ROLE OF SAFETY STANDARDS AND LAND SUBSIDENCE IN SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF FLOOD PRONE AREAS

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INTRODUCTION - I

Although there is world wide a major concern for the impacts of climate change on extreme rainfalls, increase in peak river discharges and sea level rise, 80 – 90% of the urbanisation takes place in flood prone areas

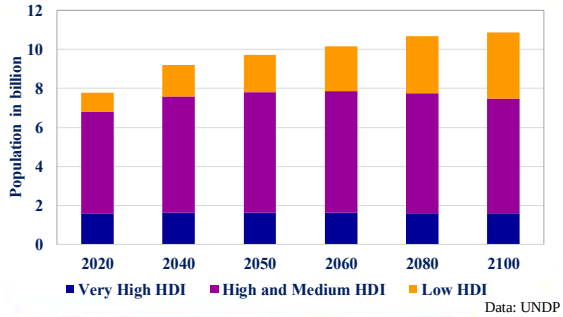
A significant part of these areas is located in tidal coastal and deltaic regions

(Schultz, 2018)

INTRODUCTION - II

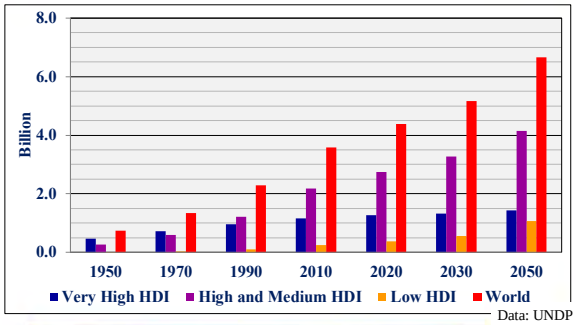
- **development and management of flood prone areas requires an integrated approach in which various relevant aspects have to be taken into account**
- **two important aspects are design standards for drainage and flood protection, and land subsidence:**
  - **risk of flooding is generally insufficiently taken into account in decision-making**
  - **in most areas there is land subsidence and oxidation of topsoil, in extreme cases more than 200 mm/year**
- **how may they impact the conditions and what measures can be considered to take them into account in sustainable development and management**

POPULATION AND GROWTH



Data: UNDP

DEVELOPMENT OF URBAN AREAS



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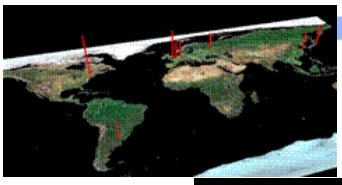
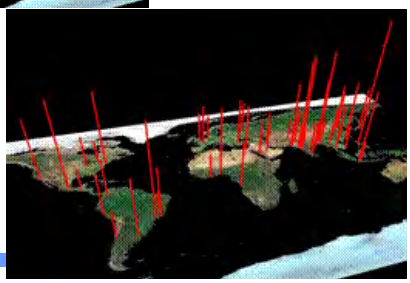


Cities with > 5 million residents

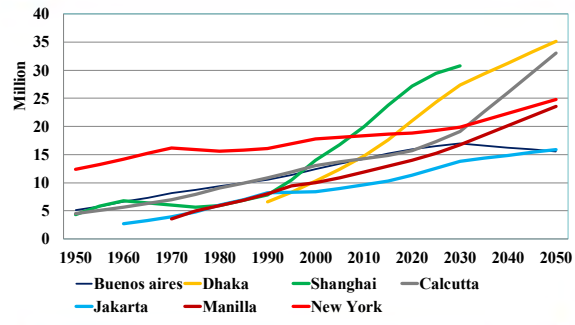
1950

2015



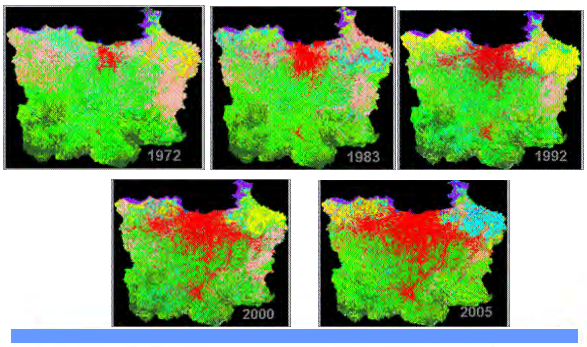
Data: UNDP

GROWTH OF MAJOR CITIES

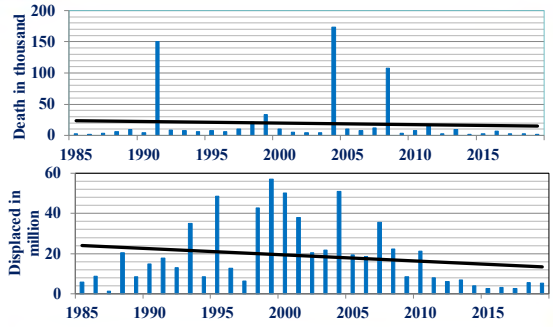


Data: UNDP and Hoornweg & Pope

GROWTH OF JAKARTA IN 30 YEARS

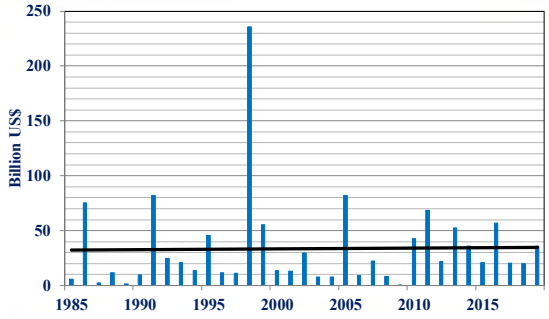


DEATH AND DISPLACED PERSONS



Data: Dartmouth Flood Observatory and Colorado State University

DAMAGE IN BILLION US$



Data: Catholic University of Leuven

EXAMPLES OF FIVE MOST DEATH DUE TO MAJOR FLOODING

Event	Year	Country	Death	Damage in billion US$
Tsunami	2004	South Asia	226,000	9.8
Cyclone	1991	Bangladesh	139,000	1.8
Cyclone	2008	Myanmar	138,000	4.0
Flash flood	1999	Venezuela	30,000	3.2
Heavy rain	1998	Honduras	11,000	3.8
		Total	544,000	22.6

Data: Dartmouth Flood Observatory, Colorado State University and Catholic University of Leuven

EXAMPLES OF FIVE MAJOR DAMAGE DUE TO FLOODING

Event	Year	Country	Damage in billion US$	Death
Tsunami	1991	Japan	210	19800
Hurrycane	2005	USA	125	1833
Hurrycane	2017	USA	95	88
Hurrycane	2017	Puerto Rico	68	64
Hurrycane	2017	USA	57	58
		Total	555	21843

Data: Dartmouth Flood Observatory, Colorado State University and Catholic University of Leuven

LANDFILL OR POLDER

DRAINAGE AND FLOOD PROTECTION - I

- in flood prone areas generally drainage and flood protection will be required:
  - value of public and private property per unit area in urban areas is much higher than in rural areas
  - in urban areas the period between precipitation and discharge is much shorter than in rural areas
- design standards for drainage and flood protection of urban areas significantly higher than for rural areas
- rapid urbanisation, especially in countries with a high, medium and low HDI, increasingly results in problems due to inadequate drainage and flood protection

DRAINAGE AND FLOOD PROTECTION - II

- flood protection measures to be designed at much higher safety level than drainage measures, while dead and displaced people and damage due to flooding may be much higher than due to inundation following exceedance of storage and discharge capacity of drains
- for actual measures on flood protection distinction is made between structural and non-structural measures and among urban and rural areas

Drainage by gravity

needs to be replaced by drainage by pumping

DRAINAGE GRAVITY + PUMPING

SAEMANGEUM COASTAL RECLAMATION, SOUTH-KOREA

STRUCTURAL AND NON-STRUCTURAL MEASURES

- **structural measures.** ***Artificial mounts, dams, dikes, bypasses, polders, land use zoning***
- **non-structural measures.** ***Flood forecasting, flood warning, evacuation***

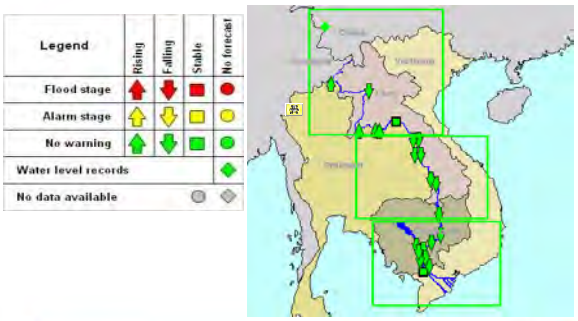
BONNET CARRÉ SPILLWAY NEW ORLEANS

DAY RIVER DAM, HANOI

RIVER DIKE, THE NETHERLANDS

INLAND DIKE, THE NETHERLANDS

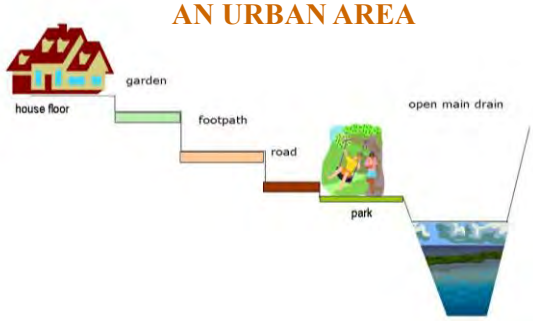
FLOOD FORECASTING MEKONG



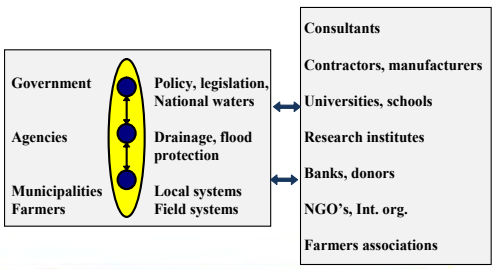
VERTICAL DIFFERENCES

- locate urban (valuable) areas higher, than surrounding rural areas
- within rural areas, locate farm buildings higher than the cropped area
- within urban areas, locate houses and buildings the highest, then the streets, and finally the parks and green areas

PREFERRED LEVELS IN AN URBAN AREA



ACTORS IN WATER MANAGEMENT AND FLOOD PROTECTION



DESIGN STANDARDS FOR DRAINAGE

- *preferred normal conditions*. Preferred water levels and operation rules for discharge structures. Strongly linked to land use and soil type
- *design conditions*. Conditions on which designs of drainage systems are based. Formulated as: *exceedance of preferred water level(s), duration of exceedance, chance per year exceedance can occur*;
- *extreme conditions*. Generally not a design criterion, control computations for extreme situations. Bankful storage in drains is generally considered

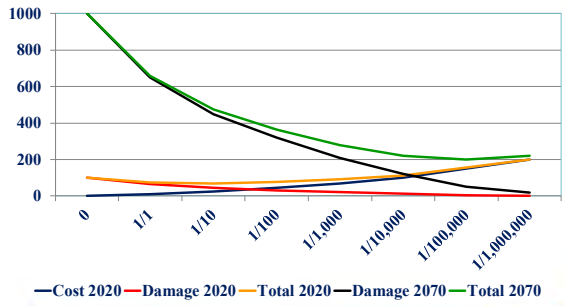
DESIGN STANDARDS FLOOD PROTECTION - I

- damage in rural areas primarily reduction in crop yield and in coastal areas risk of flooding with saline water
- design standards chance of occurrence 5 to 10% per year
- rapid urbanisation in flood prone regions >> flood protection far below economic optimum
- with exception of flood protection in Netherlands actual levels between chances of occurrence 0.5 to 5% per year
- serious risk of loss of a large number of human lives, enormous displacements of people from flooded areas and huge damage when really an extreme occurs

DESIGN STANDARDS FLOOD PROTECTION - II

City/country		Chance in percent per year
Dhaka, Bangladesh		2
Australia, United Kingdom, USA		1
India:	*urban and industry*	1
	rural area	4
China:	*major cities*	0.5
	cities	1
	rural area	5
Brits Columbia in Canada		0.5
Coast of the Netherlands		0.0001

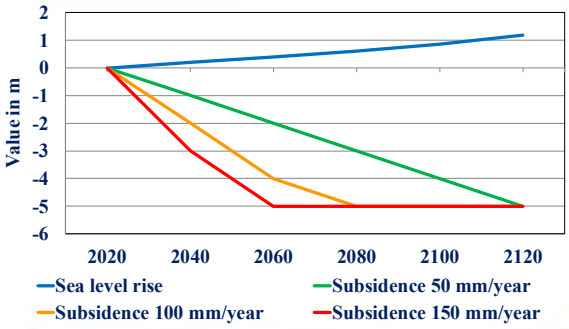
IMPACT OF DEVELOPMENTS IN FLOOD PRONE AREAS



SUBSIDENCE FLOOD PRONE AREAS

Location	Subsidence in cm/year
Tokyo	1 - 24
Semarang, Surabaya	6 – 20
Jakarta	0.5 - 17
Bangkok, Taishi	4 - 12
Tianjin	3 - 11
San Francisco Bay area, Bolivar Coast Polders	0.2 - 10
Yuanchang	6 - 8
Houston-Galveston; Ho Chi Minh City	4 - 5
Manila, New Orleans, Shanghai, Ganges Brahmaputra	2 – 4
Mekong Delta, Venice	1 – 4
Mississippi Delta	0 – 3.5

SUBSIDENCE AND SEA LEVEL RISE

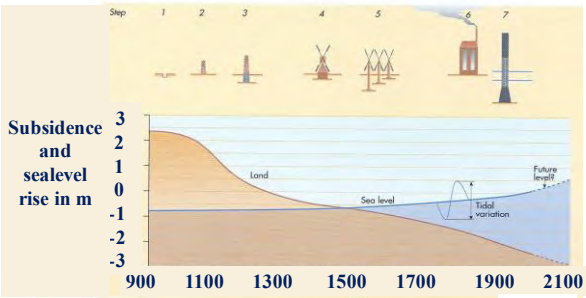


San Joaquin Valley, California, USA

Subsidence poles

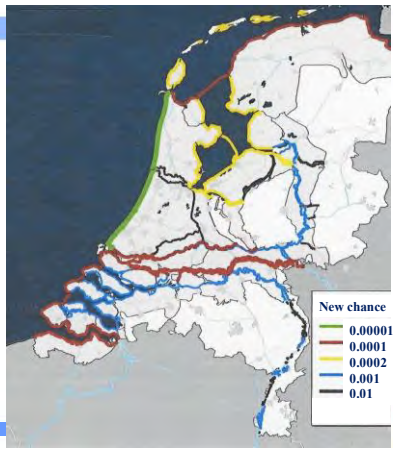
The Fens, East England

DEVELOPMENTS IN NETHERLANDS

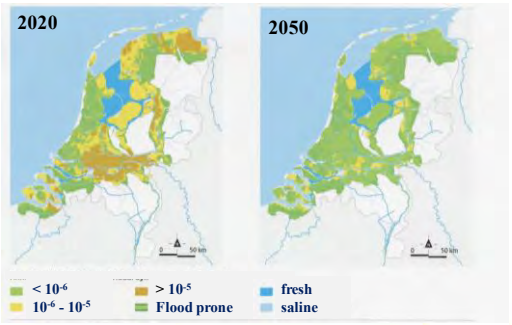


Present situation in the Netherlands

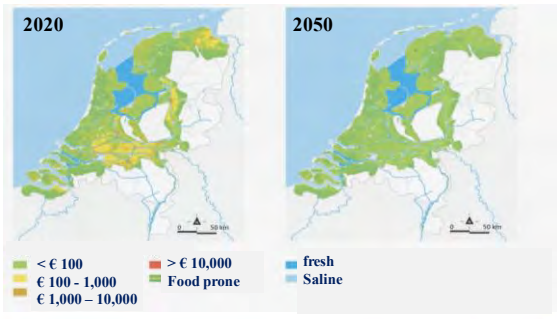
New situation in the Netherlands



ANNUAL CHANCE INDIVIDUAL DYING



ANNUAL RISK OF DAMAGE €/HA



CLIMATE CHANCE AND IMPACT OF HUMAN ACTIVITIES

- **climate change:**
  - ***rise of the mean sea level***
  - ***change in river regimes and increase in peak discharges of rivers***
  - ***increase in annual rainfall and in peak rainfall***
    - **Impact 10 – 45% per century**
- **impact of human activities:**
  - ***increase in value of public and private property***
  - ***increase in population***
  - ***increase in value of crops***

Impact 100 – 1,000% per century

CONCLUSIONS

- development and implementation of integrated drainage and flood protection packages urgently required, especially for densely populated flood prone regions
- need for modernisation of (urban) drainage schemes
- need for optimisation of flood protection measures related to increase in value of protected public and private properties, population growth and subsidence
- government, drainage and flood protection agencies, municipalities and farmers - to take the right decisions
- many parties involved. However, they only contribute

CRUCIAL POINTS

- land subsidence dominates impacts of climate change
- levels of safety generally far below economic optimum
- countries need integrated flood management plans at river basin level for short, medium and long term

CONCLUDING REMARKS

- to cope with rapid developments in flood prone regions, especially in countries with a high, medium and low HDI, a significant improvement of drainage and flood protection provisions will be required
- development and management of flood prone areas requires an integrated approach where various aspects are taken into account in a balanced way
- in such an approach specific physical conditions have to play an important role in order to prevent reduced benefits from generally considerable investments, and to reduce death, displacement and damage