

Technical aspects of Nature-Based Solutions allocation

Stakeholders Perspective and Land degradation

Example from Lower Savinja Valley, Slovenia

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GLAVAN et al., 2020 <https://doi.org/10.1016/j.envsci.2020.09.012>

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LAND4FLOOD Training course &Workshop // Stakeholders Perspective and Land degradation

nature based solutions

= flood protection infrastructure

e.g. dry detention reservoirs

Stakeholders = predominantly farmers on private land

Stakeholders' perspective on NBS allocation on private land:

Advantages

- Construction of **wet reservoirs** for **irrigation water source** - has not been considered
- Flood protection of the remaining farm land
- **Alternative locations** for dry detention ponds upstream - have not been considered

Disadvantages

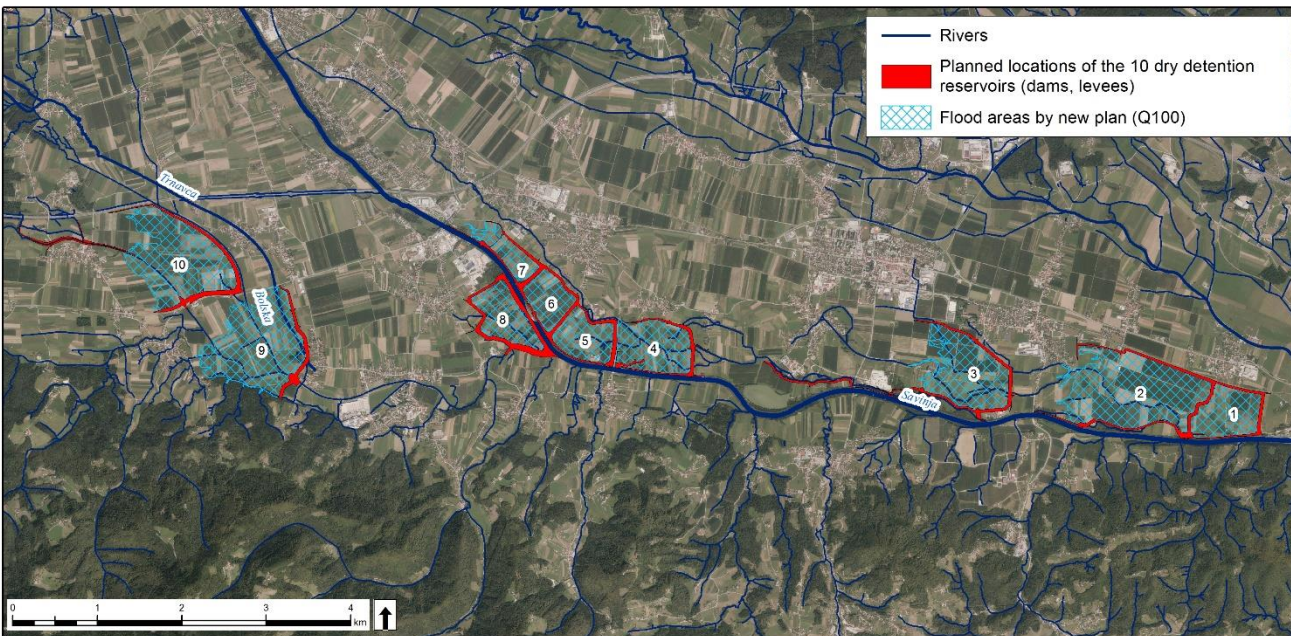
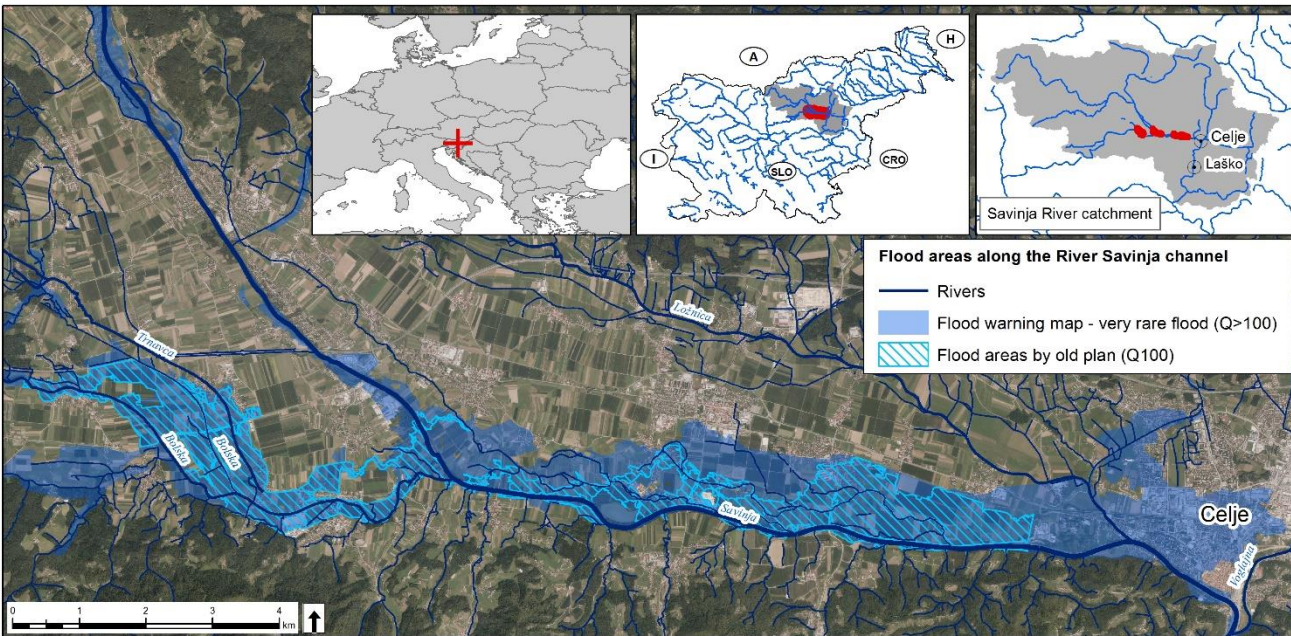
- Loss of land use autonomy.
- Flooding water would change the quality of the soil in NBS area.
- Could potentially influence contractual obligations (stipulation for certain yield quality, organic farming, etc.) – **indirect extensification of land use**
- Renaturated areas have higher protection & value than the best agricultural land

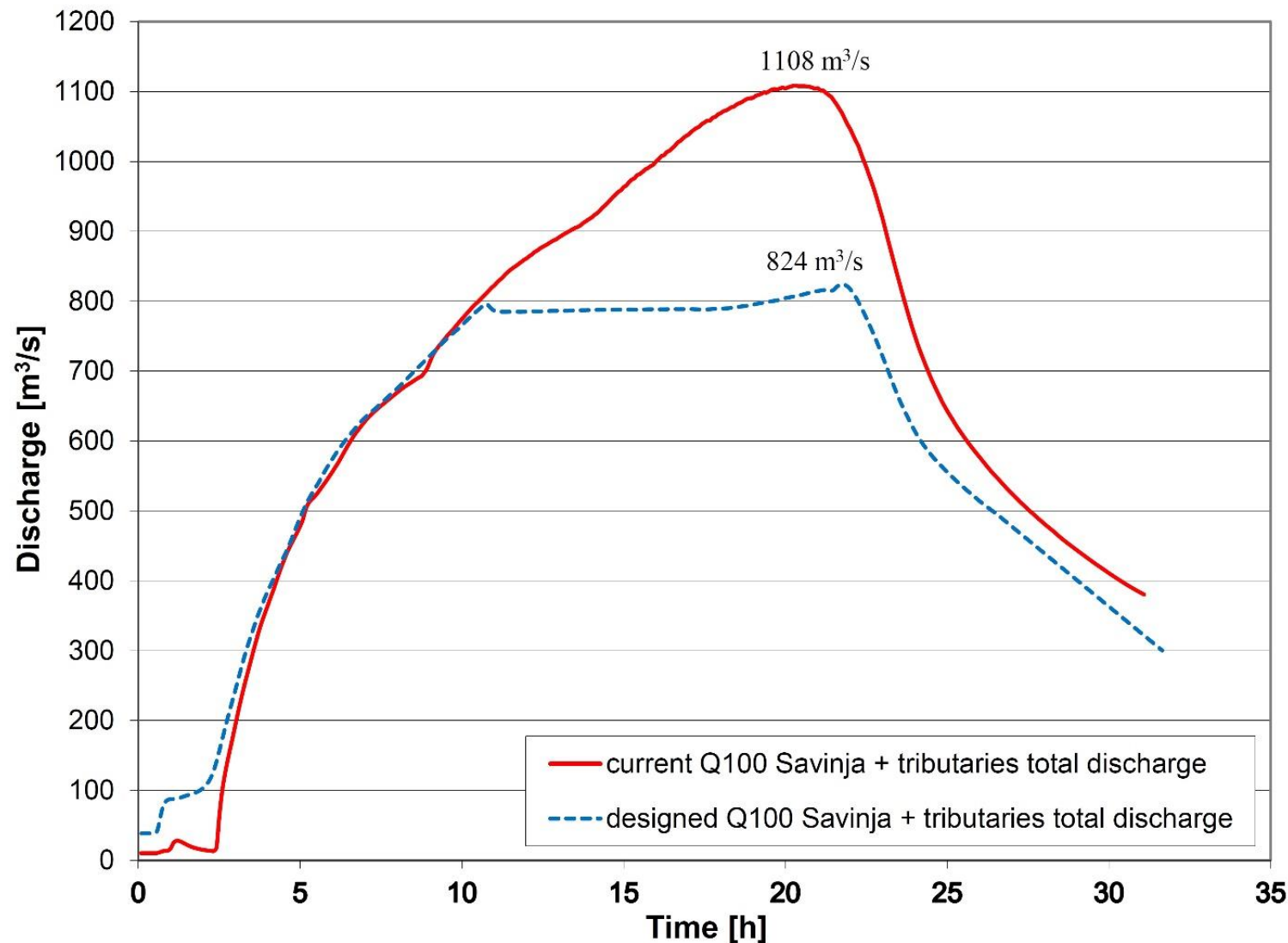
The proposed flood management plan

Why?

The current and designed flooding area for the 100-year (Q100) return period at Savinja catchment, Slovenia

- Savinja catchment, Danube river basin
- 1,900 km², some 9% of the country's total area
- Precipitation 1,000-2,000 mm per year
- Rainfall 70 mm per hour and 240 mm per day
- Mean annual flow (1961 to 1990) was 45 m³ s⁻¹, **record discharge** in 1998 was 1,490 m³ s⁻¹
- The most densely populated town, Celje, is the most flood-endangered town in the catchment. Most significant flood events in **1990** and 1998.
- The Ministry of Defence recorded more than 130 million EUR of estimated reported total damage (2009 – 2018)



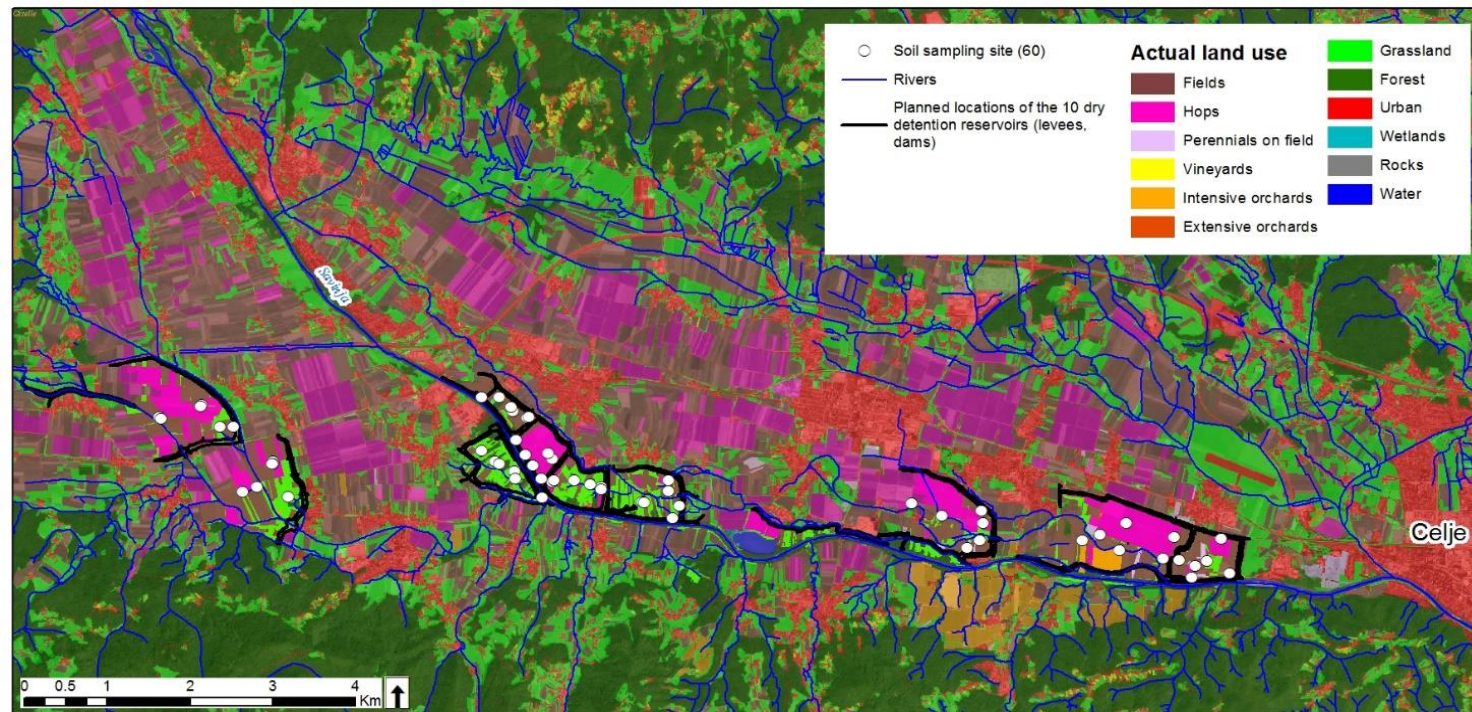


The proposed flood management plan

Magnitude of floods?

Impact of dry detention reservoirs on peak flow propagation at River Savinja upstream of town Celje, at Savinja catchment, Slovenia

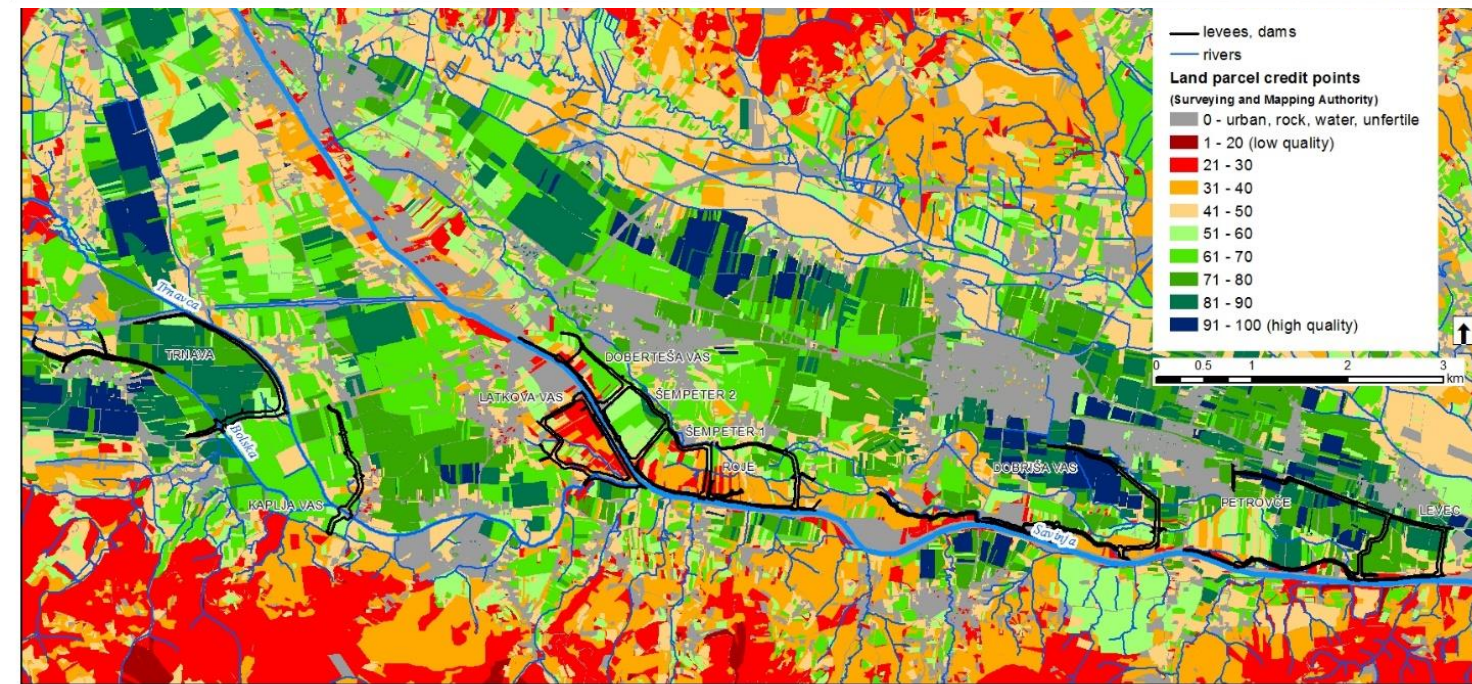
- Flood security for the area with over 12,000 citizens
- flood events could be expected mostly in November (4 events), October (1 event), and September (2 events) (1990-2017).
- The plan has two phases:
 - **first phase** - small-scale local measures on tributaries
 - **second phase (presented)** - the plan proposes introducing 10 large detention reservoirs (NBS) with 4–7 m high dams and levees for the reservoirs, with a total storage volume of 11,000,000 m^3 .
- the **frequency of the flood events** lowered from 20 floods to 2-4 floods over 100 years.
- flooding with a 500-year **return period** **significantly reduced** to a 100 to 200-year return period



The proposed flood management plan

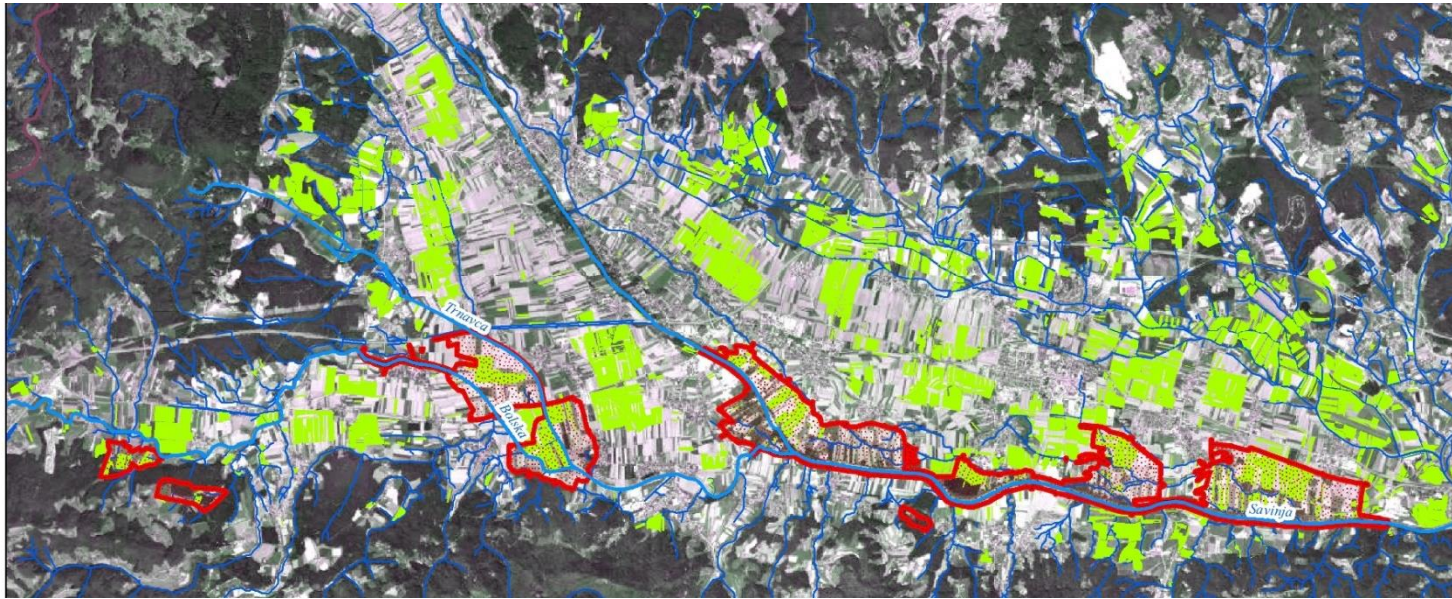
Land use, land quality?

- 10 dry detention reservoirs covering **520 ha** in total
- Flood protection infrastructure will permanently occupy **84 ha** of agricultural land.
- Reservoirs **activated** when the **flood return period** is **above 20-50 years**
- Planned height of dams and levees is between 4.2 m and 6.8 m.
- One **cycle of filling, detention and emptying** of the dry detention reservoirs takes between **24 and 60 hours**
- **Controlled release** of excess water to the river would follow **25 hours** after the **flood peak**



Land owners rights?

green – State ownership

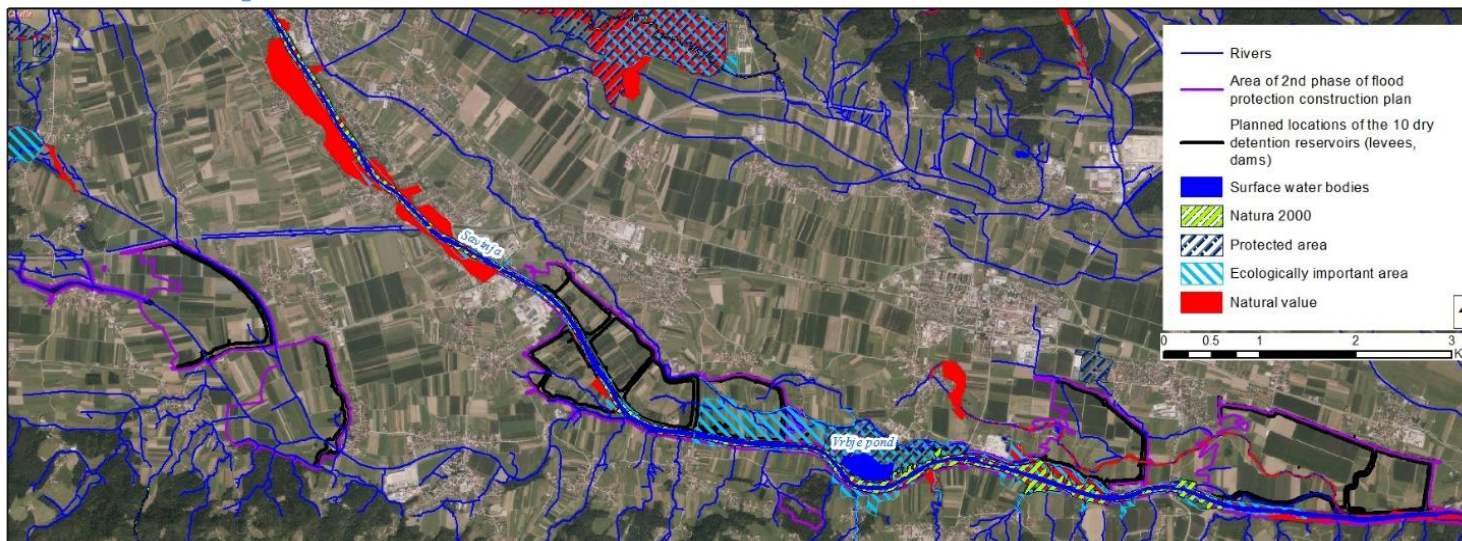


Almost 170 ha of land in the area is owned by the state (30% of all land and 33% of agricultural land)
70 % of land in private ownership.

The state needs to obtain **permission from willing private landowners.**

Farmers are not very willing to sell the land, especially when a **project of significant economic impact** is planned on their agricultural land.

Nature protection?



The state may also **expropriate** the landowners by a court ruling or offer a **compensation payment.**

Source of information and database?

Data type	Description/properties
Flood management	Flooding line Q100 (before and after); Dry reservoir infrastructure (levees and dams) Reservoir flooding schedule Long term daily river discharge Topographic map Aerial photogrammetric survey
Land use	Actual land use and aerial images; Graphic land use units of farm – agricultural holding (GERK); Irrigation and drainage systems
Soils	Soil map of Slovenia; Digital soil number
Land ownership	Cadastral units map; Land parcels credit points; Real estate valuation model; Ownership of land parcels
Farm management	Direct and Agri-environmental payments; Crops, Crop rotations; Number of animals; Agricultural Holdings characteristics
Agriculture policy	Calculation catalogue for farms; Regulation on direct payments
Protection regimes	Flood risk map; Natura 2000; Ecological sensitive areas;

- Although the planned flood protection scheme effectively protected urban settlements, it **did not take into account existing land use** at the site of the planned dry detention reservoirs
- For agriculture, the most important factors:
 - the **time window** in which the flood event occurs,
 - the **detention time** of floodwater within the dry detention reservoirs,
 - the **depth of the water**.
- For example, **floods before 20 September** can result in **catastrophic consequences for hop producers**; however, after 20 September hops have already been harvested and stored.

Stakeholders are faced with...

Damage on agricultural land due to flood water

Destruction of yield, influence on plant growth in permanent orchards



Foto Štusej, Drča

1. Soil management strategy

To preserve conditions for agricultural production, three steps are suggested

- **land reclamation guidelines**

- to ensure the quality of construction works and to undertake proper agro-technical ameliorative steps
- land reclamation work often seen as unimportant, time consuming and expensive;
- collaboration between soil scientists, agronomists and constructors

PRE construction of NBS

- **a soil monitoring plan;**

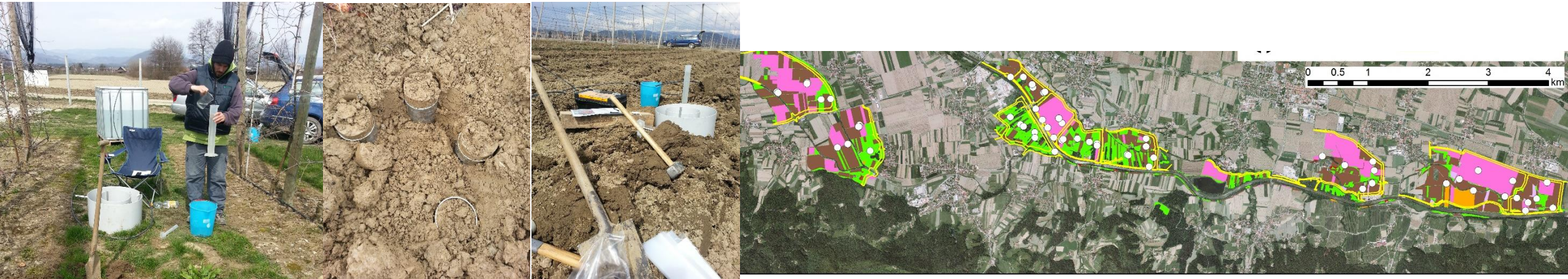
- potential chemical pollution, debris and silting (water currents can erode soil and fine soil particles rich in nutrients, silting decreases hydraulic conductivity, which can cause waterlogging)
- define the method for monitoring relevant physical and chemical soil characteristics;
- provide a detailed evaluation of soil characteristics to enable the evaluation of soil quality changes after construction work, and flooding event.

PRE & POST construction of NBS

- **a silt management plan**

- define the layer depth criterion for sediment incorporation or removal (i.e. 5 cm);
- define monitoring quality criteria (physical and chemical) and the protocol for handling sediment deposits (incorporation or removal);
- define subsequent storage and use, based on physical, chemical and microbiological parameters;
- make the supervision of sediment removal legally binding.

POST construction of NBS



Soil management strategy		Influence	Measure and recommendations	
Land reclamation guidelines	soil horizons removal and management	soil characteristics destruction	work in dry weather, store outside flood area, monitor soil initial conditions	
	soil mass storage pit set up and management	loss of soil mass for ameliorative measures or levelling	regular soil mass balance during earth works	
	PRE&DURING construction	soil suitability for use in reclamation	soil physical and chemical, characteristics	suitable soils are airy, permeable to water with low share of clay and silt particles and with 5% share of particles bigger than 2 mm.
	area levelling	agriculture production and soil productivity	work in dry weather, remove upper horizon and install low quality soils at the bottom	
	necessary agro-technical ameliorative measures	on agriculture production	graphical plan of operative fields, timeline of agro-technical works (crops, tillage, rotations)	
Soil monitoring plan	monitoring of soils’ relevant physical and chemical characteristics	food quality, productivity, economics of agriculture	monitor standard physical &chemical soil parameters, potential pollutants, e.g. pesticides, mineral oils	
	evaluation of soil quality changes after construction	soil productivity, health and environmental suitability for production	comparison of new soil values with initial soil conditions	
	evaluation of soil quality changes after flood event			
Silt management plan	layer depth criterion for sediment incorporation or removal	existing plant growth	supervision of agronomist or soil expert, specific by site characteristics (soil, vegetation) (usually 5 cm)	
	quality criteria and protocol of handling with sediment	defines between incorporation or removal	standard soil analysis of initial soil conditions for monitoring of the soil after flood	
	subsequent storage and use, based on physical, chemical and microbiological parameters	soil physical, chemical and biochemical characteristics	organise special storage sites . Separate clean silt and silt classified as hazardous waste.	
	supervision of sediment removal legally binding	obliges flood area manager and works contractor	supplement all stakeholders with knowledge from agronomy and soil sciences	

Example of flood event in 1991 in Upper Savinja valley

Detailed evaluation of damages on agricultural land post event

Type of sediments

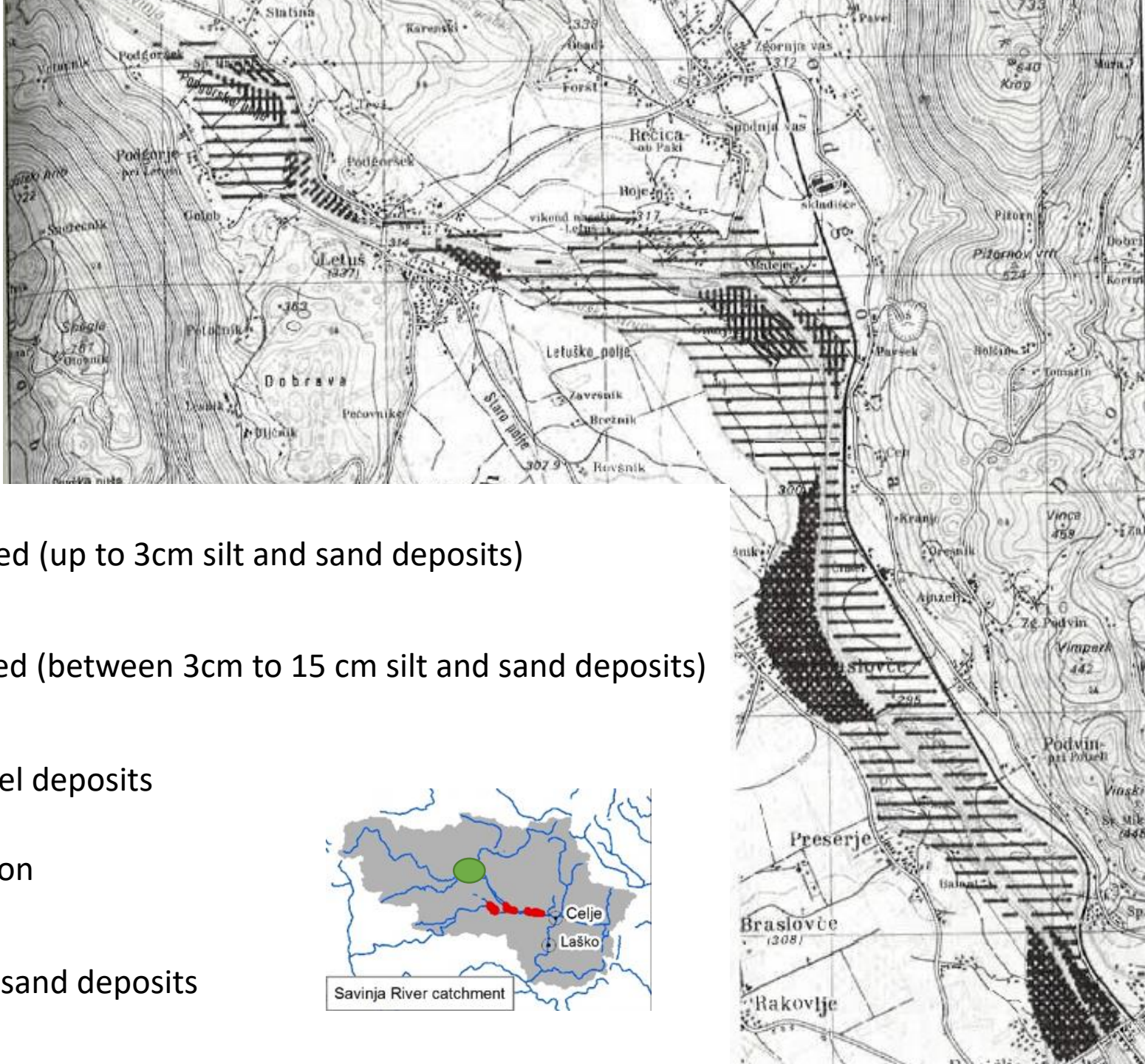
Chemical composition

Microbiological tests

Animal fodder & feces



- 1 Flooded (up to 3cm silt and sand deposits)
- 2 Flooded (between 3cm to 15 cm silt and sand deposits)
- 3 Gravel deposits
- 4 Erosion
- 5 Fine sand deposits



2. Agricultural infrastructure management

Possible impact of flooding on irrigation and drainage systems and examples of damage control measures

Agricultural infrastructure		Risk	Influence	Measure	Recommendations
Irrigation system	pumping stations	high	sedimentation dysfunction	remove	allocate outside detention area
	hydrants	high	sedimentation	protect	waterproof
	travelling sprinklers	high	sedimentation	remove	remove prior to flood
	pipes and emitters				
	at root zone	none	none	none	use in crop production
	on ≤ 1 m above ground*	high	sedimentation	clean	install at root zone or above flood water level (hop trellis)
	above hop trellises	medium	none	clean	use in hop production; be aware of plant disease
Drainage system	open canals	high	sedimentation	clean	maintain designed canal profile
	subsurface pipes	high	sedimentation	clean	pressure clean, protect drainage outlets
Trellis system	whole trellis	high	sedimentation demolishing	change the spatial position	construct trellis in the direction of flood water flow
	trellis poles	low	demolishing	improve anchoring	instead of wooden poles use concrete ones

*irrigation system in hop and fruit production is usually installed on trellises

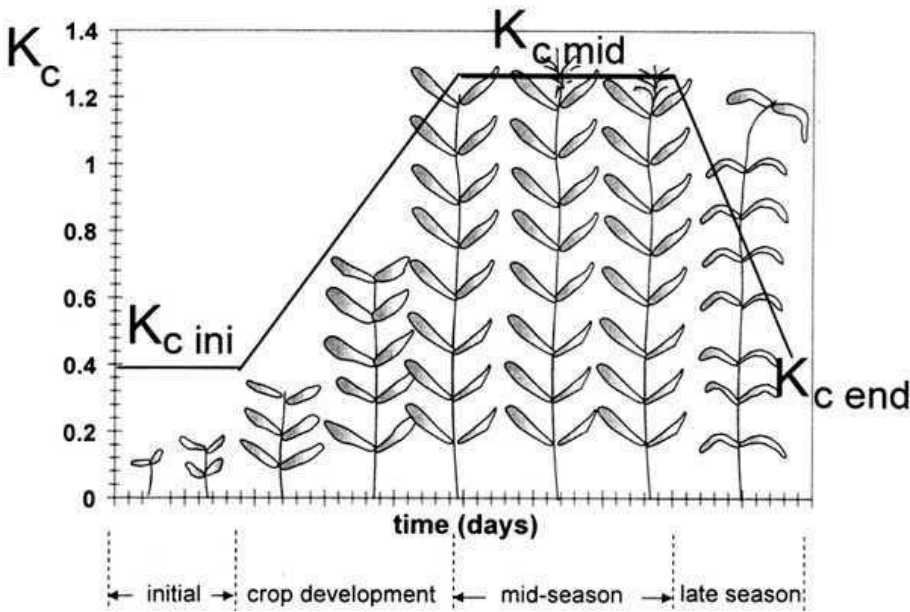


3.1 Critical-period matrix of estimated flood impact on crop yield

	water depth (A <50 cm, B 50 - 150 cm, C > 150 cm)																																			
Agricultural crop	J			F			M			A			M			J			J			A			S			O			N			D		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C			
wheat/spring	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3	3	3	3		
wheat/winter	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3	3	3	2	2	2	2	2	
rye/winter	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3	3	2	2	2	2	2		
spelt	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3	3	2	2	2	2	2		
buckwheat	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3		
maize for grain	3	3	3	3	3	3	3	3	3	3	3	3	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	3	3	3	3		
silage maize	3	3	3	3	3	3	3	3	3	3	3	3	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	3	3	3	3	3	3		
triticale	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	2	2	2	2	2	2	2		
oats/spring	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3	3	3	3	3	
barley/spring	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3	3	3	3	3	
barley/winter	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	2	2	2	2	2	2	2		
sunflower	3	3	3	3	3	3	3	3	3	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3		
oil pumpkin	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3		
oilseed rape	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	2	2	2	2	2	2	2	2		
soybean	3	3	3	3	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3		
peas	3	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
potatoes	3	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3		
sorghum	3	3	3	3	3	3	3	3	3	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	3	3	3	3	3	3	3		
fallow land	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
hop nursery	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2		
fodder carrot	3	3	3	3	3	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3		
sorghum	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3		
oilseed radish	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3		
grass	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2		
grass-clover mix	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2		
permanent grassland	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2		
clover	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2		
alfalfa	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2		
vegetables	3	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3		
herbs	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2		
hops	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	2	2	2	2	2	2		
apple	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	2	2		
plum	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	2	2	2	2	2	2		
other fruits	2	2	2	2	2	2	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	2	2	2		
nurseries	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2		

the time of flood occurrence
water depth, and
plant growth stage

direct partial or whole yield loss
indirect influence on yield through
inhibited growth
no yield loss (outside growth period).



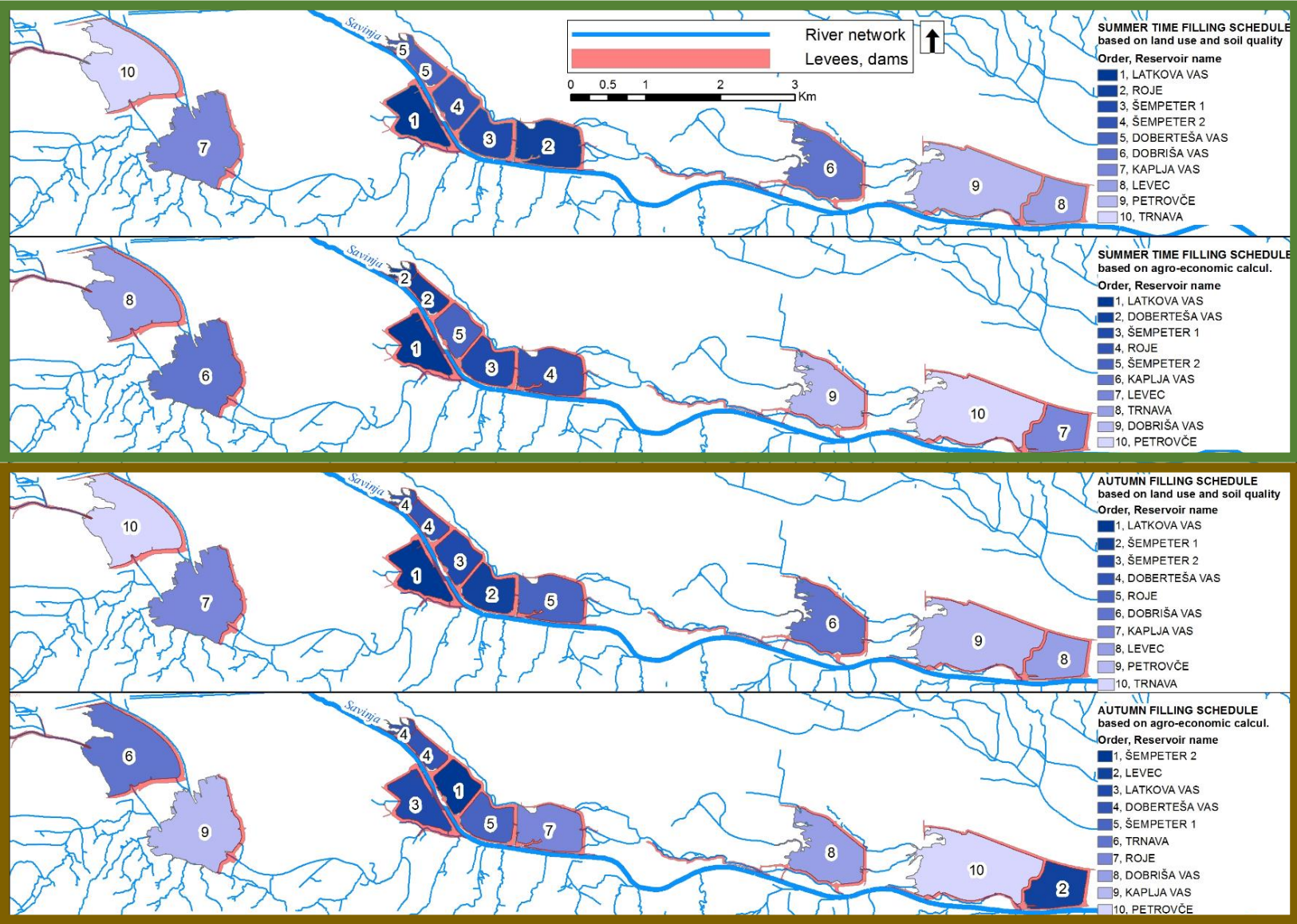
3.2 Economic impact of floods on agri-production

Gross margin (costs) of total production loss for **average yield** and an average price of **harvested crops**

Crop (yield, average price)		Gross margin Cost at a total loss of yield (EUR/ha)
Cereals	Winter Wheat (5 t/ha, 150 EUR/t)	-505
	Maize seeds (8 t/ha, 130 EUR/t)	-810
	Maize silage (45 t/ha)	-810
	Winter Barley (4.5 t/ha, 130 EUR/t)	-417
	Triticale (4.5 t/ha, 150 EUR/t)	-417
Clover and grass silage (40 t/ha)	Three cuts no baling	-368
	One cut no baling – used in the calculation	-123
	Three cuts with baling	-746
	One cut with baling	-249
Permanent grassland silage (40 t/ha)	Three cuts no baling	-591
	One cut no baling – used in the calculation	-197
	Three cuts with baling	-969
	One cut with baling	-323
Oil pumpkin	Dry pumpkin seeds (0.8 t/ha, 2,900 EUR/t)	-2.170
Hops	Hops (1.9 t/ha, 3,650 EUR/t)	-4.855
Fruit three nursery	Nursery (25,000 plants, 3.5 EUR/plant)	-69.668
Intensive orchard	Apple trees (40 t/ha, 230 EUR/t)	-7.842
Vegetable	Green salad (25/ha, 600EUR/t)	-11.845

3.3 Filling schedule of Nature Based Solution

Based on the growth requirements of hops.



SPRING – SUMMER FLOODS

AUTUMN FLOODS

**flooding of hops in late September will
cause the least damage**

**grassland can be flooded more frequently
than hops**

3.4 Agro-economic simulation for the worst case scenario (all reservoirs full - total loss) at Q100 flood.

<https://doi.org/10.15292/geodetski-vestnik.2016.04.717-733>

GLAVAN et al., 2016

Spring-summer flood water filling schedule								
Reservoir		Filling order	Economic damage of total crop yield loss (euro)					
Id	Name		April	May	June	July	August	September (until 20 th)
8	Latkova vas	1	2.026	9.115	9.115	9.115	8.553	8.553
4	Roje	2	17.313	32.209	31.465	31.465	30.298	30.366
5	Šempeter 1	3	23.777	30.495	30.495	30.495	29.531	29.531
6	Šempeter 2	4	91.598	94.826	94.826	94.826	94.432	94.432
7	Dobrtiša vas	5	1.276	12.523	12.523	12.523	11.116	11.116
3	Dobriša vas	6	341.801	358.992	324.320	323.945	319.676	319.167
9	Kaplja vas	7	106.969	133.881	125.496	125.496	122.679	122.679
1	Levec	8	181.459	199.243	199.496	199.496	194.576	194.576
2	Petrovče	9	541.428	565.118	556.230	556.230	549.996	549.599
10	Trnava	10	253.952	282.432	267.925	267.650	264.849	264.706
Total (€)		-	1.561.599	1.718.834	1.651.892	1.651.241	1.625.707	1.624.725

Autumn-summer flood water filling schedule					
Reservoir		Filling order	Economic damage of total crop yield loss (euro)		
Id	Name		September (after 20 th)	October	November (late apple varieties)
8	Latkova vas	1	8.553	6.623	58
5	Šempeter 1	2	5.819	4.062	106
6	Šempeter 2	3	3.004	818	-
7	Dobrtiša vas	4	11.116	2.985	70
4	Roje	5	24.410	15.162	180
3	Dobriša vas	6	254.199	248.675	325
9	Kaplja vas	7	84.435	65.772	603
1	Levec	8	178.544	169.768	12
2	Petrovče	9	385.445	374.940	91.457
10	Trnava	10	130.535	107.222	127
Total (€)		-	1.086.061	996.029	92.939

Economic damage
in the worst case scenario

IF THIS COMPENSATION
WOULD BE PAYED FOR
EACH FLOOD EVENT

depends on the state
willingnes to pay.

3.4 Agro-economic simulation

	Area		Agro-economic damage		
			Total loss of yield in worst case scenario		
Crop	Ha	%	EUR/ha	EUR/event	%
Future situation - New flood protection plan					
Fruit tree nursery	9.50	1.83	69,668	662,132	38.07
Hops	124.79	23.99	4,855	605,860	34.84
Intensive orchard	11.85	2.28	7,842	92,924	5.34
Maize silage	95.14	18.29	810	77,061	4.43
Maize grain	29.95	5.76	810	24,257	1.39
Permanent grassland	107.59	20.68	197	21,196	1.22
Vegetables	15.79	3.04	11,845	187,034	10.75
Other crops	125.54	24.13	varies	68,725	3.96
Total	520.15	100	3,184	1,739,189	100
Current situation - Old flood protection plan					
Fruit tree nursery	11.32	1.56	69,668	788,712	40.99
Hops	107.15	14.77	4,855	520,217	27.03
Intensive orchard	19.72	2.72	23,526	154,612	8.03
Maize for silage	127.82	17.62	810	103,537	5.38
Maize for grain	30.37	4.19	810	24,597	1.28
Permanent grassland	220.28	30.37	197	43,396	2.26
Vegetables	13.98	1.93	11,845	165,634	8.61
Other crops	194.72	26.84	varies	123,586	6.42
Total	725.37	100	2,653	1,924,291	100

3.4 Agro-economic simulation

Landowners are aware of the unpredictable future and want a clearer socio-economic picture for their farm.

When they were asked about interested in **making business plans for restructuring farms** as one of the vital mitigation measures in securing the future of the farms, **78% participants expressed interest**.

Farmers, landowners, and tenants were contacted by state (investor) during public discussions in 2011–2012.

They organized a civil initiative and delayed the project that should originally have been finished in 2015–2016, which is now projected to be completed 2023 or later.

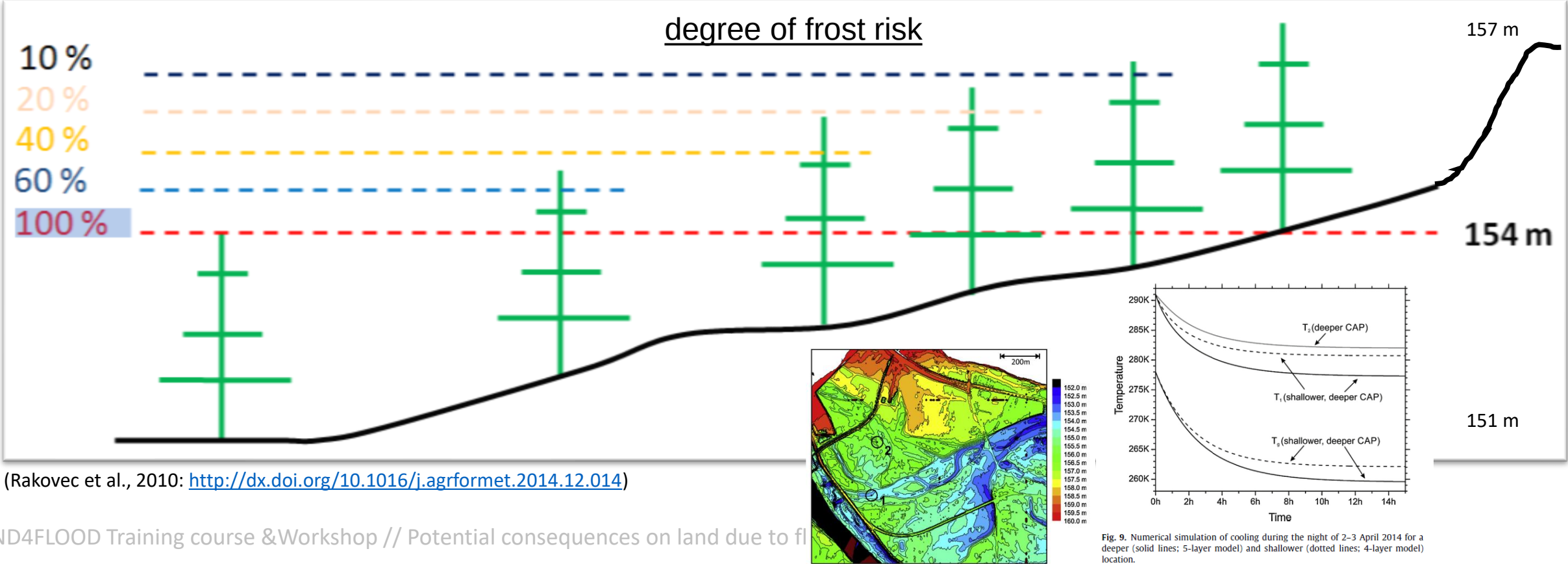
Farmers have found support in the **EU Floods Directive** that encourages the governments to implement suitable measures to **mitigate losses in agro-economic activities** due to floodwaters (Gaviglio et al., 2020).

The economic part of this study is a result of their demand.

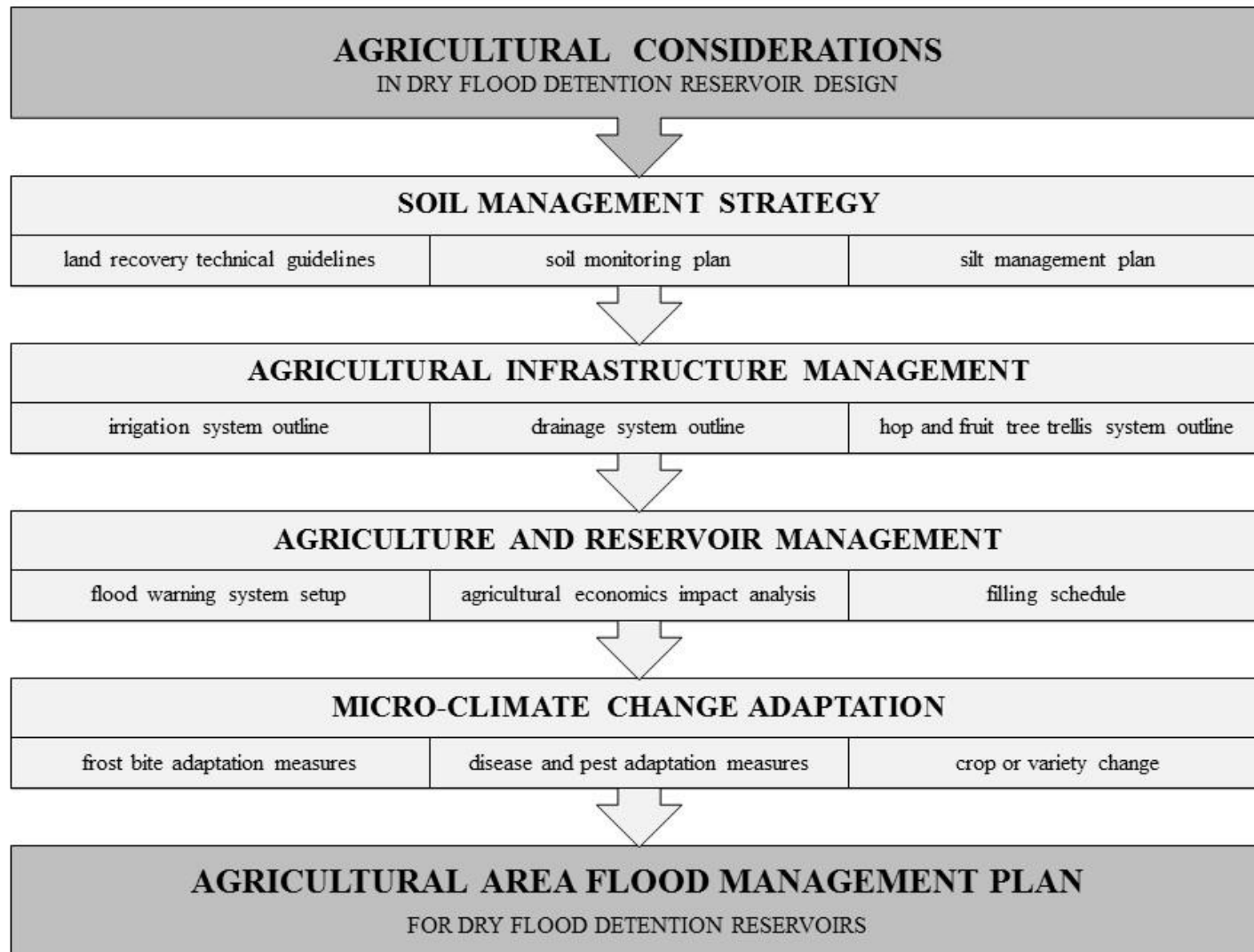
4. Micro-climate change adaptation

- Reservoirs act as barriers that reduce wind speed in an area,
- they locally reduce evaporation and increase air humidity,
- higher likelihood of pest and disease occurrence and frost

- What is needed:
- model micro-climate change;
 - foresee frost and pest protection measures;
 - or change the crop variety if necessary.



Before initiating implementation of NBS on the best agricultural land



Proposed **basic guidelines** to:

- Preserve agricultural production
- Help communication with local communities – private land owners and other stakeholders

Thank you for your attention.

How can we improve/activate **communication with landowners?**

How can we present (negative/positive) impacts of floods and NBS to the **state** – or **other stakeholders** – to be willing to **finance compensations to landowners?**

IMPORTANT for the sustainable development under climate change conditions

Practical implementation of the soil monitoring plan, agricultural infrastructure mitigation measures, agricultural socio-economic impact on individual farms, and dealing with disease or pest control and crop variety changes.

