The interplay of multiple hazards and urban development: The context of Istanbul

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Tomorrow's CITIES
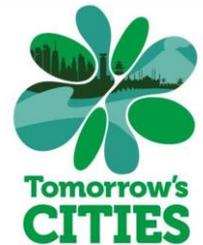
Urban growth

- >2 billion people live in cities of low-to-middle income countries exposed to multiple hazards (floods, earthquakes, landslides, volcanoes and fires).
- Expected to reach 4 billion by 2050
- Disaster Risk is a major barrier to sustainable development and poverty reduction

Urban and rural population projected to 2050, World, 1500 to 2050

Total urban and rural population, given as estimates to 2016, and UN projections to 2050. Projections are based on the UN World Urbanization Prospects and its median fertility scenario.

Number of people living in urban and rural areas, World, 1960 to 2017

Source: UN World Urbanization Prospects (2018)
Note: Urban populations are defined based on the definition of urban areas by national statistical offices.

OurWorldInData.org/urbanization • CC BY
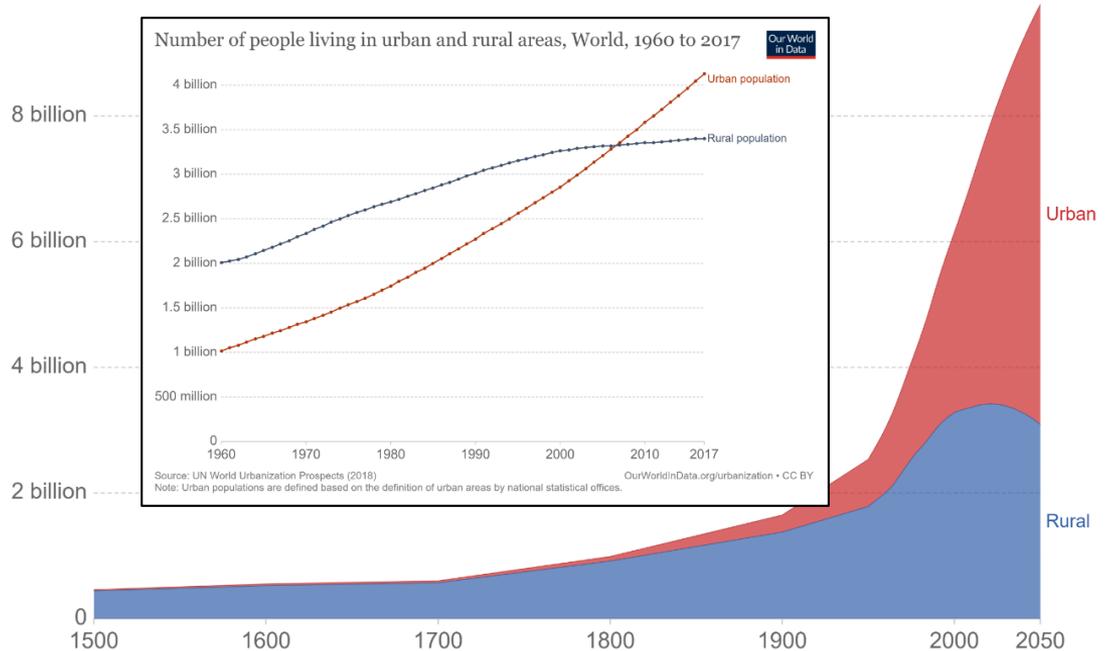
Source: OWID based on UN World Urbanization Prospects 2018 and historical sources (see Sources)

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Transforming a Challenge into an Opportunity

➤ ~60% of the area expected to be urban by 2030 remains to be built

➤ opportunity to catalyse a transition from crisis management to multi-hazard risk-informed urban planning and decision-making that strengthens the voice and capacity of the urban poor

Mission: To reduce disaster risk for the poor in tomorrow's cities

☐ Funded £20M by UKRI Global Challenges Research Fund (GCRF)

  ➢ Part of the UK AID strategy, putting research at the heart of efforts to deliver the United Nation's SDGs)

☐ A five-year global interdisciplinary research hub, one of 12 funded.

☐ Principal Investigators:

  ➢ Prof. John McCloskey, Edinburgh University
  ➢ Prof. Mark Pelling, Kings College London

☐ 38 institutions and over 150 researchers/academics
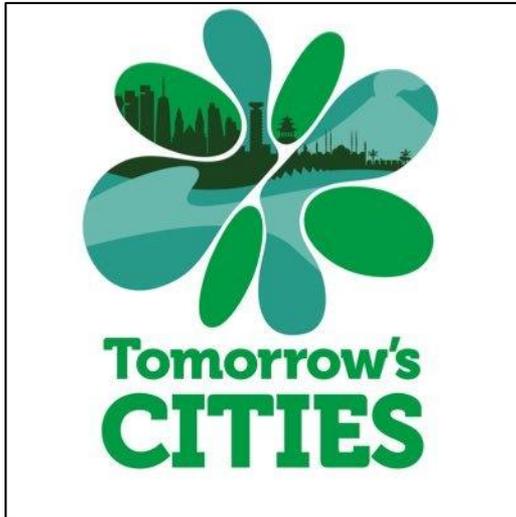
Quito, ECUADOR
2.7 million people
Growth rate: 3.4%
Volcanoes
Earthquakes
Floods
Landslides

Nairobi, KENYA
5 million people
Growth rate: 50%
Floods
Building collapses
Fires
Earthquakes

Kathmandu, NEPAL
2.5 million people
Growth rate: 6.5%
Floods
Earthquakes
Landslides

Istanbul, TURKEY
15 million people
Growth rate: 1.5%
Earthquakes
Floods
Landslides

Yarının Istanbul'u (Tomorrow's Istanbul)

City Lead: Prof. E.Çaktı   UK Coordinator: Prof. T.Rossetto

Istanbul

- Rapid growth in population from 1M in 1950 to almost 15M today and accompanying 21 times expansion in urban area

- Current population growth 1.5%, (www.tuik.gov.tr).

- **Vertical urban transformation is occurring concurrently to horizontal expansion** in order to cope with the increased housing need

- This is occurring at an extremely rapid rate, with 70% of buildings in Istanbul have been built over the last 30 years.

1975
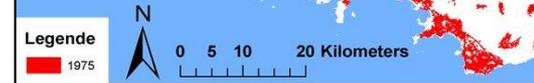
1990
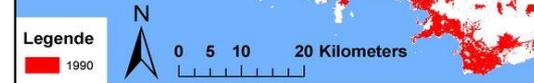
2010

Gecekondus

(Source: I.Stewart)

❑New illegal settlements started to appear in the 1950's at the then periphery

❑These were homes to the poorest migrants

❑ The Gecekondus were accepted by the city until 1980's

❑Some of these areas underwent a second phase of illegal transformation – resulting in mid- to high-rise apartment buildings constructed with minimal control or design.

❑Over time, as the city expanded, these areas find themselves near new financial and recreational centres of Istanbul – becoming desirable land

(Source: I.Stewart)

Urban renewal/transformation projects

❑Legitimised by earthquake risk and accompanying legislation

➢ e.g. Law on Transformation of Areas under Disaster Risk: Law No. 6306

❑They reshape the cities, redistributing urban resources, property and rent values

Urban renewal/transformation projects

❑The inhabitants of Gecekondus are given a flat in the new multi-storey development in exchange for their land – when successful

❑Original inhabitants do not stay and move to outskirts, as maintenance charges are high. -> Gentrification

(Source: I.Stewart)

Is urban renewal effective?

❑ Single building renewal seen to be successful but insufficient take up

❑ Area-based transformation changes the functional characteristics and social profiles of the site

❑ Lack of public participation in project proposals and implementation

❑ Although legitimised by earthquake risk considerations, are the renewal sites less risky?

  ➢ Unclear if risk information is used in their planning

  ➢ Economic drivers dictating decision making

  ➢ Safer housing but much higher occupancy

 ➢ Hazards other than earthquakes not explicitly considered

Horizontal expansion of the city - West Istanbul

LAND USE CHANGE in ISTANBUL

	2006-2012	2012-2018
ISTANBUL	29740,73	22075,47
WEST ISTANBUL	10311,31	4681,62 (Hectares)

ISTANBUL ■ WEST ISTANBUL

(Source: E. Yahya Menteşe)
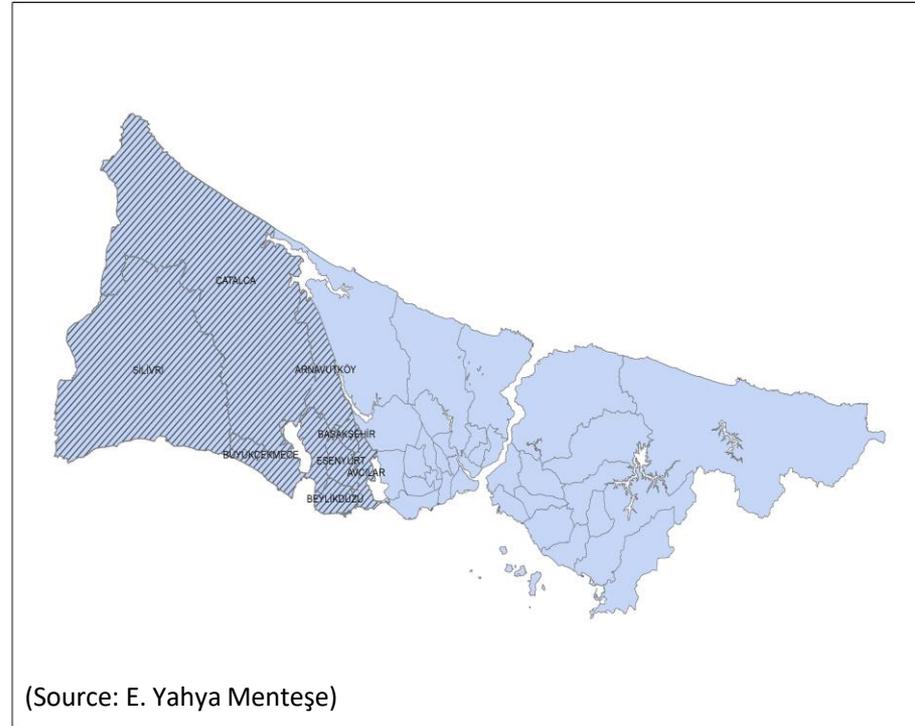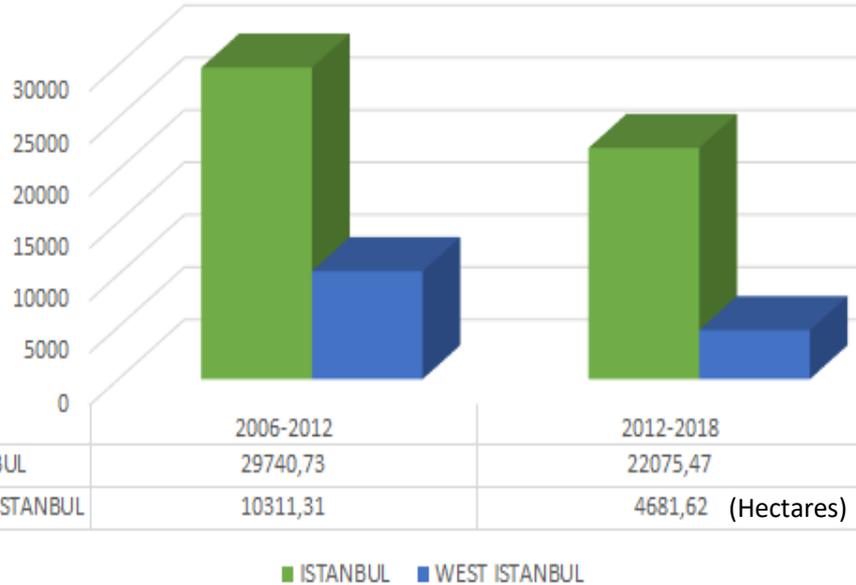
West Istanbul – Land use change 2012-18
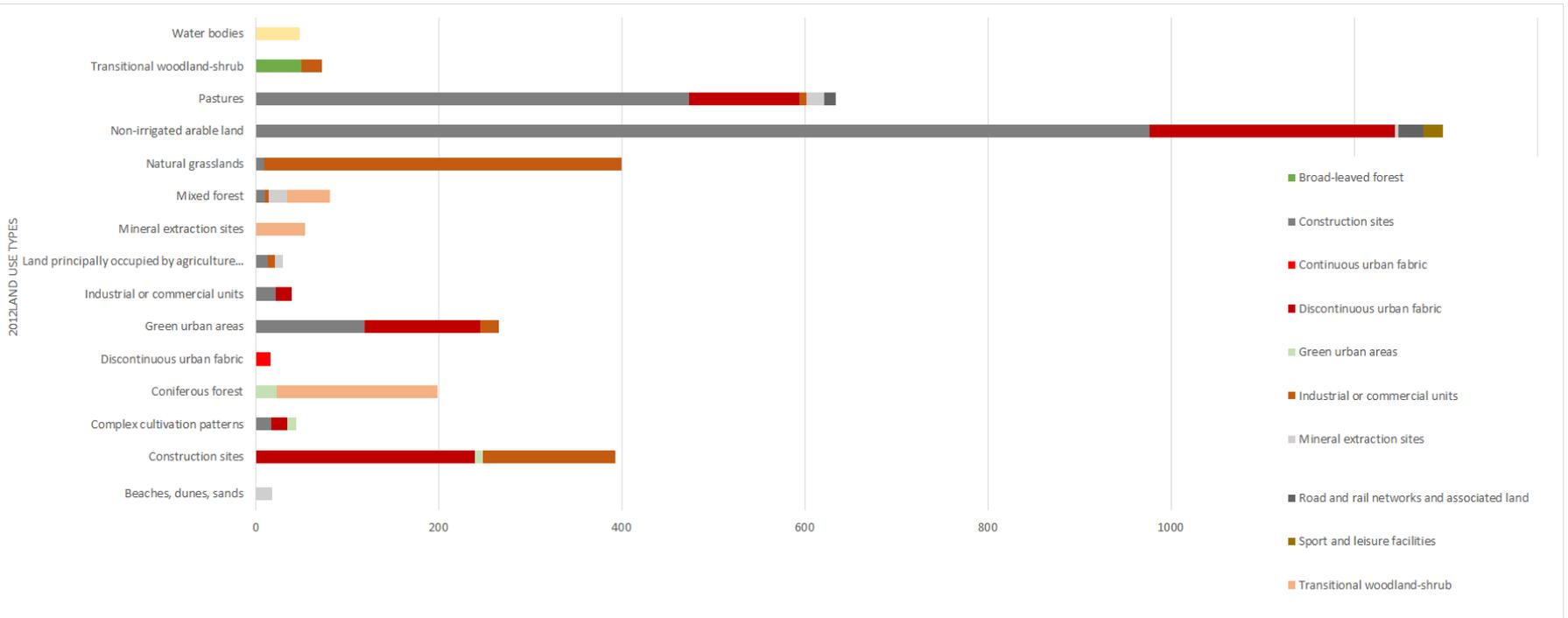
(Source: E. Yahya Menteşe)

Social vulnerability

- Many of the most vulnerable communities are settled in the fringes of the city.
- Since the 1990s, investors have focused on maximising urban rent, and this has created a 'new poor' whose share of wealth has been significantly eroded due to high rent payments for shelter
- The decline in permanent / secure jobs and persistence of fragmented (unstable) labour markets, has reduced the life chances for large sectors of the population without education or professional skills.
- Recent migrants tend to have little access to welfare

Low income alone is not able to represent social vulnerability in Istanbul

The Istanbul Hub - Phase 1 (02/2019-05/2021)

Move towards the Hub vision through

➢ 1. Understand - defines the boundaries and constraints within which hazard resilient urban development can be enacted

  ➢ Analysis of urban governance, and urban transformation processes
  ➢ Historical analysis of past disaster management (i.e. FORIN analysis)
  ➢ Community level surveys

➢ 2. Model - New hazard, fragility and consequence models.

  ➢ Improving earthquake and landslide hazard models/knowledge in Istanbul,
  ➢ New fragility models for common high-rise housing for earthquakes and fire.
  ➢ Modelling disruption to transportation system for multiple hazards

➢ 3. Communicate - Integration of multi-disciplinary concepts and risk communication.

 ➢ Resilient Urban Development Decision Support Environment (RUD-DSE)

A few examples of research conducted

Seismic Hazard – builds on in-country expertise

Development of advanced ground motion models of Istanbul, by combining two modelling approaches
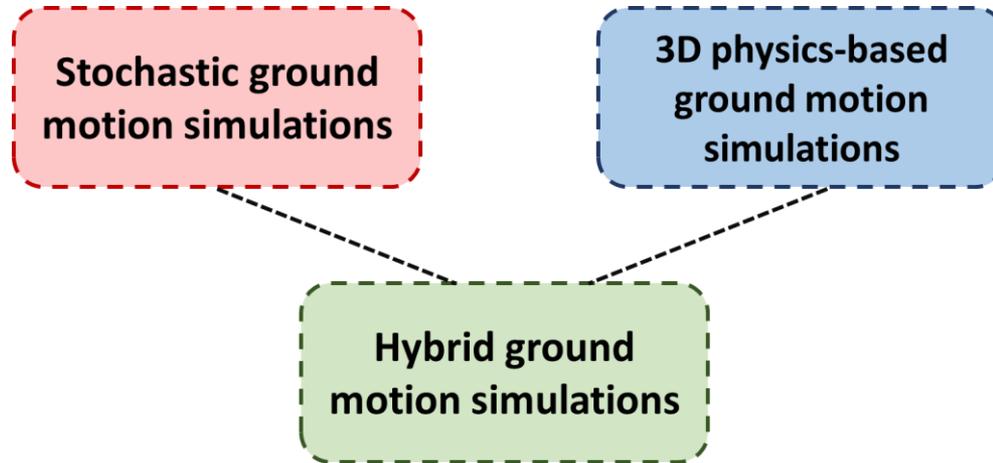

Source: E. Cakti, K. Şeşetyan, M. Çağlar, N. Yenihayat, H. Süleyman

3d Model

- Develop an advanced 3D seismic model of Istanbul, which accounts for
  - the characteristics of fault rupture scenarios in modelling,
  - including 3D geometry of sub-surface layers
  - the surface topography
- The validated, 3D physics-based ground-motion simulations will provide a more accurate and spatially more precise measure of ground shaking for future major earthquakes.

Source: E. Cakti, K. Şeşetyan, M. Çağlar, N. Yenihayat, H. Süleyman
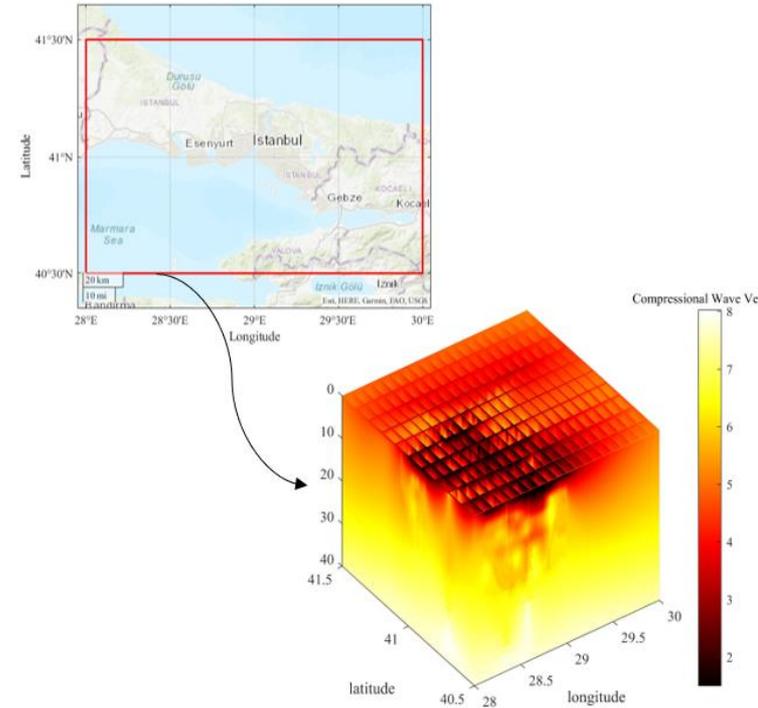
Demonstration of some sections from the prepared 3D velocity model.

Simulations to be carried out on the unruptured segments of NAF in the Marmara Sea
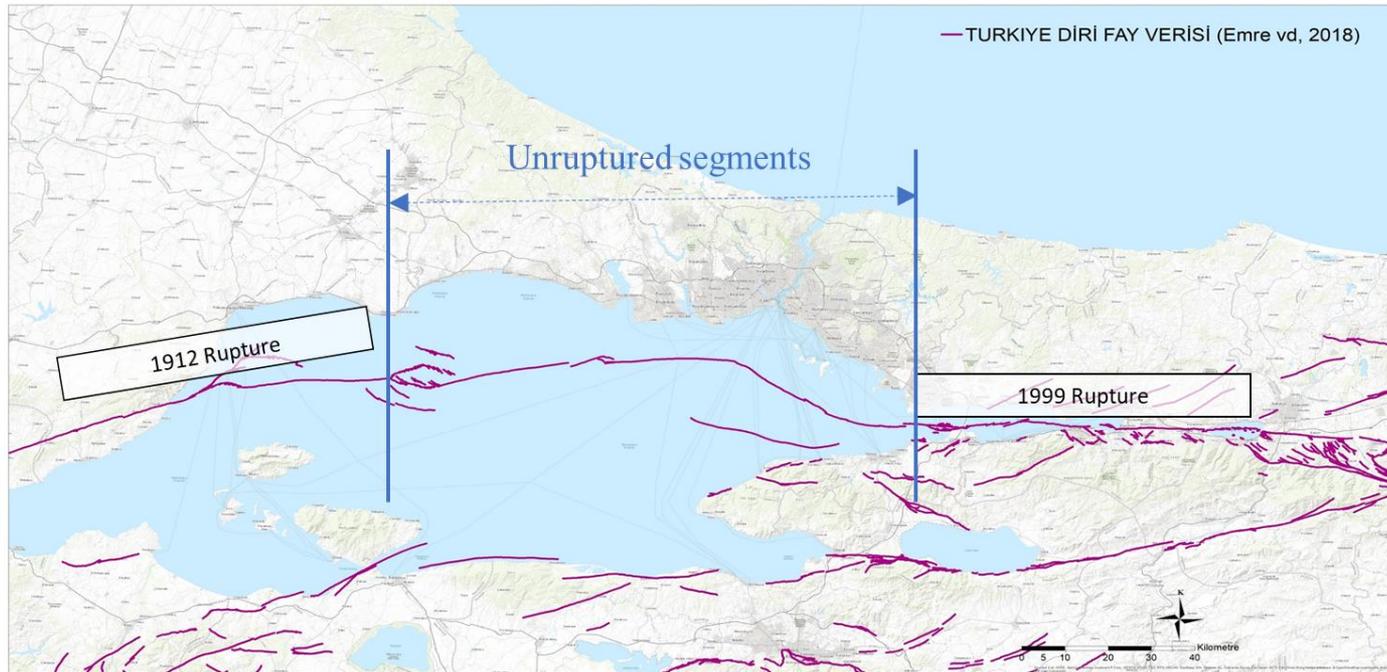

Source: E. Cakti, K. Şeşetyan, M. Çağlar, N. Yenihayat, H. Süleyman

EQ triggered landslides – West Istanbul
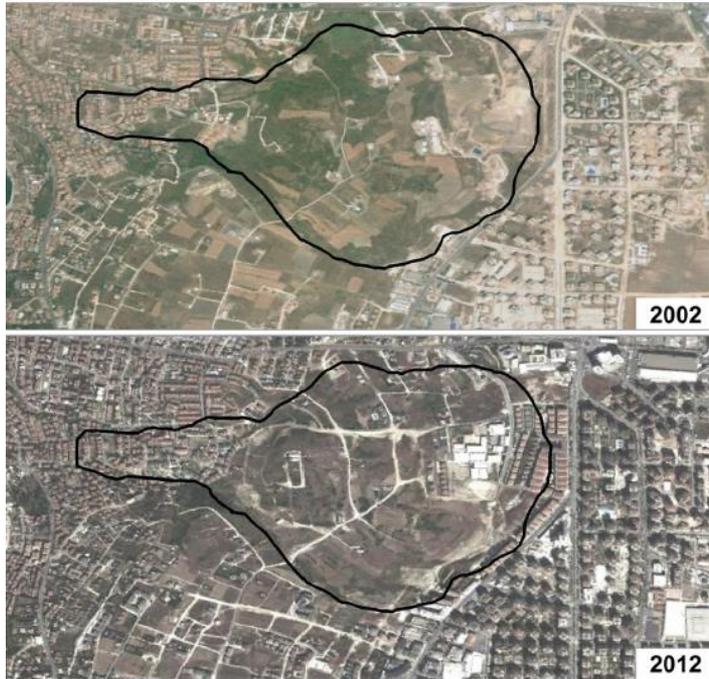
Satellite images Area's urbanisation (Martino et al. (2018))
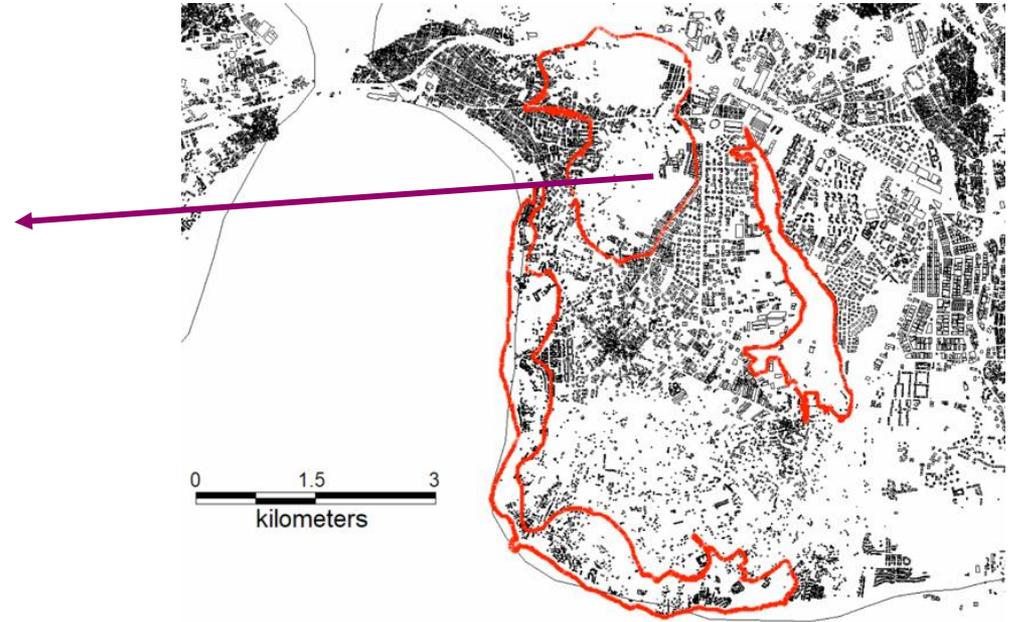
Know landslide risk zones and 2019 building inventory (Source: IMM)

EQ triggered landslides
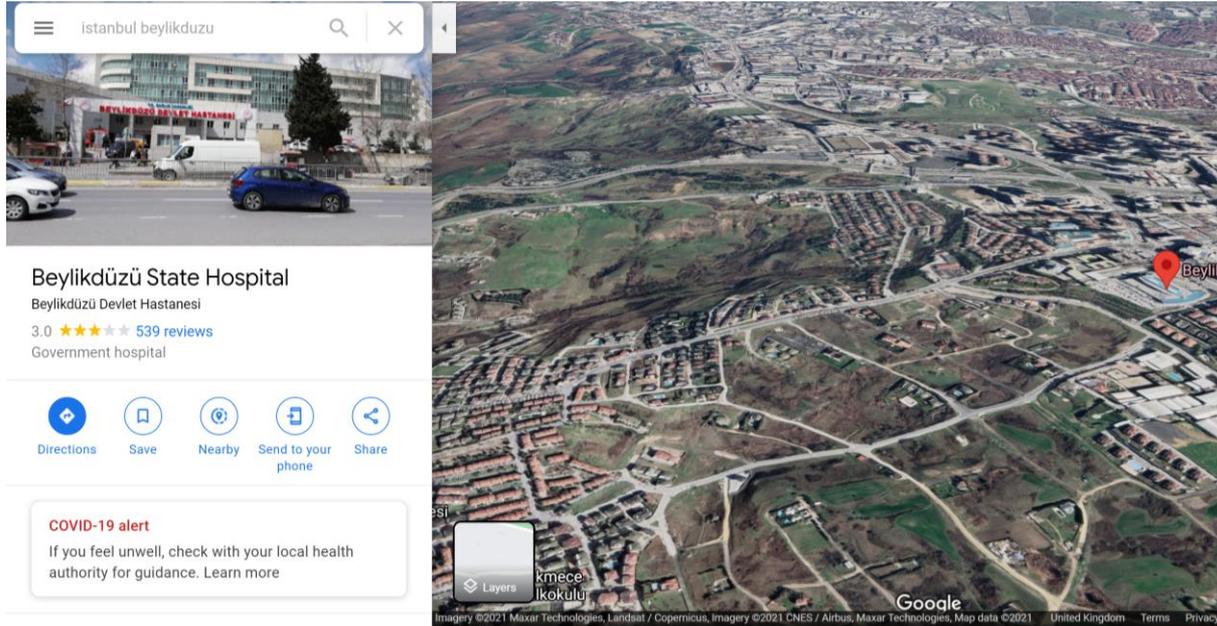
(Source: Google maps)

*Observed damage on site: Martino et al. (2018), Kaya & Gazioğlu, (2015)*

EQ triggering of landslide

- The landslide is moving at approx. 24mm/year

- From Limit Equilibrium Method analyses, a small to moderate earthquake will trigger the landslide (> 0.2g)

- Detailed simulations being conducted

- As further urbanisation occurs at the top of the landslide, added weight will increase landslide risk!

- Aim to create an evidence base to help IMM maintain these areas as "no build"
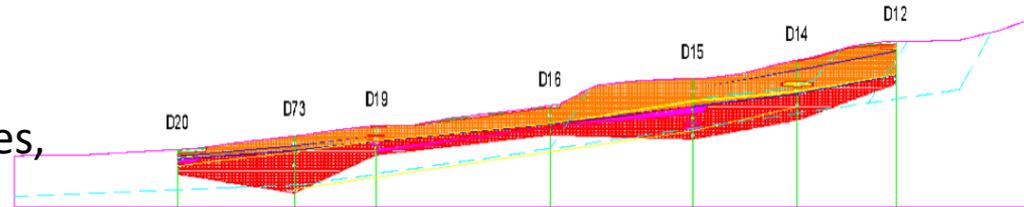
Source: U. Celep, E. Cakti, M.Kontoe, S.Lopez-Querol, T.Rossetto

EQ response of tunnel-form buildings
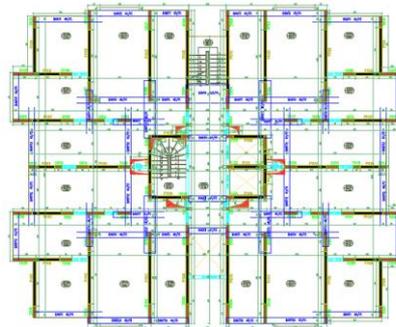
➢ Built since 1980s and widely used to construct multi-storey, multi-unit residential buildings in public- and privately-sponsored housing projects.

➢ Have been used as permanent housing units in post-earthquake reconstruction programs.

➢ 10-30 stories

➢ Lack of specific design standards

➢ Lack of past earthquake experience

(Source: U. Hancilar, E. Safak, S. Dede)

Tunnel Form Buildings by KİPTAŞ (construction company of the IMM)

➢ In 22 neighbourhoods both on European Asian sides

➢ Constructed since early 1990s

➢ Constitute more than 60,000 housing units in total

➢ The walls and the slab are cast in a single operation using specially designed half-tunnel-steel forms (upside down U shape).

➢ The forms are positioned, steel reinforcement is fixed and concrete poured.

➢ The next day when the concrete has hardened to around 60%, the tunnel forms are removed, and positioned for the next days work.

Complex FE model calibrated with vibration measurements

OpenSees Model

C1 BLOK, ROOF, E-W DIRECTION, STATION 2

FOURIER AMPLITUDE SPECTRA
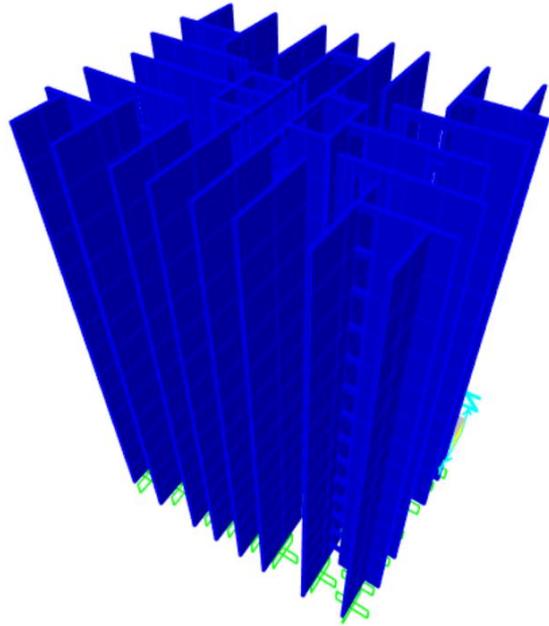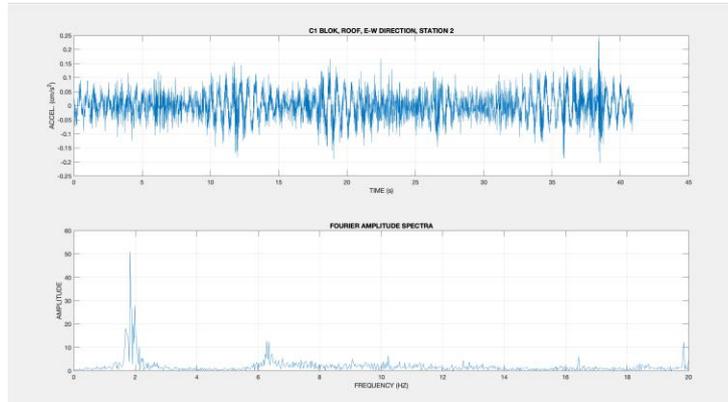
➤ Dominant Torsional Mode at around 2.0 Hz

➤ NLTHA for fragility analysis being conducted

➤ Damage starts at PGA's of 0.5-0.6g

➤ Damage observed – yielding of boundary elements and webs of some walls and shear failure of some walls

➤ Lessons on EQ risk and improved design to be fed to Chamber of Engineers

(Source: U. Hancilar, E. Safak, S. Dede)

Resilience of transport networks

- Primary hazards: earthquakes and landslides
- Dense developments in Istanbul:
  - In addition to structural damage, traffic disruptions by debris generated from adjacent buildings and overpasses
- Bayesian Network – based model has been built for a case study area (Kadıköy and Üsküdar Districts)
  - 10,063 roads, 54 bridges, 36,921 buildings
  - New EQ fragility functions for overpasses have been developed – to be included
  - Uncertainty in hazard, fragility and consequences accounted for

(Source: J-E Byun, D. D'Ayala)
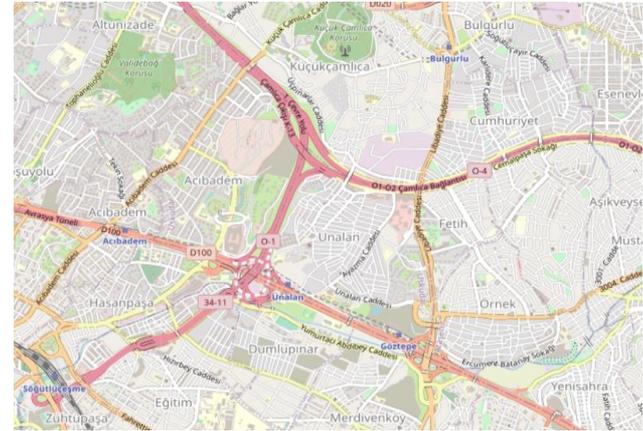
(above) Roads map
(Source:OpenStreetMap)

(below) Satellite imagery
(Source: Google Maps)

Graphical Structure of BN

Hazard

Structural damage → Recovery

Traffic capacity of roads

System performance

Time

Resilience measure

(Source: J-E Byun, D. D'Ayala)

Ground displacement by landslides

Ground motion

Paved roads

Bridges

Buildings

PGD_s

GM_s

$PD_{s,q}$ $PR_{s,q}$ $\{q\}_{q=1}^{Q_s^P}$

$BrD_{s,q'}$

$BrR_{s,q'}$

$BlD_{s,q''}$ $\{q''\}_{q''=1}^{Q_s^{Bl}}$

$BrC_{s,q}$ $\{q'\}_{q'=1}^{Q_s^{Br}}$

$\{s\}_{s=1}^S$

Traffic capacity model

BlC

Structural repair

$CF_{r,t}$ $\{r\}_{r=1}^R$

Debris clearance

System performance: Maximum flow to arterials

SF_t $\{t\}_{t=1}^T$

Resilience loss

Original flow

Time

Vl

* Connection from each parent node to:
→ all child nodes
--→ a single child node
⇒ some child nodes

BN Resilience Loss

- The map reveals the inequal distribution of resilience loss (days to restoration).

- Two significant factors are identified: Network topology and building density

- Looking to integrate social factors into the model and consequences for modes of transport used by vulnerable groups.

- Looking to assist the development of IMM's new "Sustainable Urban Mobility Programme"

(Source: J-E Byun, D. D'Ayala)

Entrance to arterials

(ratio × day)

≥ 22
21
20
19
≤ 18
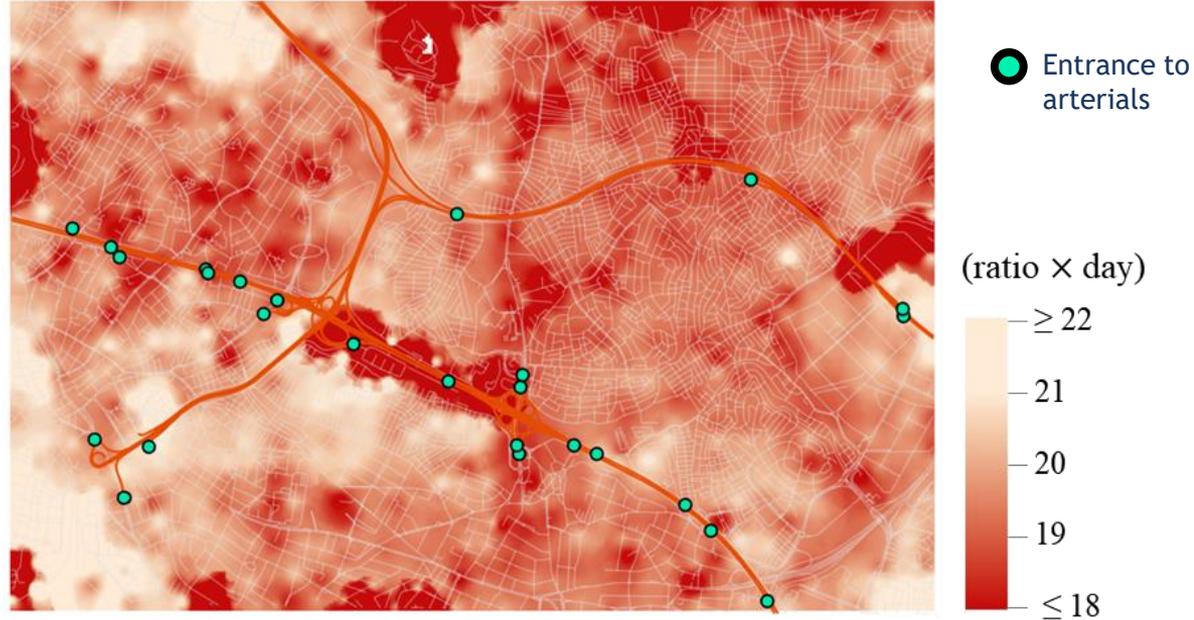
Disaster Risk Communication Stakeholder Workshops

- Planners / Media / Academia

- *How do they access risk data?*

- *What do they understand from risk data?*

- *How do they use risk data?*

- *What are their expectations for using risk data?*

Main Findings

- Limited access to risk information
- Planners find it hard to access accurate and trusted risk data.
- Media can't access to correct academic experts. Therefore they are proceeding with "who they can find in the market".
- Current political climate is too difficult to establish an efficient communication environment.
- There is a need of communication tools and/or mechanisms that enables and increases the access to risk information

(Source: E. Yahya Menteşe, I. Stewart, E. Cakti)

RUD-DSE

Resilient **U**rban **D**evelopment **D**ecision **S**upport **E**nvironment

Prototype an environment for all stakeholders to access risk information within an interactive and efficient online platform

(Source: E. Yahya Menteşe, I. Stewart, E. Cakti)

ISTANBUL HUB RUD-DSE Concept Matrix

Phase	Acquire	Analyze	Communicate
Output	Raw data sources / HUB Database	New methods / Analysis results	Communication tools & strategies
Context	IMM database, KOERI database, OPEN Datasets, HUB Datasets	Hazards, Exposure, Vulnerabilities, Risk	GIS, Interactive scenario games, Flyers, Reports, Narratives, Exhibitions
Audience	Researchers	Researchers Technocrats	Researchers Technocrats Decision-makers Communities

Cross cutting actions
- Describe (metadata & documentation)
- Manage quality
- Backup and secure
- Learn from feedbacks, update and renew

VR simulation

- Context specific
- Science and engineering based immersive film

(Source: i. Stewart)

- ❑Creating a multi-disciplinary research environment
- ❑A partnership of trust
- ❑For the first time, the Turkish Government and agencies are requesting advice from the social scientists in the Istanbul Hub
- ❑Strong engagement with IMM and with Büyükçekmece District Municipality

Impact

- ❑Potential to influence IMM Sustainable Urban Transportation Plan and risk communication approaches

………..Despite COVID!!

UK Overseas Development Aid (ODA) Cuts

❑ In March, the UKRI said its funding for international development research projects had been cut from £245m to £125m, following a Government decision to reduce ODA.

❑ Much of that funding is spent through the Global Challenges Research Fund (GCRF), set up to address some of the biggest global challenges for low-income countries

❑ Cuts made to ALL active GCRF projects – not just stopping the start of new grants

❑ The Tomorrow's Cities Hub budget for 2021-22 was cut from £5M to £1.4M - resulting in approximately 70% of employed researchers being made redundant.

The Future

❑Decisions were made by Hub management to focus efforts in Kathmandu and Nairobi, with skeleton crews remaining in Quito and Istanbul in 2021-22.

❑These cuts came at a time where strong partnerships of trust had been built.

❑We don't know the future of the Hub beyond 2022.

❑We are not giving up!

THANK YOU! ....See you in Athens in 2022!

Prof. Tiziana Rossetto

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www.ucl.ac.uk/epicentre