LIFE IP CleanEst: Assessment of aquatic ecosystem services in Estonia

Marko Vainu, *PhD*

Estonian Environment Agency
marko.vainu@envir.ee

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Background

- In 2016, the assessment methodology of aquatic ecosystem services (rivers, lakes, marine ecosystems) was compiled in Estonia (Kosk et al. 2016).
- It was not applied in practice and the full spectrum of ES had previously not been assessed in any aquatic ecosystem in Estonia.
- In 2019, the project “LIFE IP CleanEST” was initiated.
- One of its aims is to develop a practically applicable methodology for assessing ES of inland water bodies (rivers and lakes) in Estonia and to test that methodology in the project area – the Viru subbasin in northeastern Estonia.
- The services have to be assessed three times during the course of the project: in the beginning (2020), in the middle (2023) and in the end (2027).

Selection of services

- 17 ES were chosen as important for Estonian riverine ecosystems.
- 19 ES for Estonian lacustrine ecosystems.
- List of services is (mostly) in accordance with the CICES v.5.1 classification.

Provisioning services
Fish stock for professional fishing – CICES v5.1: 1.1.6.1
Animal and plant material collected for the purposes of maintaining or establishing a population – CICES v5.1: 1.2.2.1, 1.2.1.1
Surface water for drinking – CICES v5.1: 4.2.1.1
Surface water used for other non-drinking purpose – CICES v5.1: 4.2.1.2
Surface water used as an energy source – CICES v5.1: 4.2.1.3
Reed stock – CICES v5.1: 1.1.5.2, 1.1.5.3 *only for lacustrine ecosystems*
Mud stock – CICES v5.1: 4.2.3.1 *only for lacustrine ecosystems*
Maintaining and regulating services
Maintaining nursery populations and habitats – CICES v5.1: 2.2.2.3
Dilution and meditation of wastes or toxic substances in surface and groundwater – CICES v5.1: 2.1.1, 5.1.1.1
Maintaining drainage and waste water discharge – CICES v.5.1: 5.2.2.1 *only for riverine ecosystems*
Regulation of the chemical condition of freshwater by living organisms (buffer zones on shores) – CICES v5.1: 2.2.5.1
Climate regulation via carbon sequestration and storage – CICES v 5.1: 2.2.6.1 *only for lacustrine ecosystems*
Cultural services
Conditions supporting active recreation – CICES v5.1: 3.1.1.1
Conditions supporting recreational fishing and hunting – CICES v5.1: 3.1.1.1
Conditions supporting passive recreation – CICES v5.1: 3.1.1.2
Conditions that enable scientific investigation – CICES v5.1: 3.1.2.1
Conditions that enable education and training – CICES v5.1: 3.1.2.2
Conditions that enable aesthetic experiences – CICES v.5.1: 3.1.2.4
Provision of cultural, religious and national symbols – CICES v5.1: 3.1.2.3, 3.2.1.1, 3.2.1.2
Maintaining protected and vulnerable species – CICES v5.1: 3.2.2.2.

Indicators

- Two types of indicators were selected:
  - Indicators for the provision/status/functioning/ capacity of the service (S).
  - Indicators for the consumption/pressure/flow of/on the service (P).
- Indicators, where data is readily available in existing databases, were preferred.
- Rivers – 35 indicators of provision/status, 36 indicators of consumption/pressure.
- Lakes – 36 indicators of provision/status, 33 indicators of consumption/pressure

Conditions supporting active recreation	P Number of organised canoeing/kayaking, etc. trips on the water body (pcs/yr)
	P Number of people using the water body for swimming (pcs/yr)
	P Number of hikers/walkers on the shore area of the water body (pcs/yr)
	S Length of the water body suitable for canoeing/kayaking, etc. (km)
	S Number of dams on the section of the water body suitable for canoeing/kayaking, etc. (pcs)
	S Number of swimming places on the shore of the water body (pcs)
	S Length of roads/trails suitable for walking/hiking on the shore area of the water body (km)
Conditions supporting recreational fishing and hunting	P Number of recreational fishers (pcs/yr)
	P Number of crayfish catchers (pcs/yr)
	P Number of beaver hunters (pcs/yr)
	S Attractiveness for fishing (grade)
	S Legal possibility for recreational fishing (yes/no)
	S Crayfish abundance (grade)
	S Legal possibility for crayfish catching (yes/no)
	S Number of beaver families on the water body (pcs)

Assessment on a common scale

- In order to compare the situation between the water bodies and between the services, the indicators had to be normalized on a 0–4 scale.
- For the services, where several indicators of provision or consumption were used, their share in the total score of provision or consumption had to be fixed.

Ecosystem service	Score of ES provision	Indicator I	Indicator II
Maintaining nursery populations and habitats		Status of aquatic biota (index)	Area of surface water dependent terrestrial ecosystems (ha)
	0	0–0.4	0
	1	0.5–1.4	<10
	2	1.5–2.4	10–99
	3	2.5–3.4	100–499
	4	3.5–4.0	>=500
	Share of indicator	*0,75*	*0,25*

Ecosystem service	Score of ES provision	Indicator I		Indicator II	Indicator III
Conditions supporting active recreation		Suitability for boating		Number of swimming places on the shore of the water body (pcs)	Length of roads/trail suitable for walking/hiking on the shore area of the water body (km)
		Length of the water body suitable for canoeing/kayaking, etc. (km)	Number of dams on the suitable section of the water body (pcs)		
	0	0	>=6	0	<0,5
	1	1–4	4–5	1	0,5-1
	2	5–9	2–3	2–3	2-4
	3	10–19	1	4–5	5-9
	4	>=20	0	>=6	>=10
	Share of indicator	*0,6*	*0,4*	*0,2*	*0,4*
		0,6			

Prioritisation of the services

- All the services are not equally important for the society. Therefore the services were ordered by the working group members and the relative importance of the first and last service in the list was estimated. Based on that ES weights were calculated.

No	Riverine ecosystem service	Weight
1	Maintaining nursery populations and habitats	4.0
2	Dilution and meditation of wastes or toxic substances in surface water	4.0
3	Maintaining protected and vulnerable species	3.0
4	Regulation of the chemical condition of freshwater by living organisms (buffer zones on shores)	2.75
4	Conditions supporting recreational fishing and hunting	2.75
4	Maintaining drainage and waste water discharge	2.75
7	Surface water for drinking	2.25
8	Conditions supporting active recreation	2.0
8	Animal and plant material collected for the purposes of maintaining or establishing a population	2.0
10	Surface water used for other non-drinking purpose	2.0
11	Fish stock for professional fishing	1.75
11	Conditions supporting passive recreation	1.75
11	Conditions that enable aesthetic experiences	1.75
14	Conditions that enable education and training	1.5
14	Conditions that enable scientific investigation	1.5
16	Provision of cultural, religious and national symbols	1.25
17	Surface water used as an energy source	1.0

No	Lacustrine ecosystem service	Weight
1	Maintaining nursery populations and habitats	10.0
2	Maintaining protected and vulnerable species	8.5
3	Conditions supporting active recreation	8.0
4	Dilution and meditation of wastes or toxic substances in surface water	7.5
5	Conditions supporting recreational fishing and hunting	7.5
6	Conditions supporting passive recreation	7.25
7	Regulation of the chemical condition of freshwater by living organisms (buffer zones on shores)	7.0
8	Conditions that enable aesthetic experiences	6.5
9	Surface water for drinking	6.0
10	Surface water used for other non-drinking purpose	5.5
11	Animal and plant material collected for the purposes of maintaining or establishing a population	4.75
12	Climate regulation via carbon sequestration and storage	4.75
13	Fish stock for professional fishing	4.5
14	Provision of cultural, religious and national symbols	4.25
15	Conditions that enable education and training	4.25
16	Conditions that enable scientific investigation	3.75
17	Reed stock	2.5
18	Mud stock	2.5
19	Surface water used as an energy source	1.0

Ecosystem services index

- The ecosystem services index (*ESI*) (Kosk et al. 2016) is used for expressing the total provision or consumption of services by a water body. The value of the index is between 0 and 1, but will never reach 1,0.
- May be calculated for both, provision/capacity (*ESIp*) and consumption/flow (*ESIc*).
- That index was modified in the current methodology to include the weights:

$$ESI = \frac{\sum_i^n (kx_p)}{4 * \sum_i^n (k)}$$

n – number of evaluated ecosystem services, *k* – weight of the i-th ES, *x* – the value of provision or consumption of the i-th ecosystem service.

Application

- 20 riverine and 2 lacustrine water bodies in the Viru subcatchment in northeastern Estonia.

Data from 2019/2020 was used to assess all the indicators.

ES provision/capacity (rivers)

Water body	Fish stock	Pop. maintaning	Drinking water	Other water	Energy	Habitats	Water quality	Drainage and waste water discharge	Buffer zones on shores	Active recreation	Rec. fishing and hunting	Passive recreation	Science	Education	Aesthetics	Symbols	Important species
Alajõgi_2	0	2	3	2	0	2	1	2	3	1	2	2	4	0	2	0	1
Erra	0	1	2	2	0	3	1	3	2	1	2	2	4	1	1	1	1
Kohtla	0	1	0	2	1	1	1	3	3	1	1	2	4	0	2	1	1
Kunda_1	0	2	2	2	0	3	1	1	3	1	2	2	4	0	1	1	3
Kunda_2	0	3	0	3	1	3	4	2	2	4	3	2	4	3	2	2	3
Loobu_1	0	2	2	2	0	2	0	2	2	2	2	2	4	2	2	3	4
Loobu_2	3	3	4	2	1	3	1	2	3	3	3	3	4	1	2	2	4
Pada_1	3	1	0	2	0	3	1	2	3	1	3	3	4	0	2	3	3
Pada_2	3	2	2	2	0	3	1	1	3	1	2	2	4	0	2	0	3
Purtse_1	0	2	1	2	1	3	1	3	3	2	2	2	4	0	1	1	2
Purtse_2	0	2	0	2	1	2	1	3	2	2	1	2	4	1	3	1	2
Purtse_3	3	3	0	3	2	2	1	4	2	2	2	2	4	1	3	2	3
Purtse_4	2	2	0	3	1	2	1	4	2	2	2	1	4	0	4	1	3
Selja_2	0	1	0	2	0	2	2	2	3	1	2	2	4	0	2	0	2
Selja_3	0	3	0	2	0	2	1	2	2	2	2	1	4	0	1	1	3
Selja_4	3	3	4	2	0	3	1	2	3	2	2	2	4	0	3	2	2
Soolikaoja	0	1	0	2	0	1	1	4	2	1	2	2	4	4	2	0	1
Sõmeru	0	2	0	2	0	3	1	2	2	1	2	1	4	0	1	2	3
Udriku	0	2	2	2	0	2	2	2	2	1	1	1	4	0	1	1	2
Võsu_2	1	2	0	2	0	2	1	2	3	1	1	4	4	0	3	0	2

ES consumption/pressure (rivers)

Water body	Fish stock	Pop. maintaning	Drinking water	Other water	Energy	Habitats	Water quality	Drainage and waste water discharge	Buffer zones on shores	Active recreation	Rec. fishing and hunting	Passive recreation	Science	Education	Aesthetics	Symbols	Important species
Alajõgi_2	0	0	0	0	0	2	1	1	0	2	2	2	2	0	1	0	3
Erra	0	0	0	0	0	3	1	1	1	1	1	1	2	2	1	3	3
Kohtla	0	0	0	0	0	2	3	1	1	1	0	2	4	0	0	4	3
Kunda_1	0	0	0	0	0	2	2	1	0	1	2	2	2	0	1	0	3
Kunda_2	0	0	0	1	0	1	2	2	1	3	3	2	3	3	2	3	2
Loobu_1	0	0	0	0	0	3	2	1	1	2	3	2	1	2	1	3	3
Loobu_2	1	0	0	0	1	2	2	1	1	2	3	3	2	3	2	4	3
Pada_1	0	0	0	0	0	2	2	1	0	1	2	2	1	0	1	4	3
Pada_2	1	0	0	0	0	2	2	1	1	1	1	1	2	0	0	0	3
Purtse_1	0	0	0	0	0	2	1	2	1	1	2	2	3	0	1	0	3
Purtse_2	0	0	0	0	0	2	3	2	1	3	2	2	3	1	1	0	3
Purtse_3	0	0	0	1	1	2	3	2	1	3	2	2	4	1	1	0	3
Purtse_4	0	0	0	0	0	2	3	2	1	3	2	2	4	0	1	0	3
Selja_2	0	0	0	0	0	2	3	1	1	1	2	1	2	0	1	0	2
Selja_3	0	0	0	0	0	3	3	3	1	1	2	1	3	0	1	4	3
Selja_4	1	0	0	0	0	2	2	2	0	2	2	1	3	0	0	0	3
Soolikaoja	0	0	0	0	0	3	4	1	1	1	1	2	1	4	2	0	4
Sõmeru	0	0	0	1	0	3	3	1	1	1	2	2	1	0	2	4	3
Udriku	0	0	0	0	0	2	2	1	1	0	1	1	0	0	0	0	3
Võsu_2	0	0	0	0	0	3	2	1	0	1	1	2	1	0	1	0	3

Ecosystem service index and its general relevance for water management

Water body	ESI provision/capacity
Loobu_2	0.66
Kunda_2	0.64
Selja_4	0.57
Purtse_3	0.55
Pada_1	0.52
Purtse_4	0.51
Pada_2	0.49
Loobu_1	0.48
Purtse_1	0.47
Kunda_1	0.45
Purtse_2	0.43
Erra	0.43
Võsu_2	0.42
Alajõgi_2	0.42
Selja_3	0.41
Sõmeru	0.41
Selja_2	0.41
Udriku	0.40
Soolikaoja	0.39
Kohtla	0.35

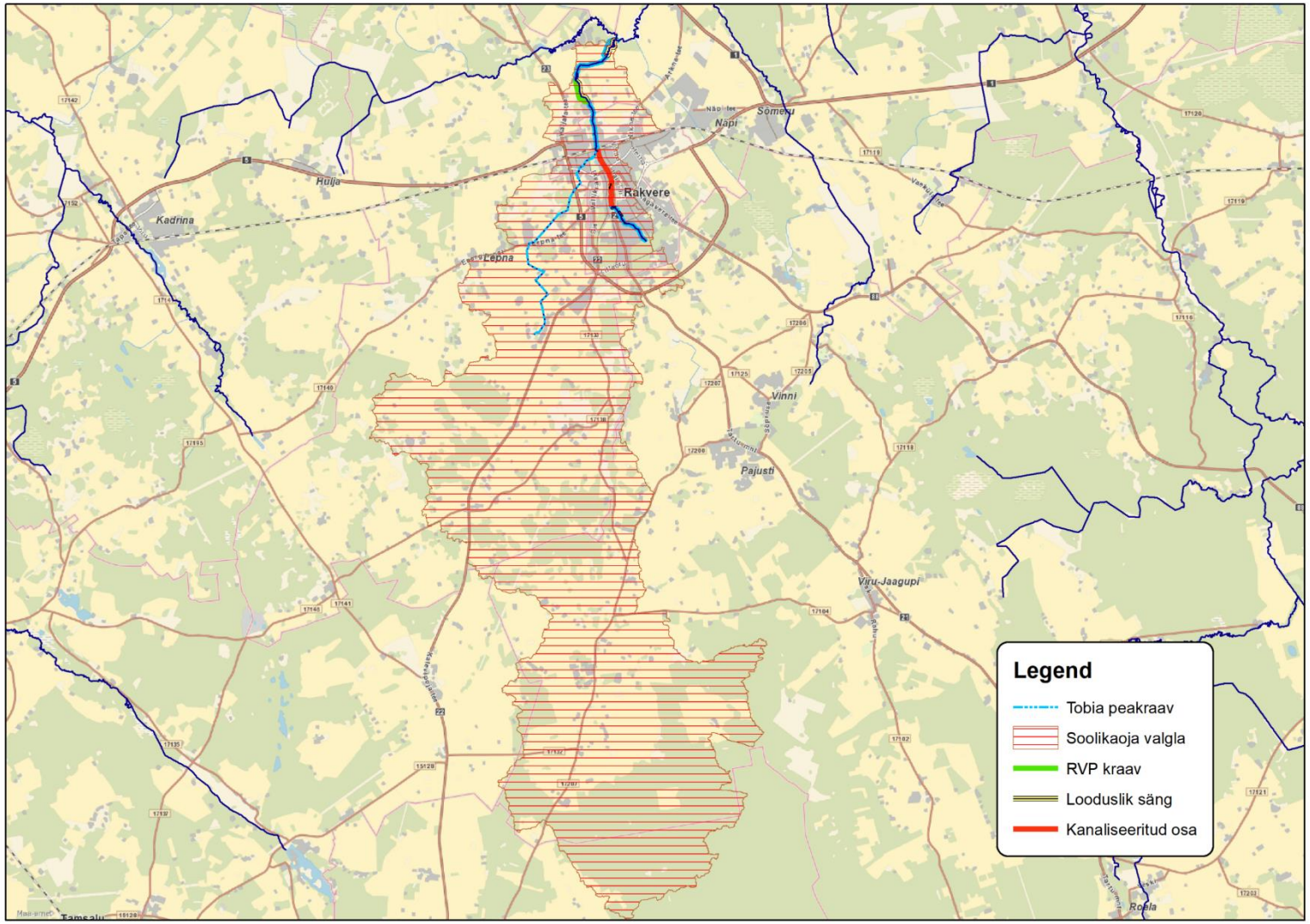
Relevance of the results:

- It is possible to pinpoint, which water bodies provide the least ecosystem services and to channelize more effort to them.
- It is possible to assess the effect of mitigation projects with a single number – if the value of the index increases, even just a bit, then the provision of ES's has increased in that water body and the effort has been justified.
- It is possible to evaluate, whether a proposed development is acceptable or not. If the *ESI* is expected to increase or stay stable as a result of that development, then it is acceptable. If the *ESI* decreases, then not. So it could be used as a new methodology for environmental impact assessments.
- The Environmental Ministry wishes that ES assessment results would be used for evaluating the effectiveness of River Basin Management Plans. The main obstacle is its data-intensive nature.

Report (summary in English):
https://lifecleanest.ee/ - Aruanded

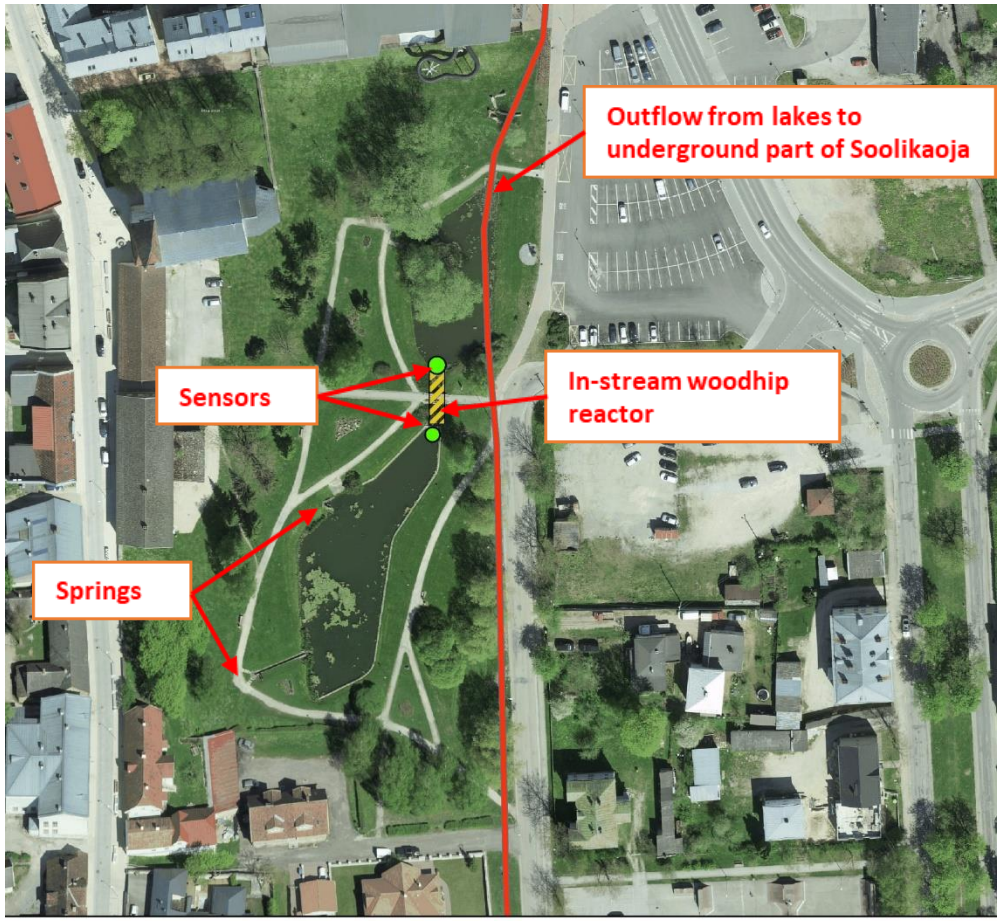
NBSs used in CleanEst – Soolikaoja

- Soolikaoja (Linnaoja) stream is located in Lääne-Virumaa and it flows through the town of Rakvere.
- Soolikaoja is a 7.5 km long heavily modified waterbody with catchment area 122.1 km^2.
- The baseflow component in the stream is in the range of 30-95 %
- The stream is located in Nitrate Vulnerable Zone
- The ecological status of Soolikaoja is bad



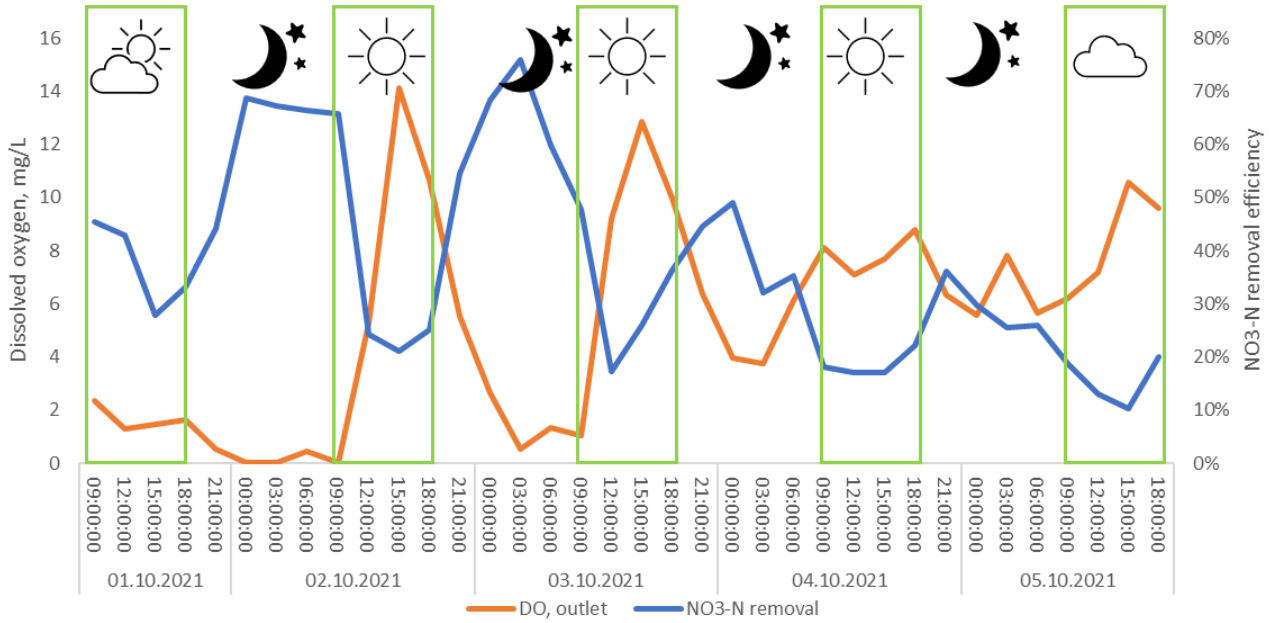
- There are several dams within the city creating an extensive network of small lakes that are eutrophic due to the high content of nitrates (8.6 ± 1.9 mgN/L).
- The middle part is canalized and flows through pipes.
- The lower part is an open water channel.

In-stream wood chip bioreactor to stimulate denitrification by the addition of external carbon sources.



First results

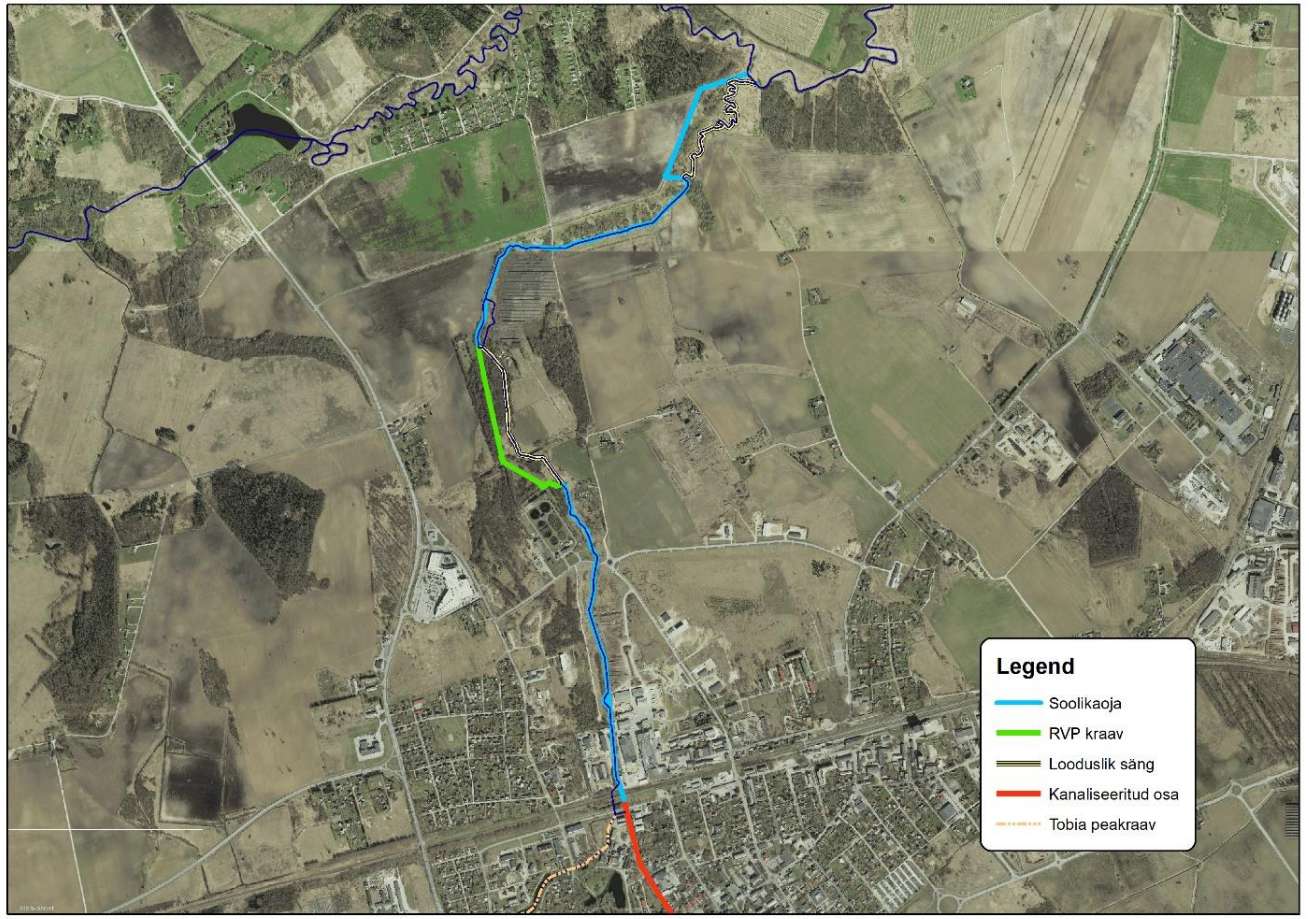
- **Sensor data** showed relevant differences in the reactor performance
- The reduction in nitrate concentrations during the daytime averaged 36.4 ± 13.0 %, while during the night-time it was significantly higher (48.8 ± 14.4 %).
- An average NO_3-N removal rate was 43.7 gN m^{-3} d^{-1}, but it varied between 9.5 and 99.3 gN m^{-3} d^{-1}.
- Bioreactor efficiency was negatively correlated to dissolved oxygen concentration in the end of the bioreactor, which in turn explains fluctuations in bioreactor performance.



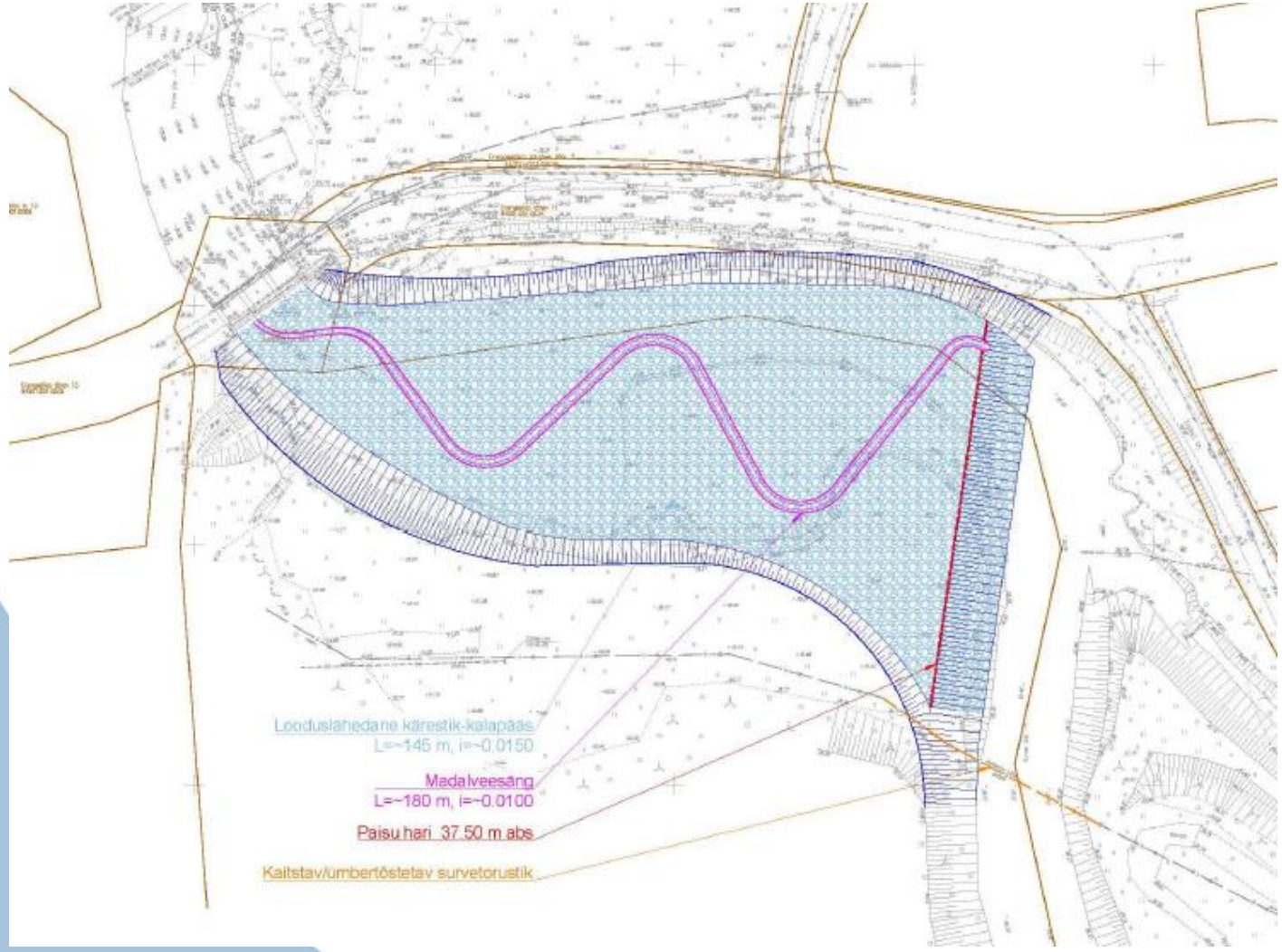
Floating islands on three ponds

Restoration of the downstream section

- Diverting the stream back to its natural channel.
- Converting straightened parts two-stage ditches, where the bottom stage is covered with wetland plants.
- Burying wood chips into the surface around the stream to aid denitrifcation.
- Roughening the bottom with wood material.



Artificial rapids instead of Püssi dam



Fish stock for professional fishing	P Amount of professional catch from the river (t/yr)
	S Fishing resource production (pcs/yr)
Animal and plant material collected for the purposes of maintaining or establishing a population	P Number of animals caught for relocation or breeding material (pcs/yr)
	S Composite index of significance of the provision of the service of maintaining or establishing a population (index)
Surface water for drinking	P Number of drinking water intakes (no)
	P Abstraction of surface water for drinking water (m^3/s)
	S Average minimal monthly discharge that exceeds environmental flow (m^3/s)
	S Accordance of water quality to quality requirements of water used to produce drinking water (quality class)
Surface water used for non-drinking purpose	P Number of surface water intakes for industrial, irrigation or agricultural water (pcs)
	P Abstraction of surface water for industrial, irrigation or agricultural water (m^3/s)
	P Number of surface water intakes for cooling or aquaculture water (pcs)
	P Abstraction of surface water for cooling or aquaculture water (m^3/s)
	S Average minimal monthly discharge that exceeds environmental flow (m^3/s)
Surface water used as an energy source	P Number of hydropower plants (no)
	P Capacity of hydropower plants (MW)
	S Hydro-energetic potential of the water body (MW)
Maintaining nursery populations and habitats	P Hydromorphological status (status class)
	P Water quality status (status class)
	P Status of aquatic biota in neighbouring water bodies (index)
	S Status of aquatic biota (index)
	S Area of surface water dependent terrestrial ecosystems (ha)
Dilution and meditation of wastes or toxic substances in surface and groundwater	P Point source pollution (point-source pollution index)
	P Nutrient load via diffuse pollution N+P (diffuse pollution index)
	S Water quality status (status class)

Maintaining drainage and waste water discharge	P Area of improved land for which the water body is the recipient (ha)
	P Share of water body length that has been declared as recipient for land improvement systems (%)
	P Number of storm and wastewater outlets to the water body (pcs)
	P Discharge of storm- and wastewater to the catchment of the water body (thous m^3/yr)
	S River sinuosity index
	S River gradient (m/km)
	S Share of the water body with restrictions for establishing or renewing land improvement systems (%)
Regulation of the chemical condition of freshwater by living organisms (buffer zones on shores)	P Share of recently (in 4–5 years) clear-cut land or forests with similar disturbance on the shore area of the water body (%)
	P Share of non-natural land cover on the shore area of the water body (%)
	S Share of full-grown forests on the shore area of the water body (%)
	S Share of natural land cover on the shore area of the water body (%)

Conditions supporting passive recreation	P Number of users of rest stop sites on the shore of the water body (pcs/yr)
	P Number of nights spent in accommodation facilities near the water body (pcs/yr)
	P Number of unique nature observations in the shore area of the water body (pcs/yr)
	S Number of rest stop sites on the shore of the water body (pcs)
	S Number of accommodation facilities on the shore of the water body (pcs)
	S Share of natural land cover in the shore area of the water body (%)
	S Number of residential properties adjacent to the water body (pcs)
Conditions that enable scientific investigation	P Number of scientific publications (pcs)
	P Number of public monitoring data (pcs)
	S *All water bodies are considered equally valuable for scientific investigation therefore no indicator is determined.*

Conditions that enable education and training	P Number of educational trips in nature and public schools related to the water body (pcs/yr)
	S Number of educational programmes in nature and public schools related to the water body (pcs)
Conditions that enable aesthetic experiences	P Number of photos in the web depicting the water body (pcs)
	S Attractiveness for landscape watching (index)
Provision of cultural, religious and national symbols	P Number of visitors of natural symbolic sites (pcs/yr)
	S Number of natural symbols (pcs)
	S Number of folklore items related to the water body (pcs)
Maintaining protected and vulnerable species	P Hydromorphological status (status class)
	P Water quality status (status class)
	S Amount of protected species (index)
	S Status of protected species (grade)
	S Share of salmonid habitats of the water body length (%)