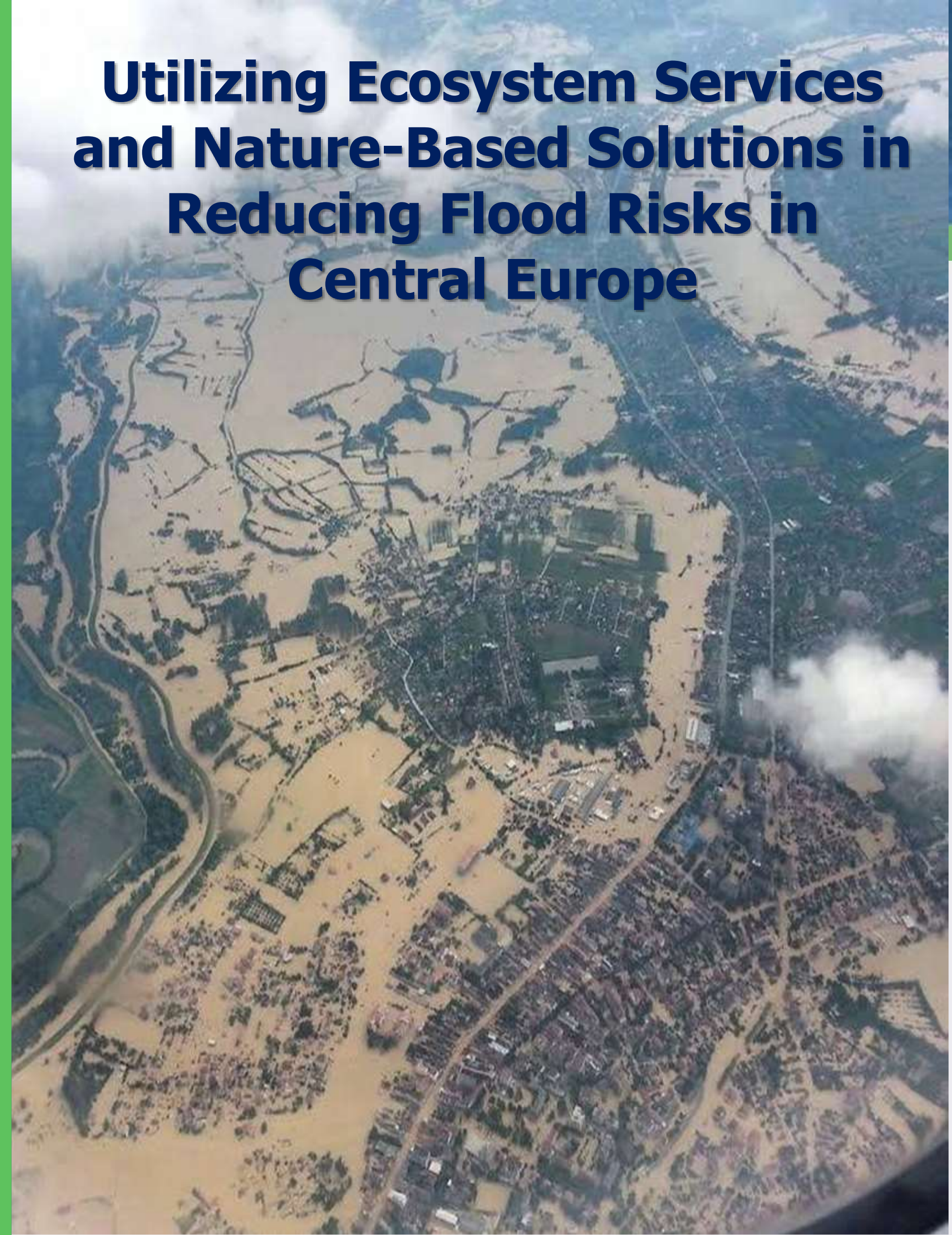
2018 ASFPM National Conference

Utilizing Ecosystem Services and Nature-Based Solutions in Reducing Flood Risks in Central Europe



Ranko S. Pudar, PE, CFM, PMP

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The Objective

- Setup a general framework for evaluation of ecosystem services and their applicability in flood risk reduction
- Apply economic analysis to optimize use of conventional flood protection infrastructure and nature-based solutions

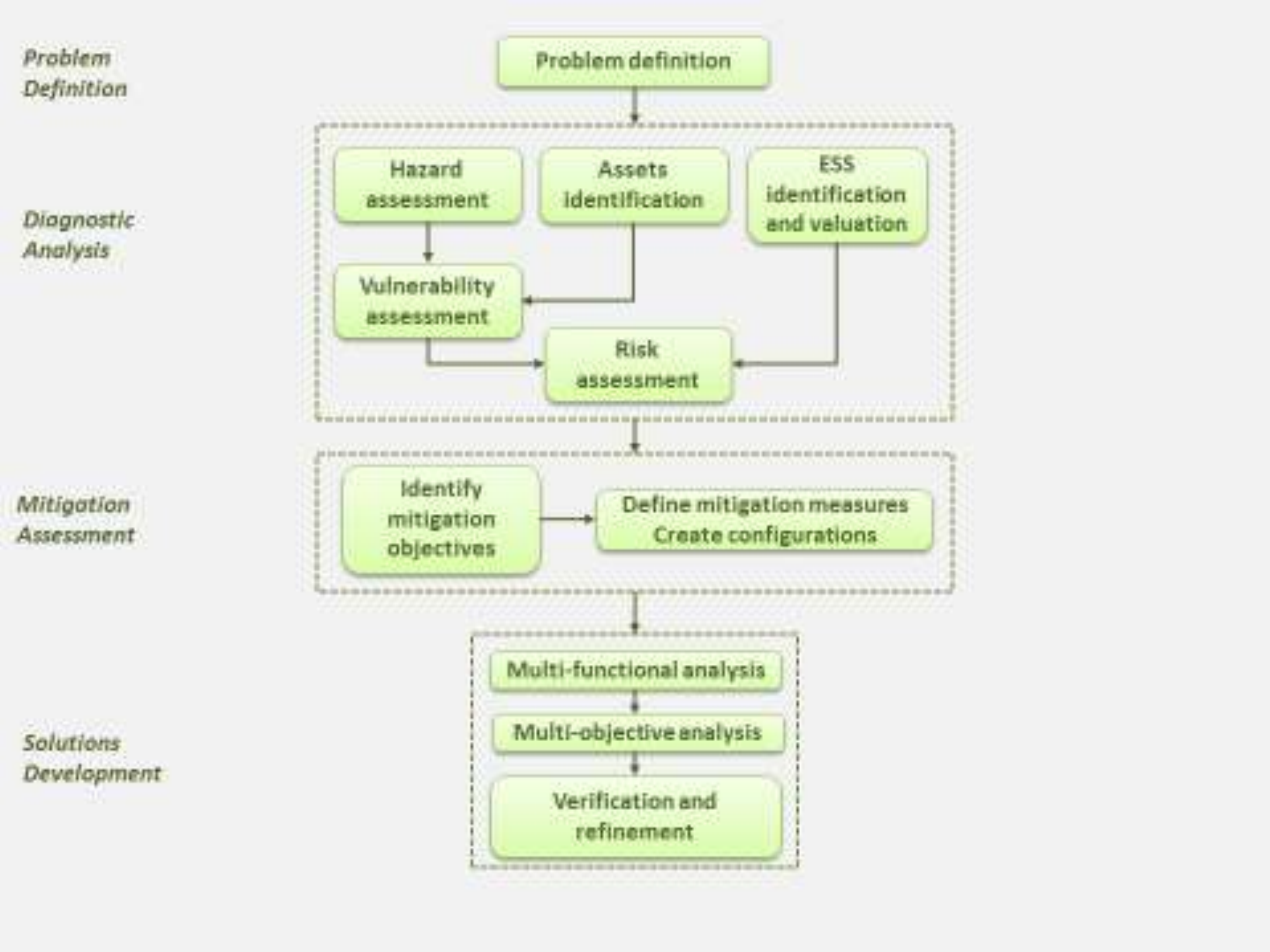
The Concept of ESS

- "Ecosystem services are the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems."
- Every ecosystem comprises some, or all of the three capitals:
  - Human Capital (population)
  - Natural Capital (all natural features)
  - Built Capital (all infrastructure and all lasting products of human building activities)
- The negative trend is where the natural capital is diminishing – this trend needs to be reversed

Eco System Services Analyzed

Eco System Service	Definition
PROVISIONING	
Drinking Water	
Food	
Raw Materials	
Medicinal Resources	
REGULATING	
Gas and Climate Regulation	
DISTURBANCE REGULATION	**PROTECTION FROM STORMS AND FLOODING, AND RECOVERY FROM DROUGHT**
SOIL EROSION CONTROL	**EROSION PROTECTION PROVIDED BY PLANT ROOTS AND TREE COVER**
WATER REGULATION	WATER ABSORPTION DURING RAINS, WATER RELEASE IN DRY TIMES, AND TEMPERATURE AND FLOW REGULATION FOR PLANT AND ANIMAL SPECIES
Biological Control	
Water Quality and Waste processing	
Soil Formation	
SUPPORTING	
Nutrient Cycling	
Biodiversity and habitat	
Primary Productivity	
Pollination	
CULTURAL	
Aesthetic	
Recreation and tourism	
Scientific and educational	
Spiritual and Religious	

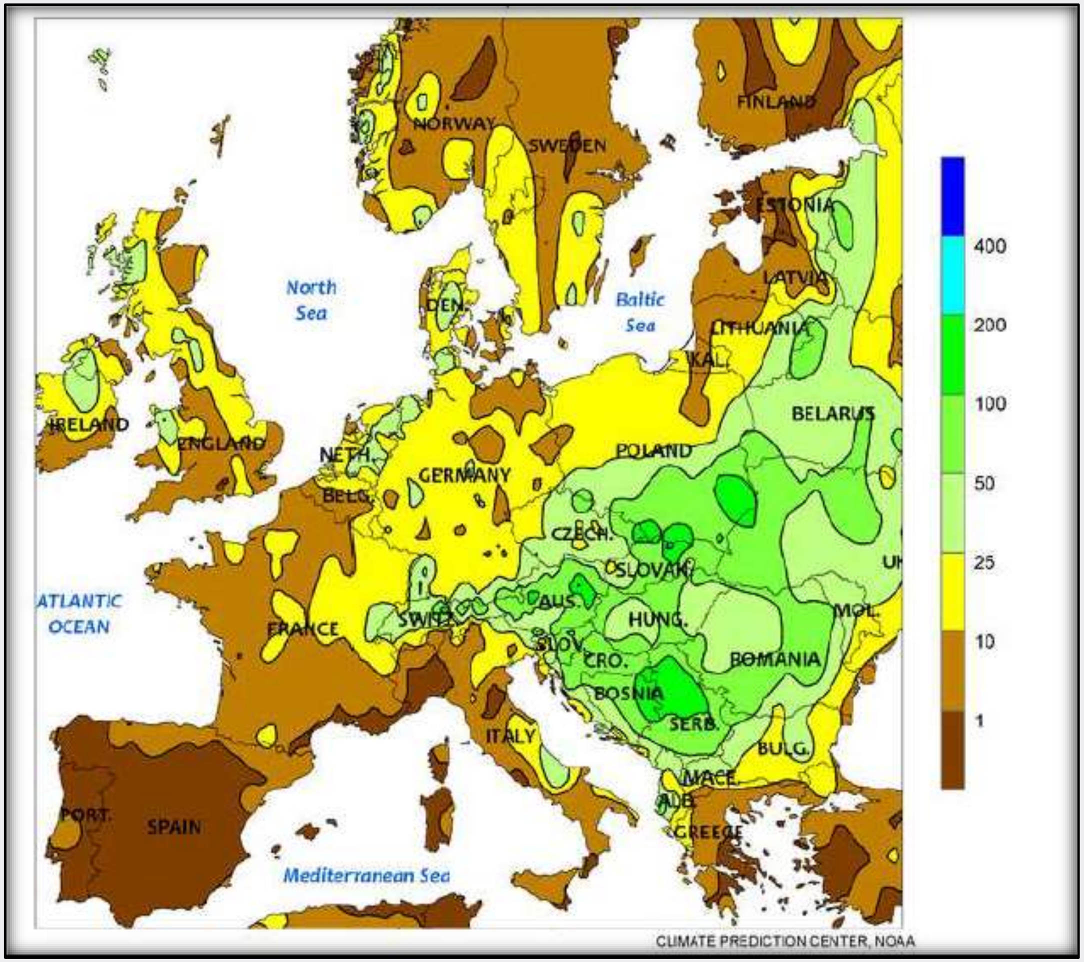
The Framework



Practical Applications of Ecosystem Approach

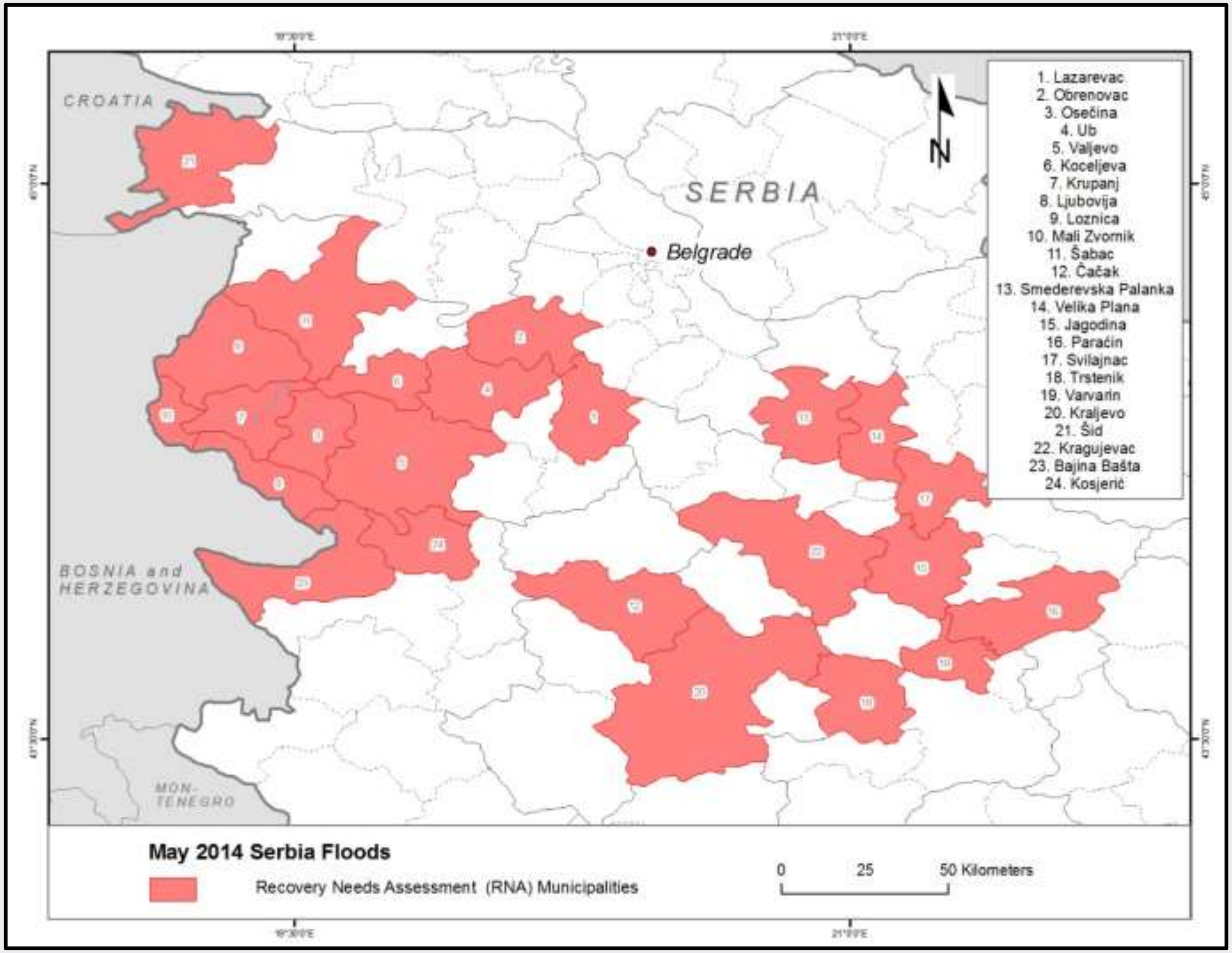
- Apply ecosystem approach as an alternative where traditional flood protection practices are well established
- Case in point: Kolubara river basin and mitigation projects to increase flood resilience after 2014 extreme events

Origins of the 2014 Disaster



Very intensive rainfall occurred during the end of May 2014, almost doubling the two-month historical maximums.

Most-Affected Municipalities included in Detailed Assessment



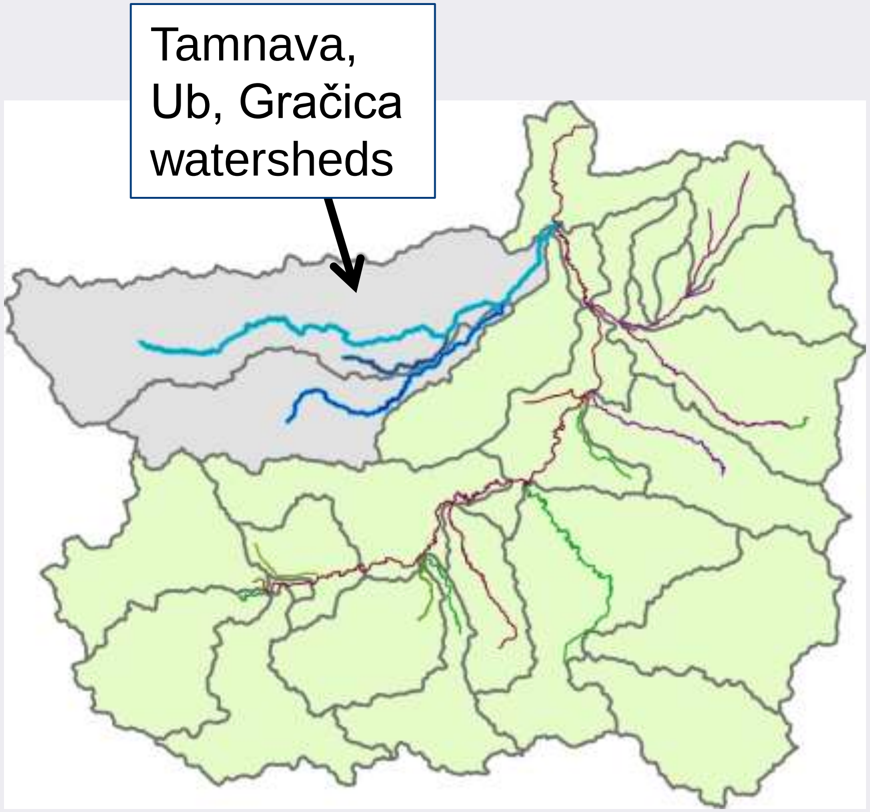
Recorded Losses

Physical damages	$1,218 million
Lost Productivity	$ 927 million
Human losses	51/21 drowned
Pop. affected	1.6 million
Pop. evacuated	30,000

Macro-economic consequences

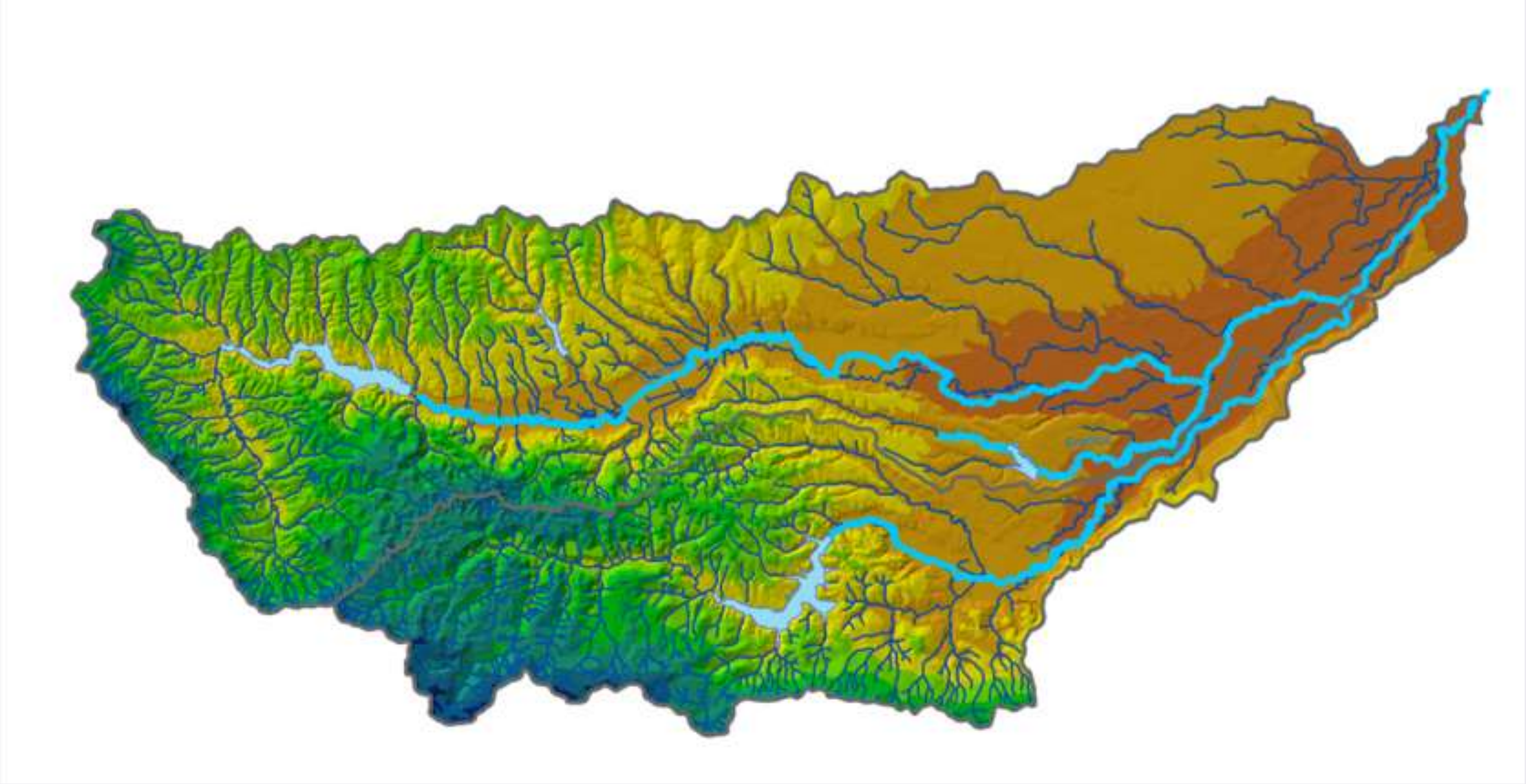
- $2.15 billion in total losses constitute 4.8% of Serbia GDP in 2014
- Reduced 2015 GDP projections by nearly 1%
- In GDP terms, the US equivalent in disaster losses would be in excess of $900 BILLION

Kolubara River Basin and Study Area



Study area: 726km^2 , 280 sqm
Kolubara watershed: 1,408 sqm
Rhode Island: 1,545 sqm

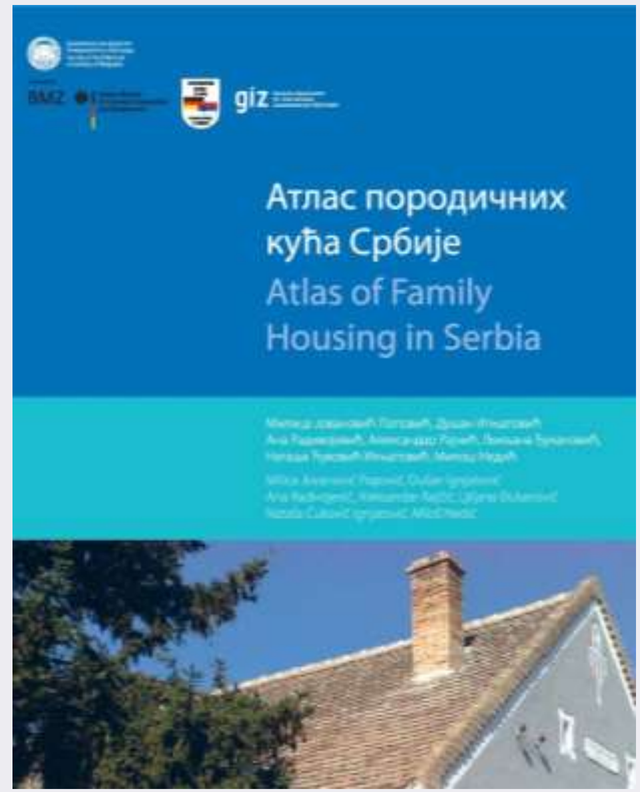
Tamnava, Ub, and Gračica Watersheds Study Area



Study Area Characteristics

- Primarily rural watershed, making it a good candidate for natural capital analysis
- Relatively well defined hydraulic models, without backwater effect for most of the reach lengths
- Comprises three in-line detentions (Kamenica, Gračica, Pambukovica), all to be built by 2025
- Good distribution of erosion counter measures in upper reaches of all three streams
- Two smaller population centers (Koceljeva and Ub)

ИНСТИТУТ ЗА ВОДОПРИВРЕДУ „ЈАРОСЛАВ ЧЕРНИ" АД
Завод за уређење водних токова
Завод за бране, хидроенергетику, руднике и саобраћајнице
СТУДИЈА УНАПРЕЂЕЊА ЗАШТИТЕ ОД ВОДА
У СЛИВУ РЕКЕ КОЛУБАРЕ
ПРЕЛИМИНАРНИ ИЗВЕШТАЈ
Књига 1: Синтезни извештај
НАРУЧИЛАЦ:
UNDP Србија у сарадњи са Канцеларијом за помоћ и обнову поплављених подручја Владе Републике Србије, уз финансијску помоћ Владе Јапана
From the People of Japan
КООРДИНАТОР ИЗРАДЕ СТУДИЈЕ:
ЈВП „Србијаводе"
Београд, март 2016.

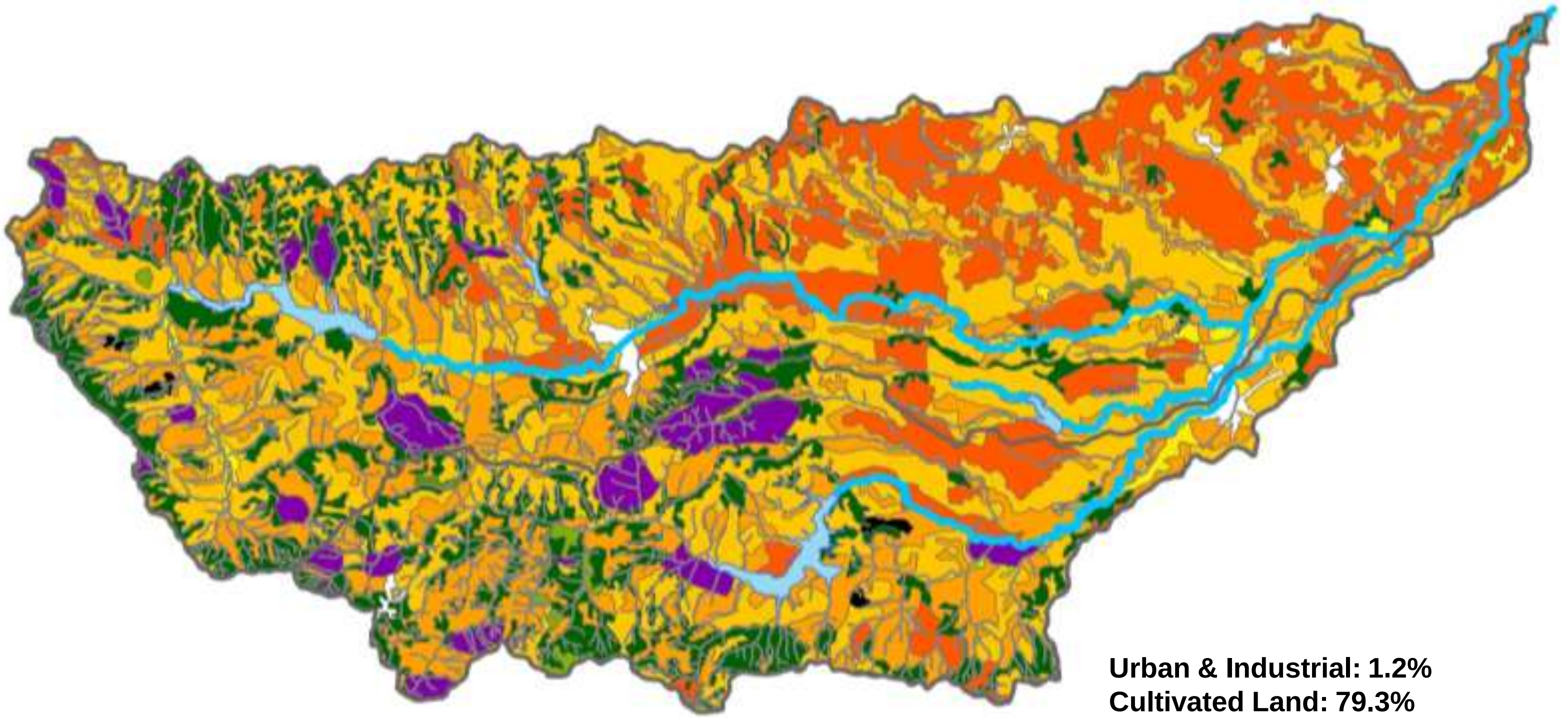


giz
Атлас породичних
кућа Србије
Atlas of Family
Housing in Serbia

In-line detention basins

Typical building types

Study Area Land Use



Urban & Industrial: 1.2%
Cultivated Land: 79.3%
Forest/Pasture/Grassland: 19.5%

Goals of Investigation

- Evaluate Tamnava/Ub/Gračica watershed as an ecosystem and investigate the efficiency of its natural capital in flood risk reduction.

- Perform initial valuation of the watershed for the selected ecosystem services (ESS).

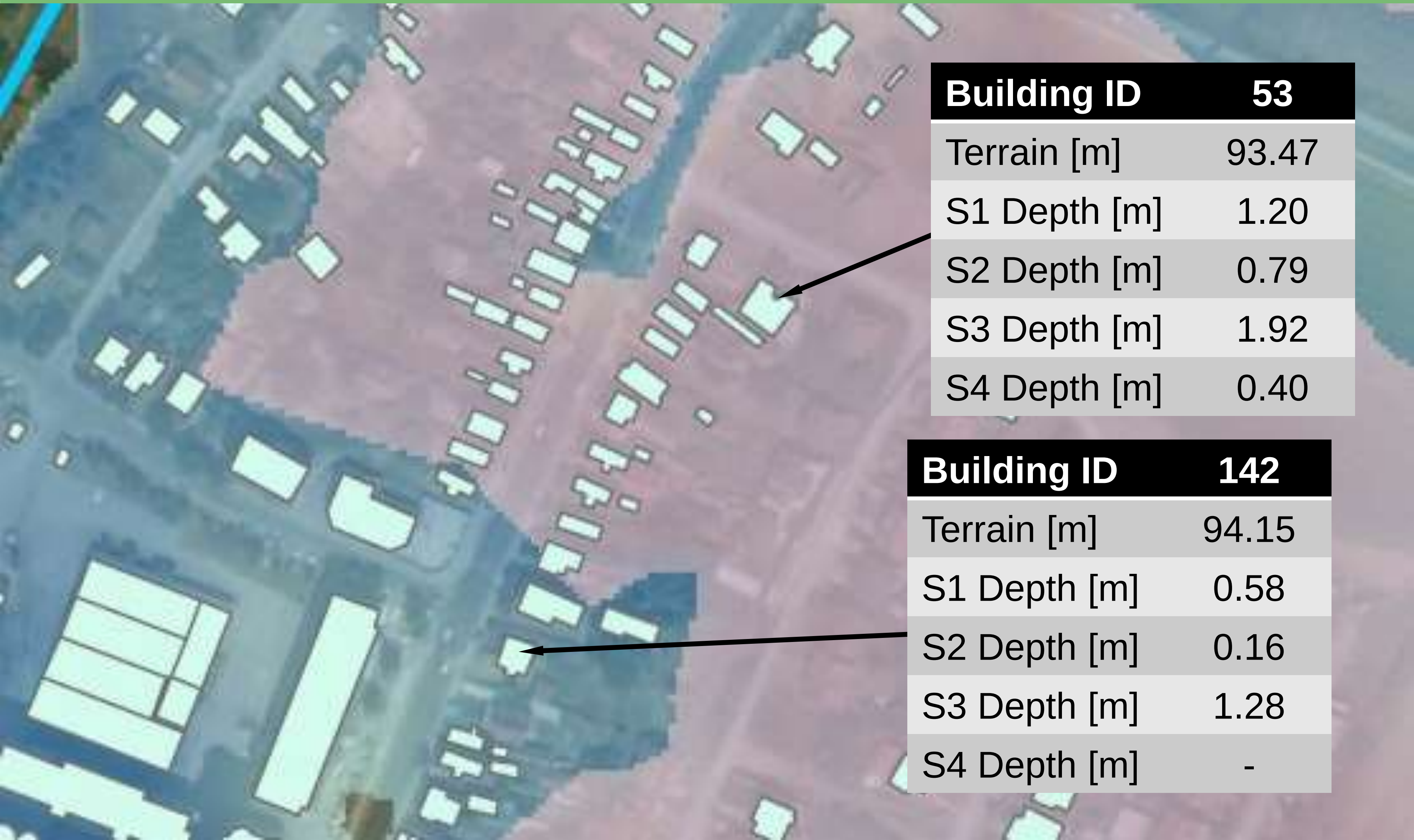
- Two concurrent evaluations:
  - Increase of natural capital by providing additional flood-protection and erosion controls ESS
  - Economic analysis using benefit-cost evaluation of combining nature-based solutions in conjunction with traditional flood-protection measures

Traditional Economic Analysis

- **Direct Losses:**
  - Buildings, contents, infrastructure, site contamination, vehicles, equipment, crops
- **Indirect Losses** (can carry up to 80% of total benefits):
  - Loss of function: loss of utility services (water, wastewater, electrical), loss of medical facilities
  - Emergency management: evacuation and rescue costs, relocation and temporary housing, debris removal and cleanup
  - Casualties: deaths and injuries

Comparison of Flood Scenarios With Depth Grids and Cadastral Data

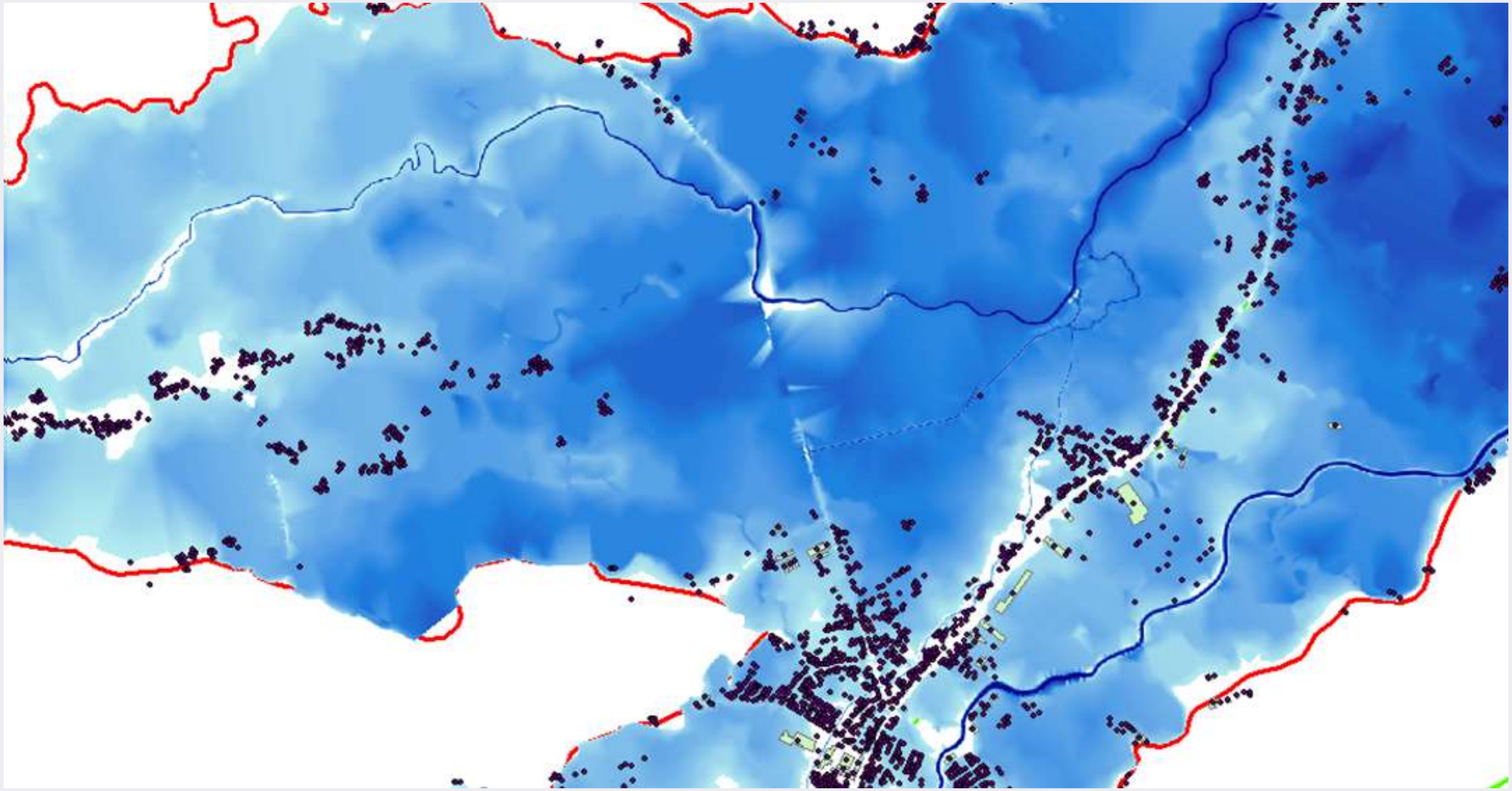
Direct Loss Quantification for Building Stock



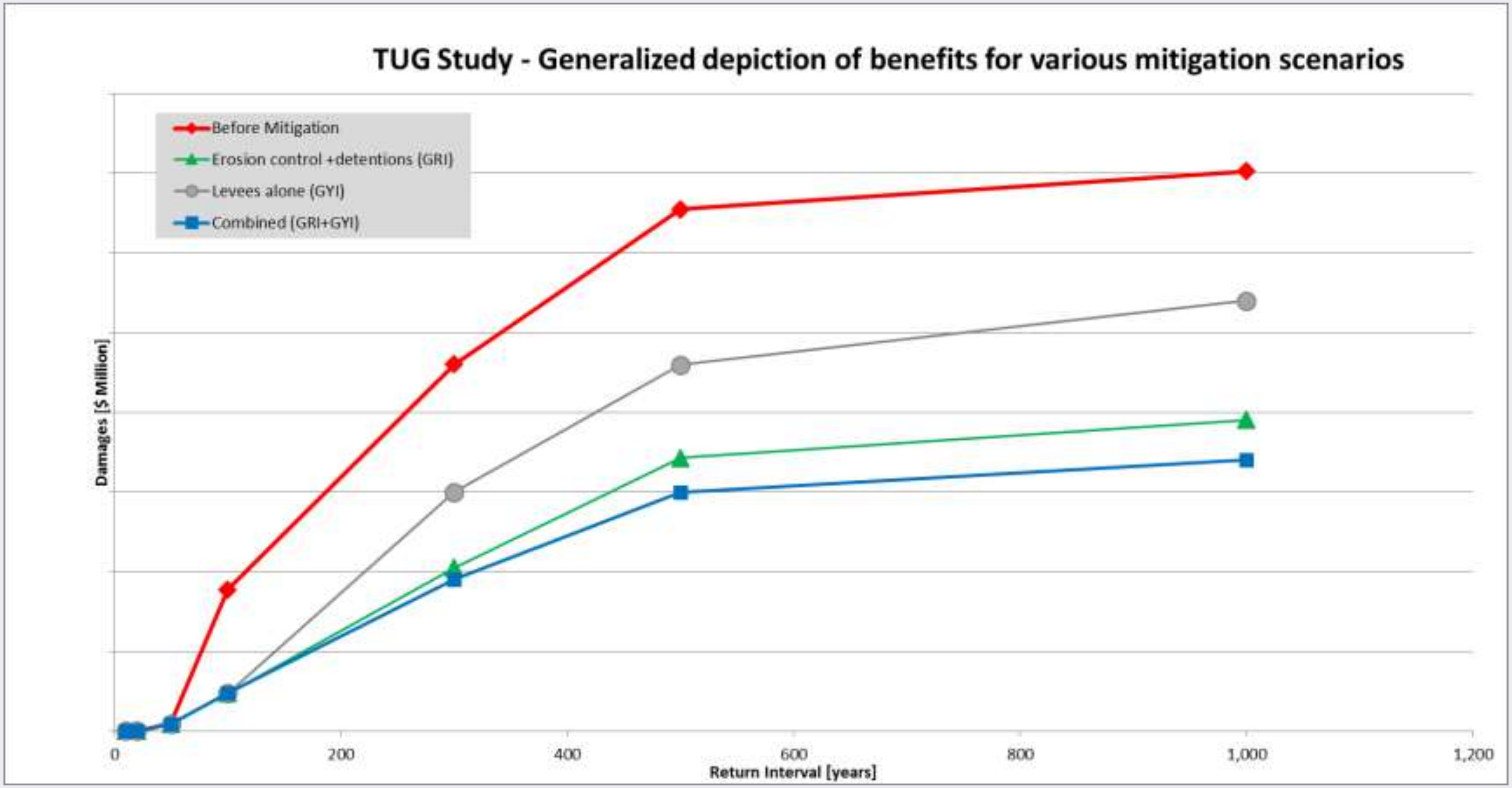
Building ID	53
Terrain [m]	93.47
S1 Depth [m]	1.20
S2 Depth [m]	0.79
S3 Depth [m]	1.92
S4 Depth [m]	0.40

Building ID	142
Terrain [m]	94.15
S1 Depth [m]	0.58
S2 Depth [m]	0.16
S3 Depth [m]	1.28
S4 Depth [m]	-

Benefits and Residual Flood Risk



Multi-functional Analysis



Multi-Objective Analysis

- The **multi-functional approach** evaluated mitigation measures from the perspective of reducing flood risk.
- The **multi-objective approach** evaluates mitigation measures from the economic standpoint.
- The reduction of direct and indirect losses constitutes losses avoided (benefits)
- The ESS applied as erosion control and peak flow attenuation measures are also quantifiable benefits.
- The costs include all the mitigation project costs with nominal maintenance (if applicable).

Conclusion

- A robust framework can be used to evaluate utilization of ESS and nature based solutions as an alternative, or complementary solution for reducing flood risks in urban and rural watersheds.
- Methodologies are similar to what is presently used in the US, with modifications in line with present EC regulations.

Thank You!

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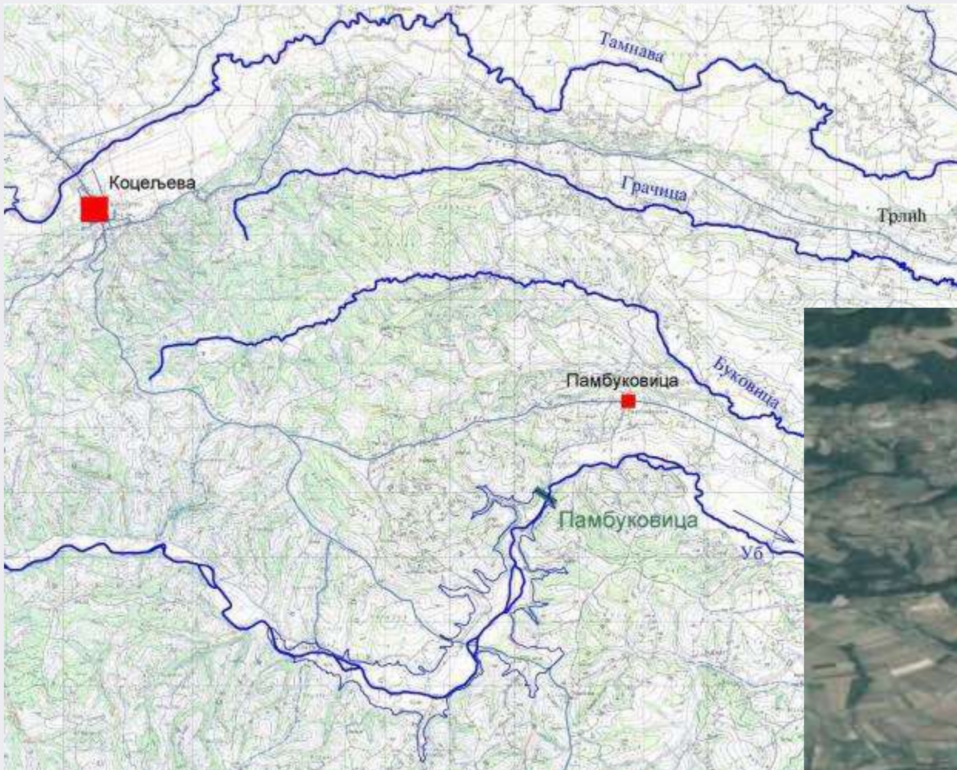
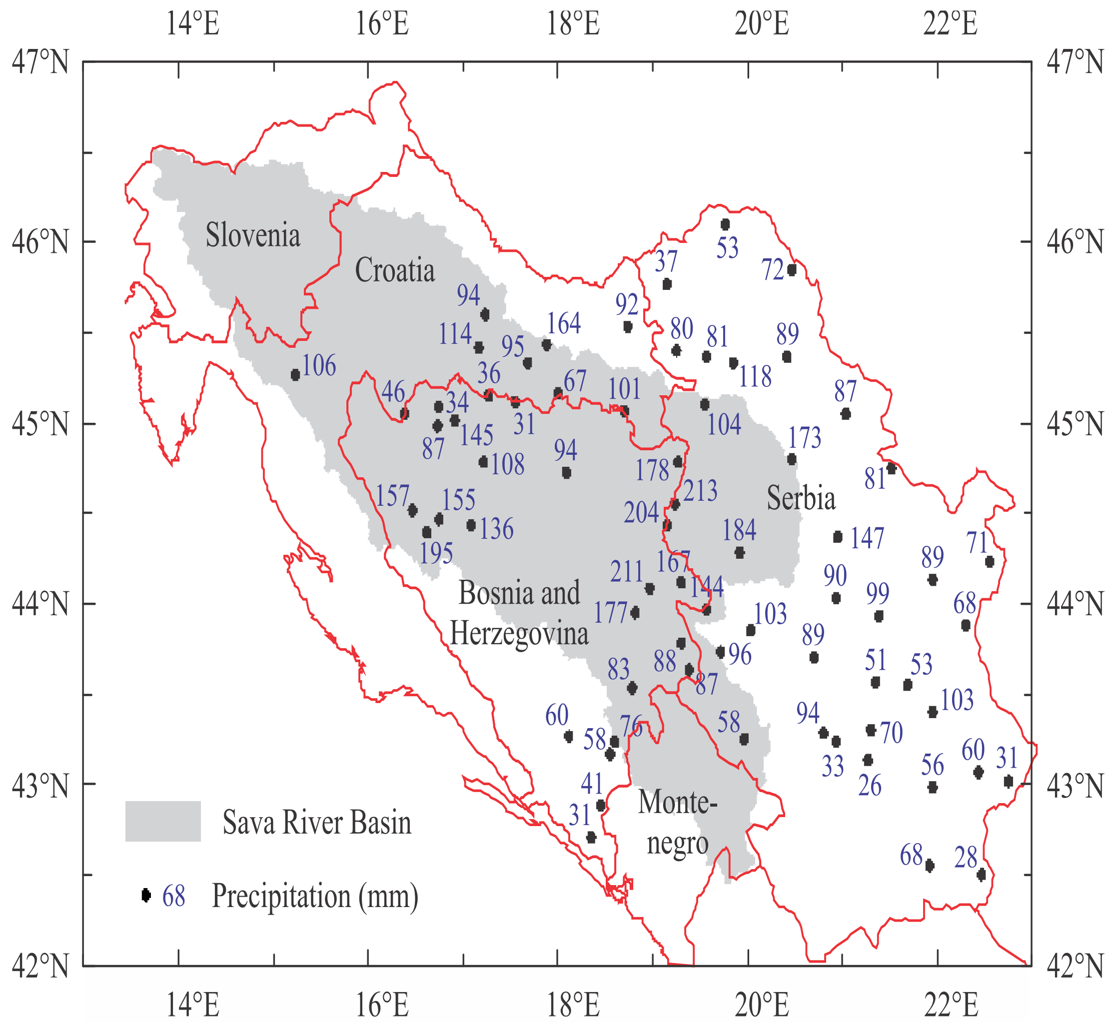

Тамнава
Коцељева
Грачица
Трлић
Буковица
Памбуковица
Памбуковица
Уб

Poplave u slivu Save u maju 2014.

Jasna Plavšić

Univerzitet u Beogradu
Građevinski fakultet

Padavine 13-16. maja 2014.



Ekstremne padavine u aprilu i maju 2014.

Majske padavine

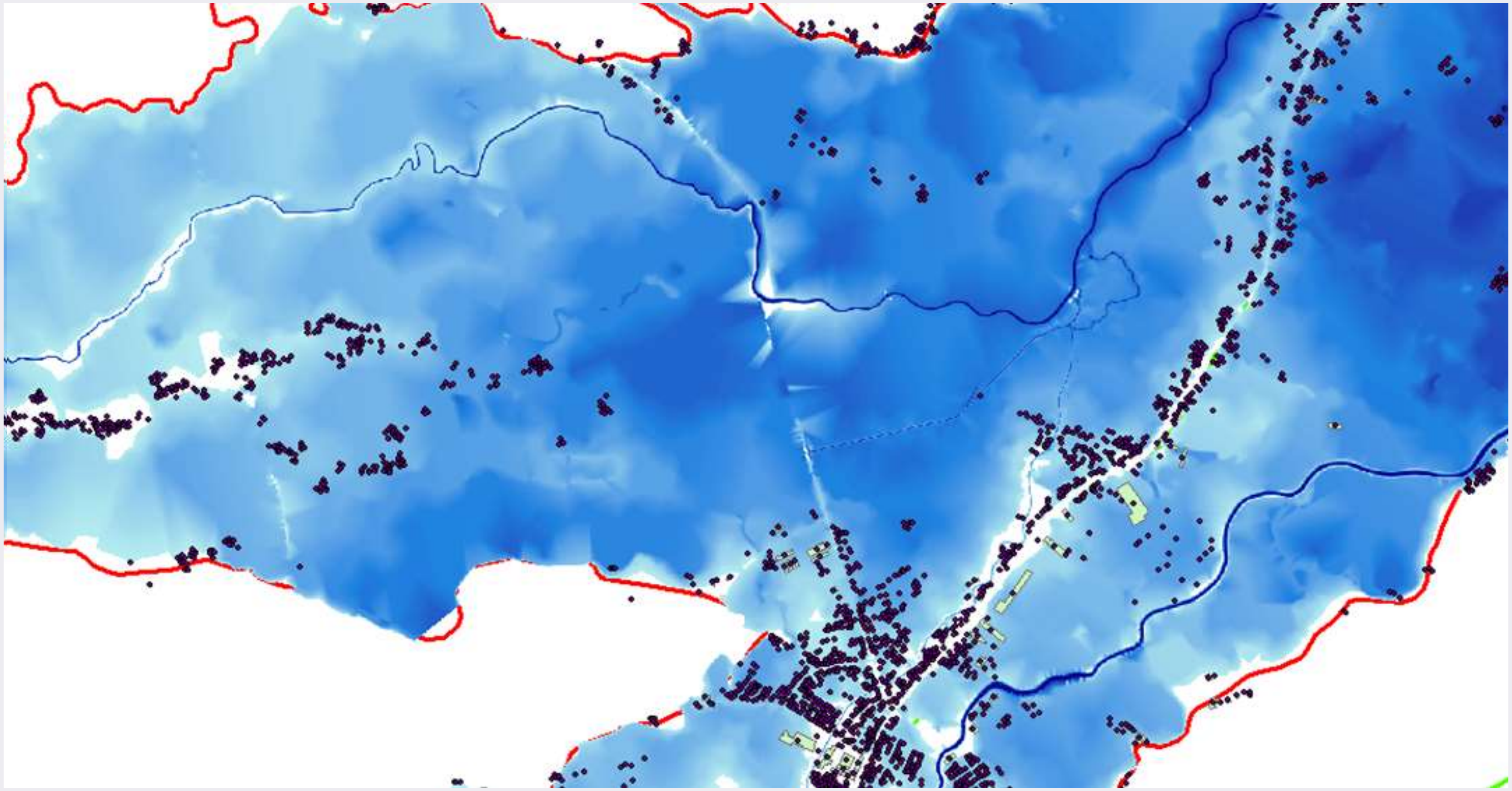
- u Hrvatskoj1.5-1.8 puta veće od proseka
- u Republici Srpskoj >2 puta veće od proseka
- u Srbiji >3 puta veće od proseka

Dvomesečne padavine značajno premašile istorijske maksimume:

Stanica	Mesec	Istorijski maks.	2014	Povećanje %
Loznica	April	123.7	151.4	18%
	Maj	207.8	306.1	40%
	April+Maj	**274.8**	**457.5**	**66%**
Valjevo	April	129.0	177.4	38%
	Maj	213.2	323.5	52%
	April+Maj	**266.0**	**500.9**	**88%**

Obrenovac





Historic Flooding Events

Disaster	Year	Flood levels [ft BPMD]	Direct Losses	Business Interruption
Nor'easter	1992	5.29	Recorded, not documented	Not recorded
Hurricane Irene	2011	5.19	N/A	Documented
Super Storm Sandy	2012	9.15	Documented	Documented

Project Costs

In general, project costs include:

- Anticipated cash and in-kind contributions
- Equipment
- Labor
- Materials
- Subcontract costs
- Additional costs include project management and annual maintenance costs

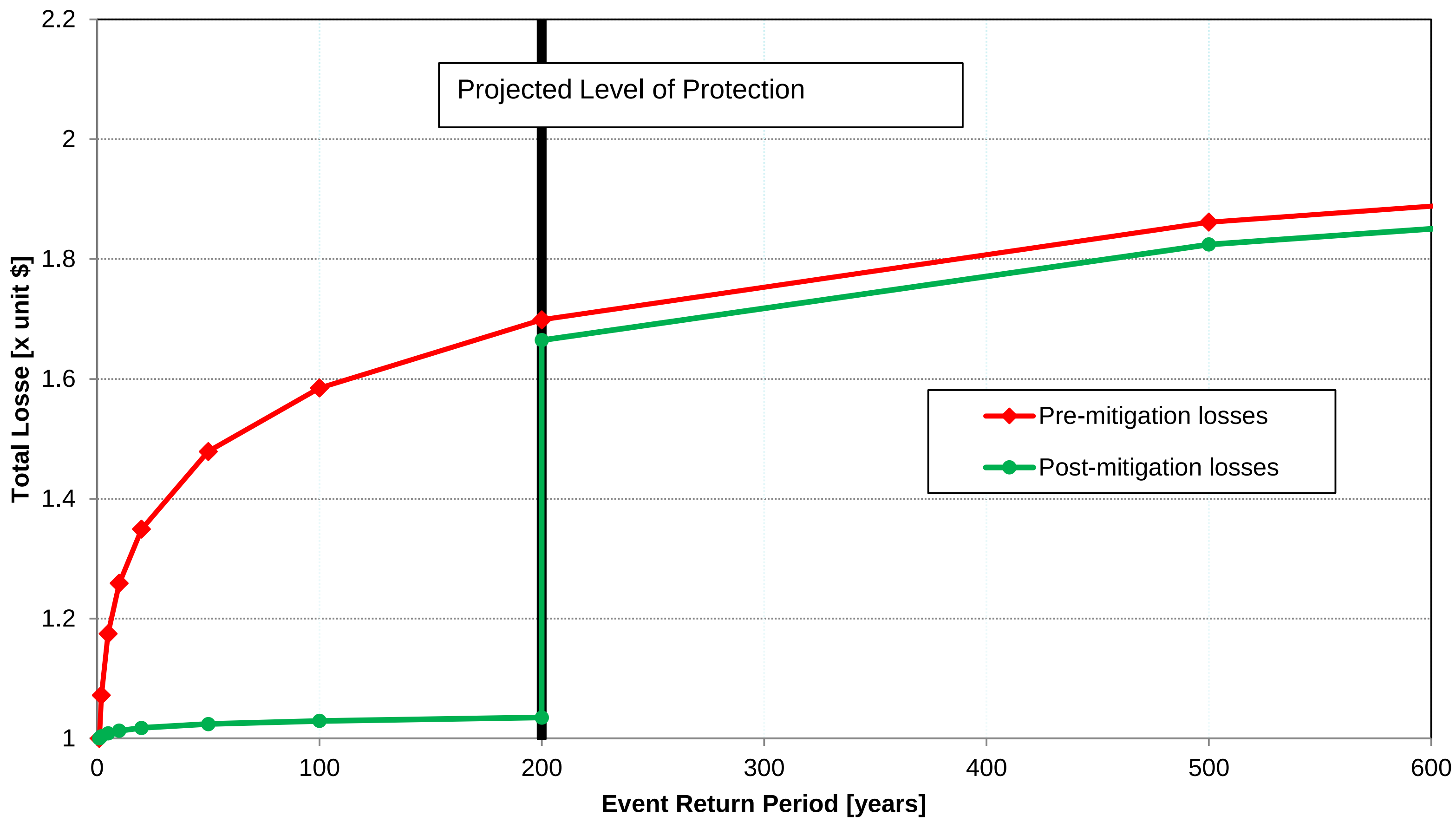
For NYULMC, project costs will be finalized after detailed consultation with FEMA staff on eligibility and effectiveness of the proposed mitigation measures.

Project Benefits

As per standard BCA procedure, benefits are defined as losses avoided due to proposed mitigation measures.

For NYULMC, losses were observed/projected for a total of eight flood events, including historically recorded occurrences of Hurricane Irene and Super Storm Sandy.

Concept of Project Benefits



Pre-Mitigation Losses

- **Physical Damages:** buildings, contents, infrastructure, site contamination, vehicles, equipment, landscaping;
- **Loss of Function:** functional down time, research disruption time, loss of public services, loss of emergency services, loss of other services;
- **Emergency Management:** costs for emergency operations centers, evacuations and rescues, security, temporary protective measures, debris removal and cleanup.
- **Casualties:** deaths, injuries, and illnesses;

Direct Loss Estimation

- Direct loses were estimated on the individual building basis, using methodology similar to FEMA Substantial Damage Estimation.
- Team of engineering experts projected water levels in each of the buildings for the designated flood events.
- Overall direct loss of each building was based on the level of damage sustained by each structural / electrical / mechanical component.
- This methodology enables maximum flexibility that applies to each individual building on the campus and can be further calibrated.

Lower Bound Analysis (LBA)

- LBA applied in the initial stages of the project
- Benefits collected from the resources available at the time
- For the NYULMC lower bound analysis, no Business Interruption (BI) losses were included
- Analysis performed on a mixed campus/building level

Lower Bound Analysis (LBA)

- LBA uses the same concept as standard BCA, but with fewer data points
- The purpose of LBA is to determine economic viability of the proposed mitigation project at a fraction of resources
- LBA takes the cost as an upper limit estimate
- Historical (pre-mitigation) losses are *collected* from the single most prominent damage category
- Projected (post-mitigation) losses are *estimated* for several design frequencies for the same damage category

Mitigation Scenarios

Scenario	Floodwall	Infrastructure/ services relocation
1	Yes	Only critical items
2	Yes	No items
3	No wall	All items
4	No wall	Only critical items
5	Yes	All items

Damage Estimation

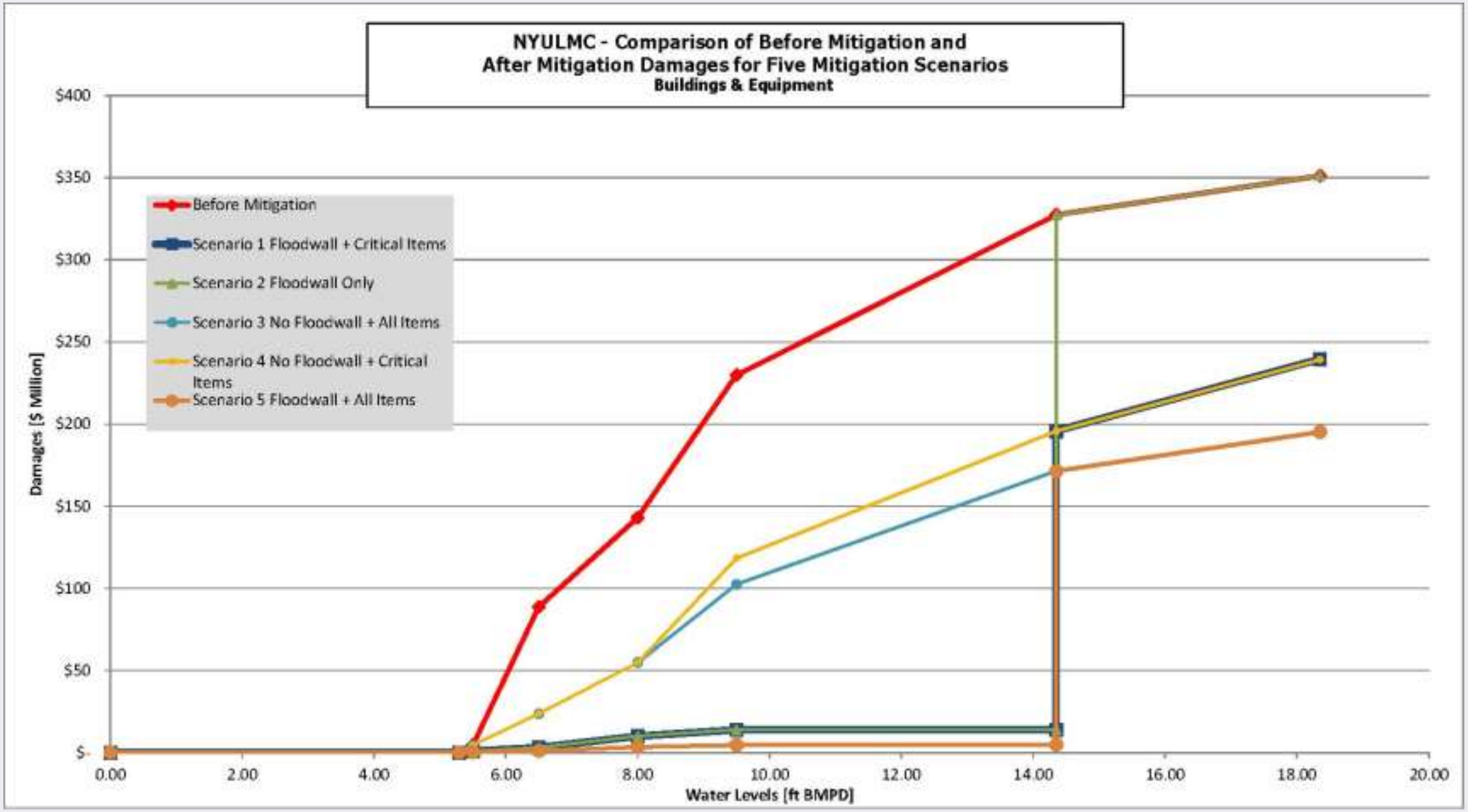
Example

Cost in $ million	Flood Event Level 2 (water level at 6.5ft BMPD)					
Mitigation Option	Pre-Mitigation	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Tisch	$ 25.97	$ 0.84	$ 0.84	$ 4.55	$ 4.55	$ 0.28
MSB	$ 26.51	$ 0.88	$ 0.88	$ 4.76	$ 4.76	$ 0.29
HCC	$ 9.22	$ 0.43	$ 0.43	$ 2.32	$ 2.32	$ 0.14
Skirball	$ -	$ -	$ -	$ -	$ -	$ -
Coles	$ -	$ -	$ -	$ -	$ -	$ -
Lec Hall	$ 0.62	$ 0.15	$ 0.15	$ 0.62	$ 0.62	$ 0.05
Smilow	$ 20.24	$ 0.57	$ 0.57	$ 5.43	$ 5.43	$ 0.19
Alum Hall	$ -	$ -	$ -	$ -	$ -	$ -
Emergency	$ 0.56	$ 0.06	$ 0.06	$ 0.44	$ 0.44	$ 0.02
Kimmel	$ -	$ -	$ -	$ -	$ -	$ -
Energy	$ -	$ -	$ -	$ -	$ -	$ -
Science	$ 5.60	$ 0.22	$ 0.22	$ 5.60	$ 5.60	$ 0.07
Total Estimated Cost	**$ 88.72**	**$ 3.15**	**$ 3.15**	**$ 23.72**	**$ 23.72**	**$ 1.05**

Residual Damage Estimation

Water Levels [BMPD]		Before Mitigation		Scenario 1 Floodwall + Critical Items		Scenario 2 Floodwall Only		Scenario 3 No Floodwall + All Items		Scenario 4 No Floodwall + Critical Items		Scenario 5 Floodwall + All Items
0.00	$	-	$	-	$	-	$	-	$	-	$	-
5.29	$	-	$	-	$	-	$	-	$	-	$	-
5.50	$	4.53	$	0.91	$	0.91	$	4.53	$	4.53	$	0.30
6.50	$	88.72	$	3.15	$	3.15	$	23.72	$	23.72	$	1.05
8.00	$	143.02	$	10.07	$	10.07	$	54.95	$	54.95	$	3.36
9.50	$	230.03	$	13.93	$	13.93	$	102.53	$	118.48	$	4.64
14.35	$	327.49	$	13.93	$	13.93	$	171.49	$	195.79	$	4.87
14.35	$	327.49	$	195.79	$	327.49	$	171.49	$	195.79	$	171.49
18.35	$	351.29	$	239.56	$	351.41	$	195.29	$	239.32	$	195.29

Mitigation Benefits



Preliminary LBA BCA results

Scenario	Floodwall	Infrastructure/ services relocation	Benefits	Cost	BCR B&E only	Annual Damages Before Mitigation	Annual Damages After Mitigation
1	Yes	Only critical items	$125,124,963	$103,680,337	1.21	$9,775,609	$709,073
2	Yes	No items	$123,925,292	$48,060,037	2.58	$9,775,609	$796,001
3	No wall	All items	$82,432,377	$117,660,000	0.70	$9,775,609	$3,998,685
4	No wall	Only critical items	$78,670,717	$55,610,000	1.41	$9,775,609	$4,262,305
5	Yes	All items	$130,533,517	$165,730,037	0.79	$9,775,609	$317,170

Final BCA results

NYU Langone Medical Center Theoretical Campus with Supplemental HMP	Total Net Direct Cost	Annual Maintenance [1% over 50 years]	Total Projected Mitigation Cost	Benefits	BCR
A. Tisch Emergency Dept	$ 23,058,610	$ 230,586	$ 26,240,869	$ 6,610,047	0.25
B. Tisch	$ 113,016,988	$ 1,130,170	$ 128,614,177	$ 282,566,498	2.20
C.+K. COLES LABS	$ 14,248,854	$ 142,489	$ 16,215,309	$ 3,046,307	0.19
D.+E. MSB	$ 74,524,596	$ 745,246	$ 84,809,547	$ 91,936,708	1.08
F. Smilow	$ 67,027,709	$ 670,277	$ 76,278,032	$ 88,380,917	1.16
G. Schwartz Lecture Hall	$ 6,746,018	$ 67,460	$ 7,677,016	$ 19,700,276	2.57
G1. Schwartz Lecture Hall Offices	$ 33,691,670	$ 336,917	$ 38,341,376	$ 2,084,354	0.05
H. HCC	$ 156,728,195	$ 1,567,282	$ 178,357,856	$ 83,971,731	0.47
I. Alumni Hall	$ 735,133	$ 7,351	$ 836,582	$ 2,428,159	2.90
J. Skirball	$ 64,715,225	$ 647,152	$ 73,646,406	$ 8,893,394	0.12
O. Rusk	$ *16,430,444*	$ 164,304	$ 18,697,962	$ 42,044,236	2.25
P. Perelman	$ *10,009,290*	$ 100,093	$ 11,390,648	$ 31,182,524	2.74
Q. 660 First Avenue	$ *9,300,622*	$ 93,006	$ 10,584,174	$ 12,658,845	1.20
TOTAL Net Project Cost	$ 590,233,354	$ 5,902,334	$ 671,689,954	$ 675,503,996	1.01

- The final FEMA aid to NYU consisted of cca $270 million in emergency services reimbursement and $1.13 billion of combined PA grant, including the above $672 million in mitigation projects;
- The second largest grant in FEMA history

Main points

- BCA required by most of the Federal programs;
- Overall mitigation projects show best cost-efficiency in flood risk reduction (5.0);
- Mitigation project cost hard to reduce significantly;
- Success of BCA driven by the amount of benefits;
- Indirect losses (benefits) very important for risk mitigation of critical facilities and services;
- Even the most complex technical solutions can be analyzed if BCA applied properly