# Impacts of climate change on floods and urban flooding management

**prof.ir. Jean-Michel HIVER**

UNIVERSITÉ de Liège

Water management in the context of climate change - Hanoï
28.05.2019

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Note: the presented results are mainly extracted from the IPCC Assessment Reports (AR4, AR5)

# 1. Intergovernmental Panel on Climate Change Synthesis of the AR5

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1.4 The main projected impacts for South West Asia

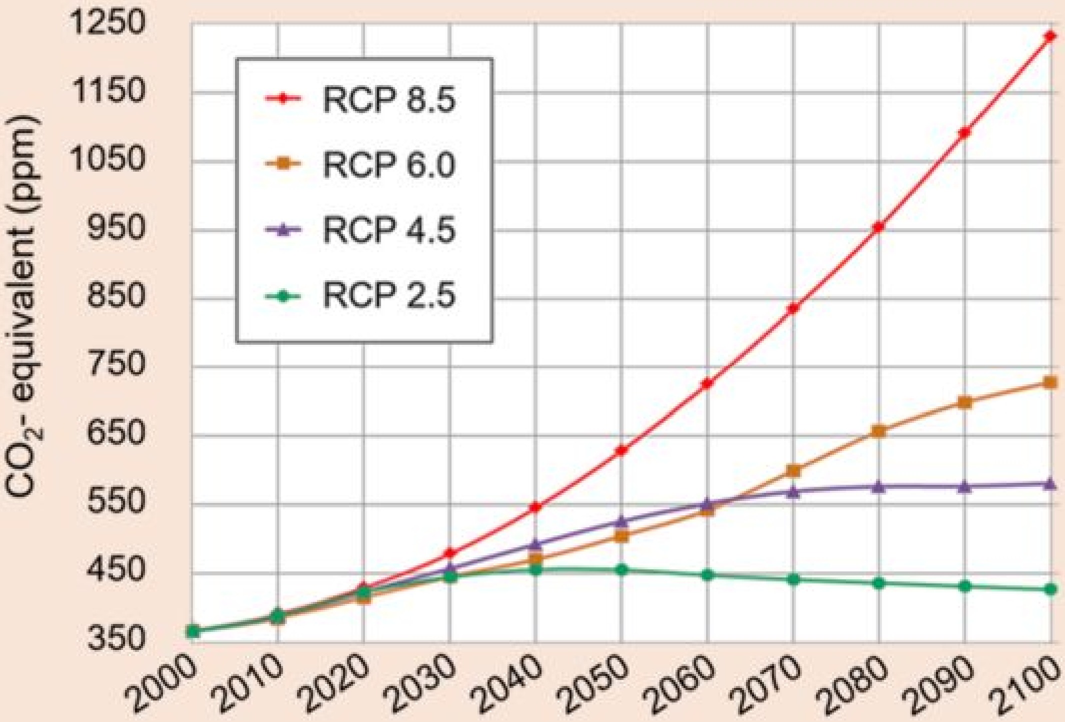
# 1.1 IPCC presentation

- Created in 1988 by the WMO and the UNED Program, the objective of the IPCC is to provide governments at all levels with scientific informations.
- For the assessment reports, IPCC scientists assess scientific papers published each year to provide a comprehensive summary of the knowneldge about the drivers of climate change (…,AR4, AR5,AR6)


- Greenhouse Gas Concentration, uncertainties,…
- Identification the strength of scientific agreement in different.

# Representative Concentration Pathways (RCPs)

- To assess Greenhouse Gas Concentration, one define RCPs to fix scenarios that stabilizes radiative forcing in the year 2100
- Four pathways have been selected for climate modeling:
  - RCP 2.5 assumes a peak between 2010–2020
  - RCP 4.5 assumes a peak around 2040
  - RCP 6 assumes a peak around 2080
  - RCP 8.5 emissions continue to rise throughout the 21st century



# Uncertainties

- However uncertainties in climate change projections are large:
  - Models dependent
  - Non-robust
  - Unknown unknowns
- Extrapolations between the Global Circulation and the Regional Circulation model
- Developing  on two metrics to improve the credibility of the assessment:
  - confidence, quality, and consistency
  - Quantification of uncertainty by an expressed probabilistically analysis
- Similar problems are faced when estimating flood probabilities for extreme events
  - Lack of data
  - Non-stationary system
  - Extrapolation

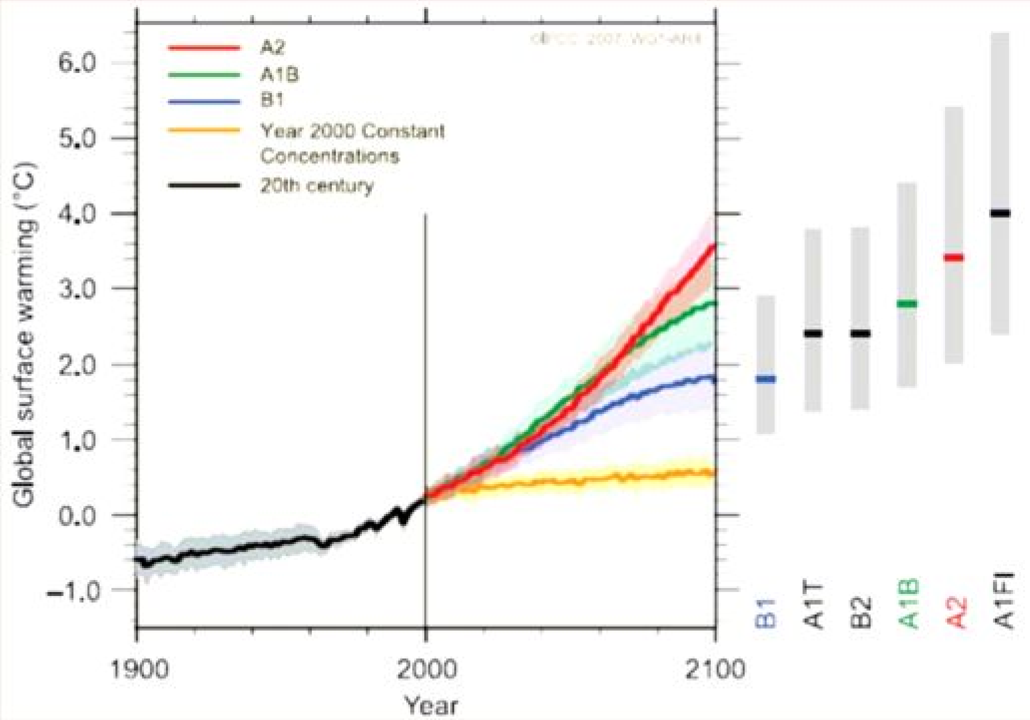
# 1.2 IPCC – Main results

The last Synthesis (AR5) gives an integrated view of climate change results, such as mainly:

- changes in many extreme weather and climate events including a decrease in cold temperature extremes, an increase in warm temperature extremes, in extreme high sea levels and in the number of heavy precipitation events in a number of regions.
- continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system
- climate change will amplify existing risks and create new risks for natural and human systems
- and, specially, that all types of floods (flash flood, urban, river and coastal flooding) are affected by climate-related factors, natural and anthropogenic.

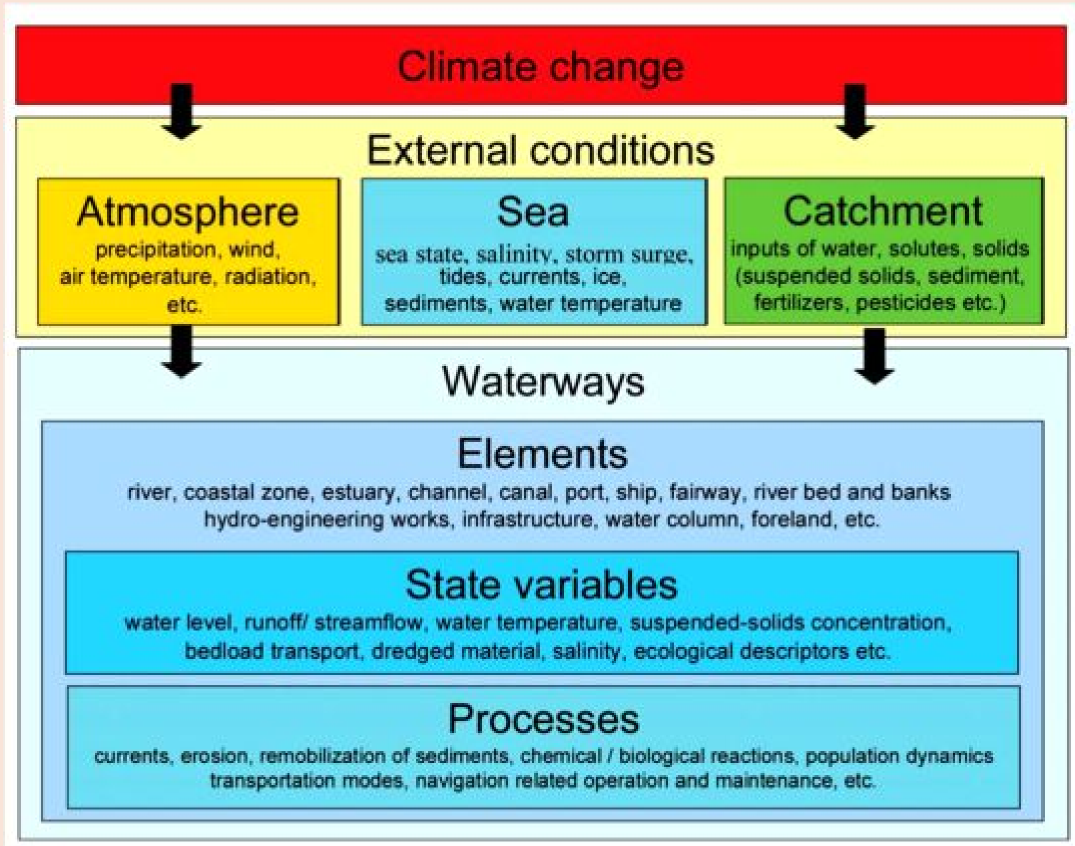
# Averages and assessed ranges for surface warning

**A2**: scenario (rapid increase in the emission of greenhouse gases
**B1**: scenario (among the moderate
**A1B**: scenario (intermediate between the others but closest to the B2 scenario




Observed (top) and predicted (bottom) change in temperature due to climate change
(reproduced from Figures 4 and 5 of AR4, SPM, IPCC, 2007d)

# Drivers of change to inland navigation are meteorological variables such as temperature, precipitation, drought, water resources and storm intensity.

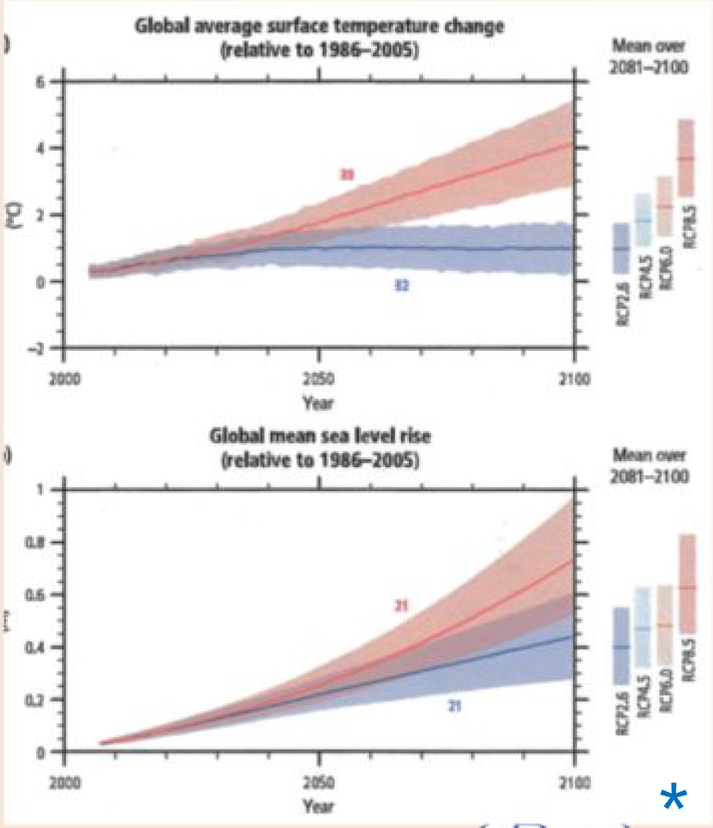



Schematization of climate change influencing the use of waterways (after BMVBS, 2007)

# 1.3 Projected Changes in Global Mean Sea Level

- The increase of global mean surface temperature by the end of the 21st century is likely to be from 0.3°C - 1.7°C under RCP2.6 to 2.6°C - 4.8°C under RCP8.5

- For the end of the 21st century, the global mean sea level rising will likely be from 0.26 - 0.55 m for RCP2.6, and 0.45 - 0.82 m for RCP8.5
- Sea level rise will not be uniform across regions. By the end of the 21st century, it is very likely that sea level will rise in more than about 95% of the ocean area.



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* Climate Change 2014 - Synthesis Report Summary for Policymakers

# 1.4 The main projected impacts for South Asia

- An increase in occurrence of extreme weather events including heatwave and intense precipitation events.
- 1 m rise in sea level would lead to a loss of almost half of the mangrove area in the Mekong River delta.
- Coastal areas, especially heavily populated megadelta regions will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers.
- Increase in extreme rains in north-west during summer monsoon in recent decades, lower number of rainy days along east coast
- Taken together and considering the influence of rapid population growth and urbanization, the risk of hunger is projected to remain very high in several developing countries.

# 2. Impact of the climate change on floods

2.1 Major flood types
2.2 Flood hazards
2.3 More floods and also more droughts

# 2.1 Major flood types

All flood types are affected by climate-related factors, some more than others.

**River flooding**

Urban flooding

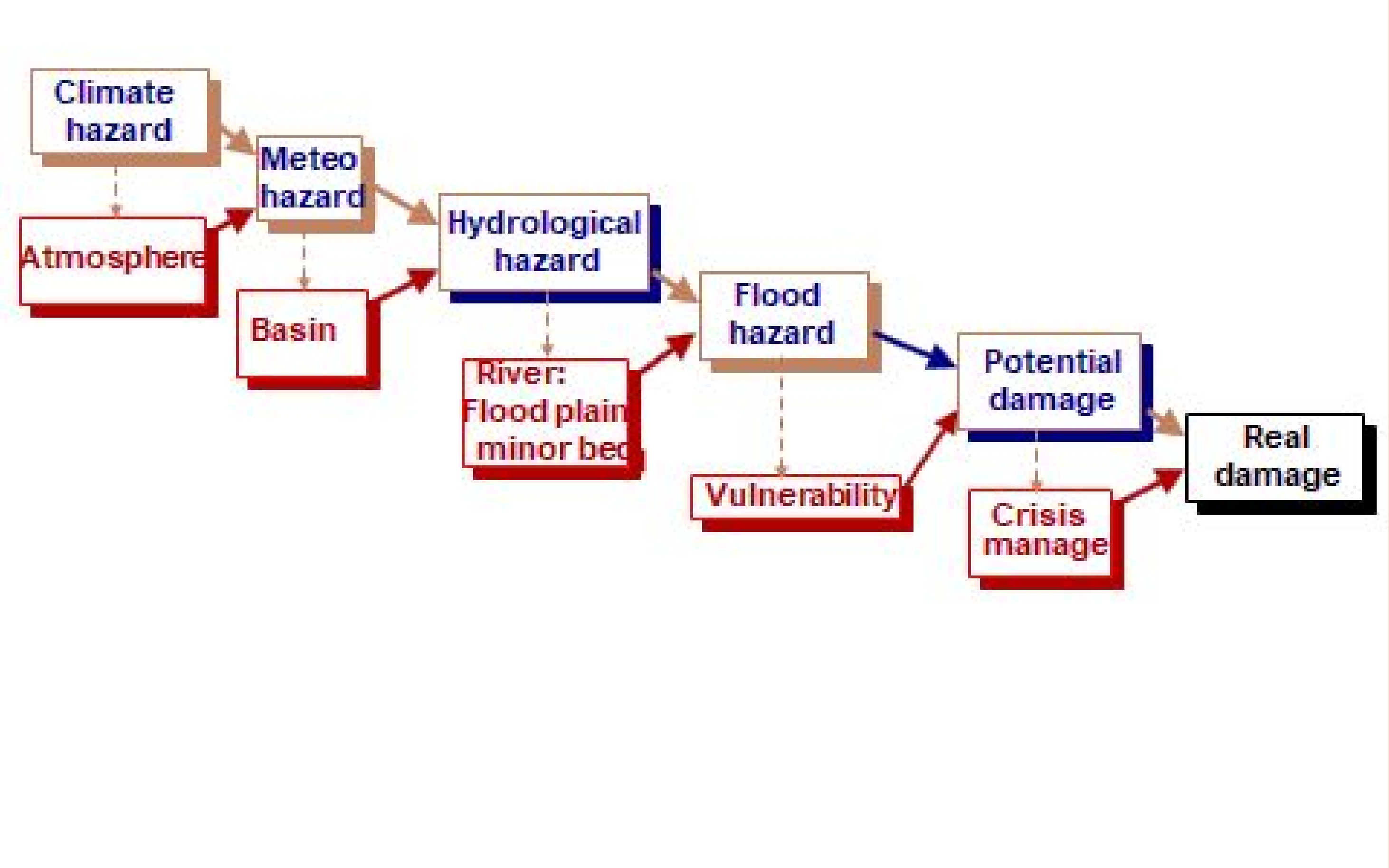
**Flash flood**

**Coastal flooding**

Debris flow

Urban flooding

# 2.2 Flood hazards

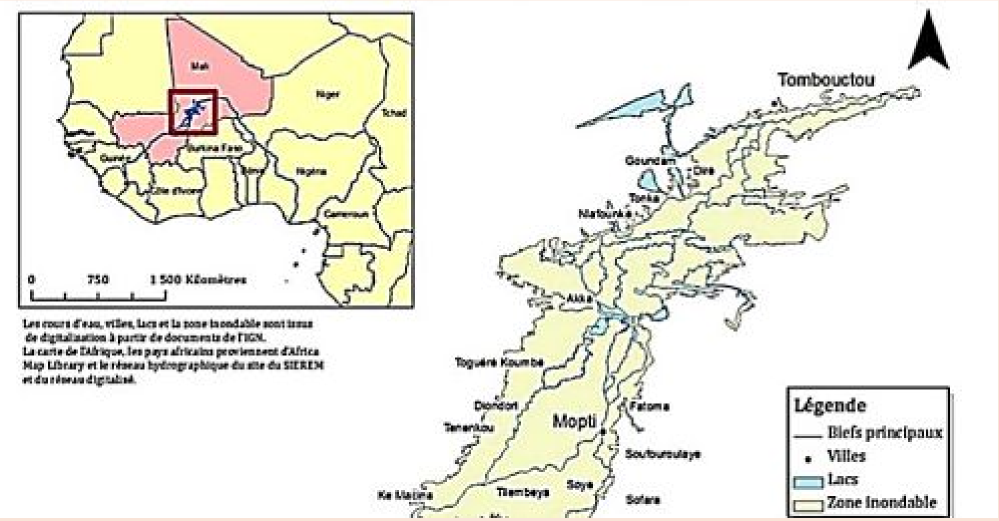


# Observations

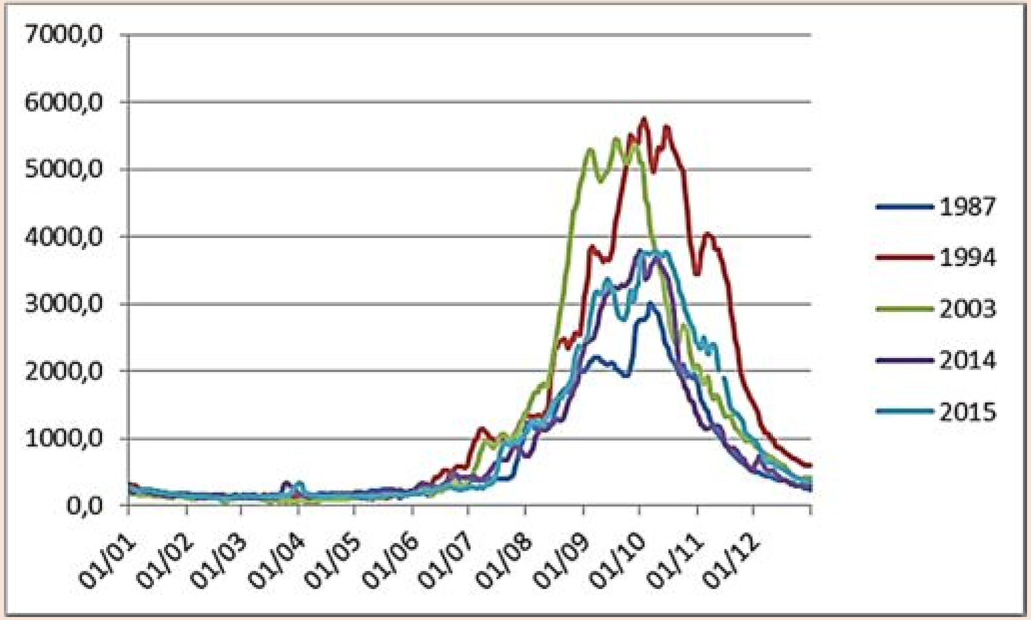
- A warmer atmosphere holds more moisture
- Scientists predict that heavy rainfall will increase in the future
- Attributing specific events only to climate change is tricky, flooding is no exception
- Flooding isn’t just about rainfall because other human factors contribute too (river training works, urbanization, Heat Island Effect,…)
- One of the most effective climate change impacts is on the unexpected occurrences of floods and especially flash floods
- Engineering risk management is very significant factor in climate change assessment and impact intensity calculations

# 2.3 More floods and also more droughts

- More records for both wet and dry weather are being set around the globe, often with disastrous consequences for the people facing such extremes events
- Under the RCP8.5, projections by the end of the century indicate an increased risk of drought is likely in presently dry
- Parts of West Africa are experiencing more months with a pronounced lack of rain (e.g. Sahelian countries; Inner Niger Delta in Mali)



# Inner Niger Delta in Mali

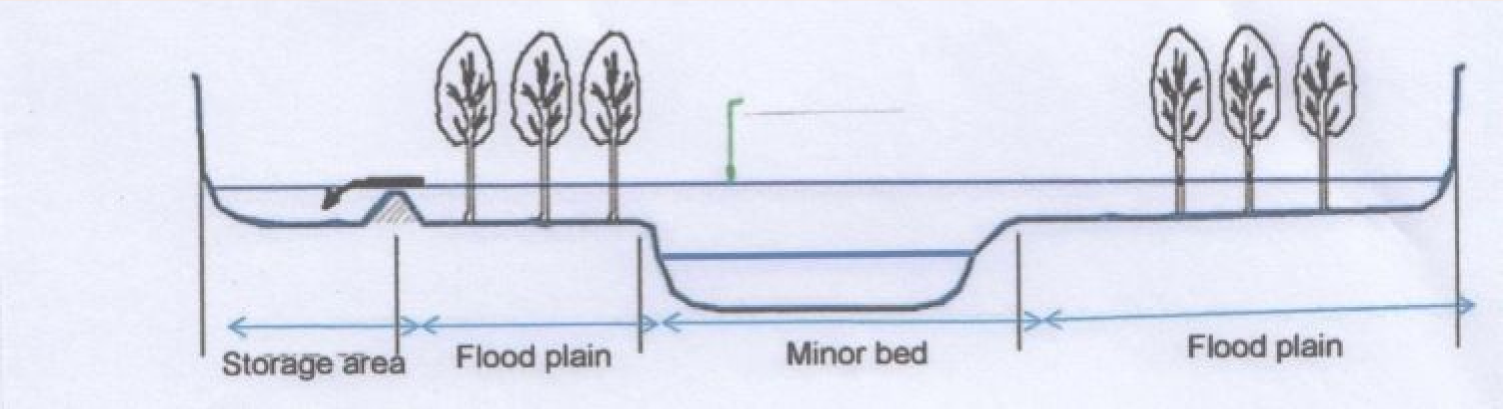



The floodplain of the Inner Niger Delta, a Ramsar site in Mali, is a green island located in the Sahelian belt of West Africa. With an area that fluctuates between 30.000 and 50.000 km², depending on the years of high and low.

- The drastic reduction in floods, followed by increasingly recurring droughts, had a negative impact on agricultural and livestock production, fish farming, forestry, transport, etc…
- For Inavigation, its duration was reduced by half (from 8 months in 4 months maximum) and the groundings became more numerous.

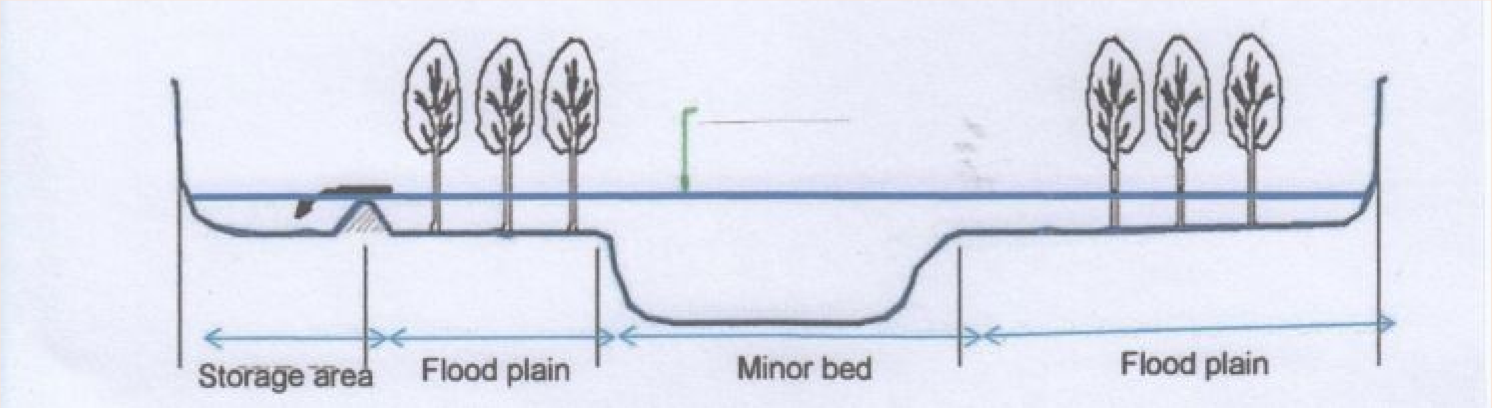
# Climate change impacts but also anthropogenic effects!

Cross section of the river in a natural situation – Low discharge



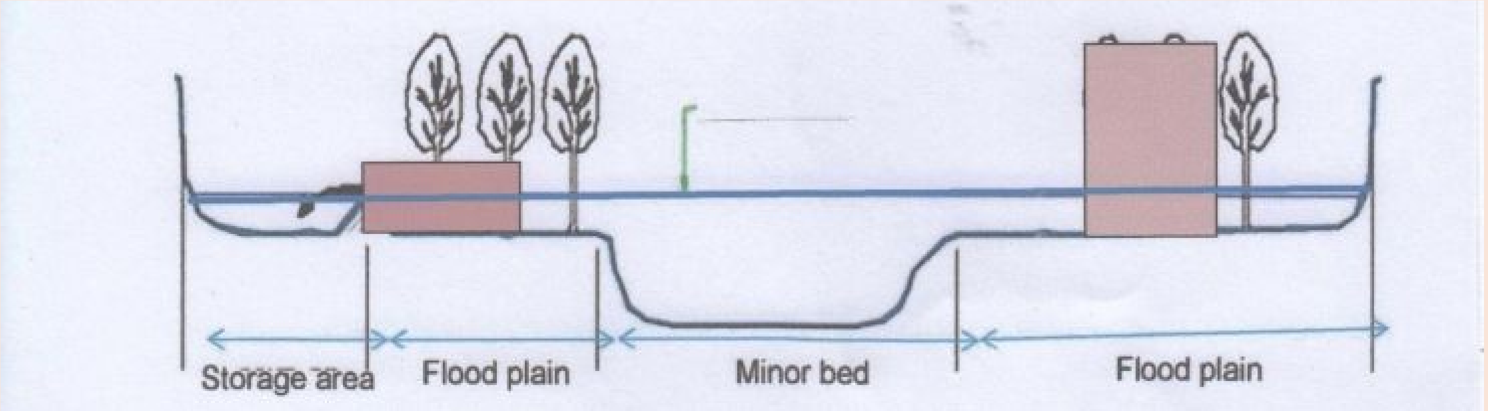
# Climate change impacts but also anthropogenic effects!

Cross section of the river in a natural situation – High discharge



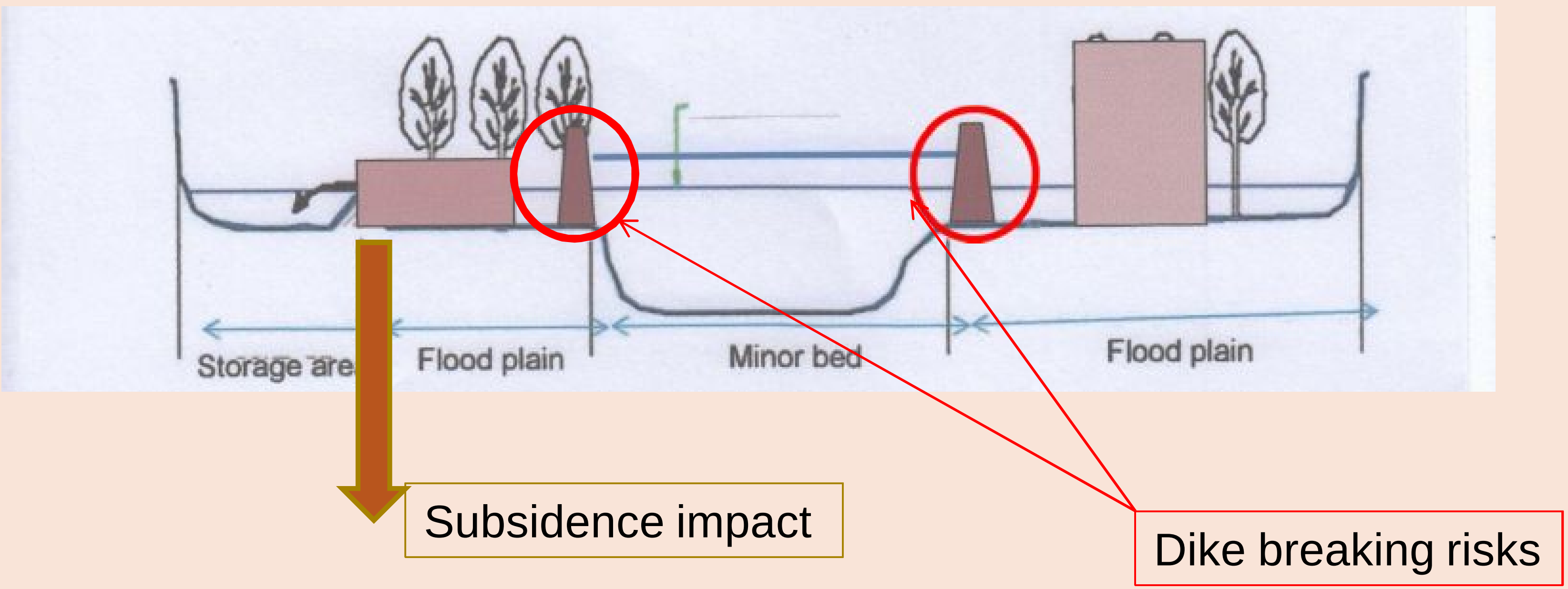
# Climate change impacts but also anthropogenic effects!

Urbanised flood plains – High discharge



# Climate change impacts but also anthropogenic effects!

Urbanised flood plains – Protection dikes along the river



# 3. Urban flooding, risks and vulnerability

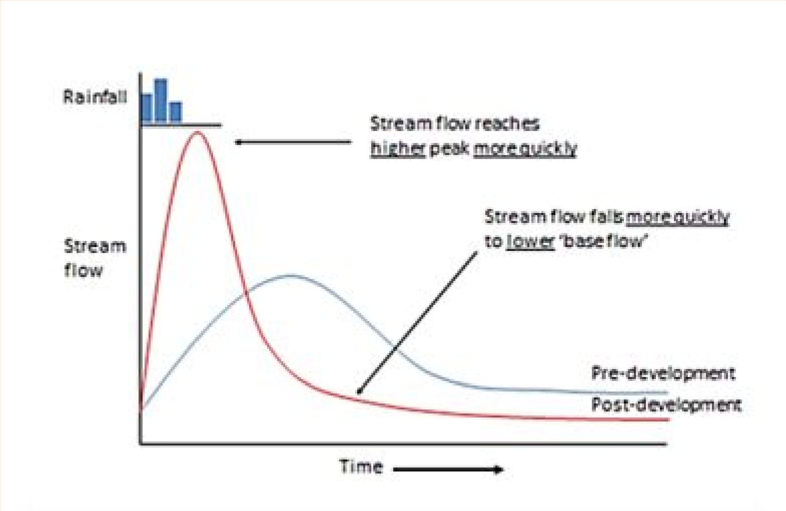
3.1 Main hydraulic characteristics of urban hydrology
3.2 How urban floods differ from rural floods?
3.3 Urban micro climate
3.4 Urban flooding hazards
3.5 Height measures to prevent urban flooding

# 3.1 Main hydraulic characteristics of urban hydrology

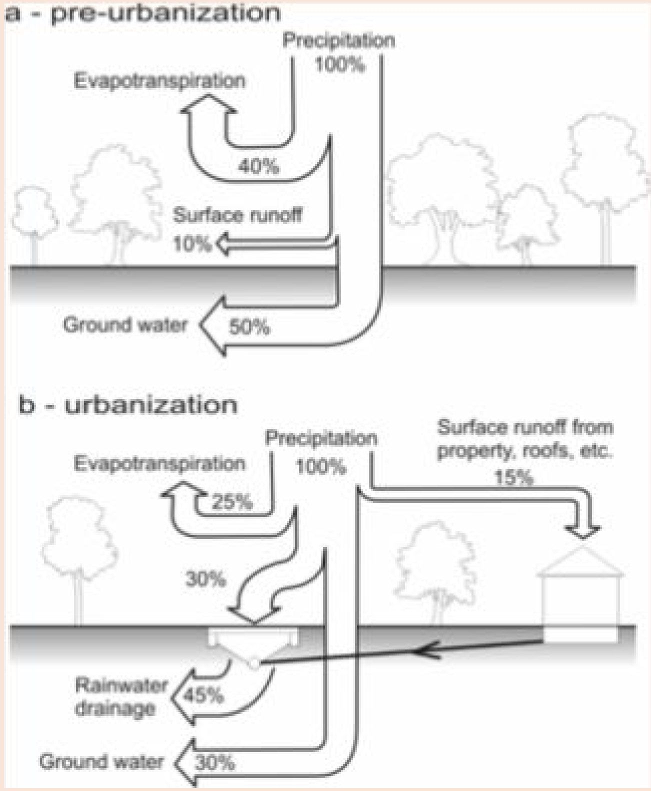
- The hydro-urban systemcan be very diverse and complex:
  - Sewer networks (combined or separate; branched or meshed, free flow surface or under pressure,…)
  - Rivers, canals or waterways
  - Lakes
- Some hydro-systems being interconnected, they create backwater effects and flow instabilities → reduced their runoff capacities
- The hydraulic response depends of the time-evolution of the variables:
  - If input = rainfall intensity → **Δ**t =1 min
  - If input = sea water level → **Δ**t =1 hour
  - If input = upstream Mekong discharge → **Δ**t =1 day
- Boundaries' conditions:
  - Upstream: rainfall → runoff, thus Q(t)
  - Downstream: river or canal water level, tide level, thus z(t)

# 3.2 How urban floods differ from rural floods

- Increase in peak flows and in frequency owing to the higher runoff capacity through conduits and canals, …




- Increased sediment production from unprotected surfaces and production of solid waste
- Disorganized implementation of urban infrastructure
- inappropriate drainage projects and works, with reduced downstream diameters, drainage without runoff

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# 3.2 Urban microclimate

- Urban areas are perhaps the most complex of all microclimates
- What changes a cities climate:
  - Human activity has a big influence on the urban climate
  - Climate is the long term behavior of the atmosphere in a specific area with characteristics such as temperature, pressure, wind, precipitation, cloud cover, humidity,…
- Pollutants are harmful to human health and also contribute to a reduction in air quality (e.g. smog or acid rain) and cause the nucleation
- Warmer temperatures in cities mean that their residents experience even greater temperatures and heat stress
- "Urban Heat Island Effect" (UHI) is an overheating of the urban ( lack of vegetation, changes in thermal properties of surface materials, human heat generation by air conditioning,…)
- UHI is clearly notticable and the trends will increase by futher rising temperatures

# 3.4 Urban flooding hazards

- Flooding in urban areas can be caused by flash floods, or coastal floods, or river floods, but there is also a specific flood type that is called urban flooding
- Urban flooding is specific in the fact that the cause is a lack of drainage in an urban area. As there is little open soil that can be used for water storage nearly all the precipitation needs to be transport to surface water or the sewage system
- High intensity rainfall can cause flooding when the city sewage system and draining canals do not have the necessary capacity to drain away the amounts of rain that are falling
- Water may even enter the sewage system in one place and then get deposited somewhere else in the city on the streets. Sometimes you see dancing drain covers

# 3.5 Height measures to prevent urban flooding

- Create a “sponge” city (green roofs/rooftop gardens, permeable pavement, sidewalks,…)
- Create flood plains and overflow areas for rivers
- Keep the performance of the sewer network (hydraulically effective cross section)
- Improve flood protection systems
- Develop and improve modelling tools and techniques for urban flood management
- Implement a dynamic real-time network management system
- Integrate the urban flooding management with the  coastal and river flood control (new paradigm:holistic approach)
- Measures to reduce systemic vulnerability or resilience to shocks

# 4. HCMC situation

# 4.1 Climate change and vulnerability

- HCMC has to struggle with already perceptible climate-related problems like flooding, heavy rain events and increased temperatures
- Taken independently, the most direct causes of flooding are:
  - heavy rainfall intensity
  - high upstream discharge of the Mekong river
  - sea level rise
  - Subsidence
  - Acceleration of urbanization
- One of the unfavorable factors for urban flooding is the river water level (backwater effect), which is affected by a semi-diurnal tide that usually reaches highest value in September and October. This unfavorable condition is made even worse because the annual tidal peak period is usually coincident with annual rainfall peak's.

# Flood protection barriers project

- Supported by WBI, University of Liege(Uliege ) and Thu Loi University (TLU),, share their efforts to develop a sustainable policy of flood protection barriers in Vietnam in the framework of climate change and sustainable development.
- This topic is presented by Dr Le Xuan Bao (IWER)

Thames barrier (UK)


Maeslant Storm Barrier (NL)

EMS barrier (DE)

# 5. Conclusions

- Climate change is likely to have implications for urban flood risk management decisions today but is one of many drivers that must be considered (e.g. urbanisation, aging infrastructure, Urban Heat Island, population growth etc...)
- Failure to adequately treat climate change in decision making today could lead to future unnecessary costs, wasted investments and risks to life
- Long-term infrastructure is an area where planning decisions are likely to be sensitive to assumptions about future climate conditions
- Strategies that reduce flexibility, such as building in exposed areas, can limit robustness

# Thank you very much for your attention