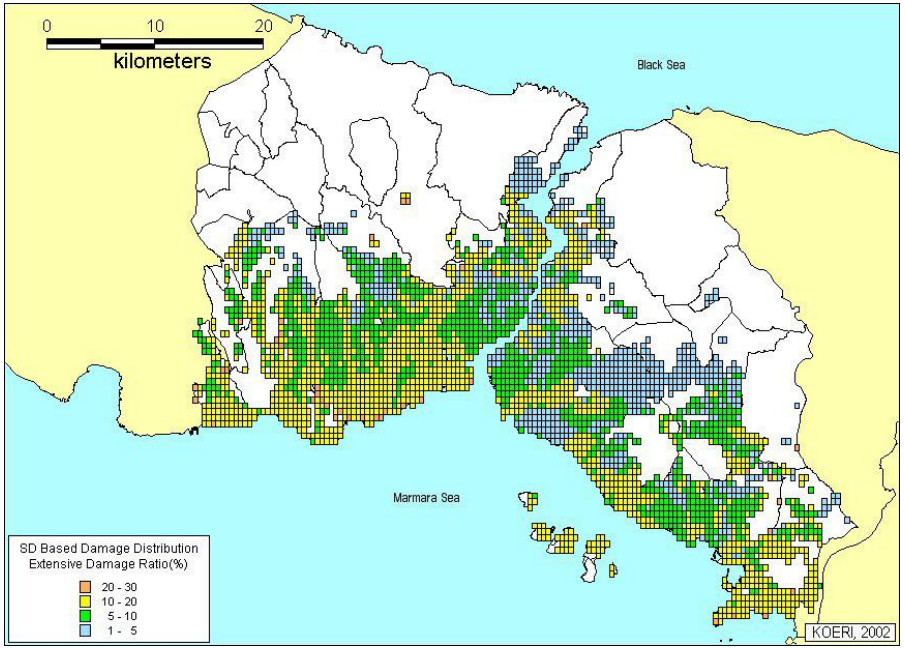




Buildings

- Multi-stage vulnerability assessment
- Heavy damage





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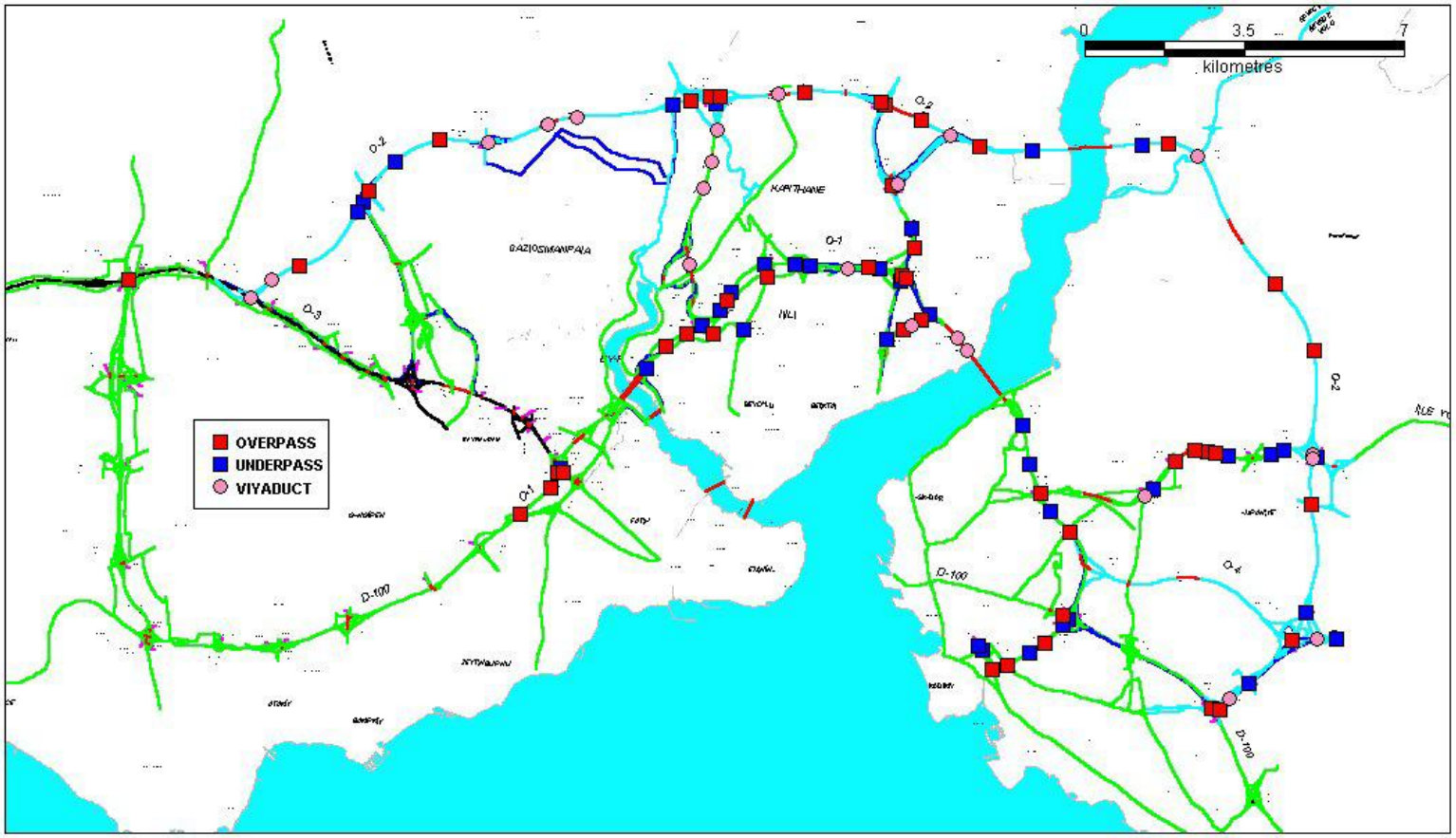
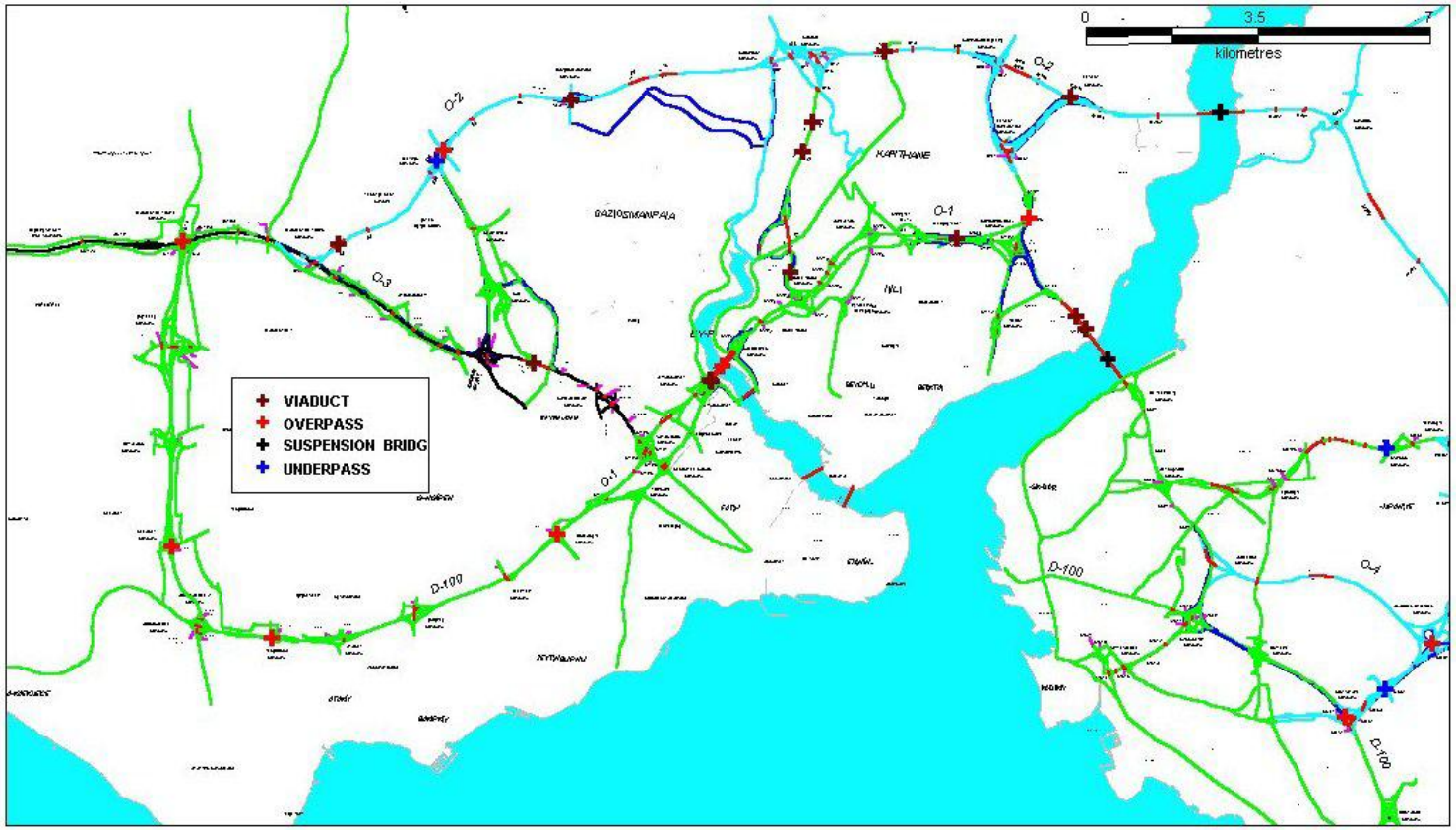
Transportation infrastructure

– Evaluated highway bridges



Transportation infrastructure

- Evaluated highway bridges
- Recommended for retrofit



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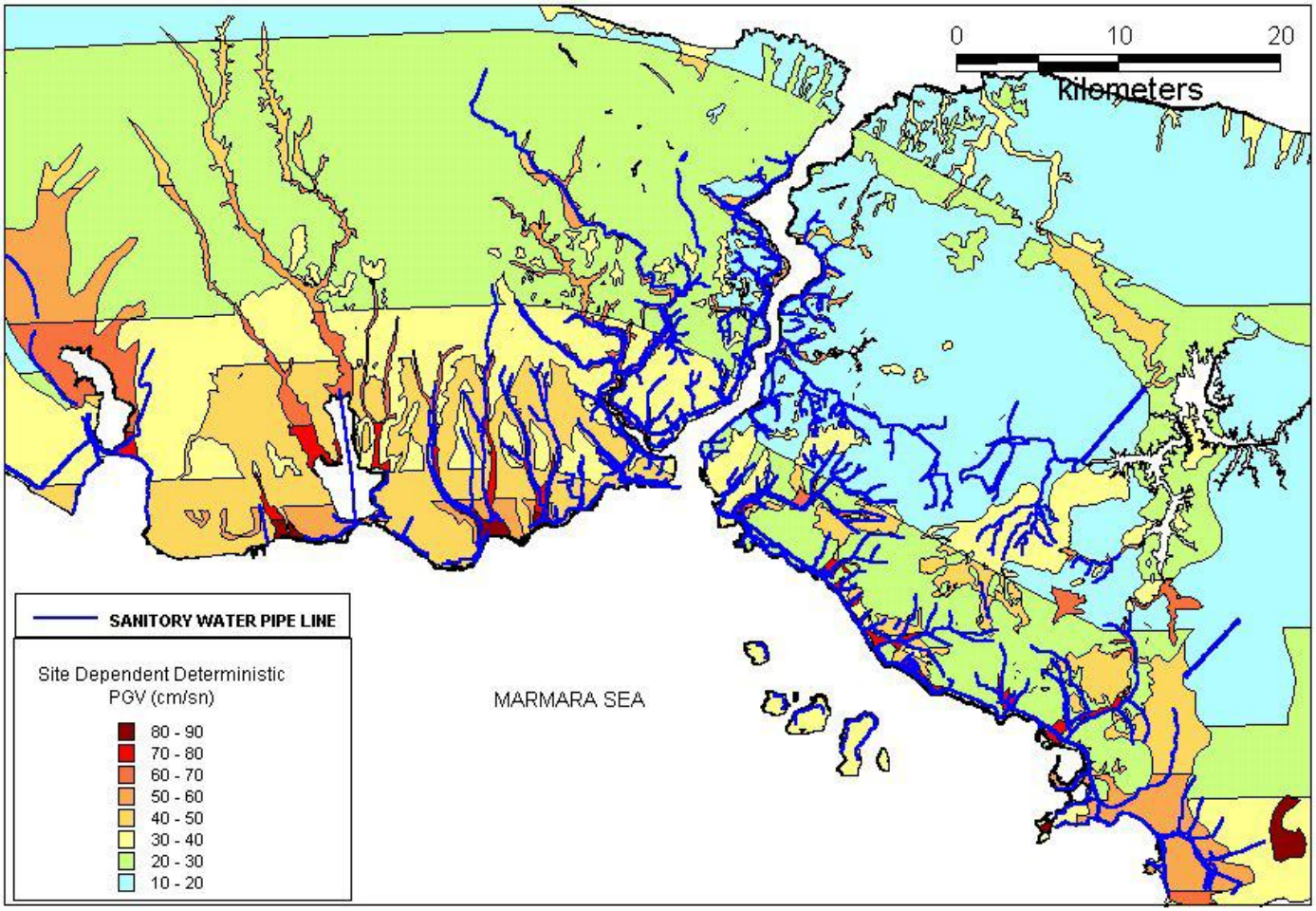
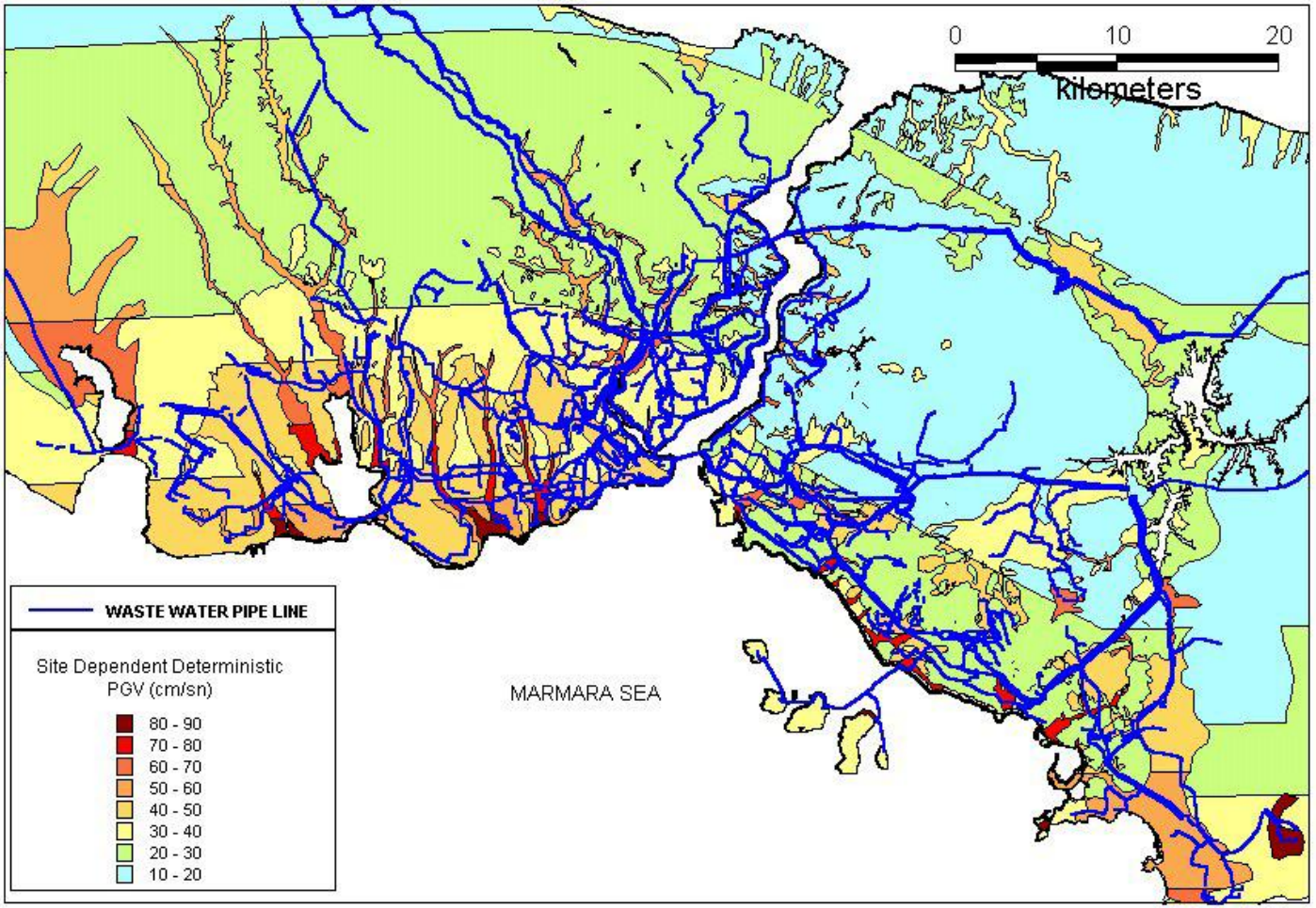
Other life lines

– Drinking water system



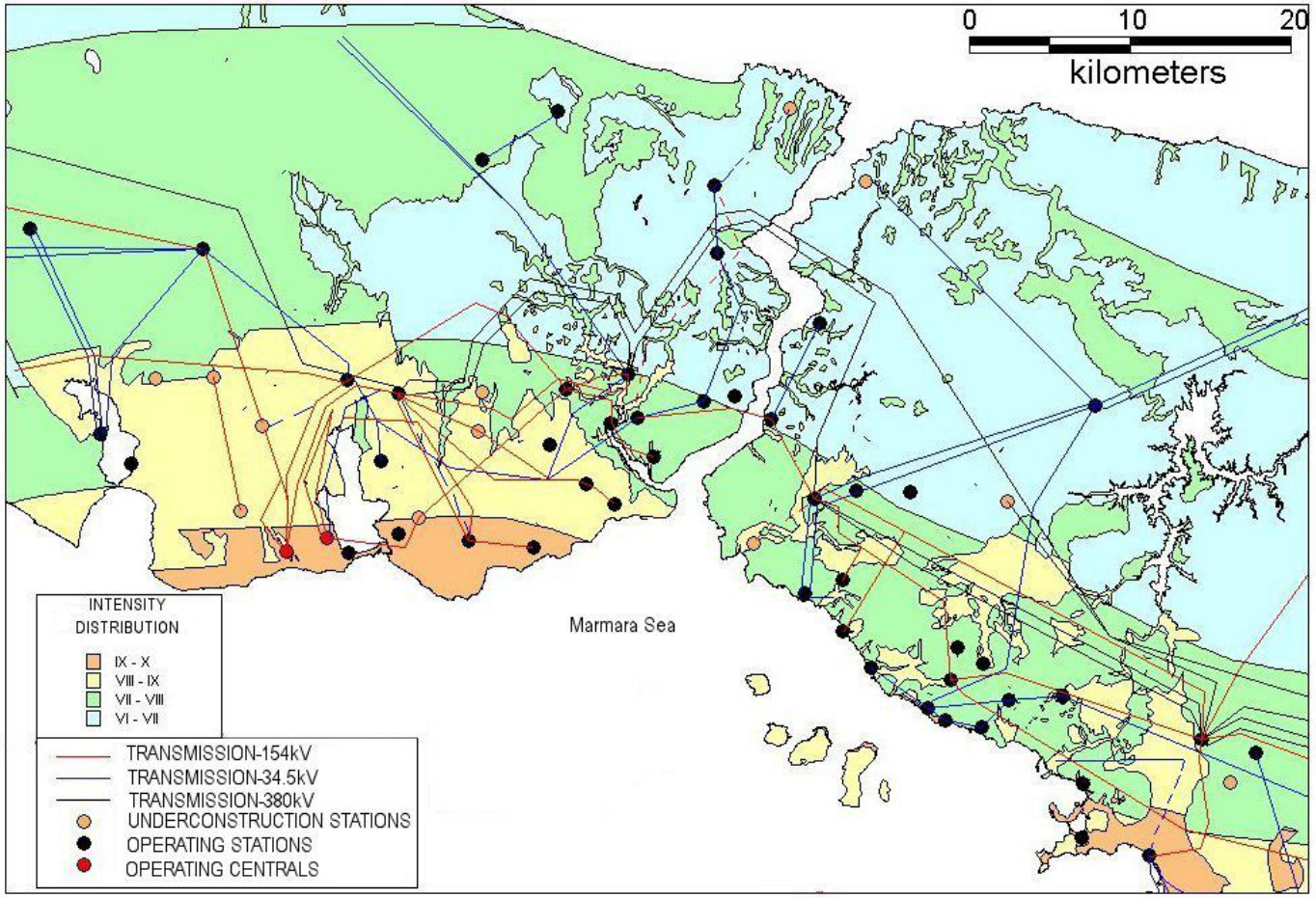
Other life lines

– Waste water system



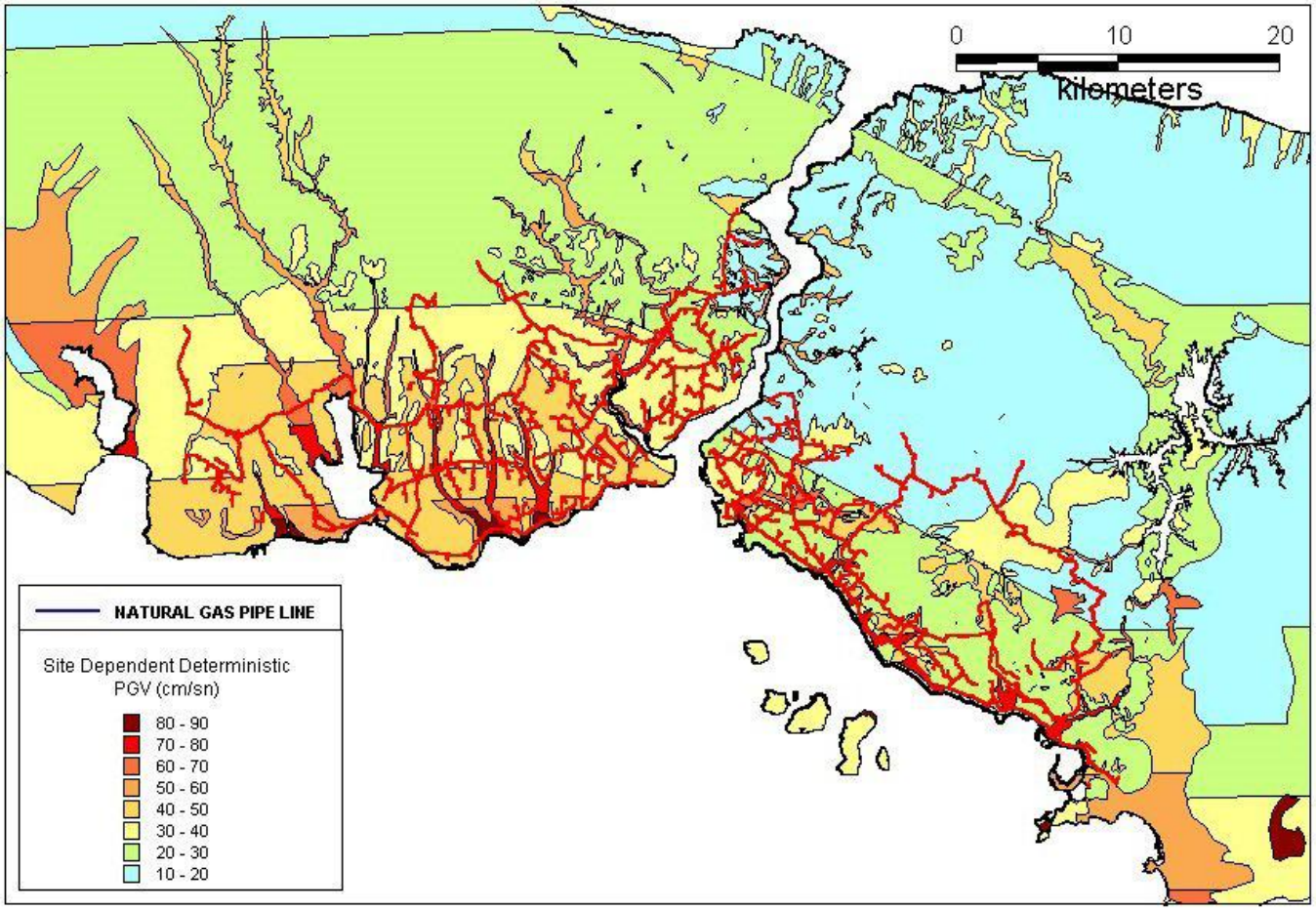
Other life lines

– Electricity



Other life lines

– Gas



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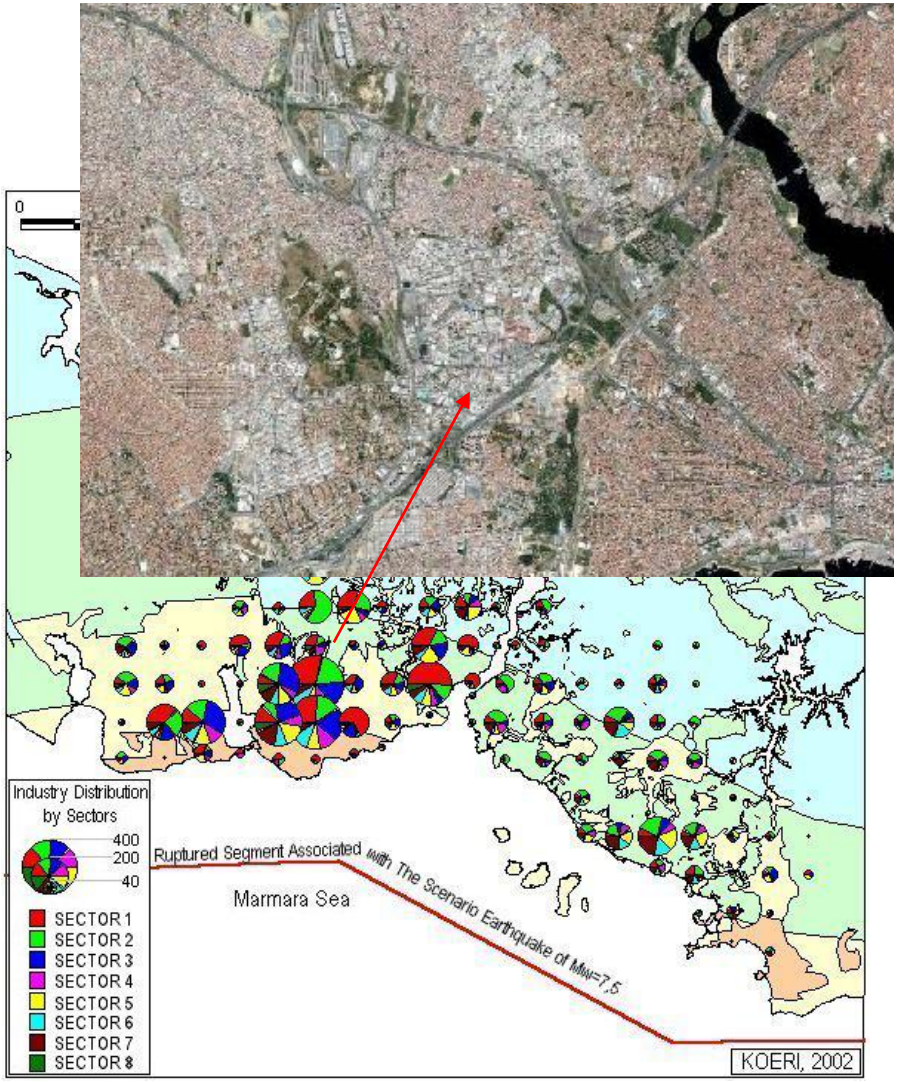
Industries

– SMEs

Nr.	Sectors
1	mining, construction, ceramics, glass
2	commercial, food & beverage
3	textile, leather
4	wood & furniture, agriculture
5	chemical & petroleum
6	metals
7	machinery, automotive
8	transport & telecom



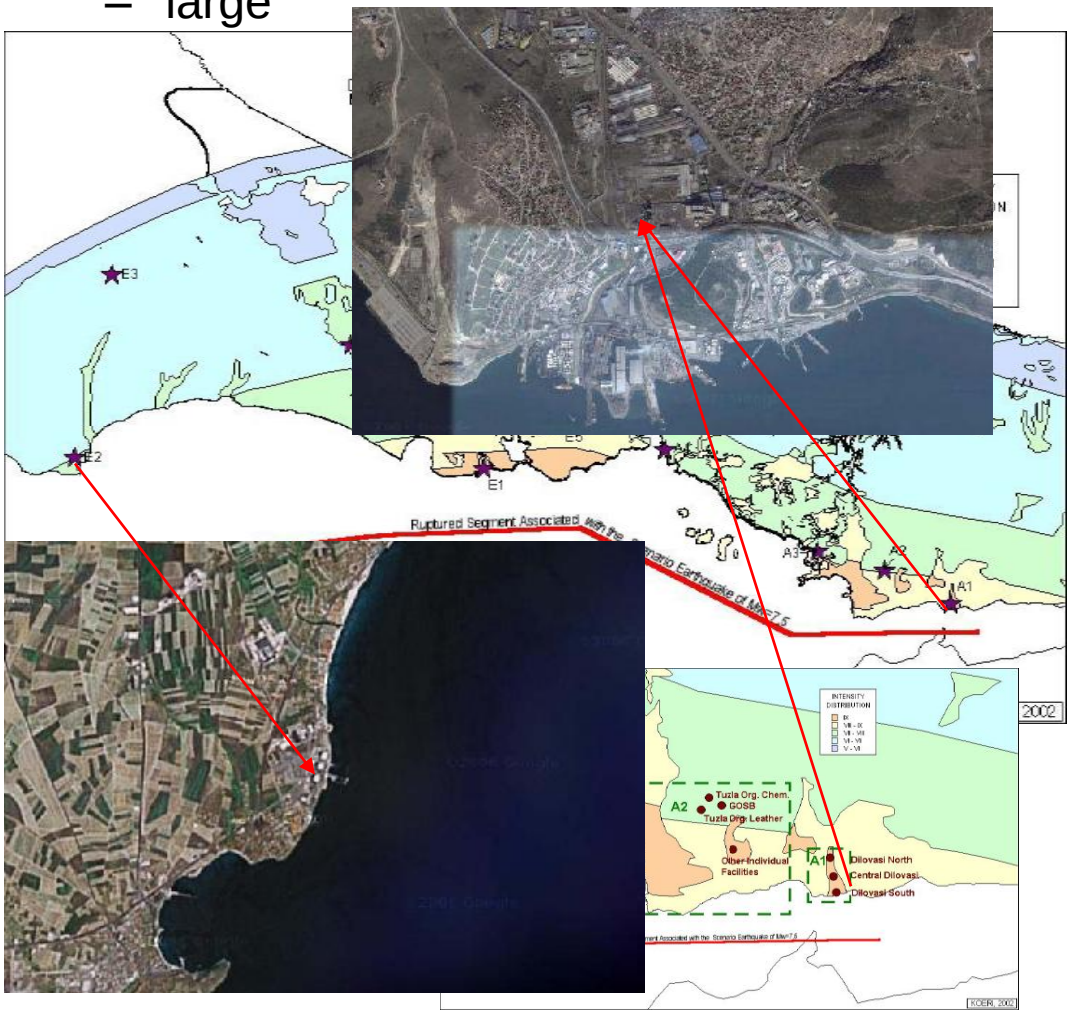
Industries

– SME sector losses

Nr.	Sectors	Equipment & machinery		Stock		Business Interruption	
		IX	VIII	IX	VIII	IX	VIII
1	mining, construction, ceramics, glass	0.011	0.013	0.011	0.013	0.075	0.025
2	commercial, food & beverage	0.009	0.011	0.009	0.011	0.075	0.025
3	textile, leather	0.013	0.017	0.039	0.050	0.30	0.20
4	wood & furniture, agriculture	0.016	0.012	0.016	0.012	0.075	0.025
5	chemical & petroleum	0.033	0.035	0.033	0.035	0.50	0.30
6	metals	0.002	0.002	0.002	0.002	0.075	0.025
7	machinery, automotive	0.002	0.002	0.002	0.002	0.15	0.1
8	transport & telecom	0.012	0.014	0.002	0.003	0.075	0.025

Industries

– large



A1	Port, tanks, chimneys, power generation, hazardous
A2	Tanks, steel mill, power generation, waste water treatment, industrial park
A3	Port, cranes
A4	Port, cranes
E1	Port, cranes, hazardous
E2	LNG tanks, port, hazardous
E3	Textile production, industrial park
E4	Industrial park
E5	Industrial park

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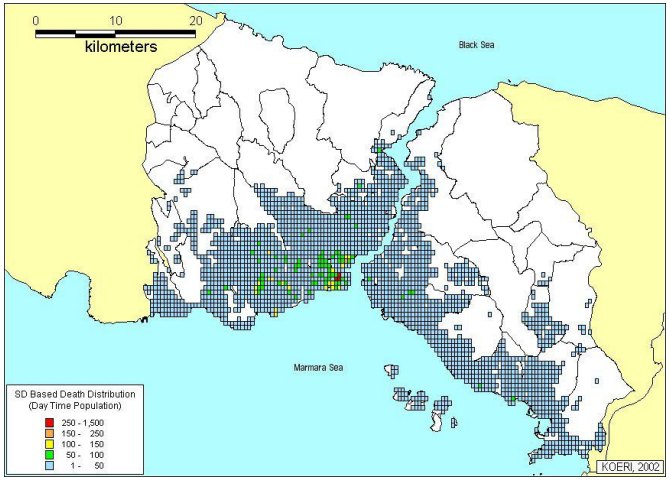
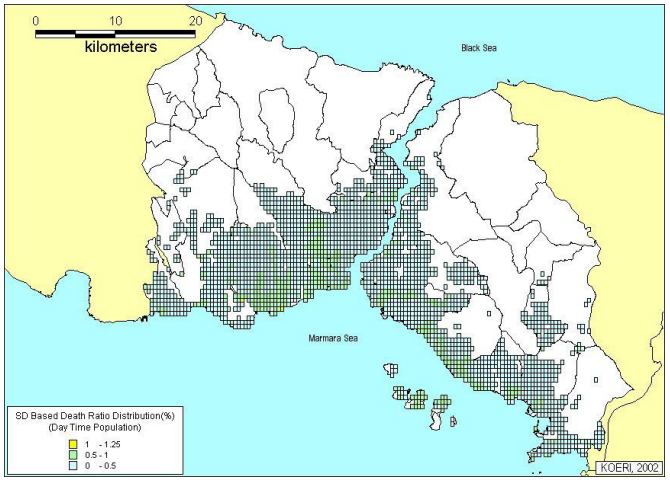
Assessment

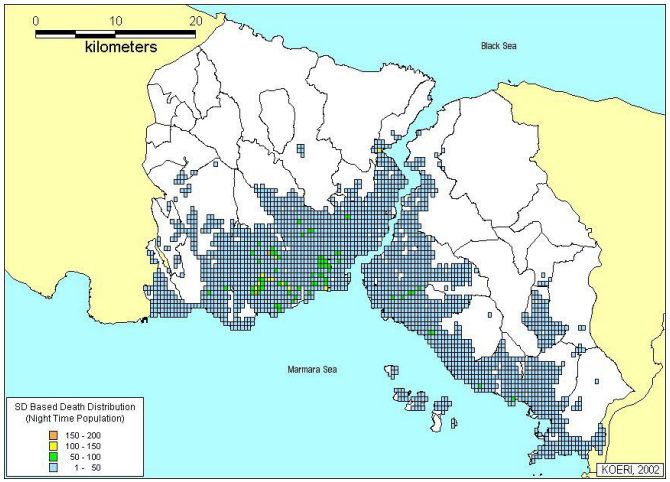
- Human Impact:
  - Health (deaths and injuries, emergency care, threat of epidemics, long-term care, psychological care)
  - Basic needs (housing, food, water, clothing, sanitation, cooking fuel, heating)
  - Emergency Administration (emergency management, security, preparedness of civil protection agencies and units, role of NGOs)

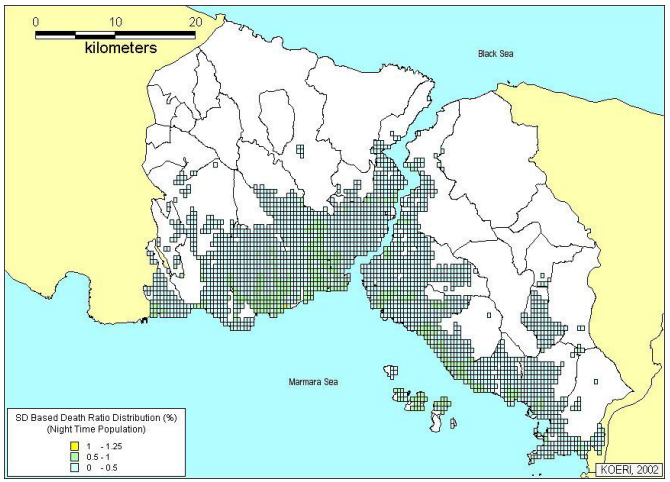
Health

– Deaths



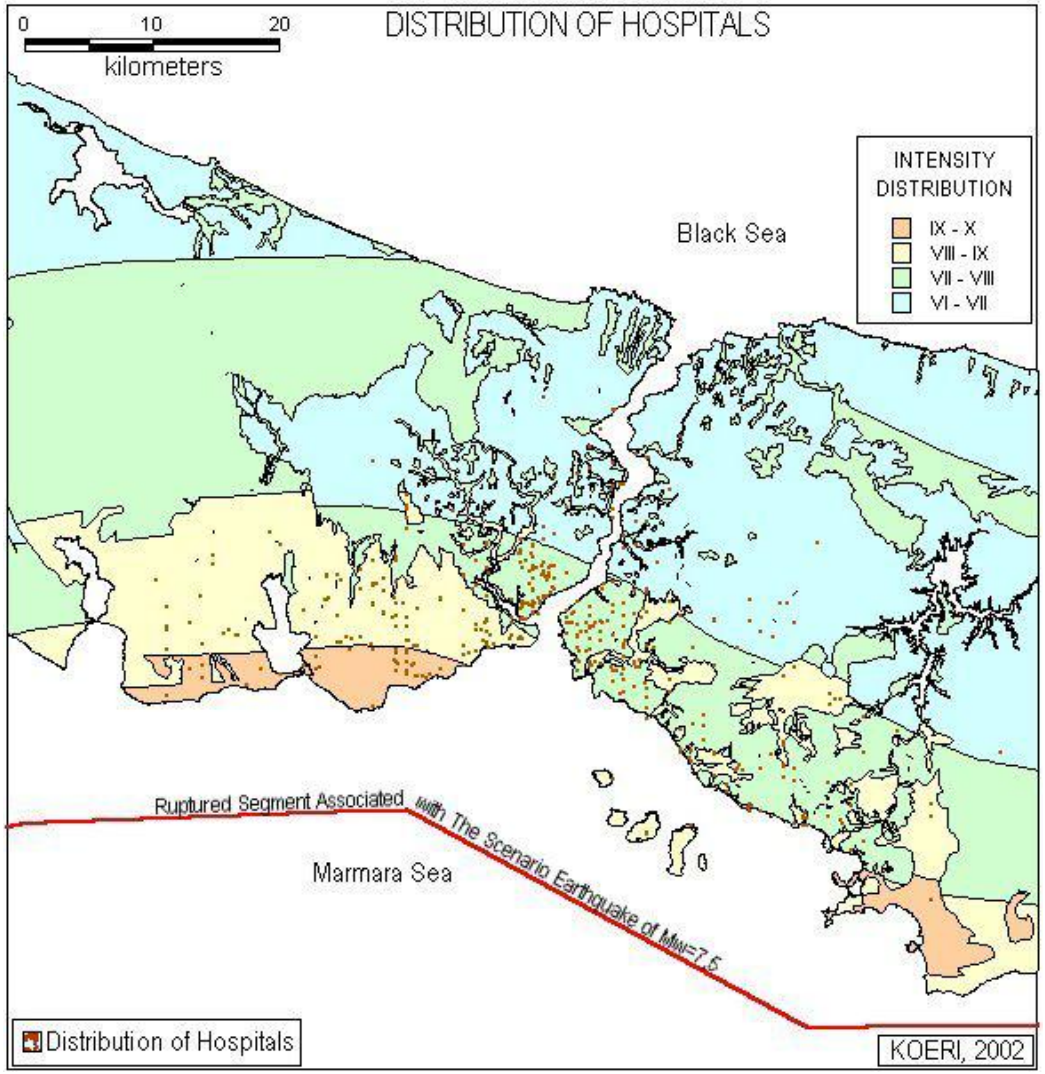






Health

– Hospitals



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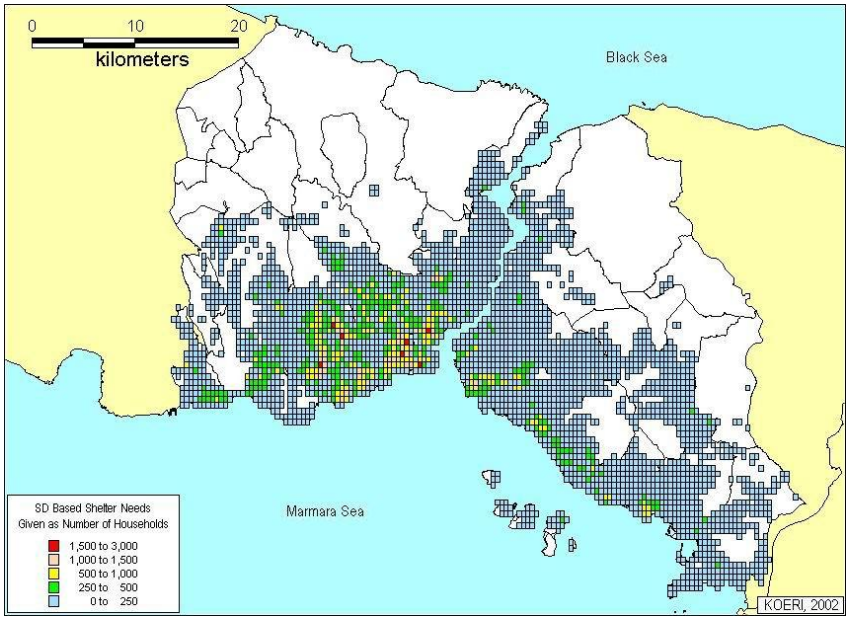
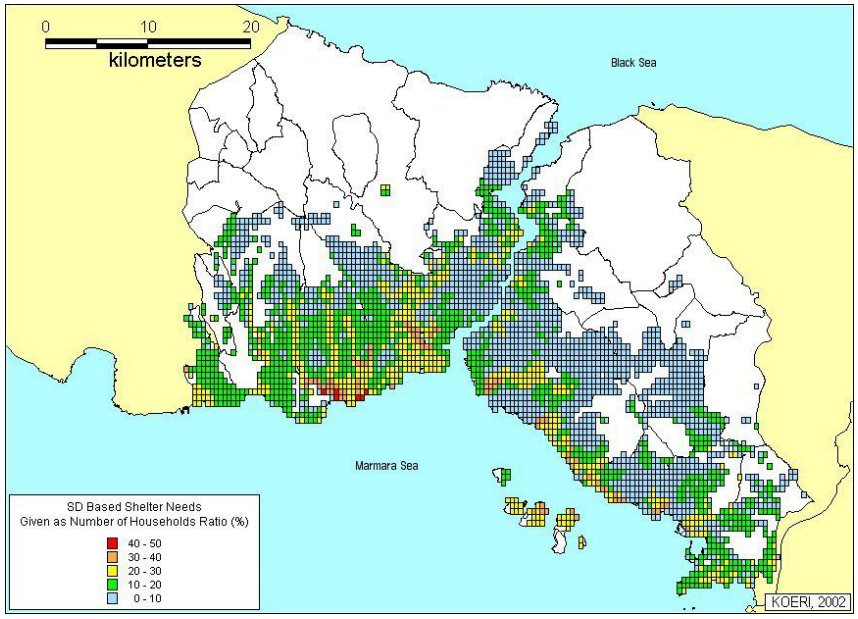
Basic needs

– Required emergency shelter





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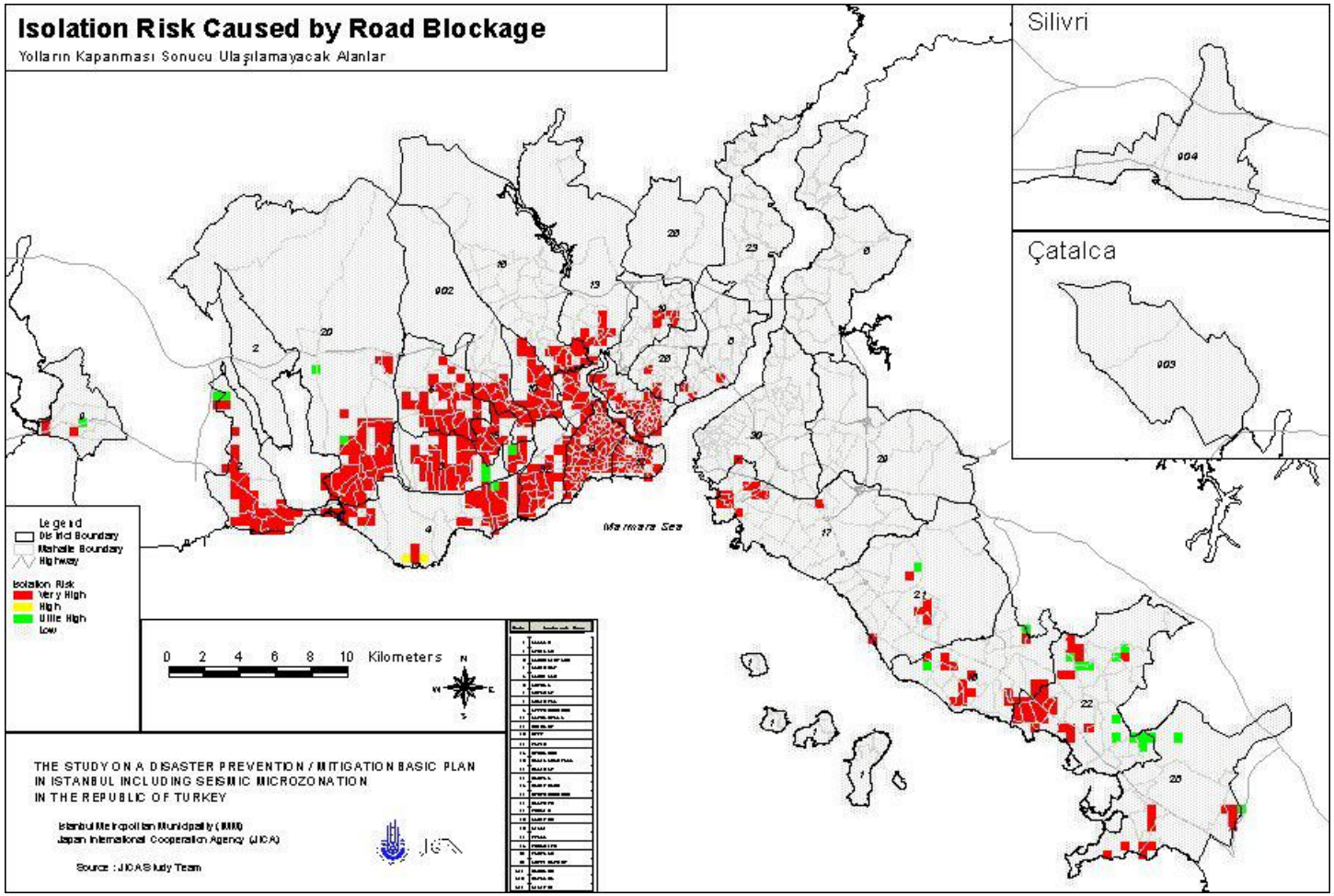
Preparedness for civil protection

– Blocked access



Mitigation

- Improve Urban Seismic Robustness and Resilience:
  - Structural improvements of buildings (occupant friendly retrofitting by strengthening or seismic control, re-building with seismically robust systems)
  - Urban re-vitalization (multiple emergency access to districts, emergency relieve areas, redundancy of transportation and other lifeline systems, restricting building height and building area to ground ratio)
  - Industry (SME eq-mitigation and insurance programs through SME-organizations, industrial earthquake emergency fund, requirement for seismic action plan of large industries)
  - Eliminate large environmental hazards (individual worst case scenarios, containment of possible hazardous spills)

Mitigation

- Improve Response of Society:
  - Education of general public about local earthquake risks
  - Emergency response (equipment and training of civil protection agencies and units, stocks of basic supplies, temporary care centers, emergency management structure)
  - Health care (base isolated hospitals with appropriate emergency care centers)
  - Social preparedness (individual earthquake insurance, earthquake improvement fund for low-income housing)
  - Activate market forces (voluntary seismic safety certificates)
  - Innovative financing tools (securitization of earthquake risk through CAT bonds, Real Estate Investment Trust)
  - **Develop disaster prevention plan** (***vulnerability reduction plan***)
  - Legal framework and enforcement (building and zoning regulations, empowerment of control agencies, migration control, emergency laws, financial regulations)

References

(1) Metropolitan Municipality of Istanbul (2003) Earthquake Master Plan for Istanbul

(2) JICA report (2002). The Study on a Disaster Prevention/Mitigation Basic Plan in Istanbul Including Seismic Microzonation in the Republic of Turkey

(3) Google Earth

(4) Applied Technology Council (ATC): ATC-13 (1985) Earthquake Damage Evaluation Data for California, ATC-25 (1991) Seismic Vulnerability and Impact of Disruption of Lifelines in the Conterminous United States, Redwood City, CA.

(5) HAZUS (1999) Earthquake Loss Estimation Methodology, Technical Manual, RMS, NIBS and FEMA Washington DC