

Spatial Correlation between Land Subsidence and Flooding in Urban Areas of Indonesia

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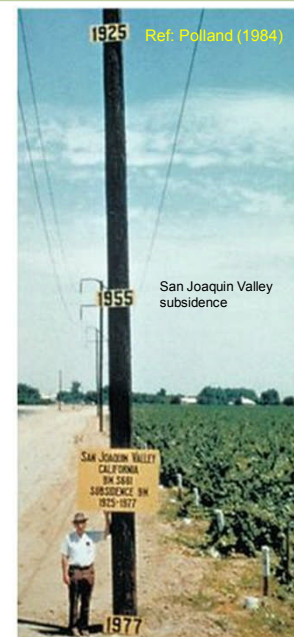
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Land Subsidence

- **Land subsidence** is the downward displacement of the land surface relative to certain reference surface, such as mean sea level (MSL) or reference ellipsoid.
- It may **occurs** in active volcanic and tectonic areas, mining areas, oil and gas exploration areas, and large urban areas.
- Can be **caused** by natural and/or human activities.



Hasanuddin Z. Abidin, 2012

Land Subsidence

Types of Subsidence in large Indonesian cities :

- subsidence due to groundwater extraction,
- subsidence induced by the load of constructions (i.e. settlement of high compressibility soil),
- subsidence caused by natural consolidation of alluvium soil, and
- tectonic subsidence.

Hasanuddin Z. Abidin, 2006

Land Subsidence in Indonesian Cities



Observed land subsidence :

- Jakarta
- Bandung
- Semarang

Expected land subsidence :

- Surabaya
- Denpasar
- Cilegon
- Medan

*observed decrease
in groundwater level*

Hasanuddin Z. Abidin, 2011

Geodetic Methods for Land Subsidence Monitoring in Urban Areas of Indonesia

City	Leveling	GPS	InSAR	Gravity
JAKARTA	Since 1982	Since 1997	Since 2005	Since 2008
BANDUNG	Limited	Since 2000	Since 2007	Since 2008
SEMARANG	Since 1999	Since 2008	Since 2007	Since 2002

GRD of ITB mainly involved with GPS Surveys and InSAR.

Hasanuddin Z. Abidin, 2012

IMPACTS OF LAND SUBSIDENCE IN URBAN AREAS (CITIES)

Cracking of buildings and infrastructure	The wider expansion of inland & coastal flooding areas	Malfunction of drainage system
Increasing the maintenance costs for the affected buildings and infrastructure		Changes in river canal and drain flow systems
Lowering the quality of living environment and life (e.g. health and sanitation condition) in the affected areas		

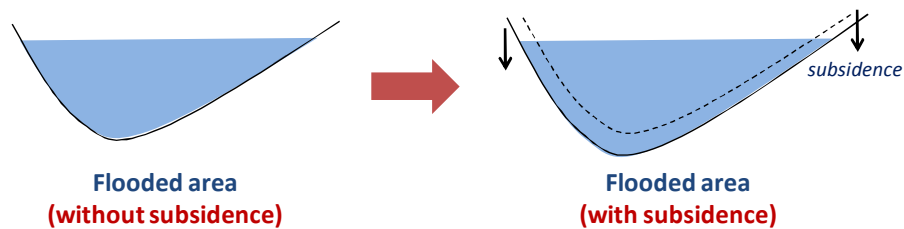
Hasanuddin Z. Abidin, 2012

Land Subsidence and Flooding in Indonesian Cities



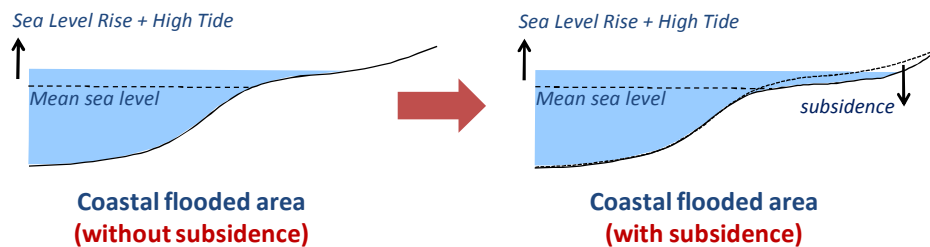
Flooding	Jakarta	Bandung	Semarang
Coastal	√√	X	√√
Inland (Riverine)	√√	√	√

Land Subsidence and Flooding (1)



*Expanded coverage and deeper water depth
of flooded (inundated) areas*

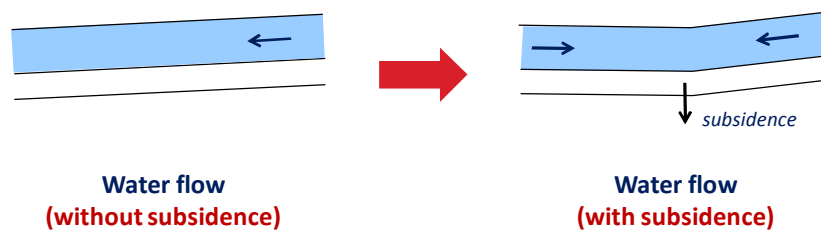
Land Subsidence and Flooding (2)



Expanded coverage and deeper water depth of coastal flooded (inundated) areas

Hasanuddin Z. Abidin, 2013

Land Subsidence and Flooding (3)



Changes of water flow pattern in drainage, canal and river systems passing the subsidence area

Hasanuddin Z. Abidin, 2013

Major (Inland) Floods In Jakarta

1699 (caused by Salak volcano eruption), 1711, 1714, 1854,
1942, 1976, 1996, 2002, 2007, 2013



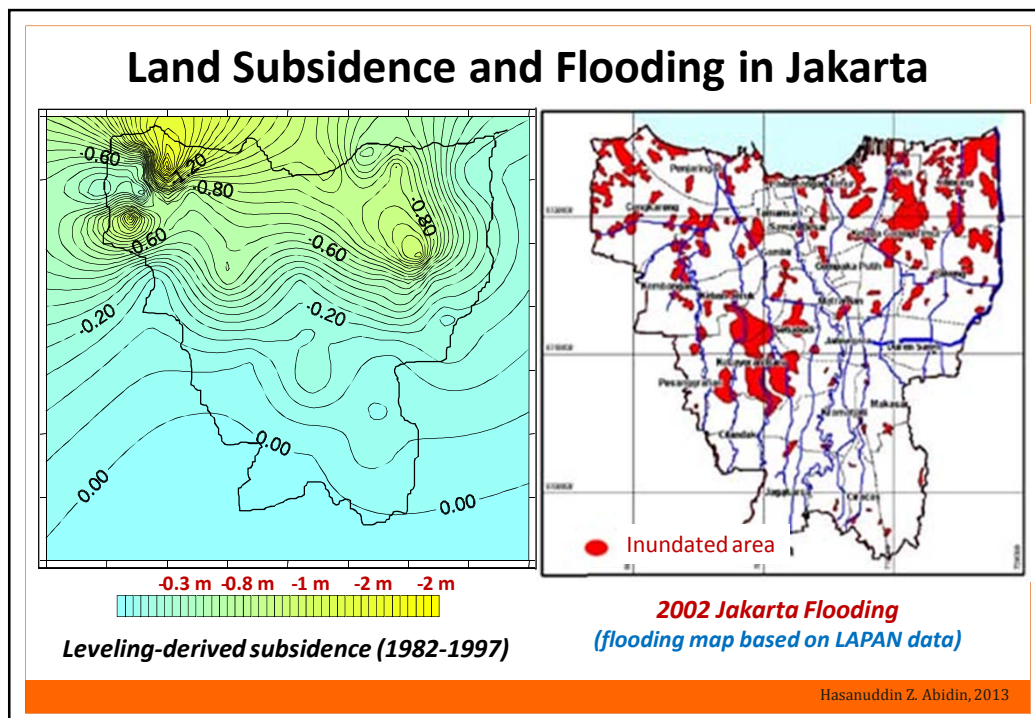
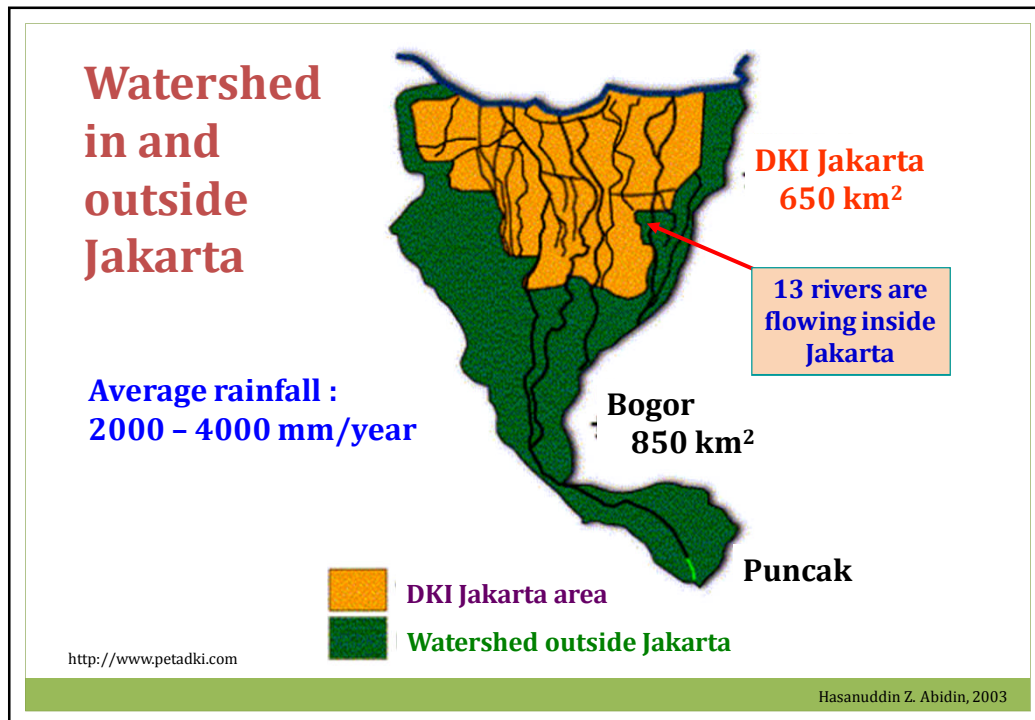
*Is there any contribution of land subsidence to inland flooding ?
How much and how is the mechanism ?*

Hasanuddin Z. Abidin, 2013

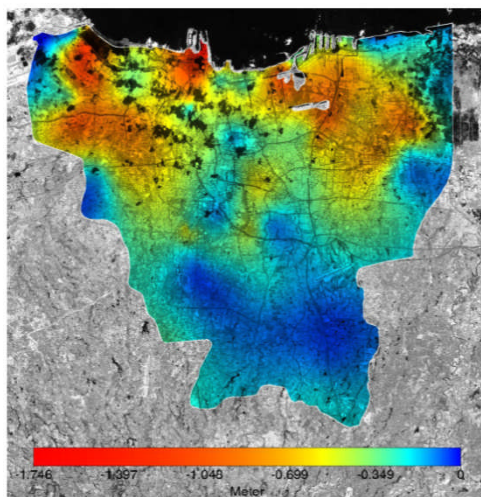
Causes of Flooding in Jakarta

- High rain fall (2000 – 4000 mm/year)
- **Sea tides and sea level rise (northern part)**
- 13 rivers flowing through
- Topography : 40 % is lowland
(about 1.0-1.5 under maximum tides).
- Rapid population growth
- Environmental degradation in the river upstream
- Land use changes (uncontrolled)
- Settlement along the rivers (illegal)
- Poor drainage and sewerage system
- **Land subsidence**

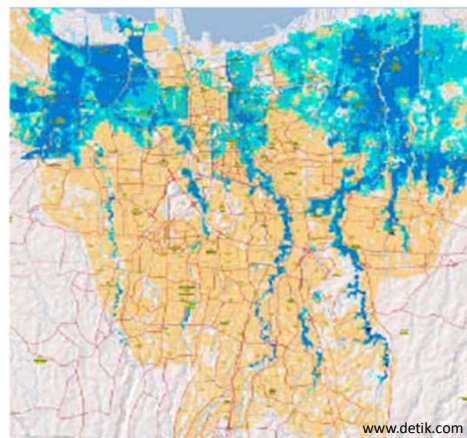
Hasanuddin Z. Abidin, 2003



Land Subsidence and Flooding in Jakarta



GPS-derived subsidence (2000-2011)

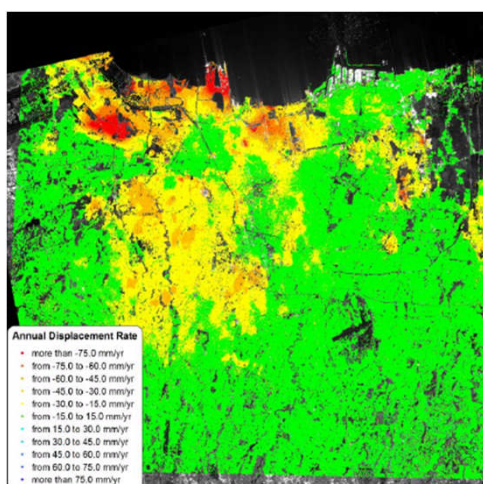


Water depth (m) of 2007 Flooding

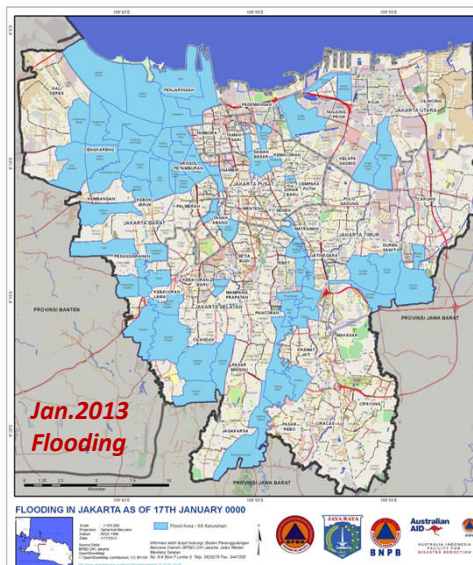


Hasanuddin Z. Abidin, 2013

Land Subsidence and Flooding in Jakarta



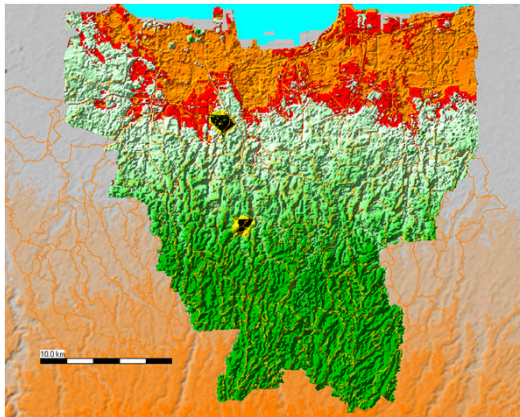
InSAR-derived subsidence (2007-2011)
(Koudogbo et al., 2012)



Hasanuddin Z. Abidin, 2013

Coastal Subsidence and Flooding

Watch out subsidence along the coastal areas of North Jakarta



Sea Level Rise:
0.1 – 0.5 cm/year (IPCC)

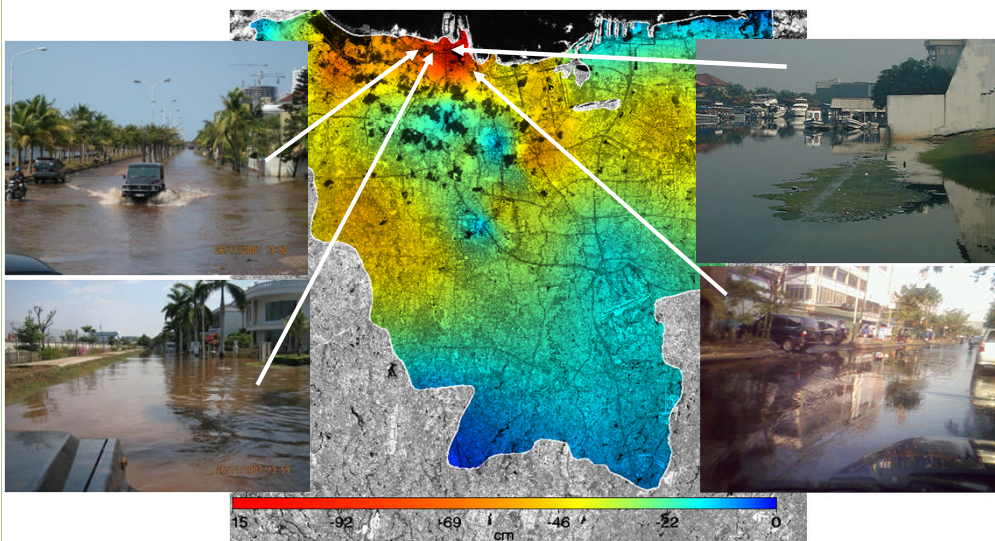
Coastal Subsidence:
1 - 15 cm/year

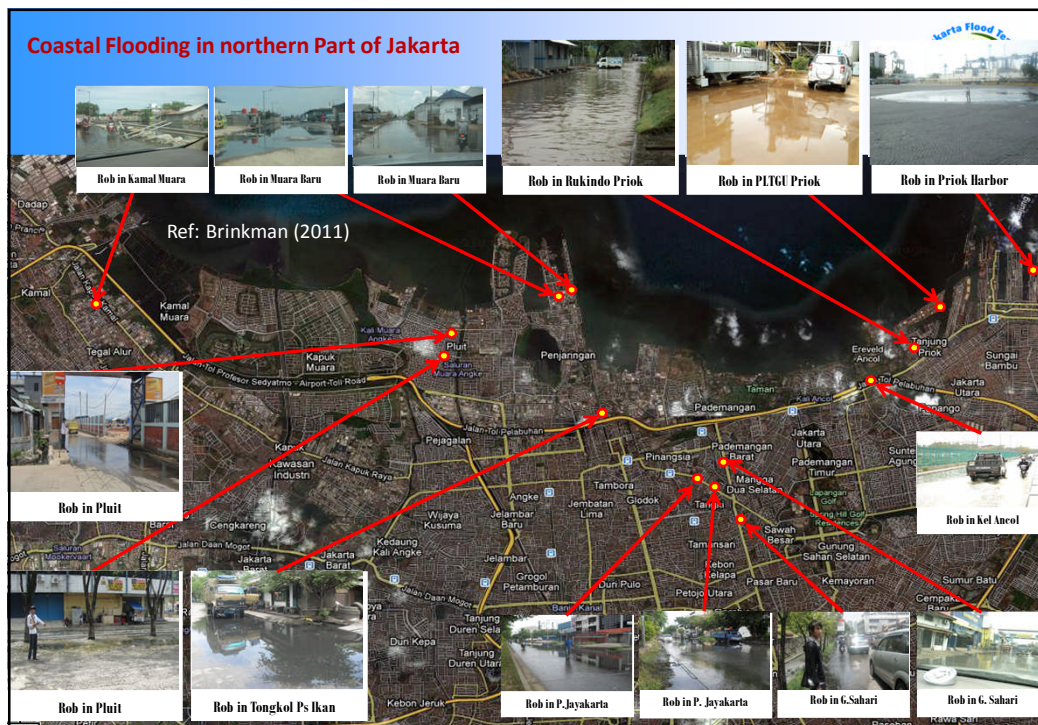


- *Tidal Flooding*
- *Surface water degradation*
- *Decrease in livelihood quality*

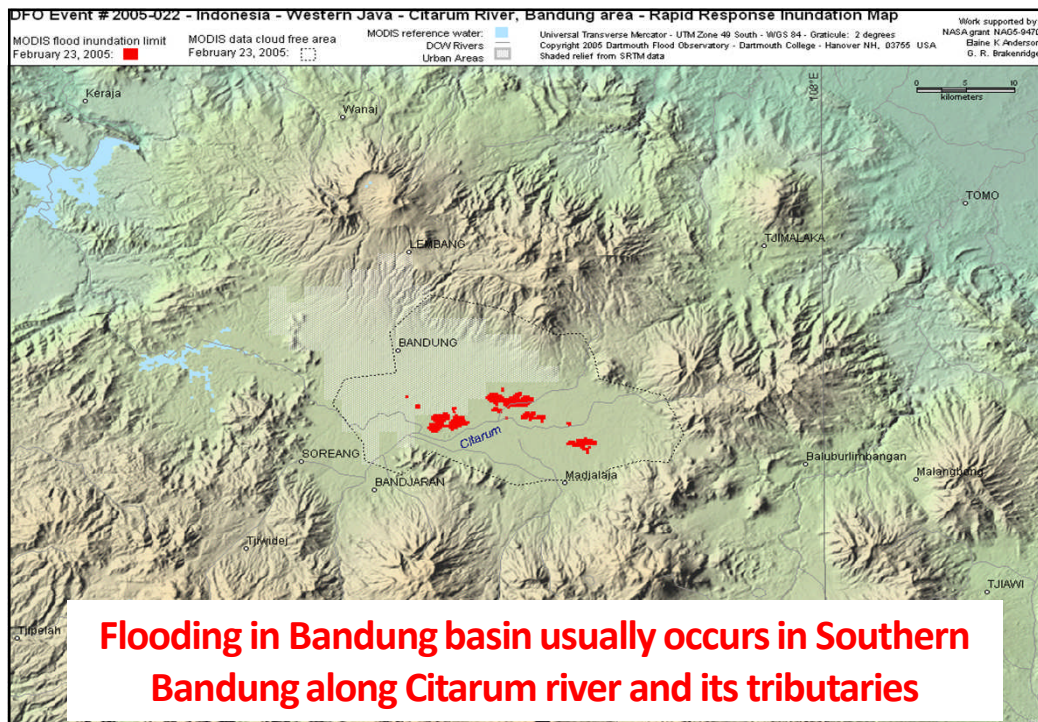
Hasanuddin Z. Abidin, 2008

Coastal flooding (Rob) in Northern Jakarta







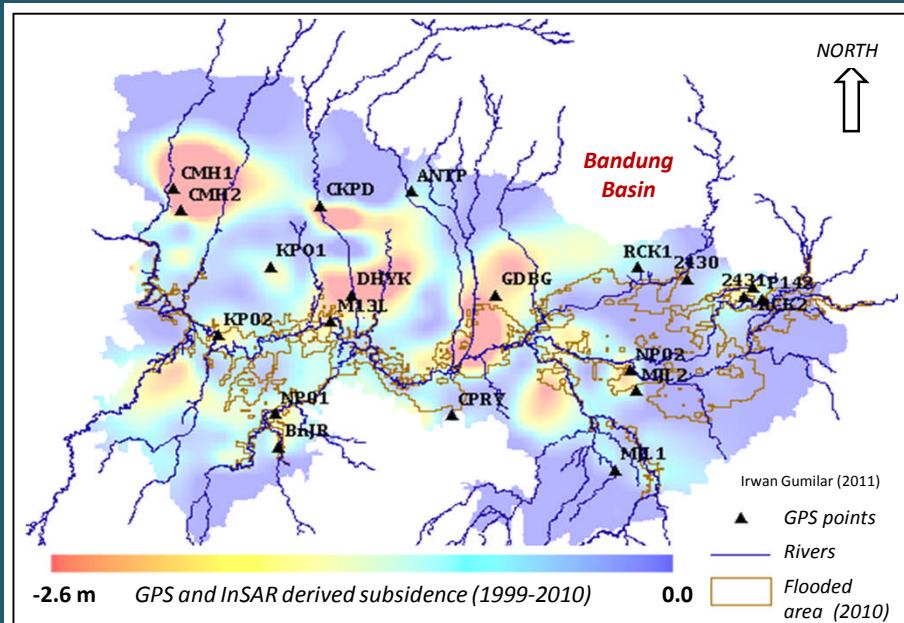


Flooding in South Bandung

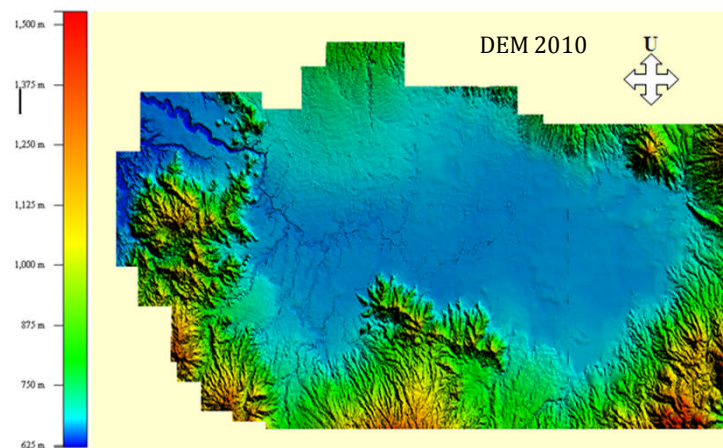


Sumber: <http://www.kompas.com/data/photo/2010/02/20/3696729p.jpg>

Land Subsidence and Flooding in Bandung Basin

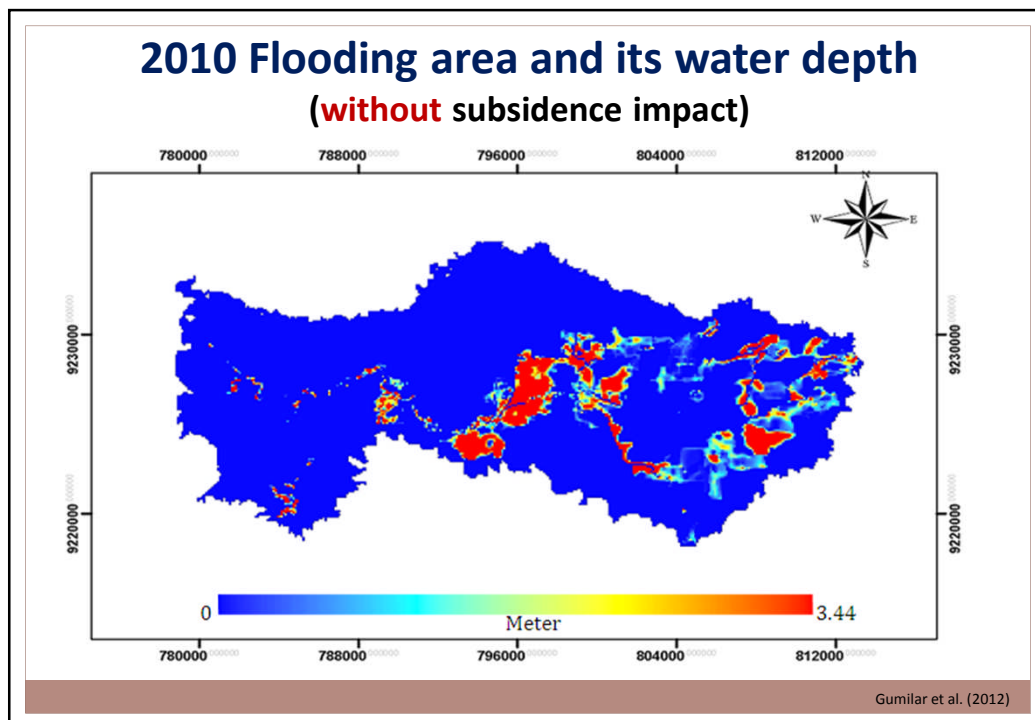
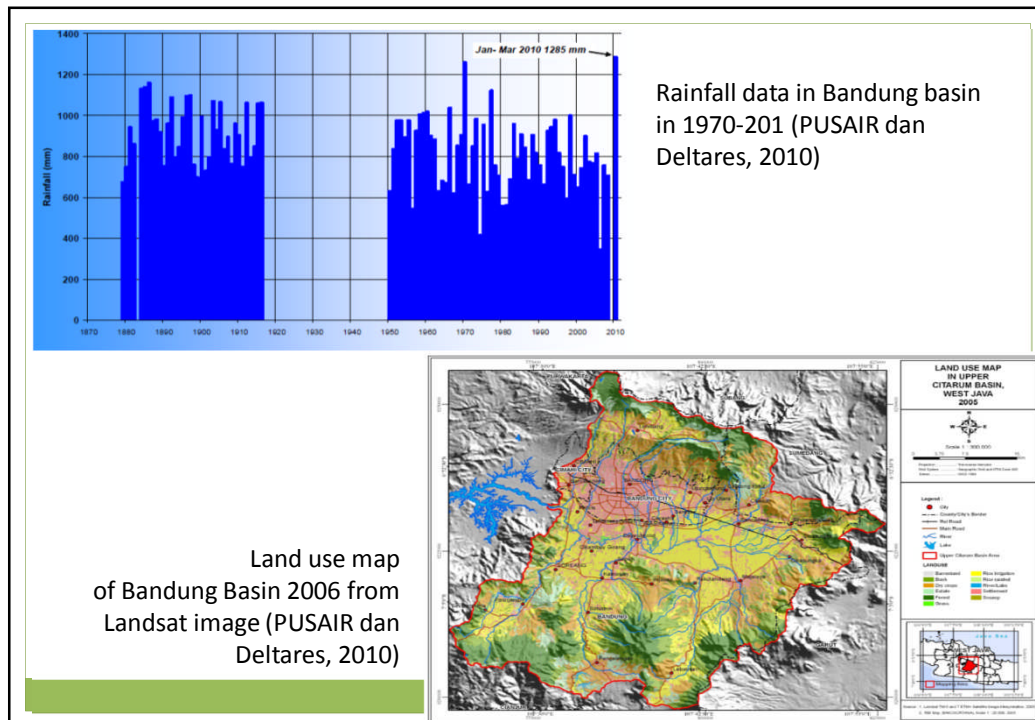


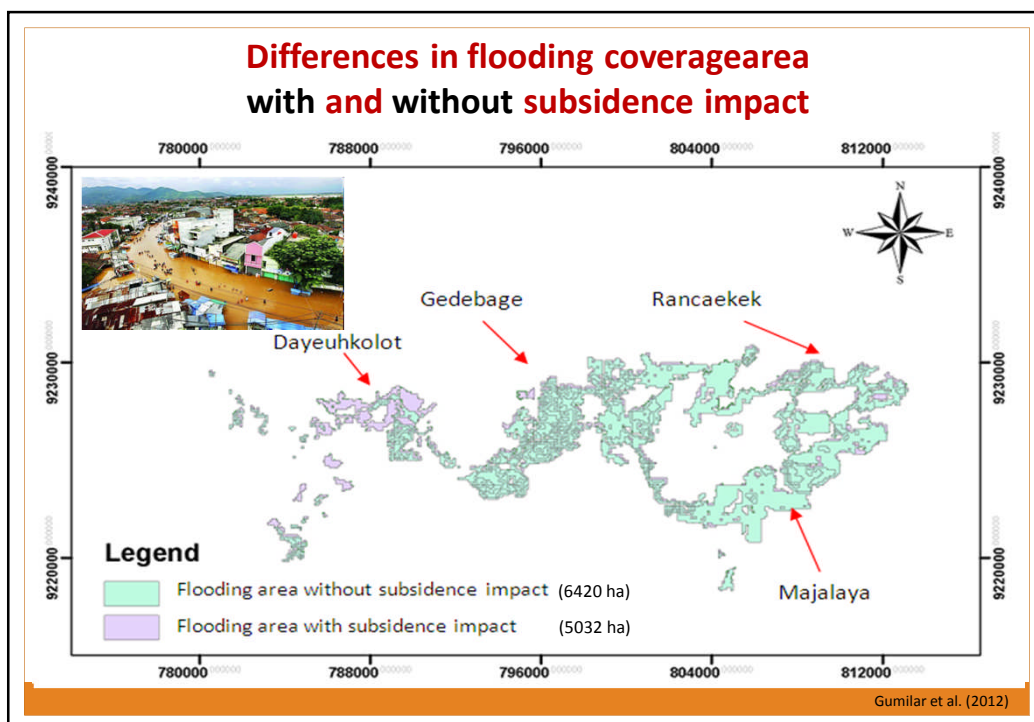
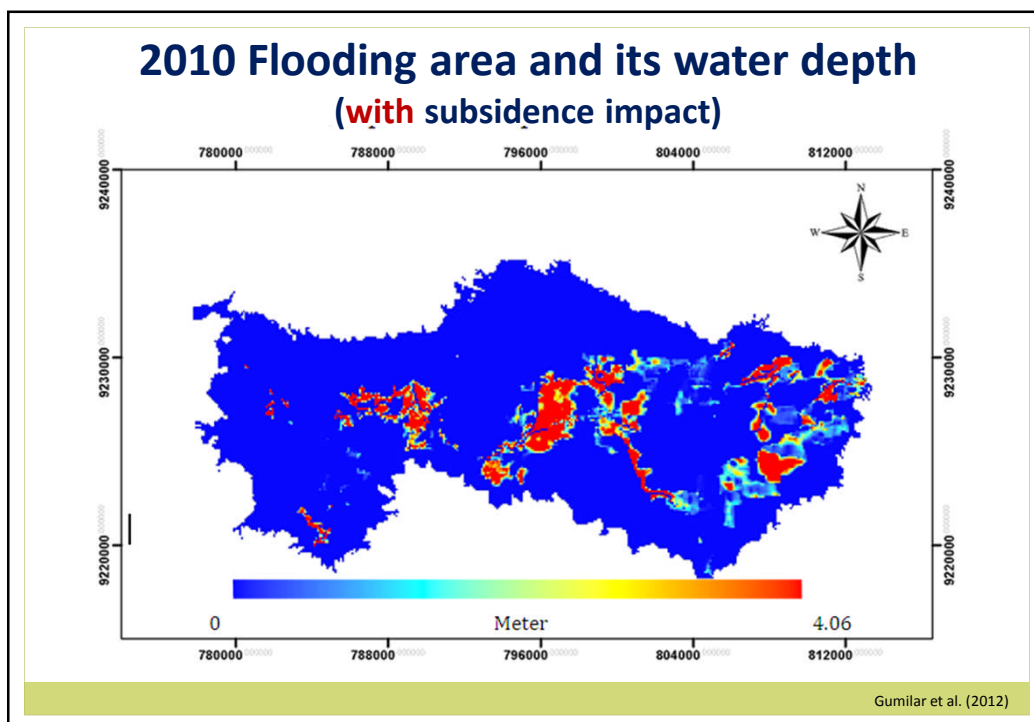
Modeling Flood in Bandung

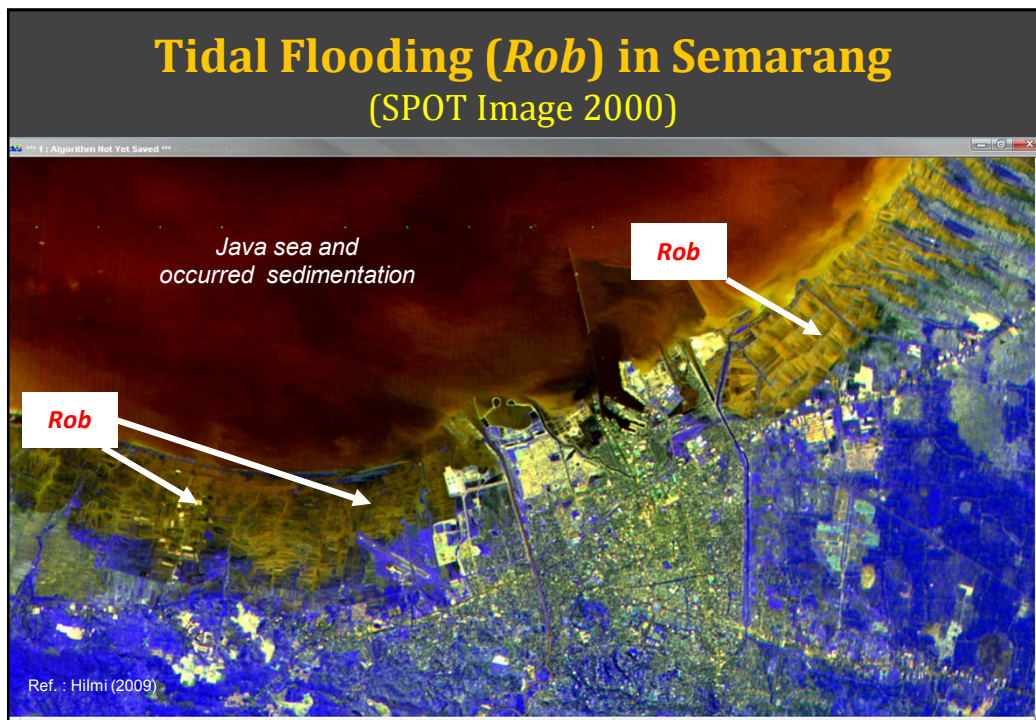
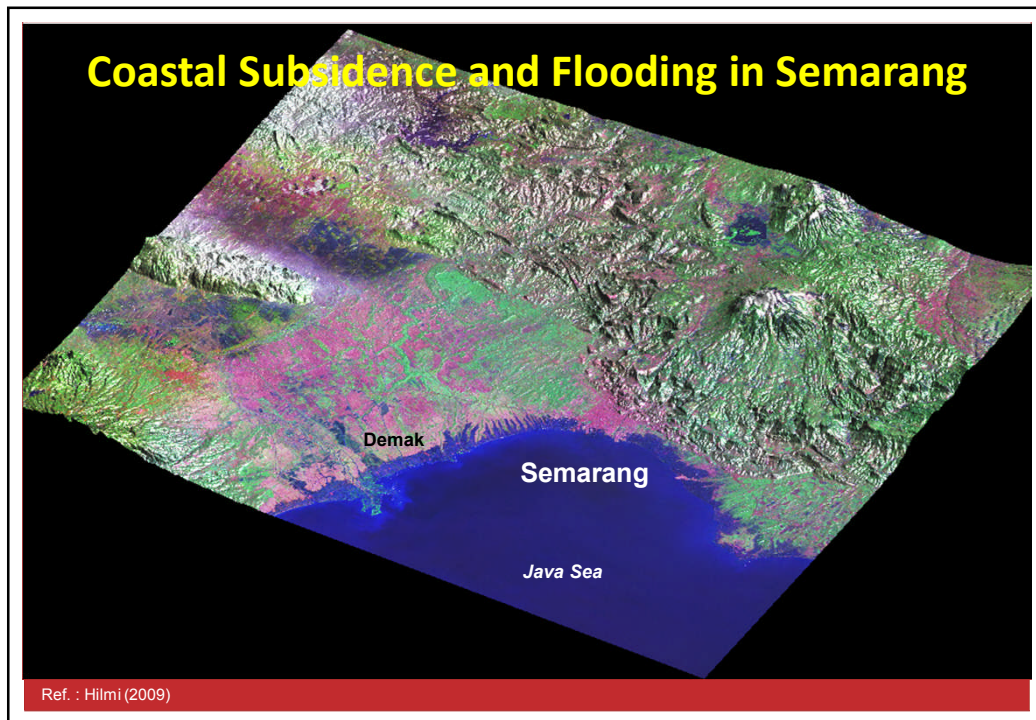


The flooding area in Bandung Basin modelled by using SOBEK software from Deltares (Holland). Sobek software designed to estimate 2D flooding area. The input of this software are the rainfall data, geometry of Citarum river, land use, and Digital Elevation Model (EDM) in 2010.

Gumilar et al. (2012)







Coastal Flooding in Semarang (mid April 2009)

courtesy of Kompas photo, 2 July 2009



Hasanuddin Z. Abidin (2010)

Land Subsidence and Flooding in Semarang

