

СТО ГОДИНА
МИЛАНКОВИЋЕВЕ ТЕОРИЈЕ
О КЛИМАТСКИМ
ПРОМЕНАМА



1920202120

100 YEARS of
MILANKOVIC'S THEORY of
CLIMATE CHANGE



BENEFITS OF GREEN INFRASTRUCTURE FOR CLIMATE-RESILIENT FLOOD MITIGATION IN A RURAL WATERSHED

Jasna Plavšić¹ and Ranko S. Pudar^{1,2}

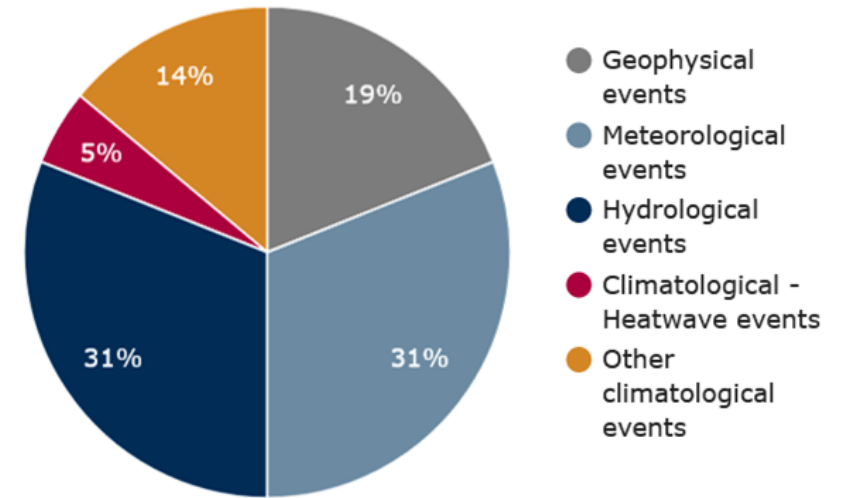
¹ University of Belgrade – Faculty of Civil Engineering

² Pudar Mitigation Consulting, Inc., Marietta, GA, USA

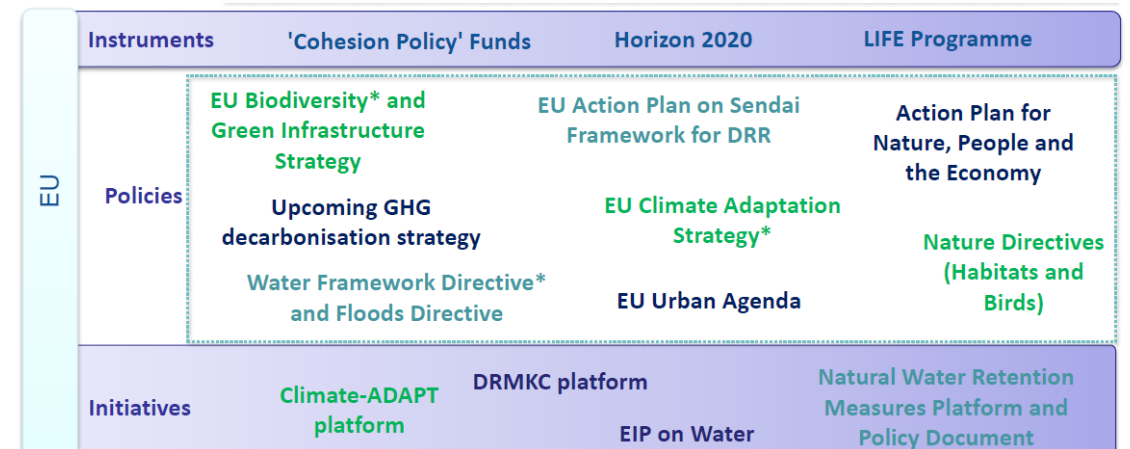


Natural hazards and disasters

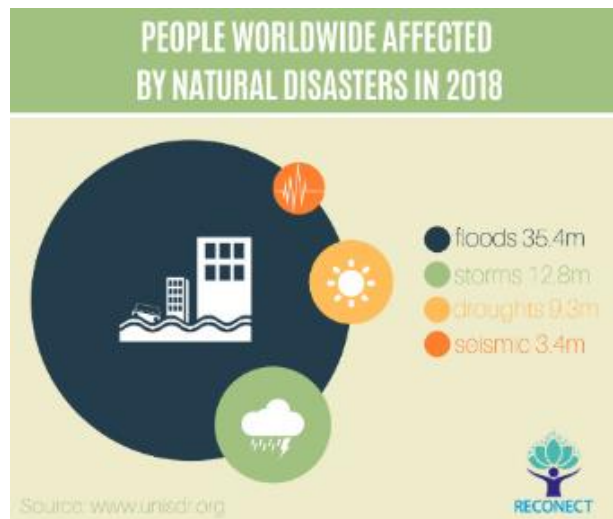
- Natural disasters in EU 1980-2017: overall loss EUR 557 billion
 - Share of hydrometeorological events (floods, storms...) in reported damages: 62%
 - Share of climatological events (droughts, heat and cold waves, forest fires...): 19%
- Various EU strategies and policies for disaster management
 - Shift towards green infrastructure and nature-based solutions



Source: European Environment Agency



Flood risk increases



- Flood control traditionally based on structural measures, i.e. grey infrastructure
 - culverts, concrete-lined river channels and levees
 - exposed to natural degradation, requires costly maintenance
 - detrimental to ecosystem functions and decrease their value
- Existing infrastructure under additional stress due to climate change
- Assets value increases with time, exposure to floods grows fast

Green vs. grey infrastructure for flood risk reduction

- Today, growing attention towards green infrastructure and nature-based solutions
 - initial focus on urban areas and small-scale measures
 - little attention for settings other than urban and for large-scale systems
 - very little research on quantitative and cost effectiveness of GI for large areas
- 2016 call for H2020 projects: Large-scale demonstrators on nature-based solutions for hydro-meteorological risk reduction
- RECONNECT project



Regenerating **ECO**systems with
Nature-based solutions for
hydro-meteorological risk **rEduCT**ion

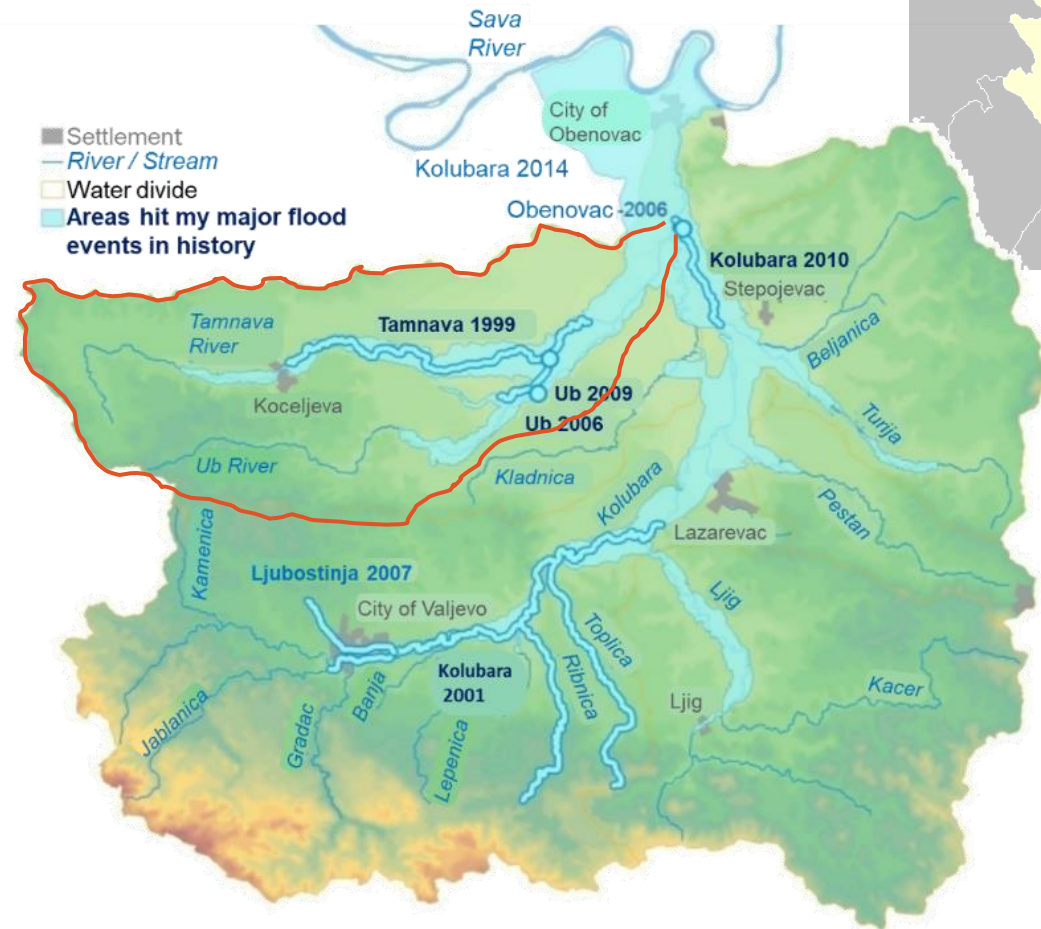
Green vs. grey infrastructure for flood risk reduction

- Green infrastructure can be less expensive and provides a wide array of co-benefits for local population, economy, and environment
- Both types have advantages and drawbacks, and should complement each other, especially where grey infrastructure already exists
- Selecting the most effective strategy within the flood risk assessment framework
 - provides a quantitative evaluation of different measures

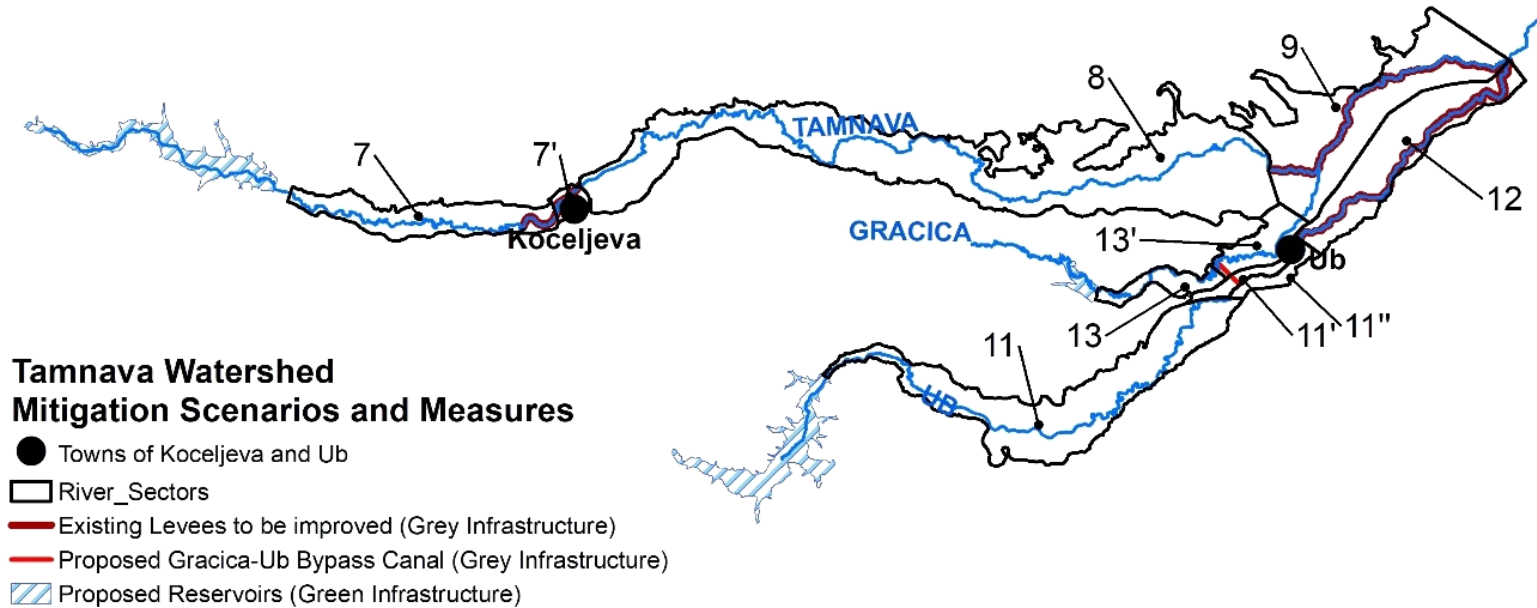


Study area: Tamnava River

- Tamnava River watershed, part of the Kolubara River basin
 - 730 km², agricultural land 80%, small population centers
 - significant impact on downstream flood risk (town of Obrenovac and open-pit coal mine)
 - frequent floods
- May 2014 flood follow-up: measures for upgrading the flood protection level for the Kolubara River basin (UNDP study)



Flood mitigation scenarios for Tamnava



Existing

levees in urban centers,
low-level levees in
agricultural areas

Green

detention ponds

Green-grey

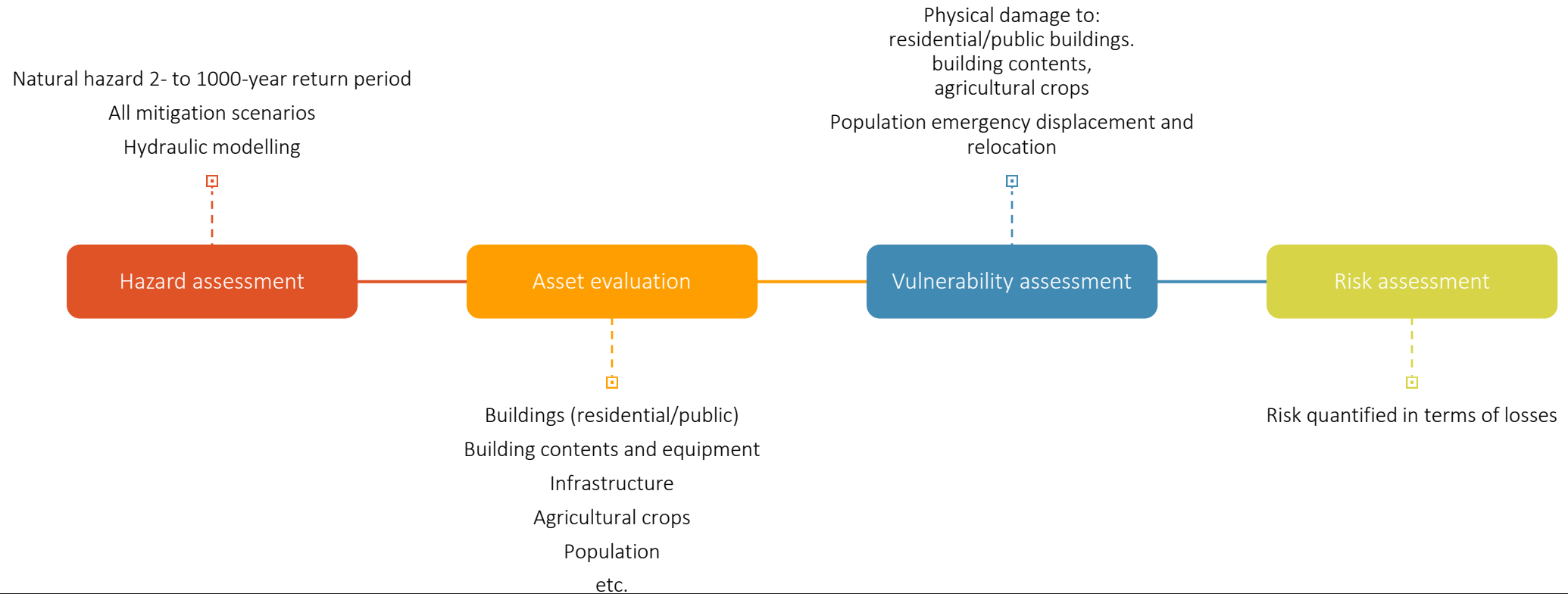
detention ponds,
elevated levees

Grey

elevated levees, Gračica-
Ub diversion

Flood risk assessment

- Risk defined here as the product of the probability of the hazard and the vulnerability
- Micro-scale risk model



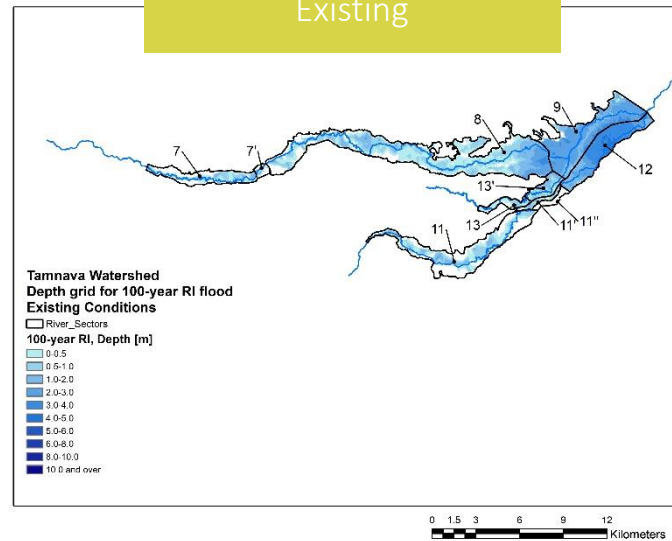
Natural hazard 2- to 1000-year return period

All mitigation scenarios

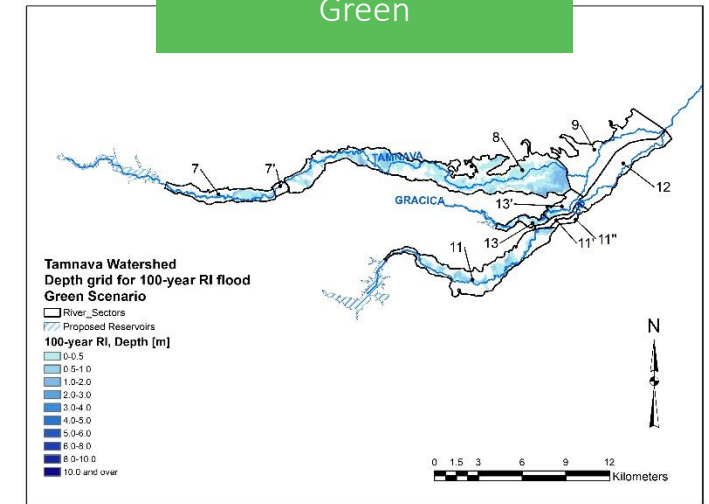
Hydraulic modelling

Hazard assessment

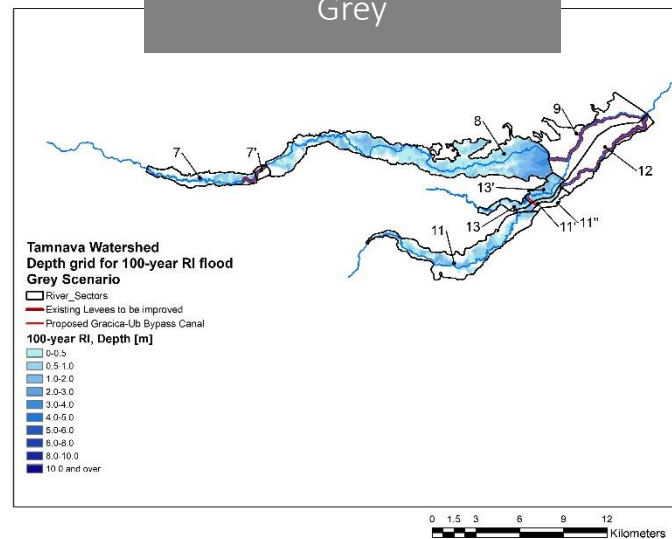
Existing



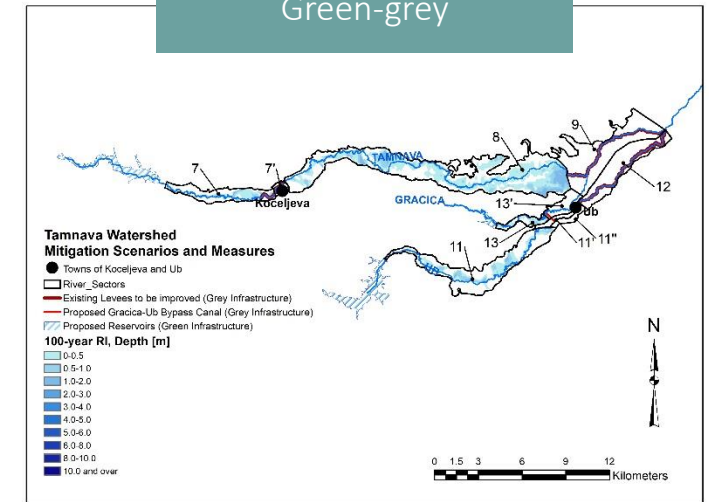
Green



Grey



Green-grey



- Asset identification on a micro-level
 - on a level of individual buildings, total of 5,984 permanent structures identified from aerial photogrammetric imagery
 - number of structures and their occupational classes verified in field visits

Asset evaluation



Buildings (residential/public)
Building contents and equipment
Infrastructure
Agricultural crops
Population
etc.



Existing

Green

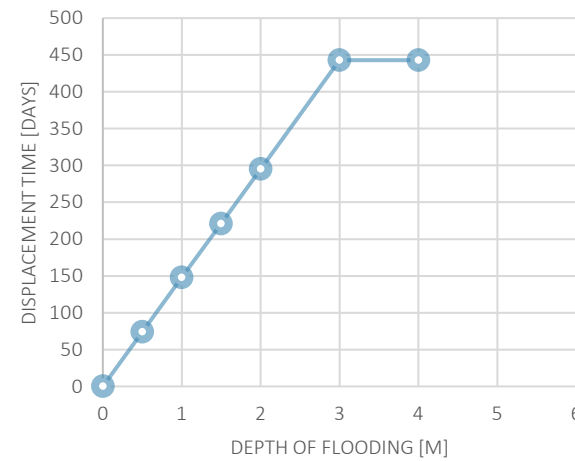
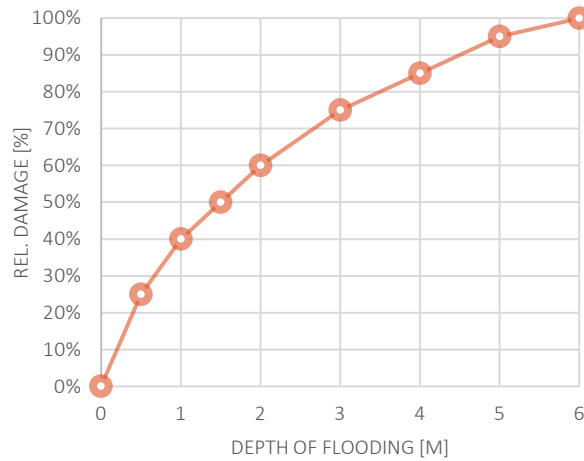


Physical damage to:
residential/public buildings,
building contents,
agricultural crops

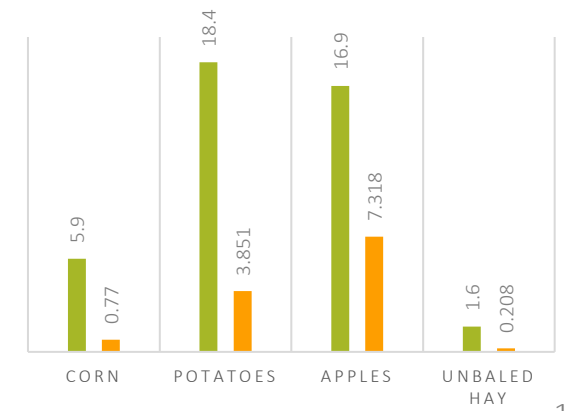
Population emergency displacement and
relocation



Vulnerability assessment



Yield [tonnes/ha] Annual revenue [1000s €/ha]



Risk assessment

Risk quantified in terms of losses

- Establish the distribution of damages (for a range of hazard scenarios)

- Expected annual damage for scenario s

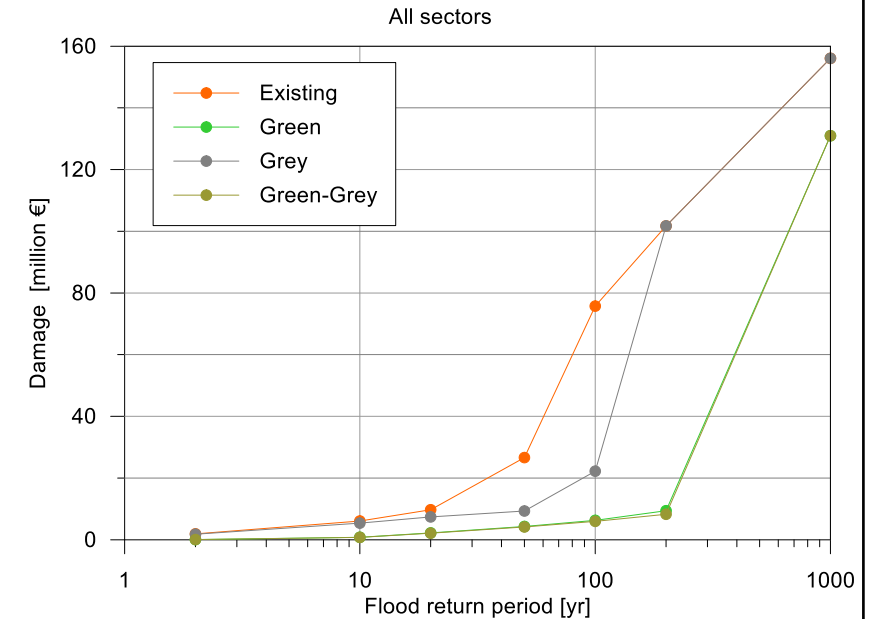
$$EAD_s = E(D) = \int_0^{\infty} Df(D)dD \approx \sum D_i p_i$$

- Expected annual benefit for scenario s is the reduction of losses compared to the baseline scenario

$$EAB_s = EAD_0 - EAD_s$$

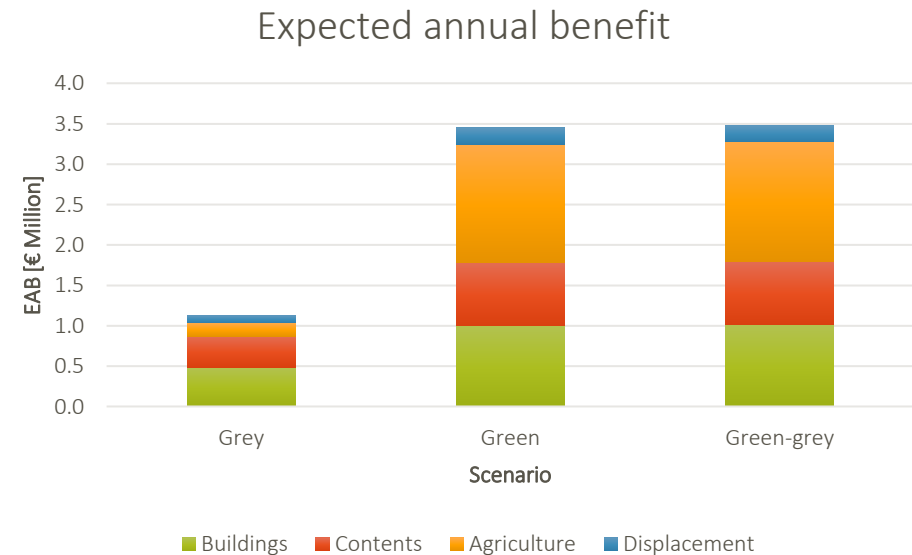
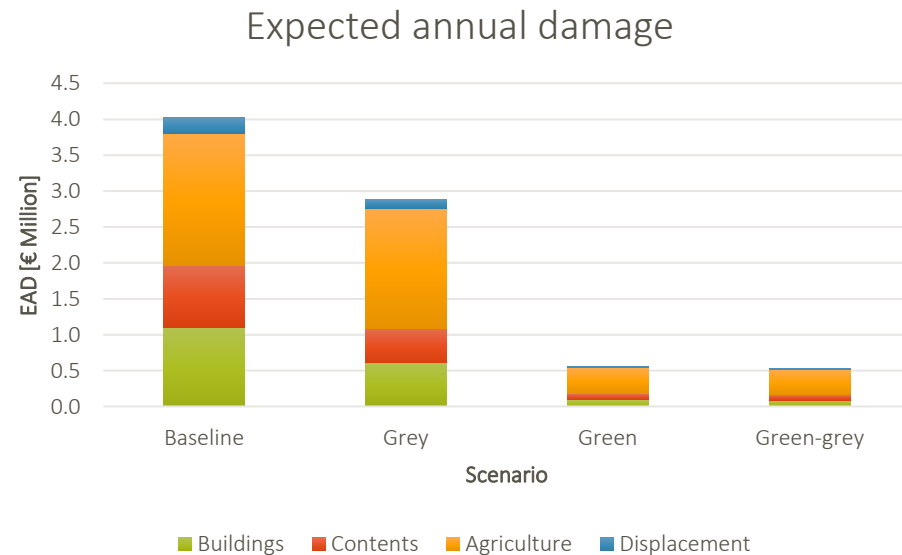
- Net present value – adjustment with a discount rate for a planning horizon of N years

$$NPV_s = \sum_{t=1}^N \frac{EAB_s}{(1+d)^t}$$



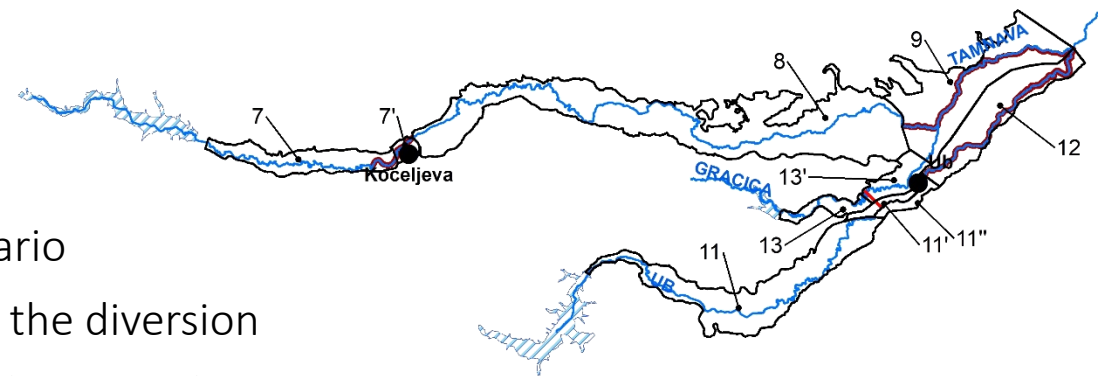
Benefits for flood mitigation scenarios

- By loss category
 - agricultural losses play the major role

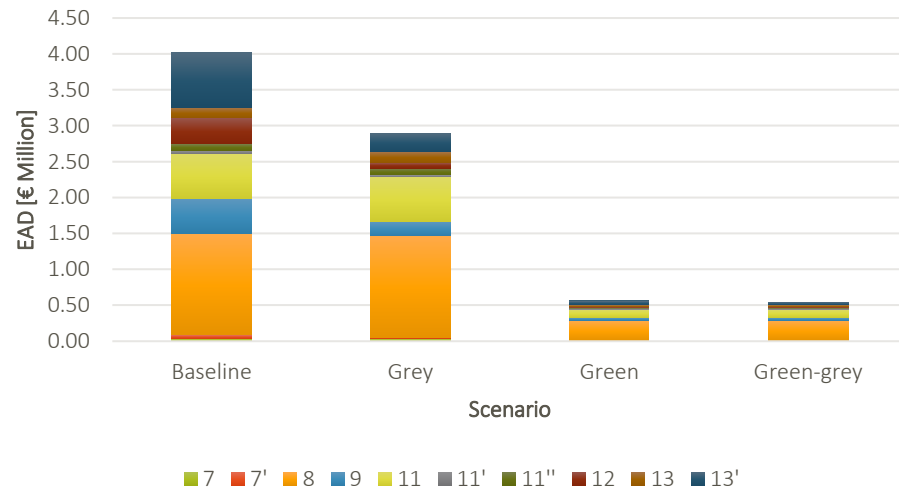


Benefits for flood mitigation scenarios

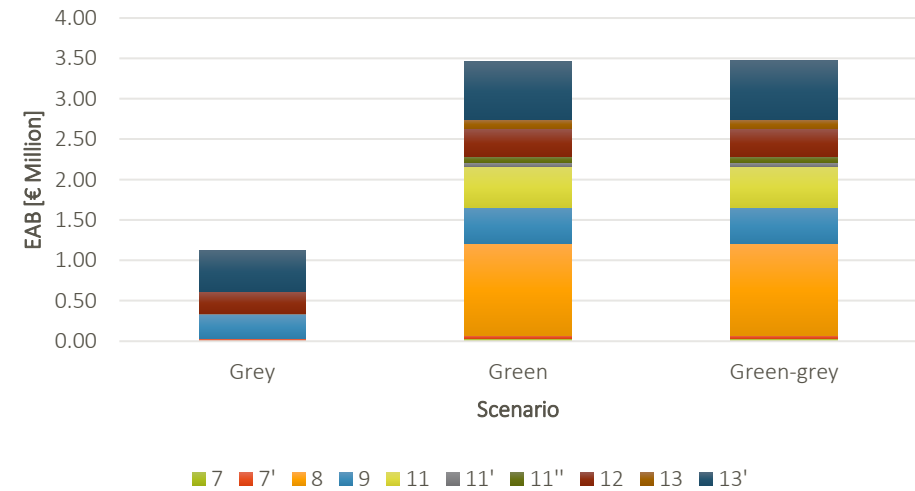
- By sectors
 - no benefits for sectors without levees under grey scenario
 - marginal advantage of green-grey scenario only due to the diversion
 - levee heightening not beneficial when combined with detention basins



Expected annual damage



Expected annual benefit



Conclusions

- Agricultural losses can have critical impact on the selection of measures
 - In general, they depend on local agricultural setup and prevalence of higher-value crops
 - Unlike urban watersheds (high-priced assets concentrated to smaller areas), the agricultural areas have assets distributed over large areas and can suffer significant losses despite significantly lower asset value per unit area
- In Tamnava watershed, the levees provide only local protection and are inferior to the green measures aimed at peak flow reduction
 - Levees over large areas and along river banks would be costly and not as effective as the green measures
- Micro-scale assessment reduces uncertainty generally inherent in this type of studies
 - flood hazard remains the main source of uncertainty
- Further work should include evaluation of co-benefits from the green measures, for the environment and population, as well as other applicable green measures



THANK YOU FOR YOUR ATTENTION