The impact of wetland restoration on water retention in the catchment scale in the Neman basin – costs and benefits

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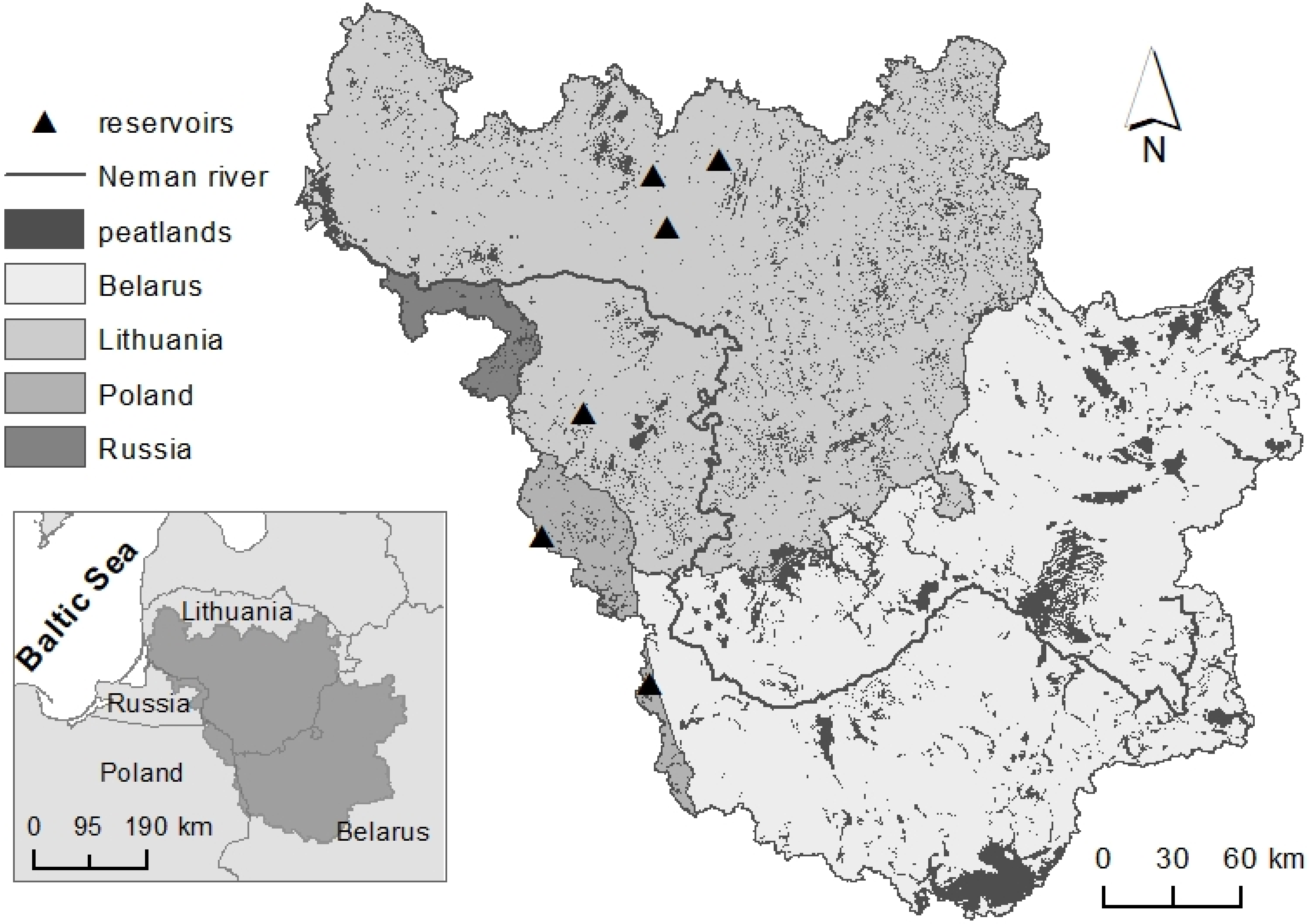
PEATLAND DEGRADATION

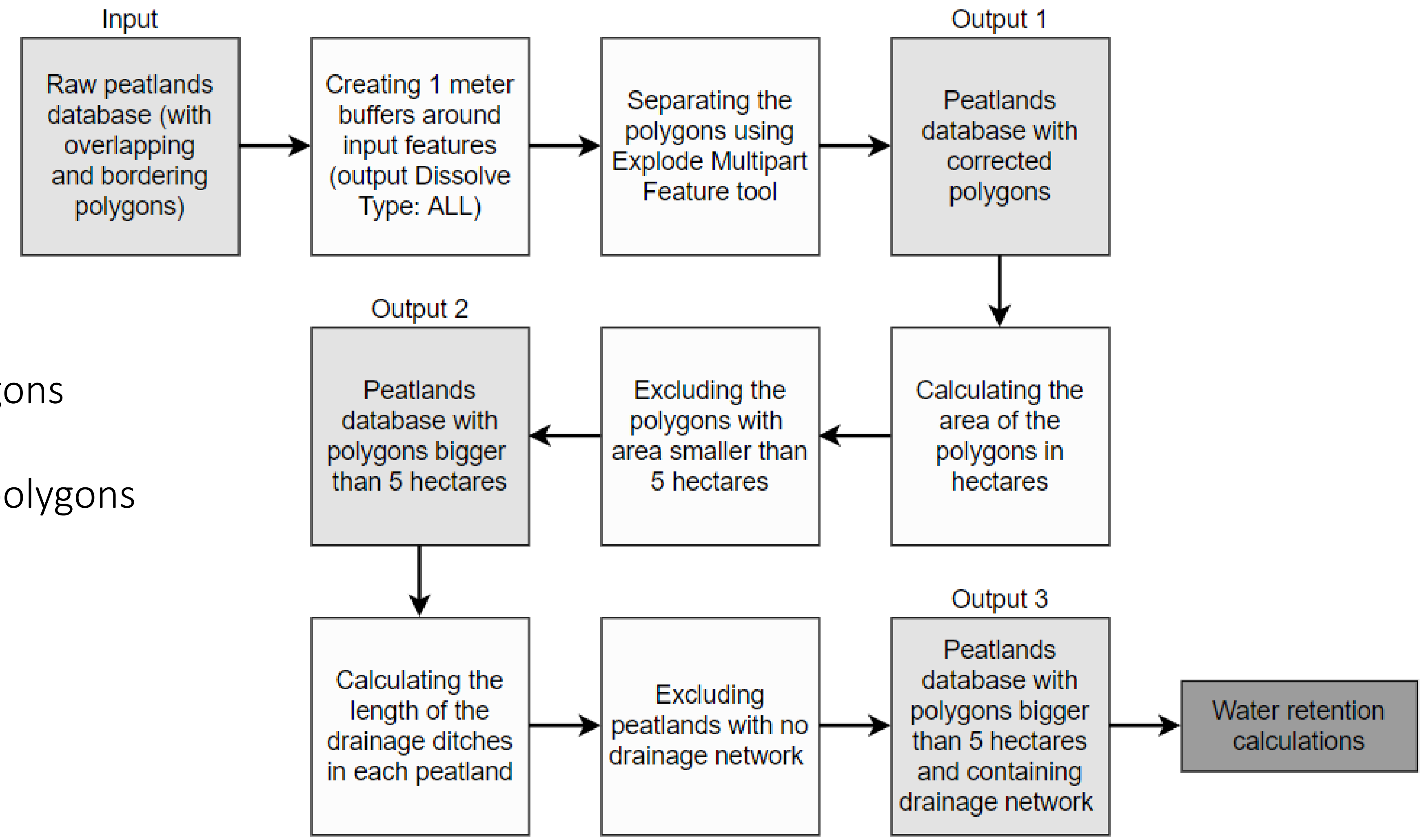
- Land use change, peat extraction and intensification of agriculture and forestry have caused loss and degradation of peatlands across the globe (Glina et al., 2018; Harpenslager et al., 2015; Jones et al., 2017; Urák et al., 2017).
- In Europe, the number of drained peatlands for agricultural purposes exceeds 50% (Loisel et al., 2021).
- Peatland restoration through rewetting is the first major step of the restoration process (Grand-Clement et al., 2015, Jarašius et al., 2015), allowing the subsequent application of paludiculture.

RESEARCH AREA

- Catchment area: 95 753 km^2
- Peatland's area: 10 068 km^2 (Manton et al., 2021)



DATA PROCESSING



- All peatlands: 14 780 polygons
- Drained peatlands: 9 507 polygons

QUANTIFICATION OF WATER STORAGE CAPACITY

- Only in drained peatlands.
- The following equation was used (Grygoruk et al., 2018):

$$V = a \cdot h \cdot l \cdot \left(\frac{b}{2} + \frac{r}{3} \cdot p\right), \text{ where:}$$

V – water retained due to damming up on the ditches in m^3,

a – coefficient correcting the actual damming capacity on the ditch,

h – stacking (damming) height in m,

l – stacking range in m,

b – average width of the ditch in m,

r – the average radius of water level rise in a cross-sectional view in metres from the ditch,

p – soil porosity.

VALUATION OF WATER RETENTION

- Based on the construction costs of 6 reservoirs located in the Neman catchment.

Table 1. Reservoir construction costs within Lithuanian and Polish part of the Neman catchment

No.	Country	Name of the reservoir	Year of construction	Volume [m^3]	Original construction costs	Current construction costs [EUR]	Water retention value [EUR/m^3/year]
1	Poland	Kuźnica - Łosośna	2004	52 970	424 210 EUR	545 276	0.26
2	Poland	Suwałki	2021	4 323	267 920 EUR	267 920	1.55
3	Lithuania	Angiriai	1980	15 500 000	1 423 600 Rub	25 317 382	0.04
4	Lithuania	Vaitiekūnų	1980	500 000	1 247 220 Rub	22 163 603	1.11
5	Lithuania	Krekenavos	1978	337 000	106 780 Rub	1 899 432	0.14
6	Lithuania	Balsupių	1977	848 000	165 000 Rub	2 938 149	0.09
						Average	**0.53**

COSTS OF RESTORATION

- Derived from the actual costs of rewetting different peatlands in Belarus, Lithuania and Poland per one action (dam).
- Based on 8 rewetting actions from Poland, 6 from Lithuania and 3 from Belarus.
- Different types of actions were taken into account, including construction of: peat, wooden, plastic, composite and mixed dams.
- The cost of construction of one dam varies between 50 and 5000 EUR.

COSTS OF RESTORATION

- Rewetting through damming the drainage ditches located within the peatland's boundaries.
- 3 different scenarios of damming costs, derived from various types of actions:
  - 148 EUR/dam – averaged cost of peat dams and dams used for smaller ditches (1.0 – 2.0 m)
  - 655 EUR/dam – averaged cost using half peat dams and half more solid dams
  - 1231 EUR/dam – averaged cost of all types of dams (peat, wooden, plastic, composite dams)

Parameters	Value	Unit
Correction coefficient (a)	0,8	-
Stacking height (h)	0.1; 0.3; 0.5	m
Average width of the ditch (b)	2	m
Range of the ditch influence (r)	20; 50	m
Porosity (p)	0.71; 0.83; 0.951	-

RESULTS – WATER RETENTION

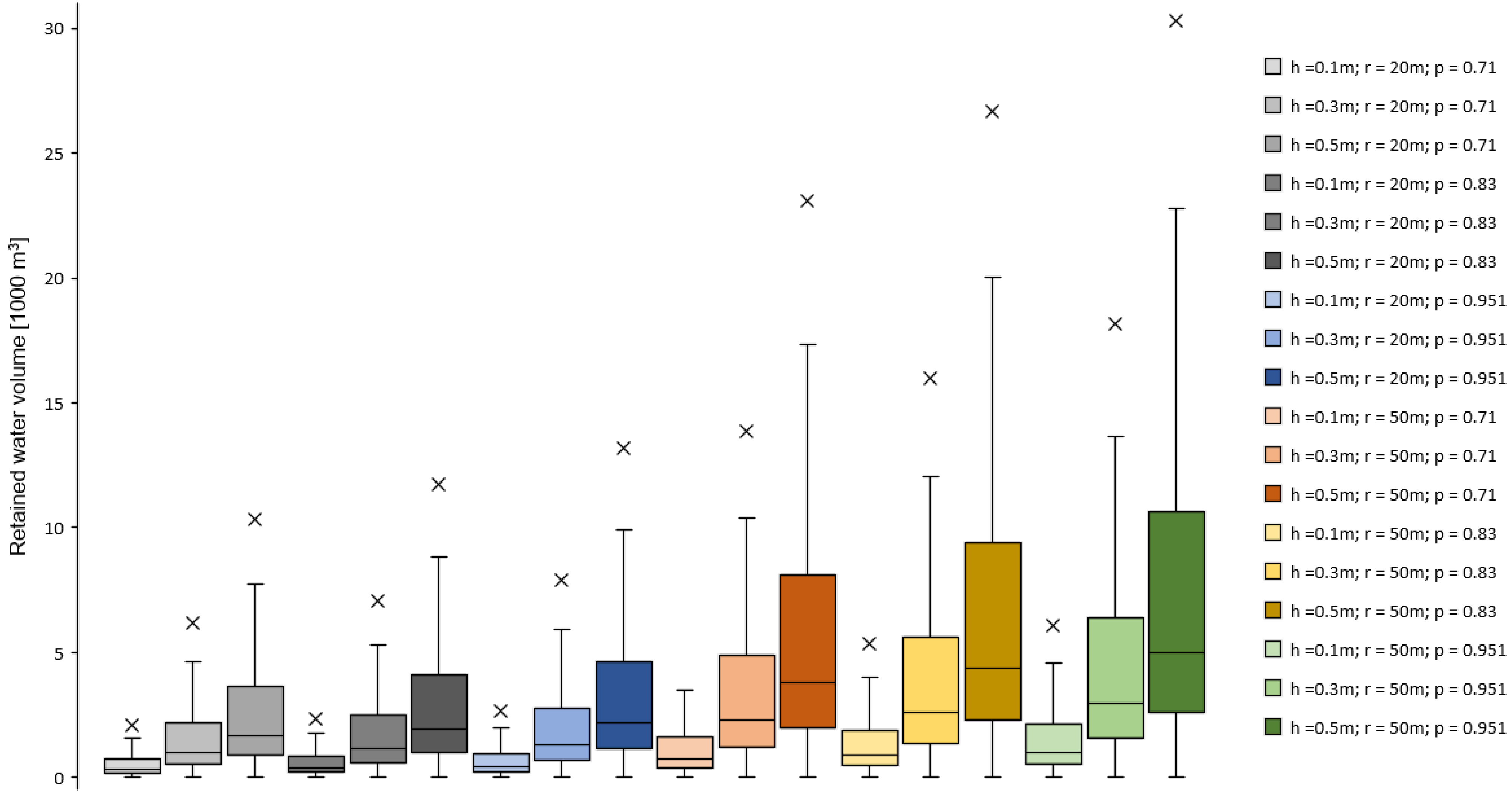


Fig. 1. Boxplots comparing retained water volume in 18 scenarios, using various values of the average radius of water level rise in a cross-sectional view from the ditch, porosity and stacking height (outliers excluded).

RESULTS – COSTS AND BENEFITS

Table 2. Estimated costs of restoration and water retention values

Calculated values		Belarus	Lithuania	Poland	Russia (Kaliningrad Oblast)	Total
Cost of dams – min. [EUR · year^{-1}]		8 891 722	5 411 794	233 785	106 371	14 643 671
Cost of dams – average [EUR · year^{-1}]		39 351 876	23 950 845	1 034 654	470 765	64 808 140
Cost of dams – max. [EUR · year^{-1}]		73 957 495	45 012 961	1 944 518	884 750	121 799 725
Total water retention value [EUR · year^{-1}]	0.1	18 249 951	8 016 951	373 202	231 041	26 871 144
	0.3	54 749 853	24 050 852	1 119 606	693 122	80 613 433
	0.5	91 249 755	40 084 754	1 866 009	1 155 203	134 355 722
Net water retention value – minimum costs of restoration [EUR · year^{-1}]	0.1	9 358 229	2 605 157	139 417	124 669	12 227 473
	0.3	45 858 132	18 639 058	885 821	586 751	65 969 762
	0.5	82 358 034	34 672 960	1 632 225	1 048 832	119 712 050
Net water retention value – average costs of restoration [EUR · year^{-1}]	0.1	- 21 101 925	- 15 933 894	- 661 453	- 239 724	- 37 936 996
	0.3	15 397 977	100 008	84 951	222 357	15 805 293
	0.5	51 897 879	16 133 909	831 355	684 438	69 547 582
Net water retention value – maximum costs of restoration [EUR · year^{-1}]	0.1	- 55 707 544	- 36 996 011	- 1 571 317	- 653 710	- 94 928 581
	0.3	- 19 207 642	- 20 962 109	- 824 913	- 191 629	- 41 186 292
	0.5	17 292 260	- 4 928 208	- 78 509	270 453	12 555 996

RESULTS – NET WATER RETENTION VALUE

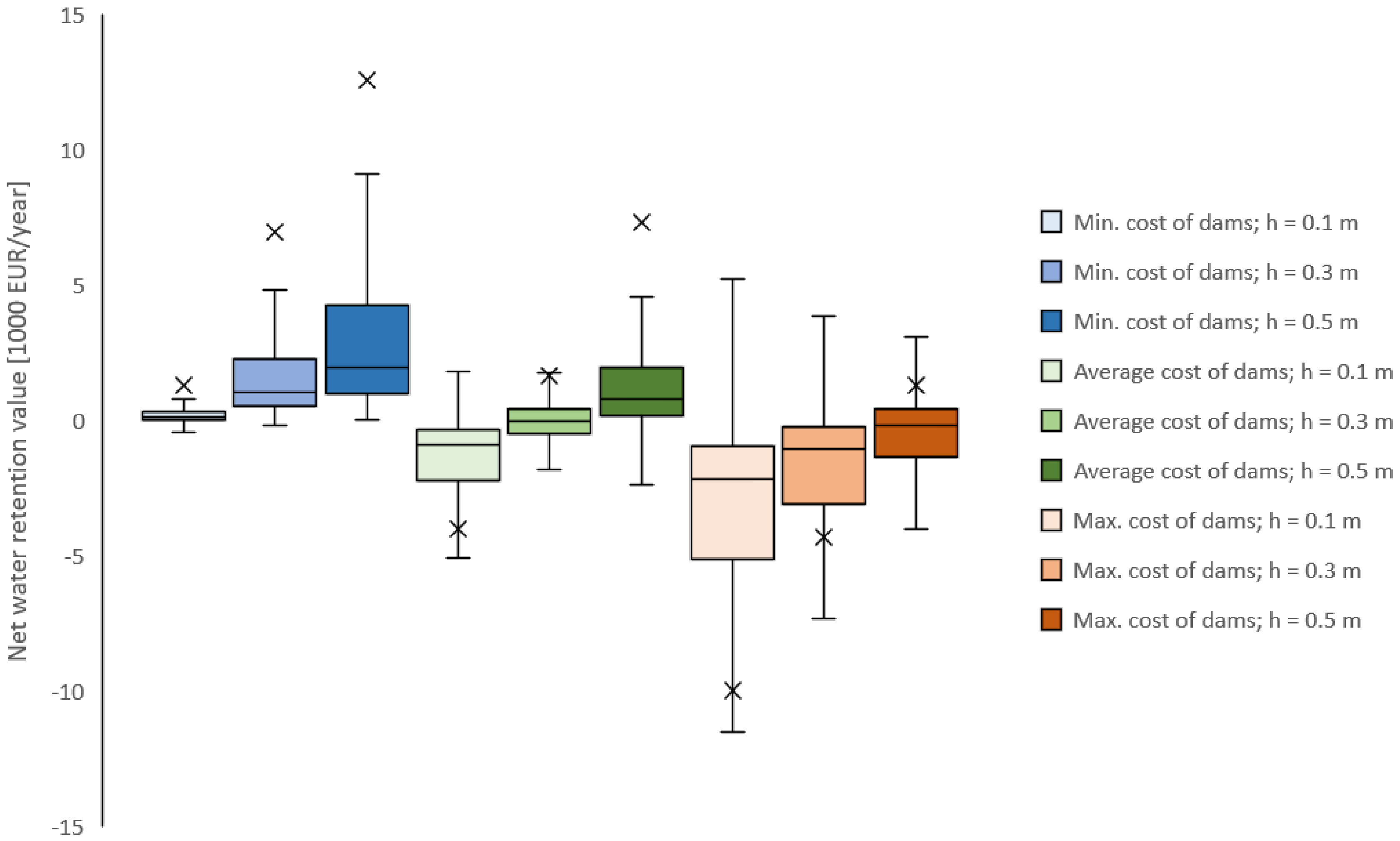


Fig. 2. Boxplots comparing net water retention values with different stacking height scenarios and used costs of restoration (outliers excluded) ($p = 0.83$, $r = 50$ m).

CONCLUSIONS

- Restoration of drained peatlands could increase water retention by approximately 1.5% throughout the entire Neman River catchment.
- In most scenarios the benefit from increased water retention exceeds the costs of rewetting.
- With the average cost of dams and stacking height equal 0.5 m, the total income from retained water due to damming exceeds 2 times the costs of restoration.
- The study only considers the benefits that come from increased water retention, but peatlands provide many other ecosystem services. Considering this, the costs incurred for the restoration of drained peatlands in the Neman basin remain an investment for the future.
- The results obtained in this study are estimates and should be assumed to be of some error. A more in-depth analysis is recommended.

REFERENCES

- Glina, B., Bogacz, A., Mendyk, Ł., Bojko, O., Nowak, M., 2018. Effectiveness of restoration of a degraded shallow mountain fen after five years. Mires and Peat 21, 1–15.
- Grand-Clement, E., Anderson, K., Smith, D., Angus, M., Luscombe, D.J., Gatis, N., Bray, L.S., Brazier, R.E., 2015. New approaches to the restoration of shallow marginal peatlands. J. Environ. Manage. 161, 417–430. https://doi.org/10.1016/j.jenvman.2015.06.023
- Grygoruk, M., Osuch, P., Trandziuk, P., 2018. Delineation of key zones for water retention enhancement in the Polish part of the Oder catchment. Analysis of potential water retention in land reclamation systems and its possible role in mitigating winter low flows of Oder. Report. German League for Nature and Environment. 109 pp.
- Harpenslager, S. F., van den Elzen, E., Kox, M. A. R., Smolders, A. J. P., Ettwig, K. F., Lamers, L. P. M., 2015. Rewetting former agricultural peatlands: Topsoil removal as a prerequisite to avoid strong nutrient and greenhouse gas emissions. Ecological Engineering, 84, 159–168.
- Jarašius, L., Lygis, V., Sendžikaitė, J., Pakalnis, R. 2015. Effect of different hydrological restoration measures in Aukštumala raised bog damaged by peat harvesting activities. Baltic forestry, 21(2): 193-203.
- Jones, C. N., Evenson, G. R., McLaughlin, D. L., Vanderhoof, M. K., Lang, M. W., McCarty, G. W., Golden, H. E., Lane, C. R., Alexander, L. C., 2017. Estimating restorable wetland water storage at landscape scales. Hydrological Processes 32(2), 305–313.
- Loisel, J., Gallego-Sala, A.V., Amesbury, M.J. et al., 2021. Expert assessment of future vulnerability of the global peatland carbon sink. Naure Climate Change 11, 70–77.
- Manton, M., Makrickas, E., Banaszuk, P., Kołos, A., Kamocki, A., Grygoruk, M., Stachowicz, M., Jarašius, L., Zableckis, N., Sendžikaitė, J., Peters, J., Napreenko, M., Wichtmann, W., Angelstam, P. 2021. Assessment and spatial planning for peatland conservation and restoration: Europe's trans-border Neman River basin as a case study. Land 10, 174.
- Urák, I., Hartel, T., Gallé, R., Balog, A., 2017. Worldwide peatland degradations and the related carbon dioxide emissions: the importance of policy regulations. Environmental Science & Policy 69, 57-64.

THANK YOU FOR ATTENTION

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