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Subsidence & development in the Ganges-Brahmaputra-Meghna: Past uncertainties & future challenges



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Deltas in Times of Climate Change II

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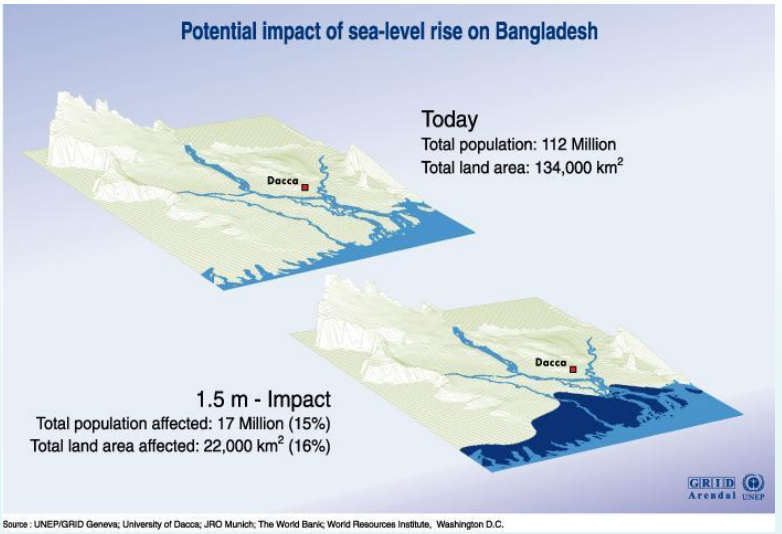
Potential sea-level rise and Bangladesh



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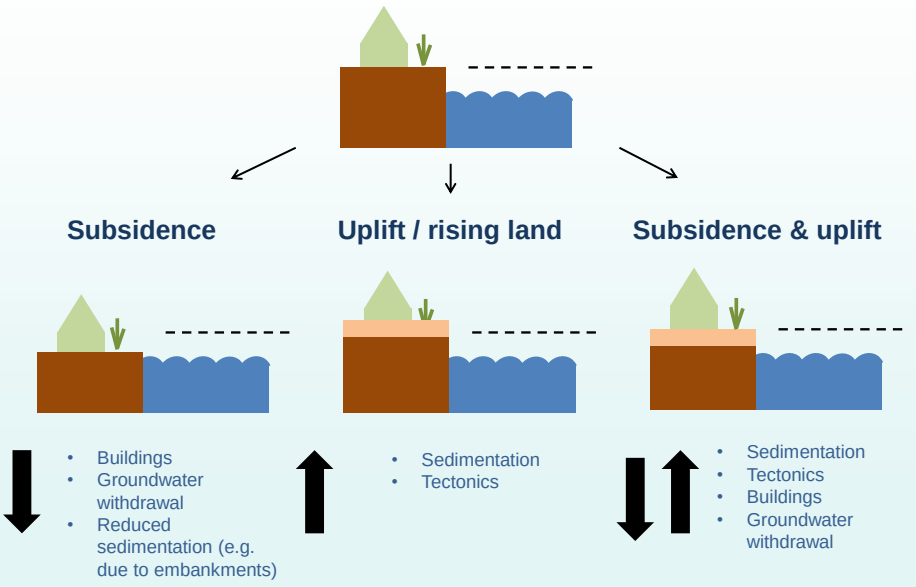
Net subsidence



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Multiple causes of subsidence

- Natural subsidence
  - Tectonic subsidence
  - Compaction of sediment, including peat
- Anthropogenic subsidence
  - Land use
  - Buildings
  - Embankments and polders
  - Water diversion, e.g Farakka Barrage (changing sediment patterns -> net subsidence)
  - Groundwater abstraction
- Some subsidence is very local and of short duration, whereas other subsidence is more wide spread and has been occurring for thousands of years.

Potential climatic threats

- Increased rate of local relative sea-level rise (land level and sea-level change).
- Extreme events and cyclones (surges)
  - Increased erosion
  - Increased flooding
  - Increased salinity
- Precipitation
  - Increased variability
  - Increase in summer monsoon rainfall
  - Lead to possible changes in seasonal discharge.

➢ **Challenges for local development, engineering and agriculture / aquaculture production.**

What is the rate of subsidence in Ganges-Brahmaputra-Meghna delta?

How does this influence development?

- Setting
- Methods
- Results
- Threats to food security
- Conclusions

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Setting

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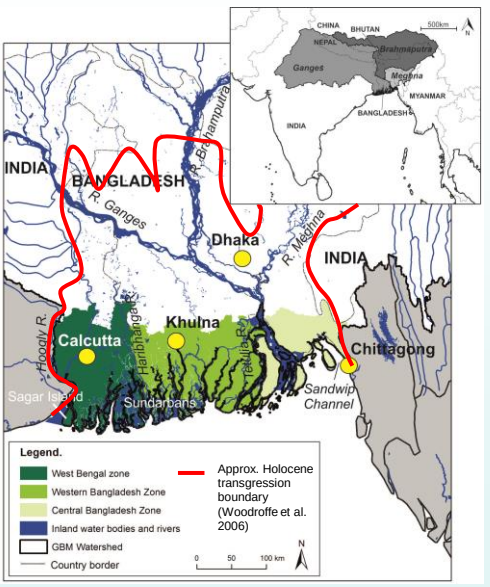
Setting



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Setting

- Area: 100,000km^2. Population: 111 million.
- Land gradient 0.016m/km^2. (15m elevation in the north of the country, to 1m in the south)
- Low income country, dependent on land and agriculture (particularly rice)
- Highly influenced by their surrounding environments, including water demand for crops.
- Fine balance between sufficient food production and surrounding physical / human environment, including transboundary issues (e.g. water resources).

Ericson et al. (2008); Islam and Gnauck (2008); World Bank (2014); Akanda et al. 2012.

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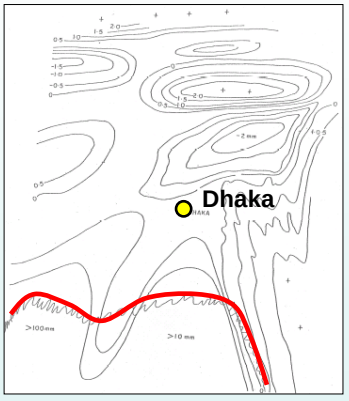
Methods and Results

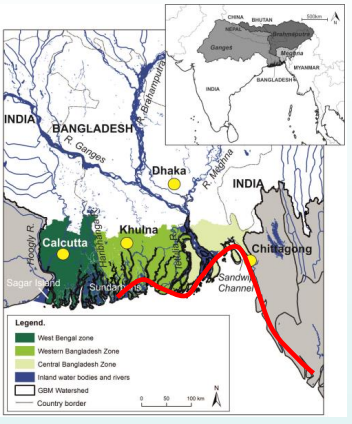
Methods

- Desk study of available literature up to spring 2014.
- Attempted to read as many original articles as possible as many articles had been requoted, with additional assumptions made.
- Recorded causes, location, rate, age, measurement method.
- Reviewed the food security and climate change literature to establish links with subsidence.

Types of evidence

- 143 measurements from 14 author teams citing 19 articles.





Approximate rates of subsidence and uplift (Figure 3.3 of Singh et al., 2000, reproduced from Master Plan Organisation, 1985).

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Types of measurements

Method	Proportion of measurements
Archaeological	5%
Borings / well / auger	18%
Carbon dating	44%
Geomorphic survey	7%
GPS	4%
Gravity survey	5%
Neotectonics	10%
Magnetostratigraphic dating	1%
Tank excavation	6%

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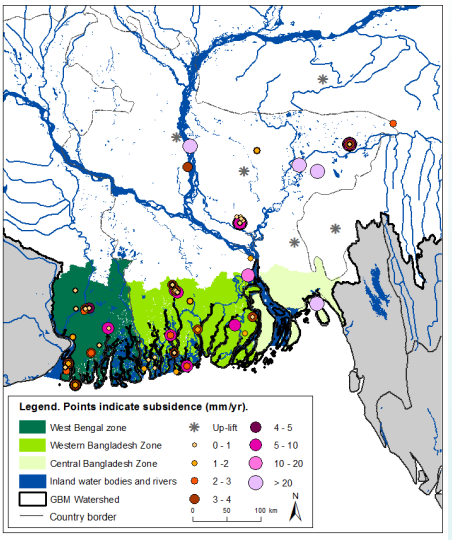
Geographical distribution



Data compiled from 19 articles.

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Range of measurements

Zone	Subsidence (mm/yr)		Author
	Maximum	Minimum	
West Bengal	7.1	0.3	Stanley and Hait (2000); Hoque and Alam (1997)
West Bangladesh	20	0.2	Hoque and Alam (1997)
Central Bangladesh	30	22	Alam (1996); Hoque and Alam (1997)
Interior	41	-1.1	Morgan and McIntire (1959); Hoque and Alam (1997)

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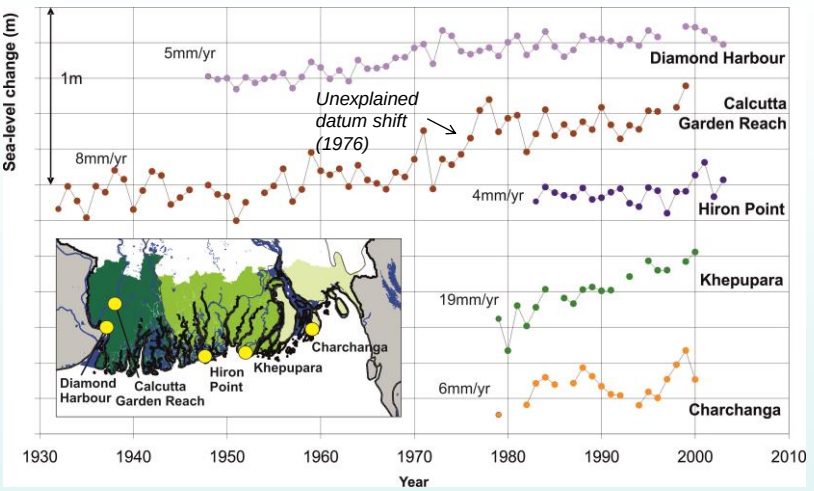
Relative sea-level rise



- Global mean sea-level rise: 1.9±0.2mm/yr (1901-2010)

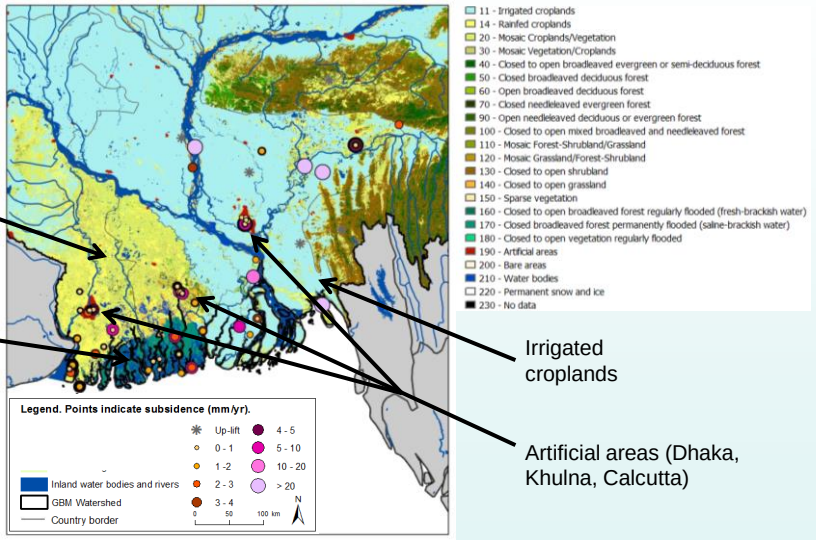
Tide gauges: PSMSL (2013). Church et al. (2013)

Threats to food security

Land use and subsidence

Rainfed croplands; Mosaic croplands / vegetation; Mosaic vegetation / croplands

Mangroves (brackish-saline water)



Irrigated croplands

Artificial areas (Dhaka, Khulna, Calcutta)

Data from: GlobCover v2.2 (2009) and 19 articles on subsidence

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Implications for food security

Rice

Increase yield & changing conditions:
Irrigation, fertilisers, GM-crops, salt tolerant varieties

Build embankments

Restricted flow and sediment deposition, rivers filled with sediment, embanked areas flooded, water logging and increased salinity. Reinforced by sea-level rise and reduced water discharge.

Shrimp farming

An initially successful, growing industry. But…adjacent rice growing areas became salinised, leading to further conversation to shrimp farming. Employs fewer people.

Increased salinisation

- Change in sediment movement.
- Salinisation means irreversible changes.
- Changes livelihoods.
- Small changes to subsidence can have major implications over several decades.

Swapan and Gavin, 2011; Paul and Vogl, 2011; Ahmed 2013.

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Conclusions

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Conclusions

- Subsidence is complex varying over the delta area and wider basin, making patterns in subsidence challenging to see.
- There are multiple causes of net subsidence which affects food security in different ways.
- Sea-level rise could make conditions worse causing further salinisation.
- Factors other than sea-level rise need to be considered.
- Decision making needs to consider the long-term outlook and wider development issues.

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