

# Study on Causes and Impacts of Land Subsidence in Bandung Basin, Indonesia

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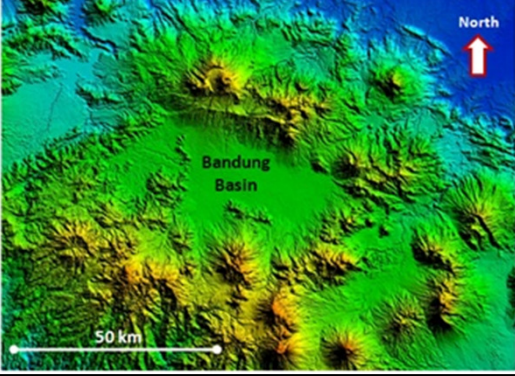
Marrakech WW2011


**FIG Working Week**  
 – Bridging the Gap Between Cultures  
 Marrakech, Morocco  
 May 18-22 2011

**FIG 2011**  
**Marrakech, Morocco**

BANDUNG  
West Java  
Indonesia







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 US Dept of State/Geoportal  
 Data: ETOPO1, SRTM30 PLUS, GEBCO

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## 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, 2006

## Geodetic Methods for Land Subsidence Monitoring

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.

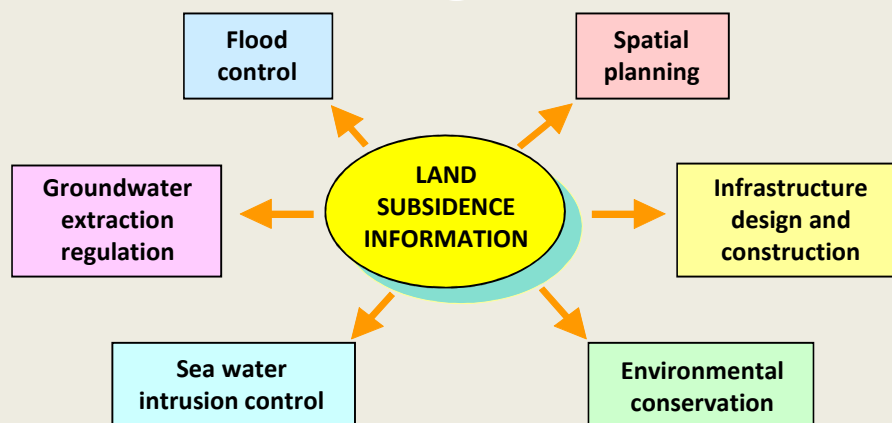
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## Types of Land Subsidence

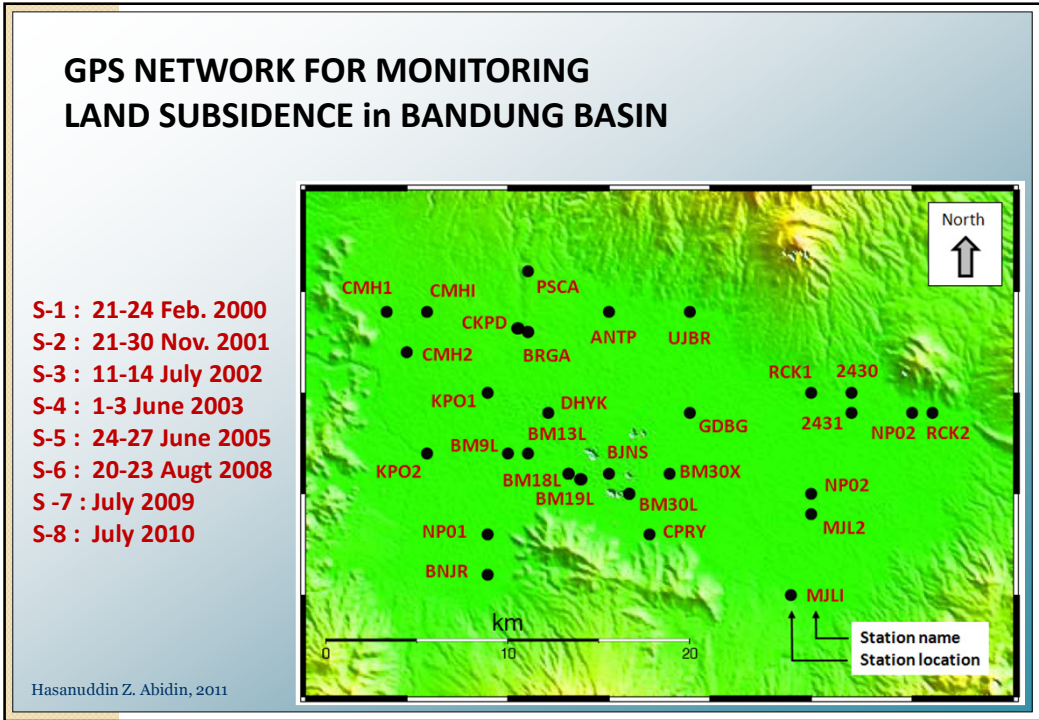
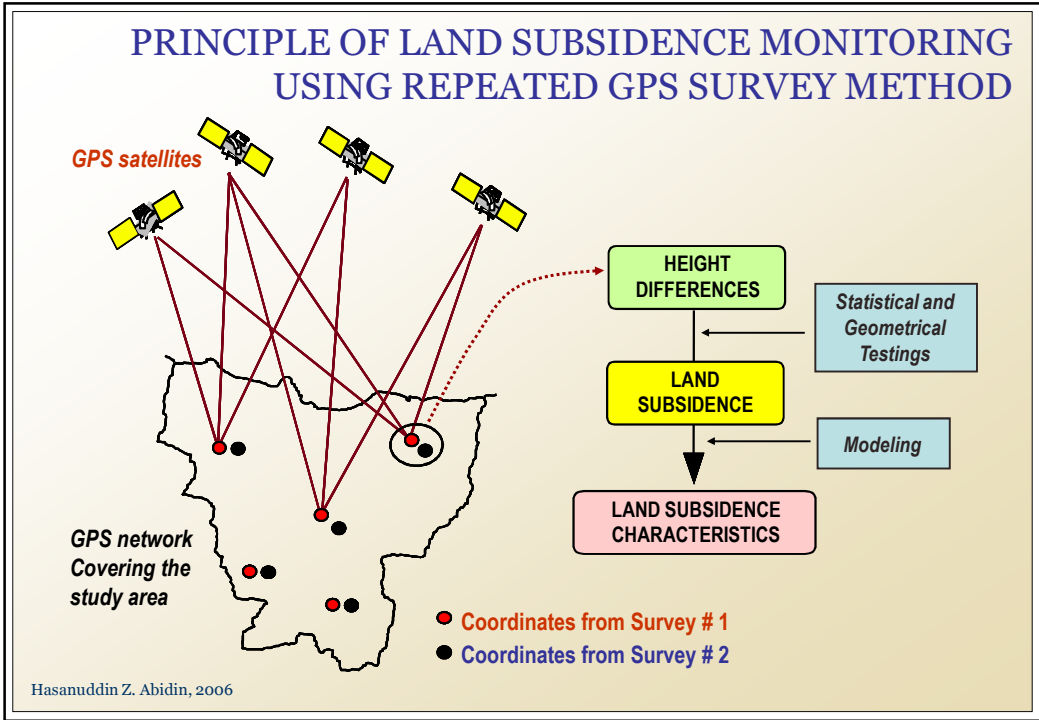
- subsidence due to groundwater extraction,
- subsidence induced by the load of constructions (i.e. settlement of high compressibility soil),
- subsidence caused by natural consolidation of alluvium soil, and
- tectonic subsidence.

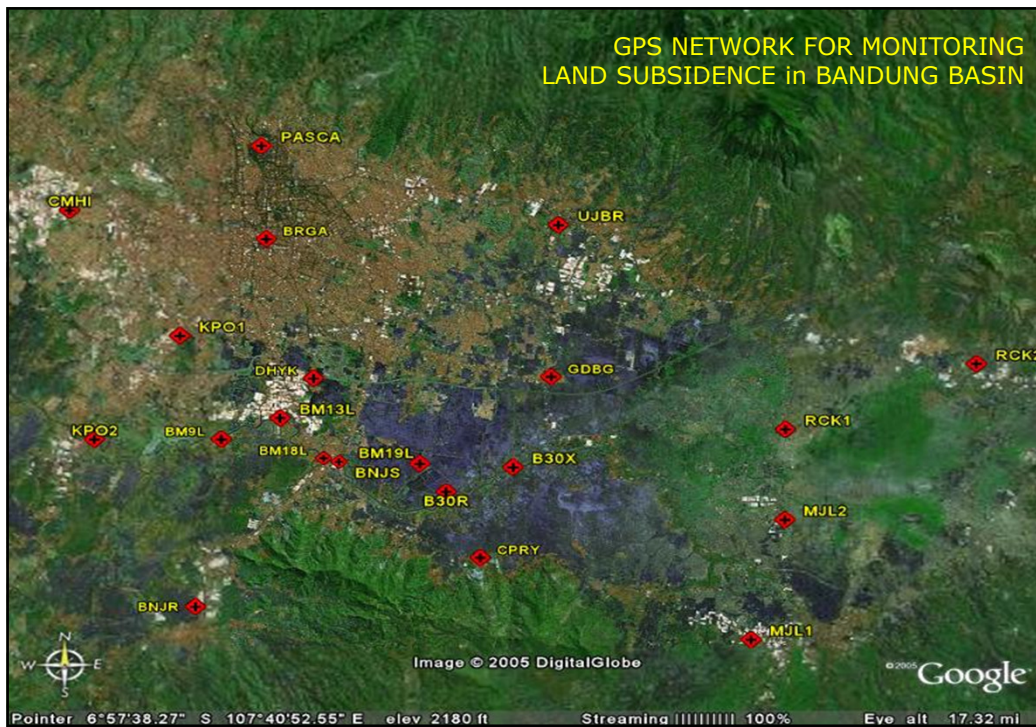
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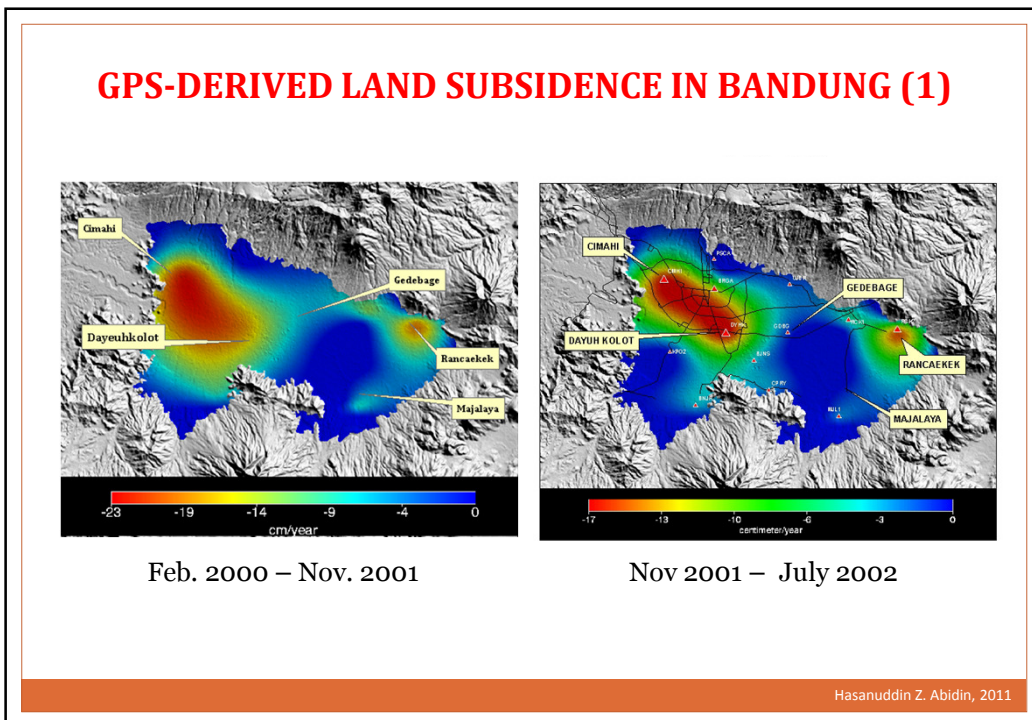
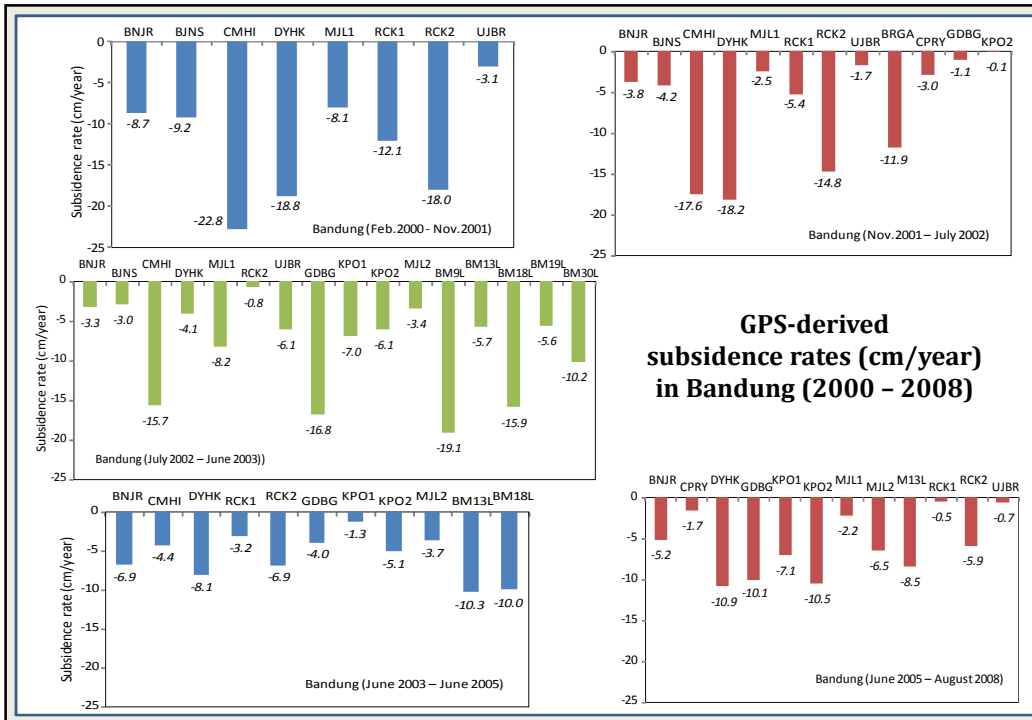
## IMPORTANCE OF LAND SUBSIDENCE INFORMATION



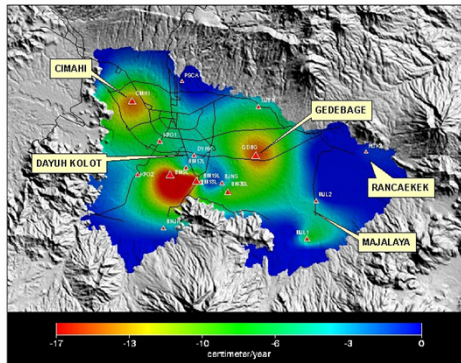
Hasanuddin Z. Abidin, 2006



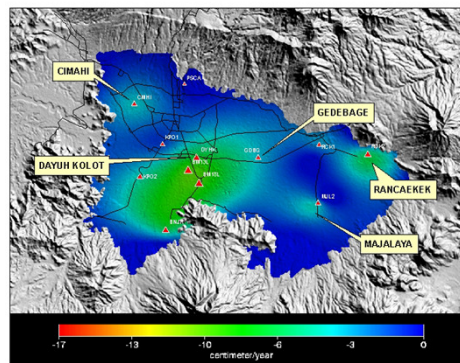




## GPS-DERIVED LAND SUBSIDENCE IN BANDUNG (2)



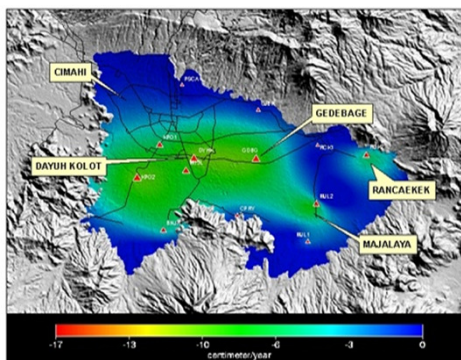
July 2002 – June 2003



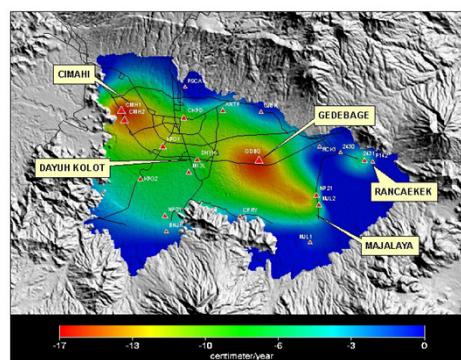
June 2003 – June 2005

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## GPS-DERIVED LAND SUBSIDENCE IN BANDUNG (3)

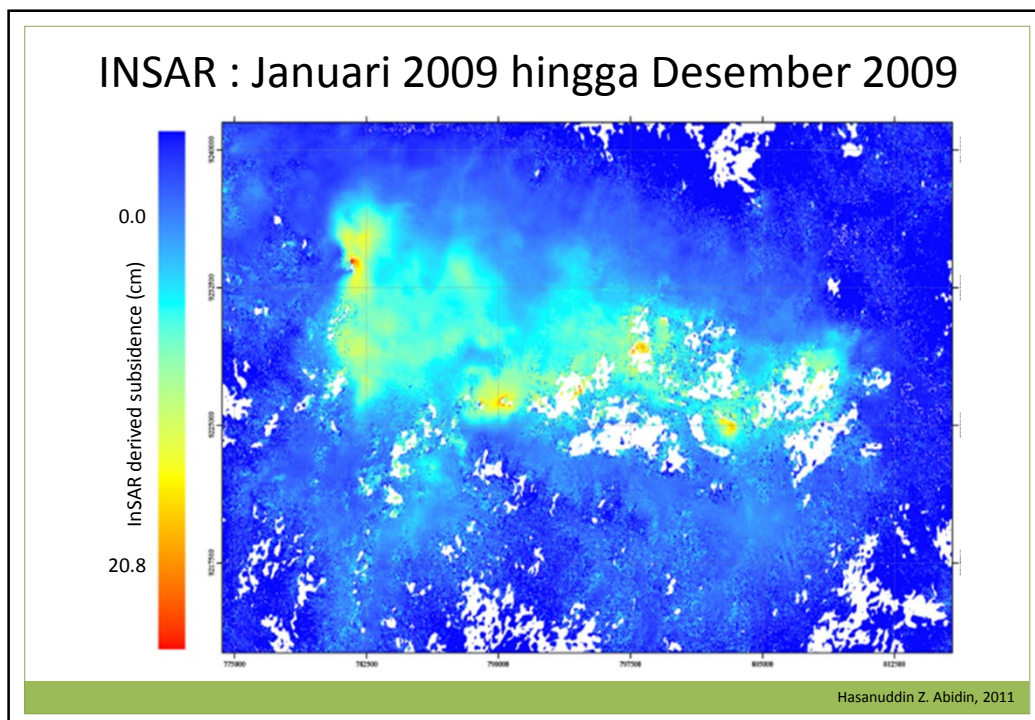
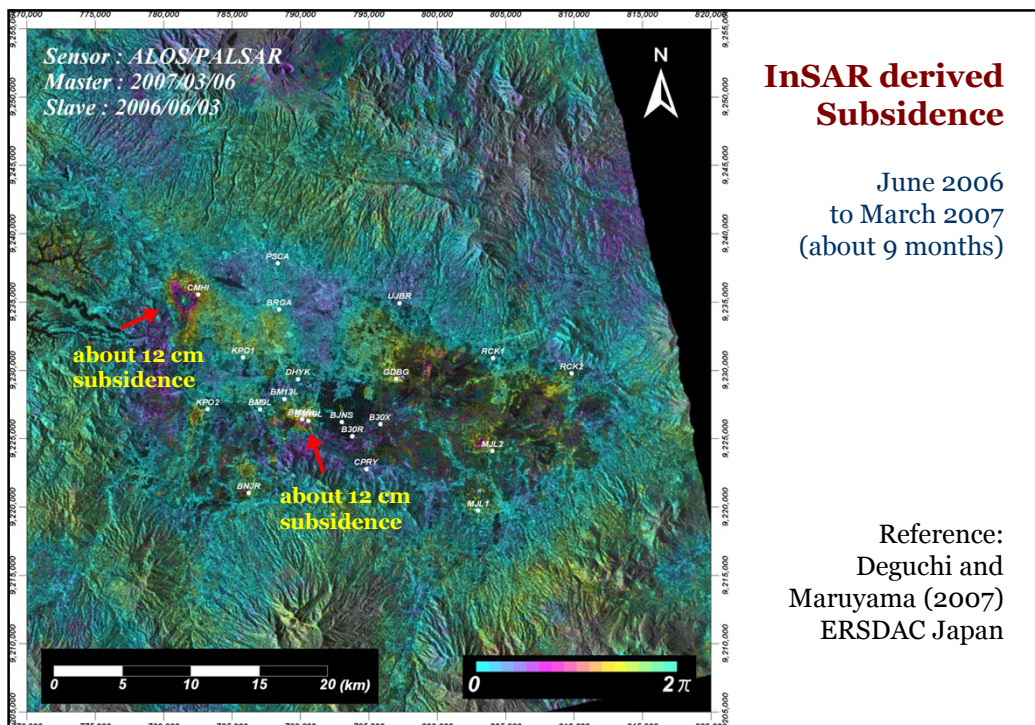


June 2005 – Augt 2008



Augt 2008 – July 2009

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## IMPACTS OF LAND SUBSIDENCE

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

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### Impacts of Land Subsidence in Bandung (1)



A: Rancaekek, B: Leuwigajah, C: Ujungberung, D: Gedebage, E: Dayeuh Kolot, F: Leuwigajah

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## Impacts of Land Subsidence in Bandung (2)



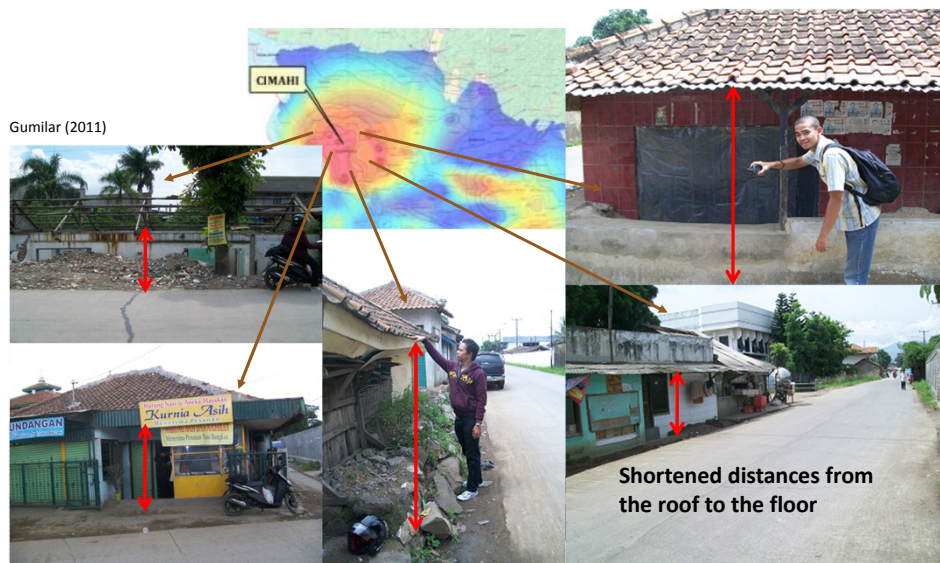
G: Dayeuh Kolot  
J: Gedebage

H: Cimahi  
K: Leuwigadjah

I: Gedebage  
L: Dayeuh Kolot

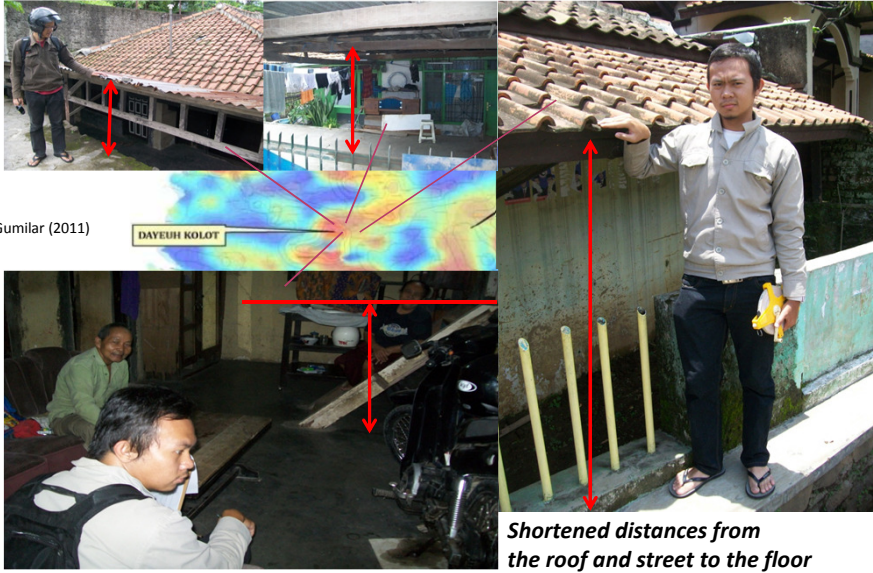
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## EVIDENCE OF LAND SUBSIDENCE IN BANDUNG (Cimahi)



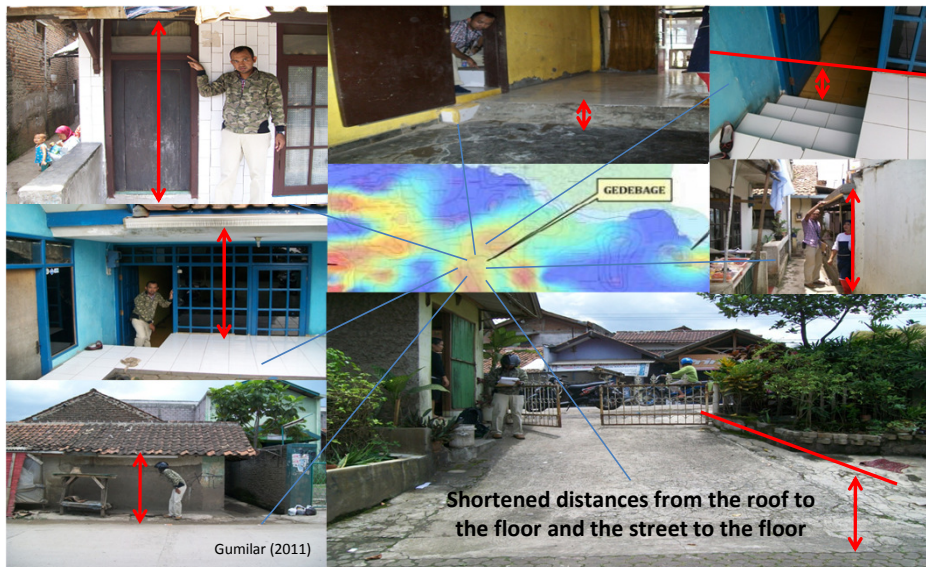
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## EVIDENCE OF LAND SUBSIDENCE IN BANDUNG (Dayeuh Kolot)



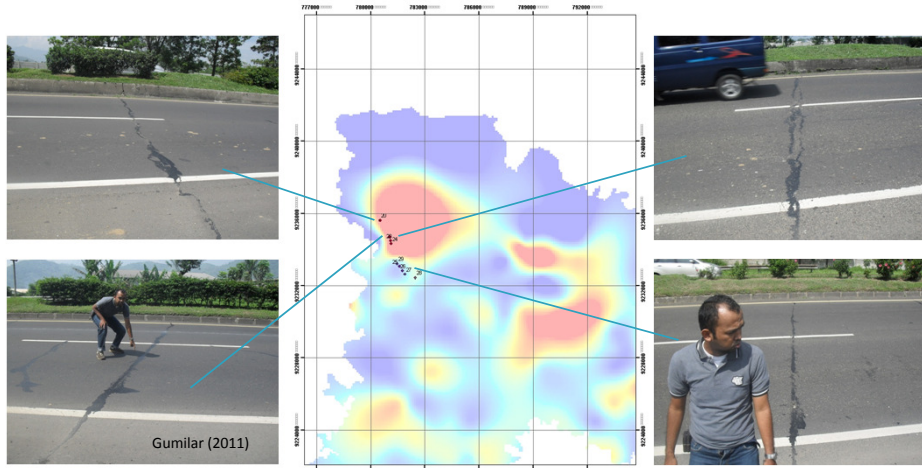
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## EVIDENCE OF LAND SUBSIDENCE IN BANDUNG (Gede Bage)



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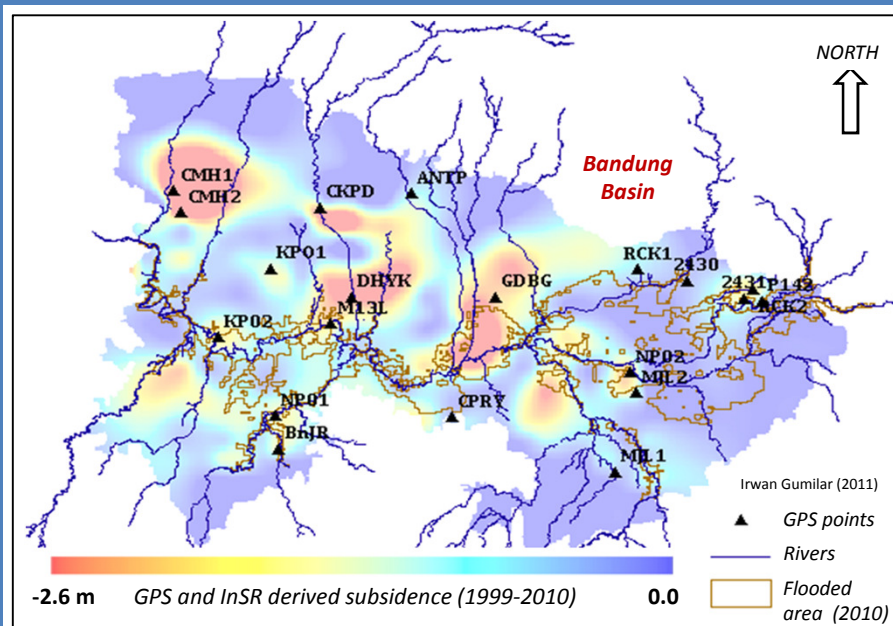
## EVIDENCES OF LAND SUBSIDENCE IN BANDUNG BASIN



*Crack on the highway (TOL Padalarang Cileunyi – Kilometer Pasirkoja)*

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## Land Subsidence and Flooding in Bandung Basin



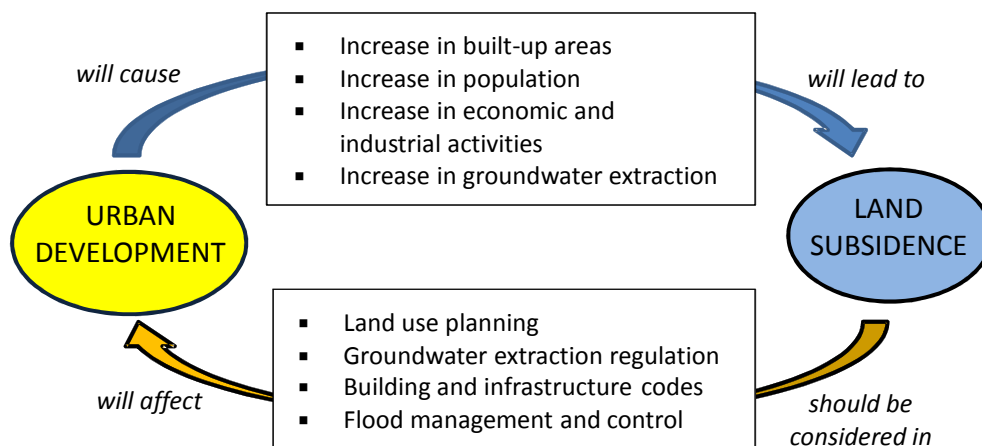
## Causes of Land Subsidence in Bandung ?

- Excessive groundwater extraction
- Natural consolidation of alluvium soil
- Load of buildings and constructions
- Tectonic activities

*Contribution of each causes  
in spatial and temporal domain,  
is not fully known yet.*

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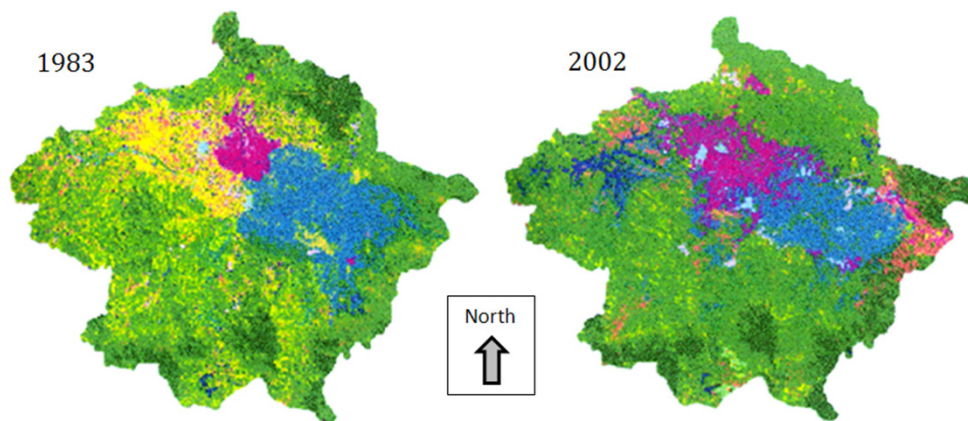
## Urban Development and Subsidence in Bandung Basin



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## LAND USE CHANGES IN BANDUNG BASIN

adapted from *Sampurno* (2006).

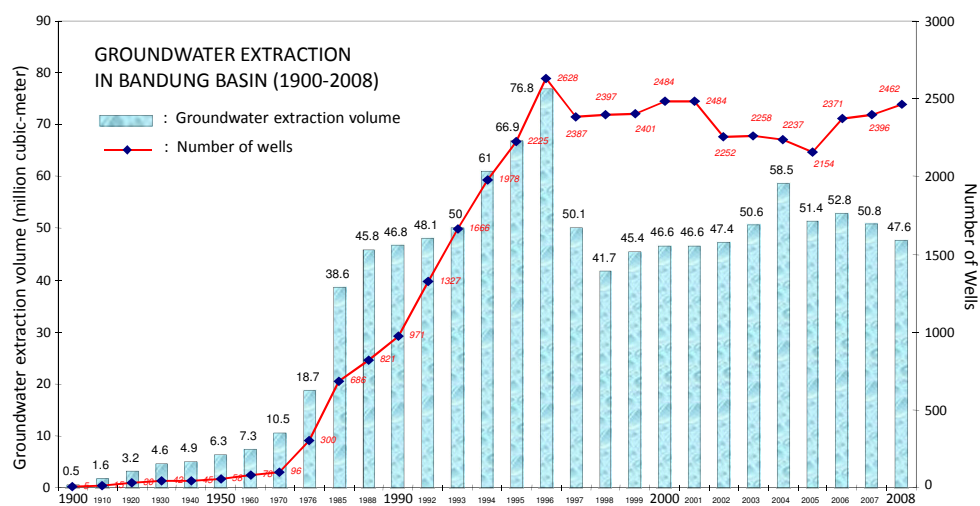


The urban areas are indicated with the red-pink colour region.

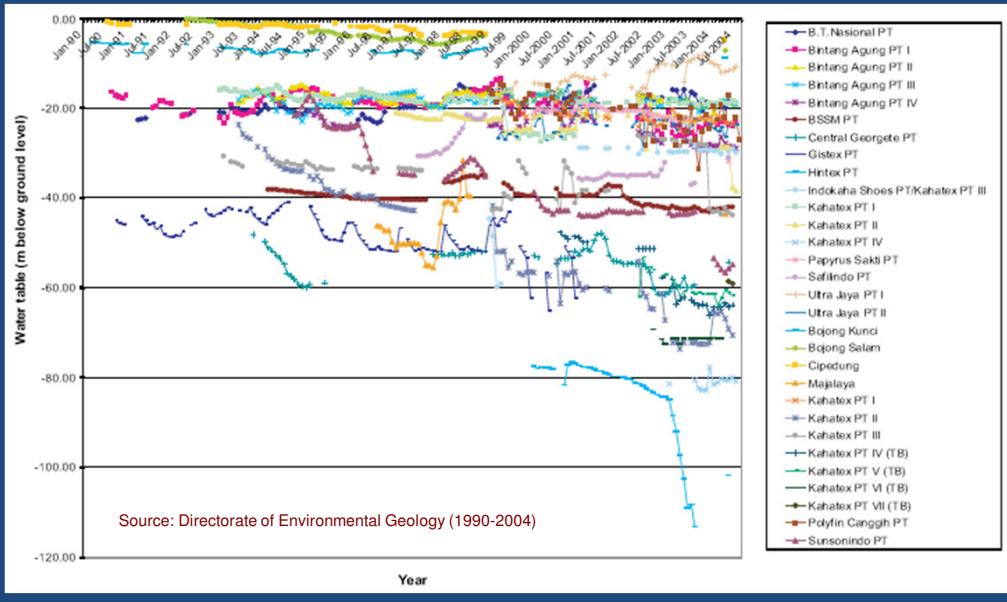
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## GROUNDWATER EXTRACTION IN BANDUNG

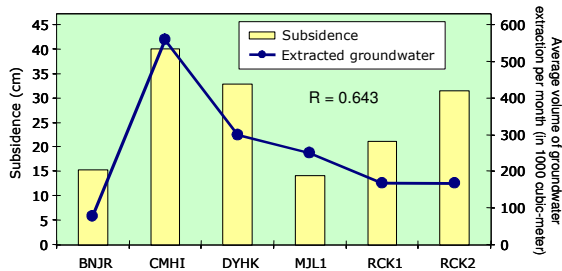
[Badan Geologi, 2009]



## GROUNDWATER TABLE DEPLETION RECORDED BY MONITORING WELLS IN METROPOLITAN BANDUNG (1990–2004)

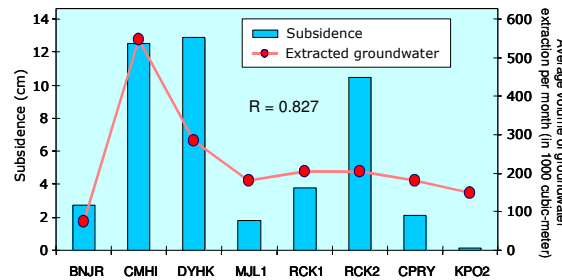


## Land Subsidence and Groundwater Abstraction



**INITIAL HYPOTHESIS :**  
Land subsidence observed in several locations in Bandung basin is caused by an excessive groundwater abstraction.

GPS survey results show that this hypothesis is not always true for all observed stations.

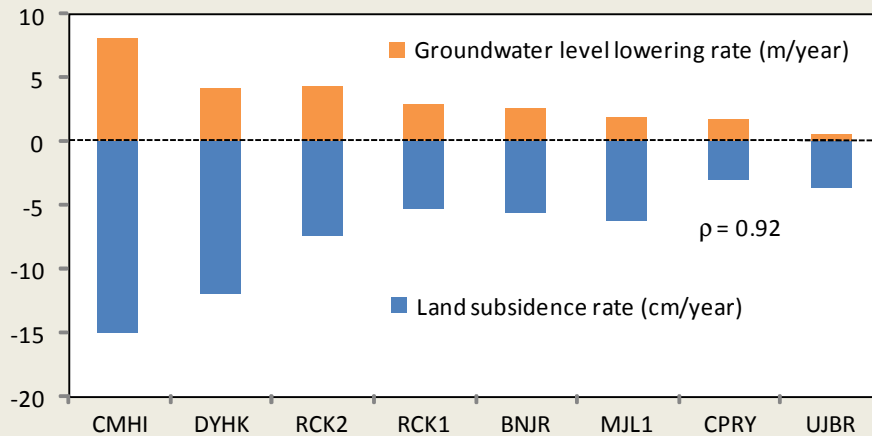


### WHY ?

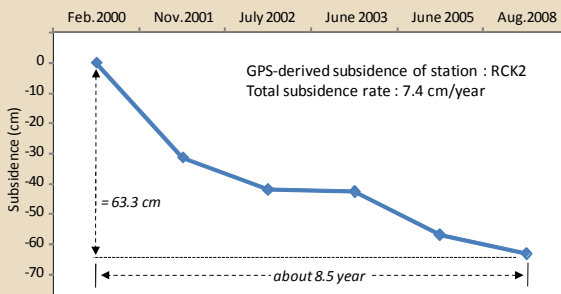
- the registered groundwater abstraction volume does not reflect the real groundwater abstraction, and/or
- the land subsidence is also governed by other factors.

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## Groundwater Level Lowering and Land Subsidence in Bandung Basin

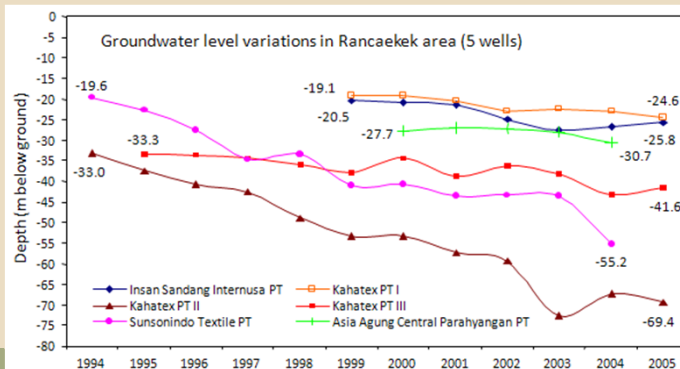


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Subsidence of the RCK2 station located in the Rancaekek area from 2000 to 2008.

Indication of groundwater level fall in the Rancaekek area, adapted from Wirakusumah (2006).

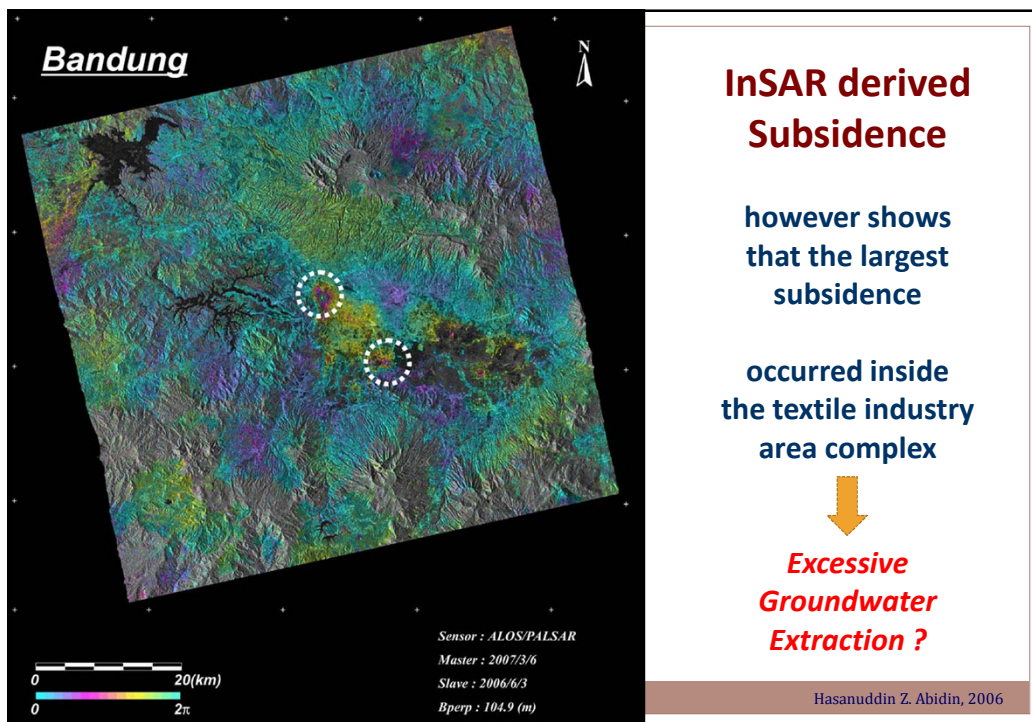


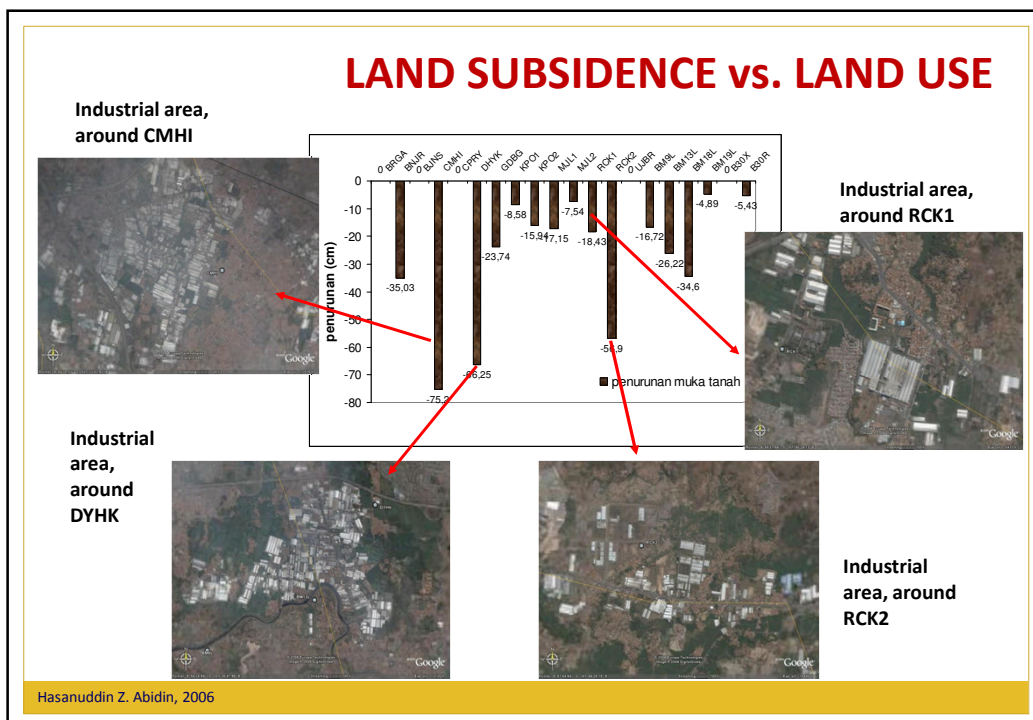
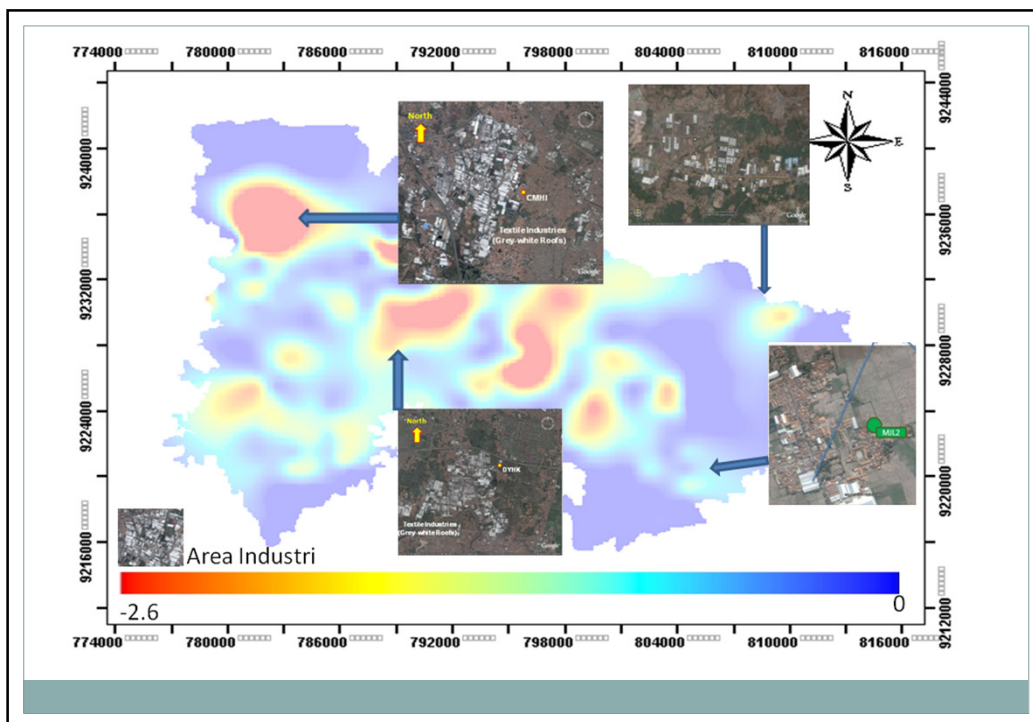


## Groundwater Level Lowering and Land Subsidence in Bandung Basin

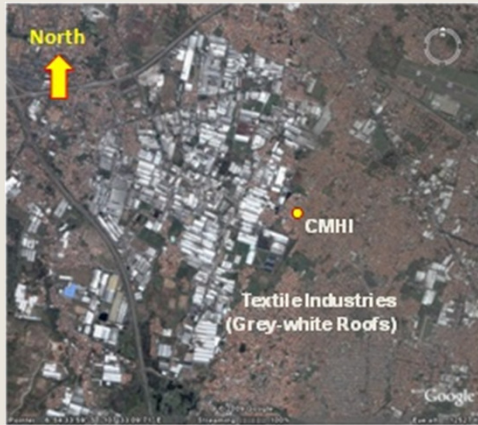
Groundwater level lowering rate, adapted from <i>Ruchijat</i> (2006)			Average subsidence rate (from GPS surveys)		
Area	Rate (m/year)	Period	GPS station	Rate (cm/year)	Period
North Cimahi	1.3 – 8.0	1994–2004	CMHI	-15.1	2000–2005
South Cimahi	0.2 – 3.2	1994–2004			
Dayeuh Kolot	≈ 2.4	1980–2004	DYHK	-12.0	2000–2008
	0.2 – 4.1	1994–2004			
Rancaekek	0.5 – 4.2	1993–2004	RCK2	-7.4	2000–2008
Cileunyi	2.3 – 2.8	2000–2004	RCK1	-5.3	2000–2008
Banjaran	0.3 – 2.5	1989–2004	BNJR	-5.6	2000–2008
Majalaya	≈ 1.8	1980–2004	MJL1	-6.3	2001–2003
Ciparay	0.4 – 1.6	1992–2004	CPRY	-3.0	2001–2002
Ujung Berung	0.2 – 0.5	1994–2004	UJBR	-3.6	2001–2003

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Location of GPS Stations CMHI and DYHK  
(in the areas of textile industries)



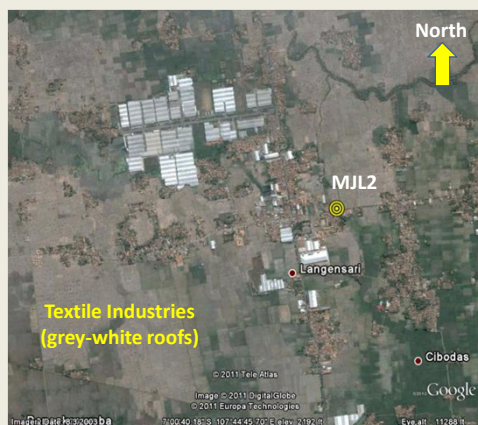
Subsidence rate (2009 – 2010):  
**14.5 cm/year**



Subsidence rate (2009 – 2010):  
**7.4 cm/year**

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Location of GPS Stations MJL2 and RCK2  
(in the areas of textile industries)

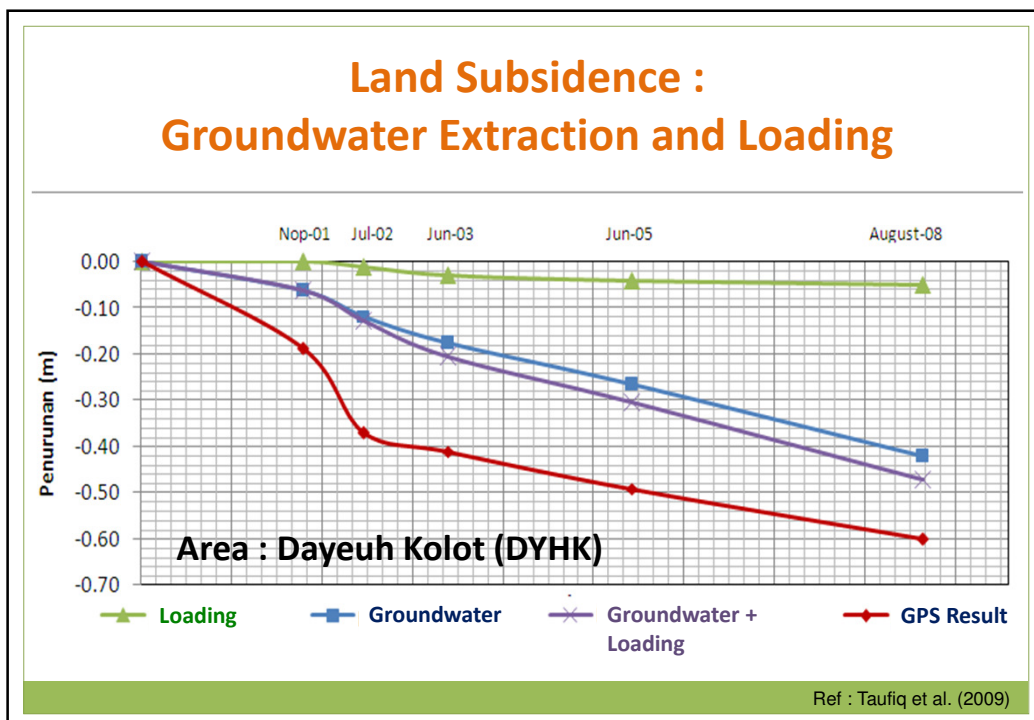
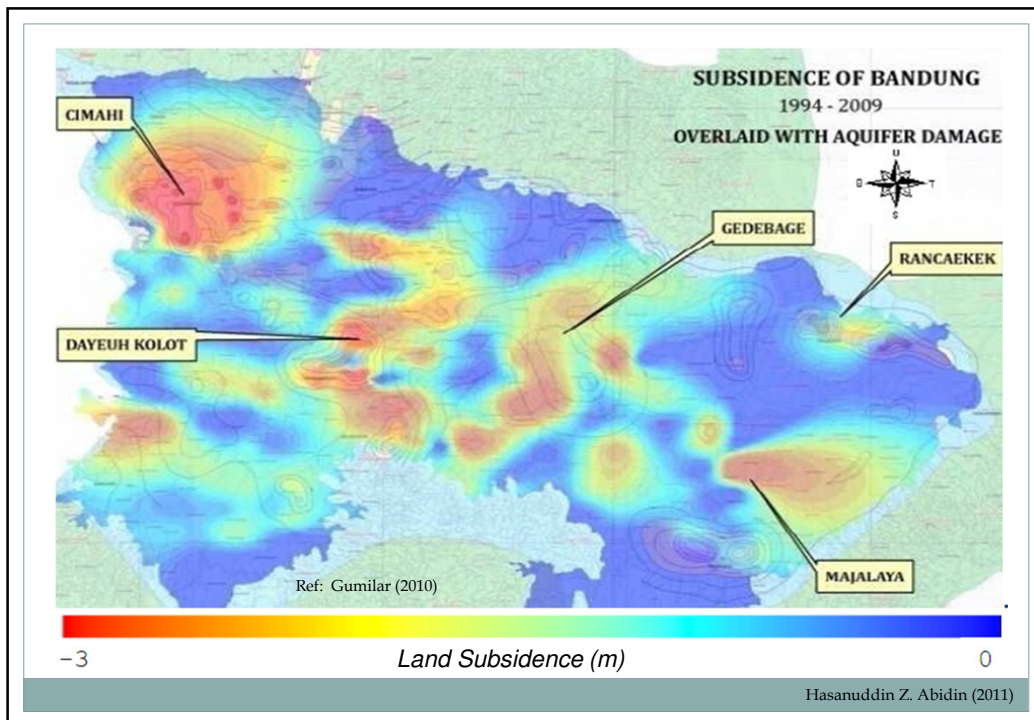


Subsidence rate (2005-2008):  
**6.5 cm/year**

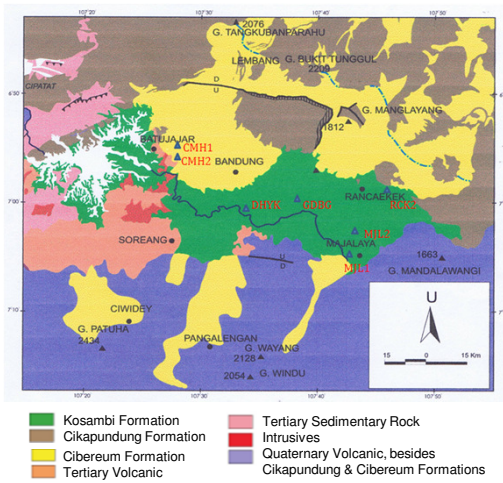


Subsidence rate (2005 – 2008):  
**5.9 cm/year**

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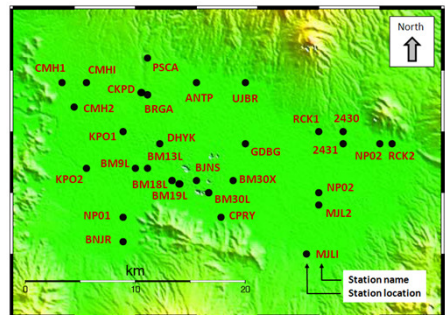


## Land Subsidence and Natural Consolidation of Alluvium Soil



Ref: Hutasoit (2010)

*Kosambi formation = lake alluvium (sediment)*



Hasanuddin Z. Abidin (2011)

## Location of GPS Stations GDBG

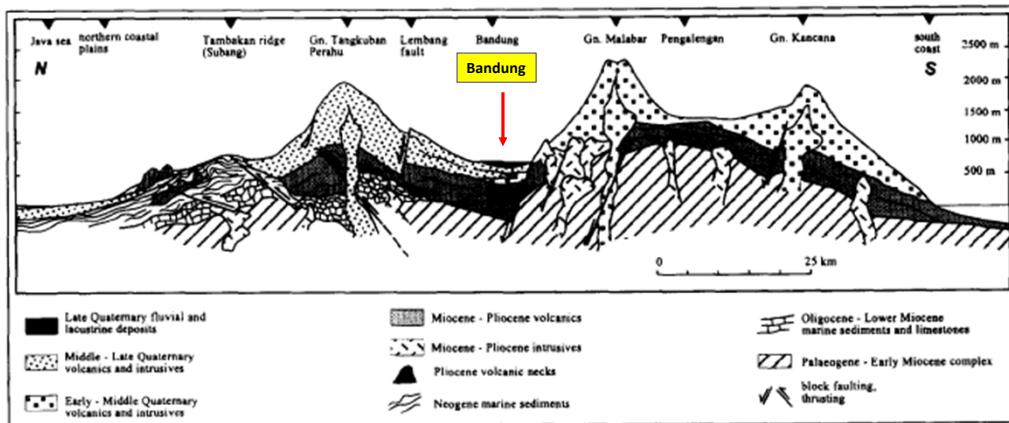


Subsidence rate (2009 – 2010):  
**9.1 cm/year**

**Combined effects of groundwater abstraction and natural consolidation ?**

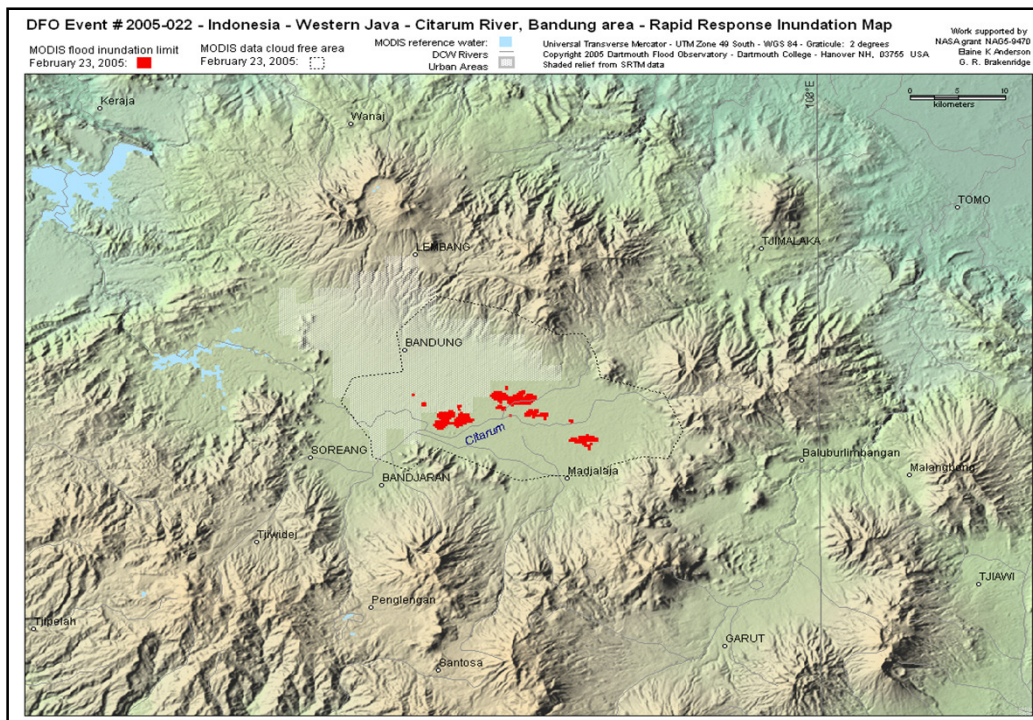
Hasanuddin Z. Abidin (2011)

# Land Subsidence and Tectonic Activity



Ref: [Dam et al., 1996]

Hasanuddin Z. Abidin, 2006



## CLOSING REMARKS

- Significant subsidence in Bandung basin occurred in the textile industry area, where very large volumes of groundwater are usually extracted.
- Land subsidence in Bandung =  
 $f \{ \text{excessive groundwater abstraction, building load (??), tectonics activity (??), natural compaction (?)} \}$
- Further research is needed to clarify the real mechanism and pattern (spatial and temporal) of land subsidence phenomena in Bandung basin.

Hasanuddin Z. Abidin, 2011



**THANK YOU VERY MUCH**