Towards a rapid, multi-scale assessment of earthquake vulnerability
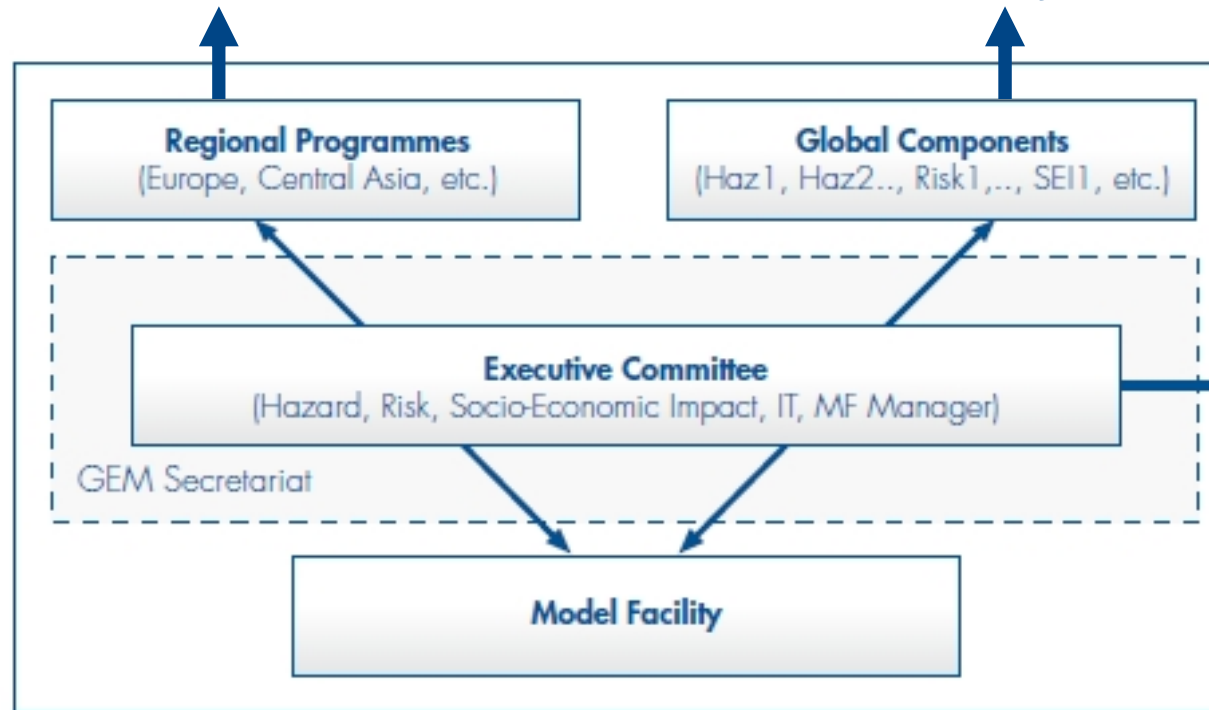
based on satellite remote sensing and omnidirectional imaging

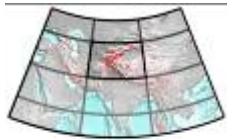M. Wieland, M. Pittore, S. Parolai, J. Zschau
GFZ Potsdam, Section 2.1 Earthquake Risk and Early Warning

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•**www.globalquakemodel.org**

Uniform And Open Standards To Calculate And Communicate Earthquake Risk Worldwide

Earthquake Model Central Asia (EMCA)

Inventory Data Capture Tools (IDCT)

Regional Programmes
(Europe, Central Asia, etc.)

Global Components
(Haz1, Haz2.., Risk1,.., SEI1, etc.)

Executive Committee
(Hazard, Risk, Socio-Economic Impact, IT, MF Manager)

GEM Secretariat

Model Facility

ImageCat, Inc.

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

OPENGEO

CAMBRIDGE ARCHITECTURAL RESEARCH LIMITED

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EMCA
EARTHQUAKE MODEL CENTRAL ASIA

Coordinated by GFZ Potsdam
www.emca-gem.org

GSHAP (1999)
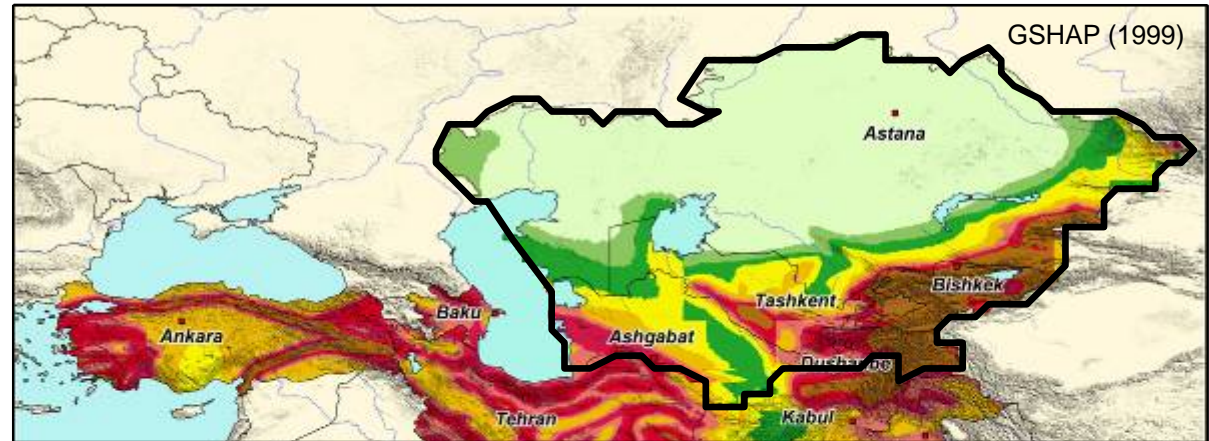
Seismic Risk

Seismic Hazard
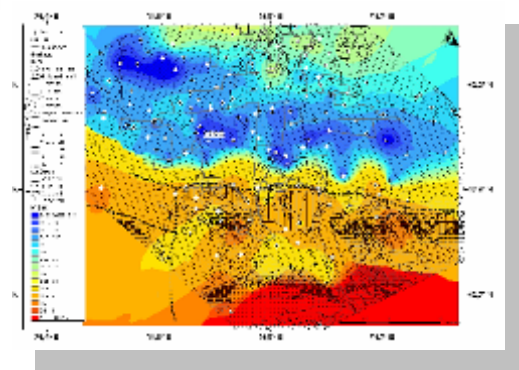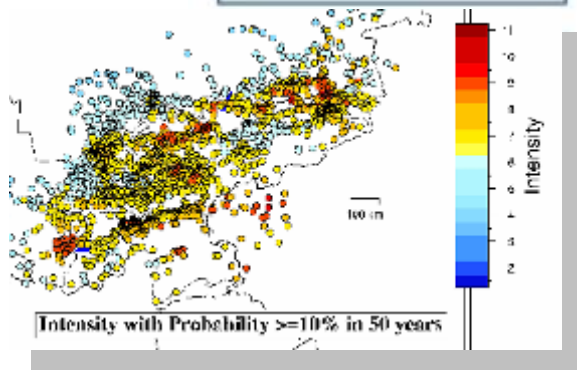
Exposure

Vulnerability

Intensity with Probability >=10% in 50 years

Motivation

> **Seismic vulnerability of buildings** is a key component in risk assessment.

> Best results come from a thoroughly (outside and inside) assessment of a building by experts, **but:**

Rank	Megacity	Country	Continent	Population	Annual Growth
1	Tokyo	Japan	Asia	34,000,000	0.60%
2	Seoul	South Korea	Asia	24,200,000	1.40%
3	Mexico City	Mexico	North America	23,400,000	2.00%
4	Delhi	India	Asia	23,200,000	4.60%
..	…	…	…	…	…
11	Osaka	Japan	Asia	16,800,000	0.15%
12	Kolkata	India	Asia	16,300,000	2.00%
13	Karachi	Pakistan	Asia	16,200,000	4.90%
14	Jakarta	Indonesia	Asia	15,400,000	2.00%
15	Cairo	Egypt	Africa	15,200,000	2.60%

Karachi: Next year: ~ 800,000 people more.
Over ~ 170 km² of new urban areas.
In next 5 years the equivalent of Berlin area.

source: Brinkhoff 2010

> **Inventory data** is often out-of-date, spatially fragmented or highly aggregated.

> **Need for new approaches** to estimate building inventory and thus vulnerability in a rapid, standardized, comparable and scalable way.

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Vision

> A **rapid visual survey** can lead to a reasonable first assessment over broad areas.

> By coupling remote sensing (topview) with omnidirectional imaging (streetview), this could be done in an optimal way (in terms of time and resources).

source: www.digitalglobe.com
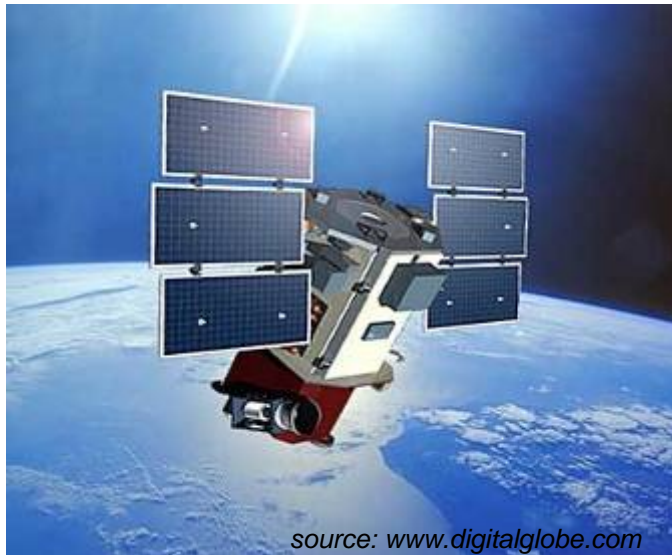
> **Open-source** tools, **low-cost** data sources.

> **Globally applicable** on regional and local scale.

Overview of the approach
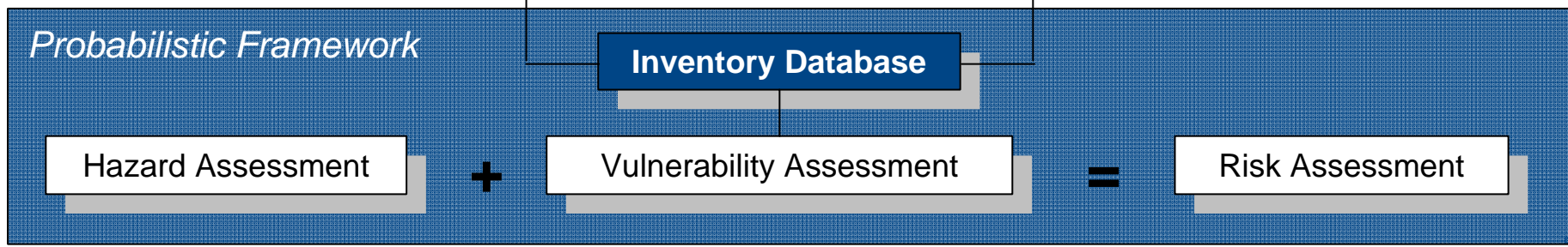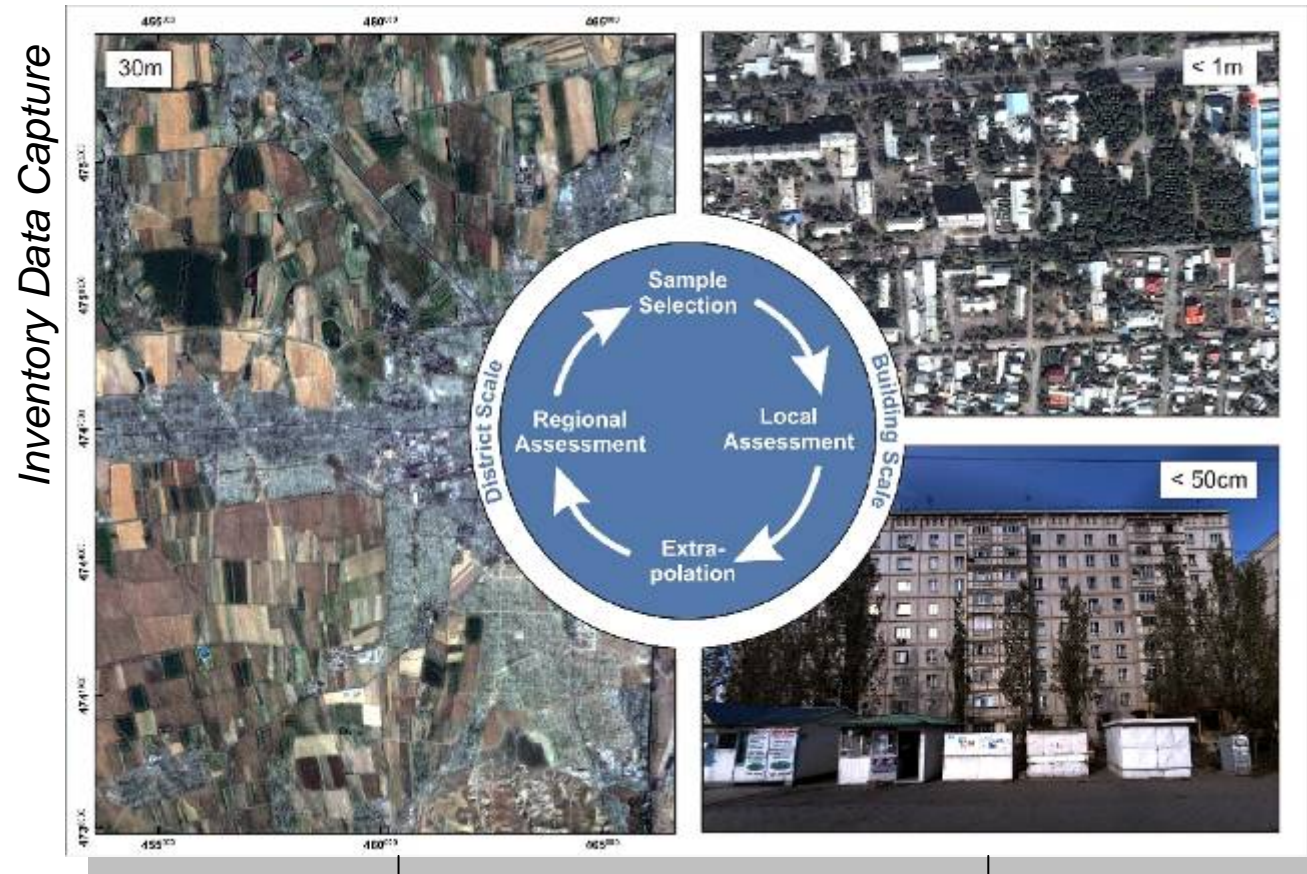
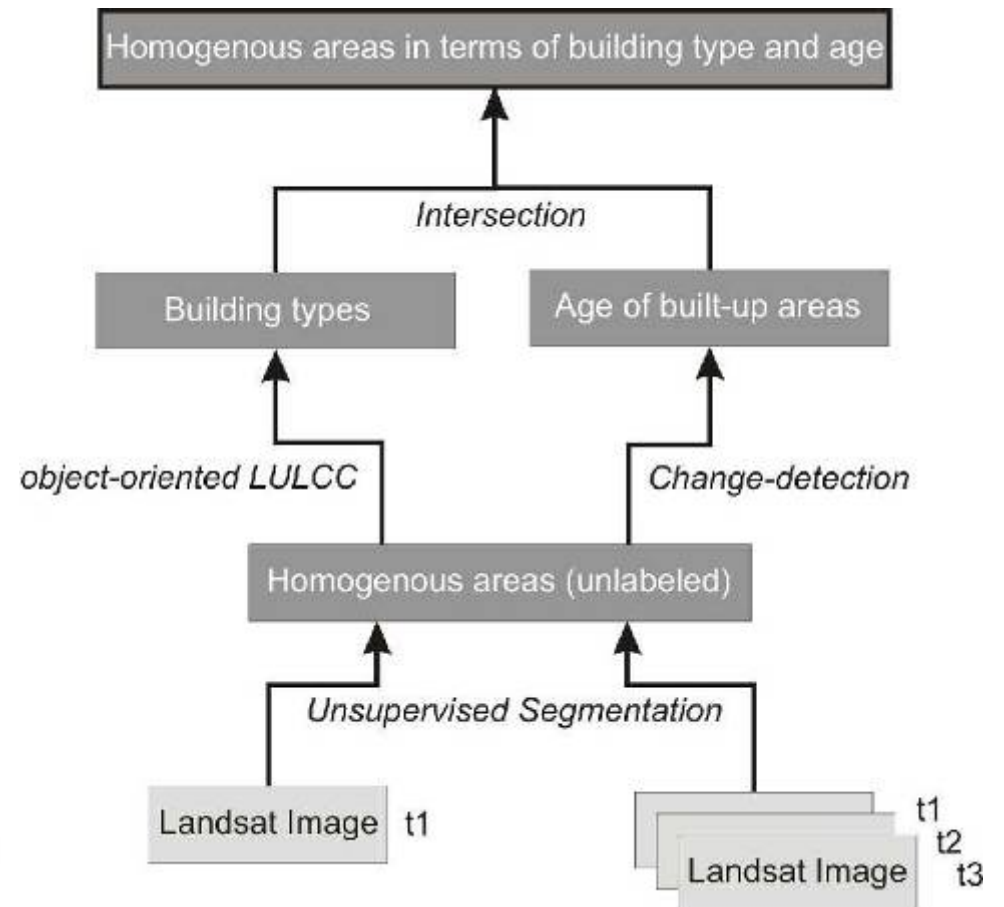## Analysis of medium-resolution satellite images

Stage of Stratification
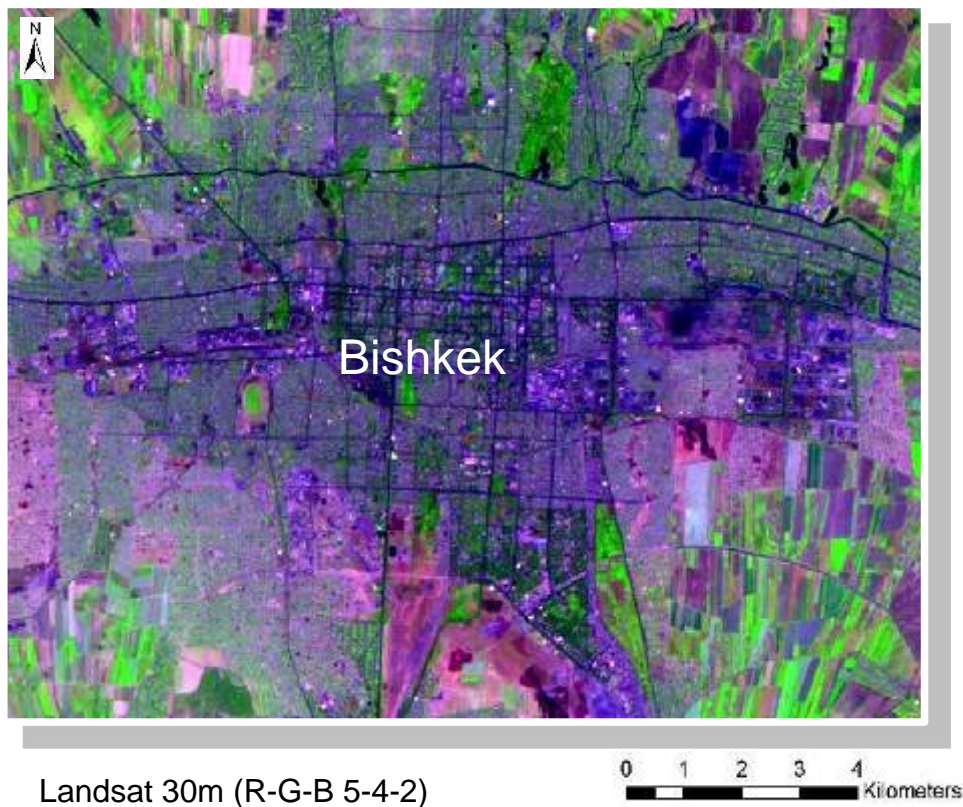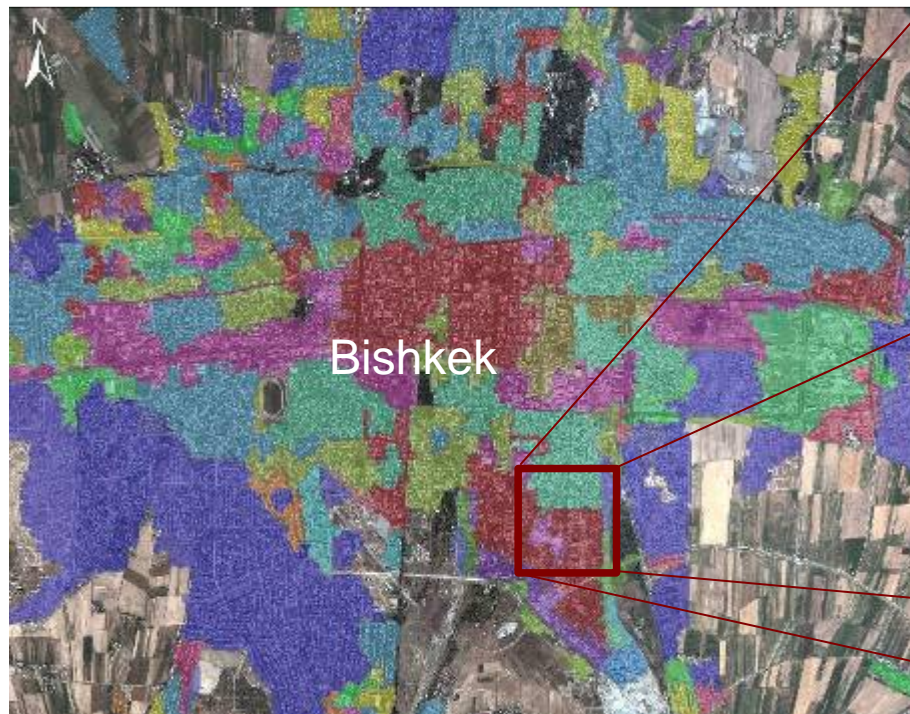
Workflow / Results

Pixels

Landsat 30m (R-G-B 5-4-2)

Pixels → Segments → Thematic classes → Urban Structure Types

Analysis of medium-resolution satellite images

Stage of Stratification

Urban Structure Types

Bishkek

Urban Structure Type: 10
Type: 3-6 storey brick, concrete, panel
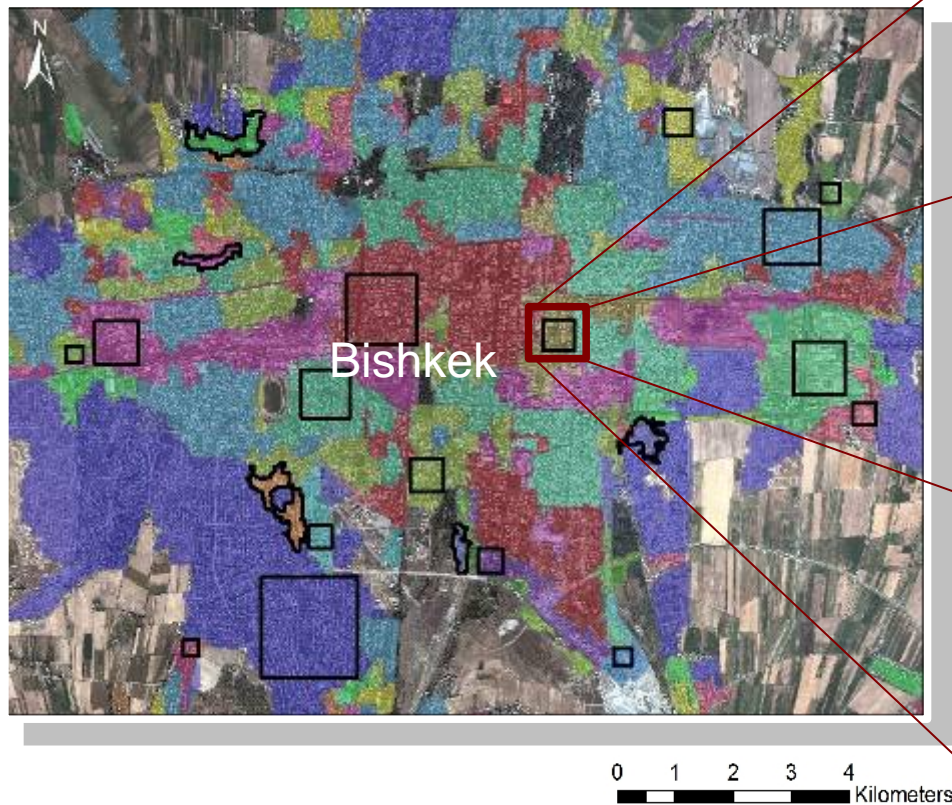Age: built before 1977

Urban Structure Type: 16
Type: industrial, commercial
Age: built before 1977

Urban Structure Type: 8
Type: 1-2 storey masonry, brick
Age: built between 1994 and 2009

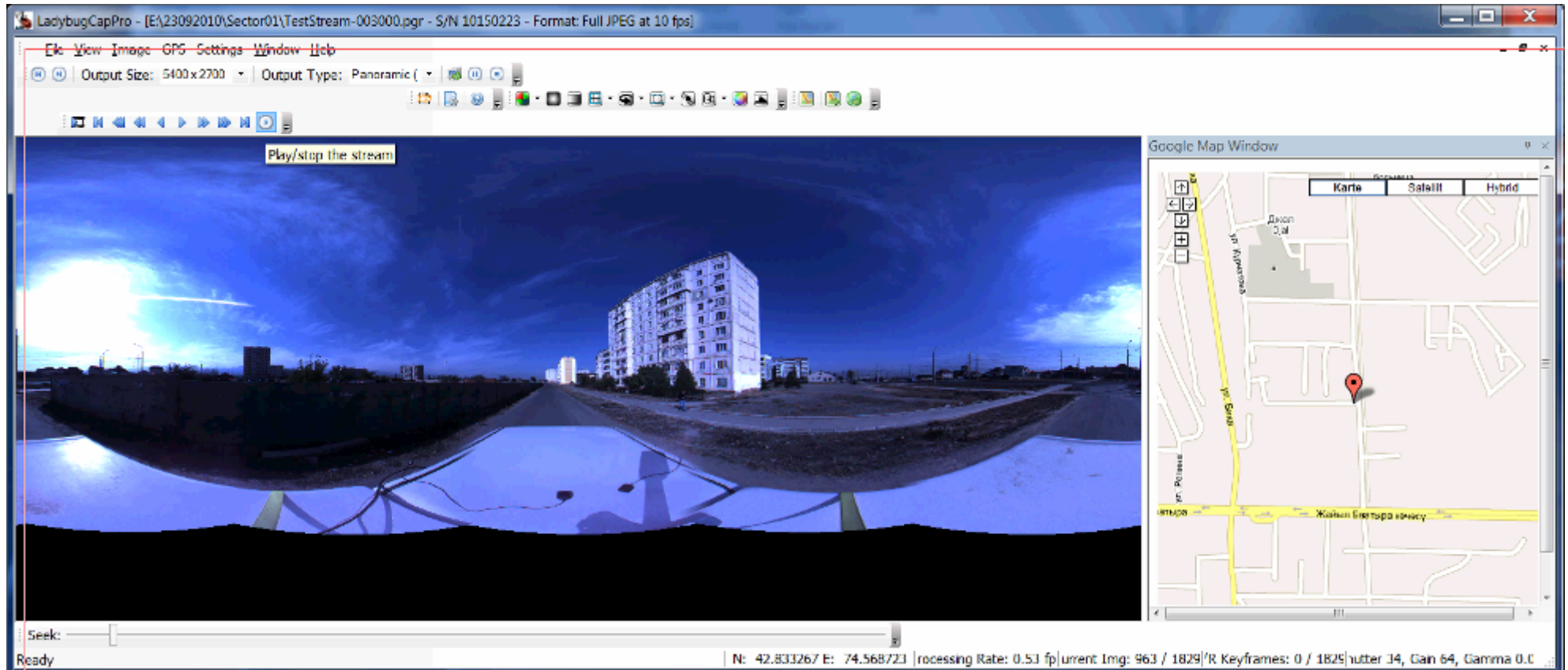## Stratified sampling and analysis of high-resolution satellite images

Extraction of building footprint and location

Sample areas

Quickbird R-G-B (3-2-1)

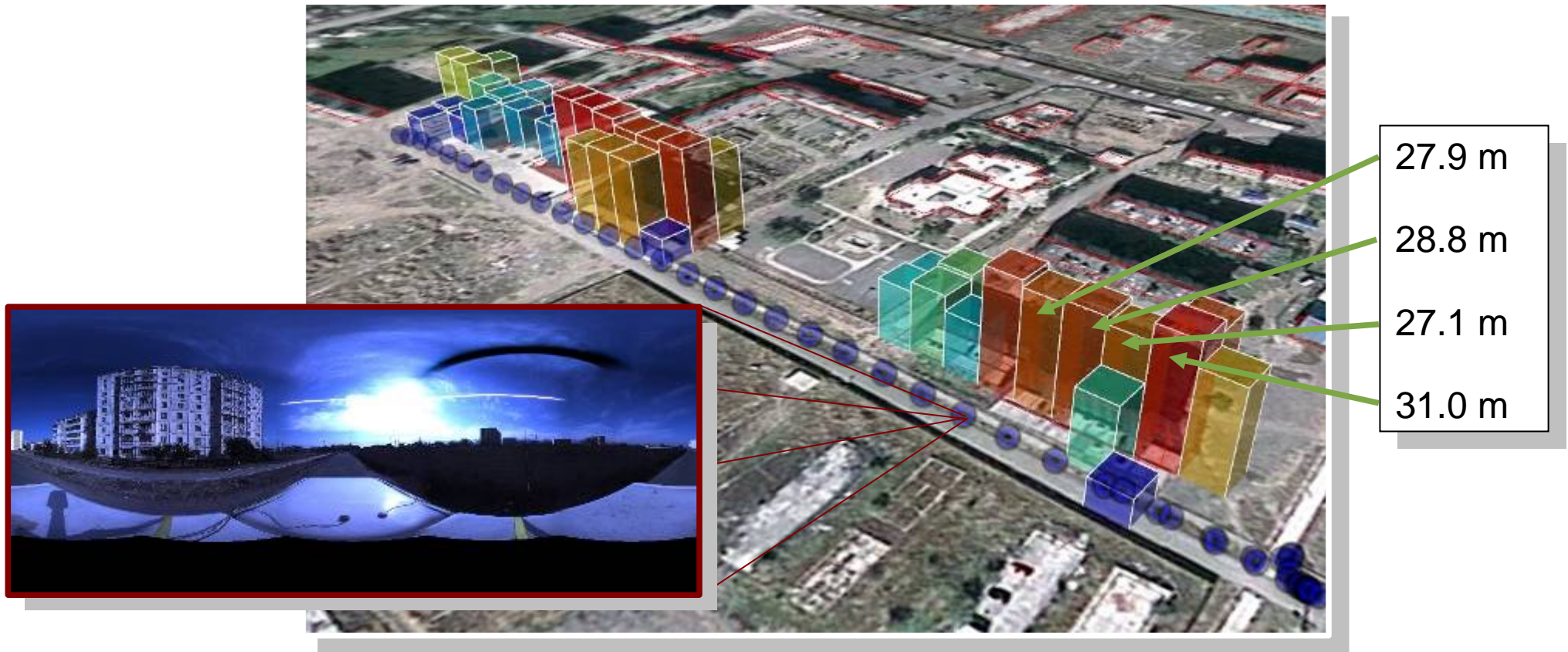*Building shape, area, roof-type, roof-color/-material, etc.*

Acquisition and analysis of high-resolution omnidirectional images

Omnidirectional image stream (Bishkek 2010)

# Acquisition and analysis of high-resolution omnidirectional images

Automated height measurement from 3d-points

27.9 m

28.8 m

27.1 m

31.0 m

Vertical shape, soft-storey detection, no. of windows, etc.
*+ manual image interpretation by local (+global) experts from civil-engineering*

Data integration

- ➢ *Priors* **from medium-resolution satellite images:**
  - ➢ Estimated Age
  - ➢ Land-Use / Land-Cover

- ➢ **Information from high-resolution satellite images:**
  - ➢ *Building footprints*
  - ➢ *...*

- ➢ **Information from omnidirectional images:**
  - ➢ *Estimated Height of Structures*
  - ➢ *...*

- ➢ *Priors* **from manual data entry:**
  - ➢ Expert knowledge
  - ➢ Ancillary data
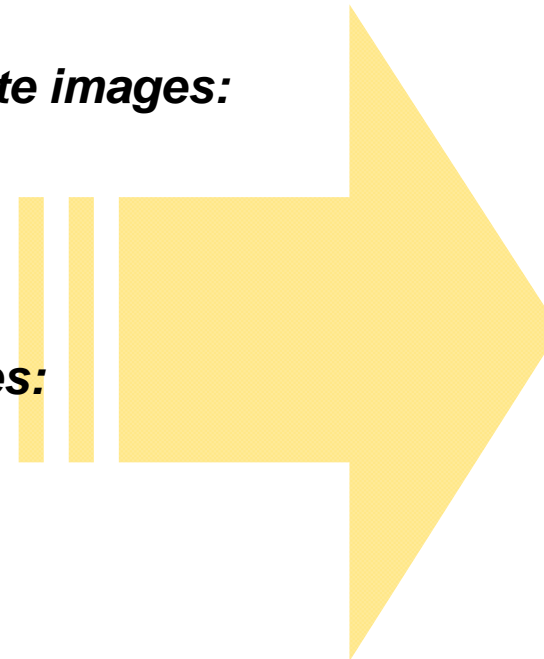
VULNERABILITY

Vulnerability estimation (EMS-98): Bayesian Network
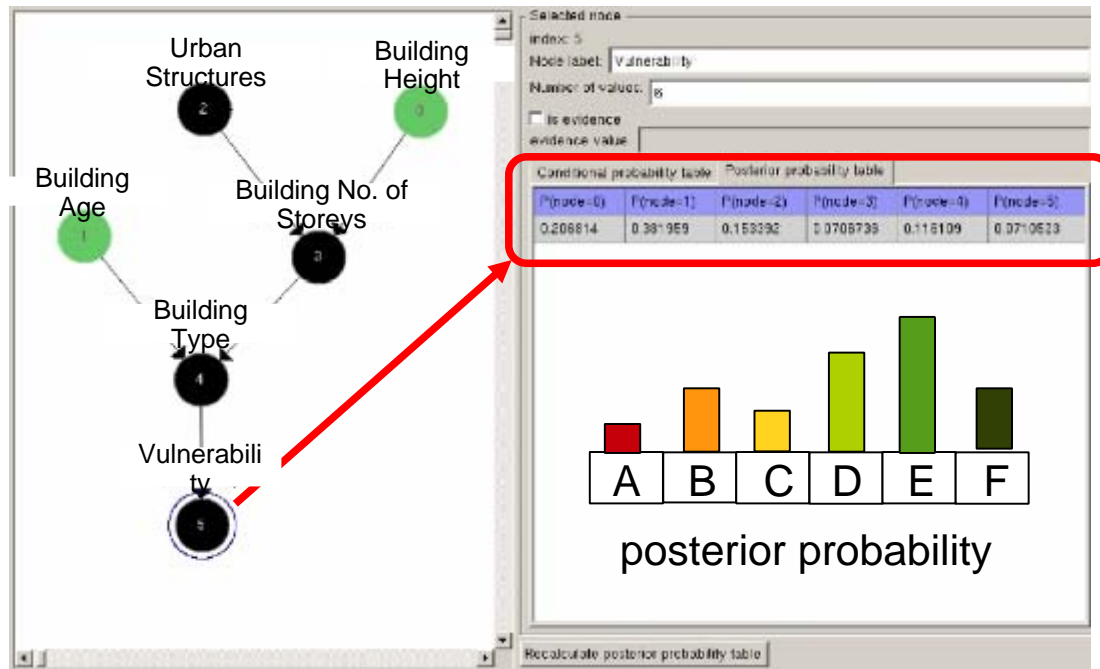
Age: 1994-2009
No. of storeys: 9
Type: 5-9 storey,
concrete, panel, frame
Vuln: E

source: earth.google.com

Conclusion

- Stratified **sampling** using remote sensing helps to focus local analysis.
- Omnidirectional imaging: **fast** deployed, **easily** operated.
- **Feature extraction** from multiple image sources proved successful**.**
- Bayesian approach to **data integration** seems promising.

- Approach is **scalable**, flexible and transferable.
- Acquisition **time and costs** could be significantly reduced.

- Need to further strengthen the use of **open source** GIS and RS software.
- Need to improve **geo-data access** already in the pre-disaster phase.
- Global initiatives need interaction with **local experts**.

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Thank you for your attention!