Wyniki ekspertyzy dotyczącej retencji wodnej w polskiej części zlewni Odry

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Słubice, 20.06.2018

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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

Requirements

Possibilities

Quantified solutions

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.

Water retention

Volume of water that remains stored and temporarily excluded from the short-exchange circulation in a catchment scale.

Natural water retention

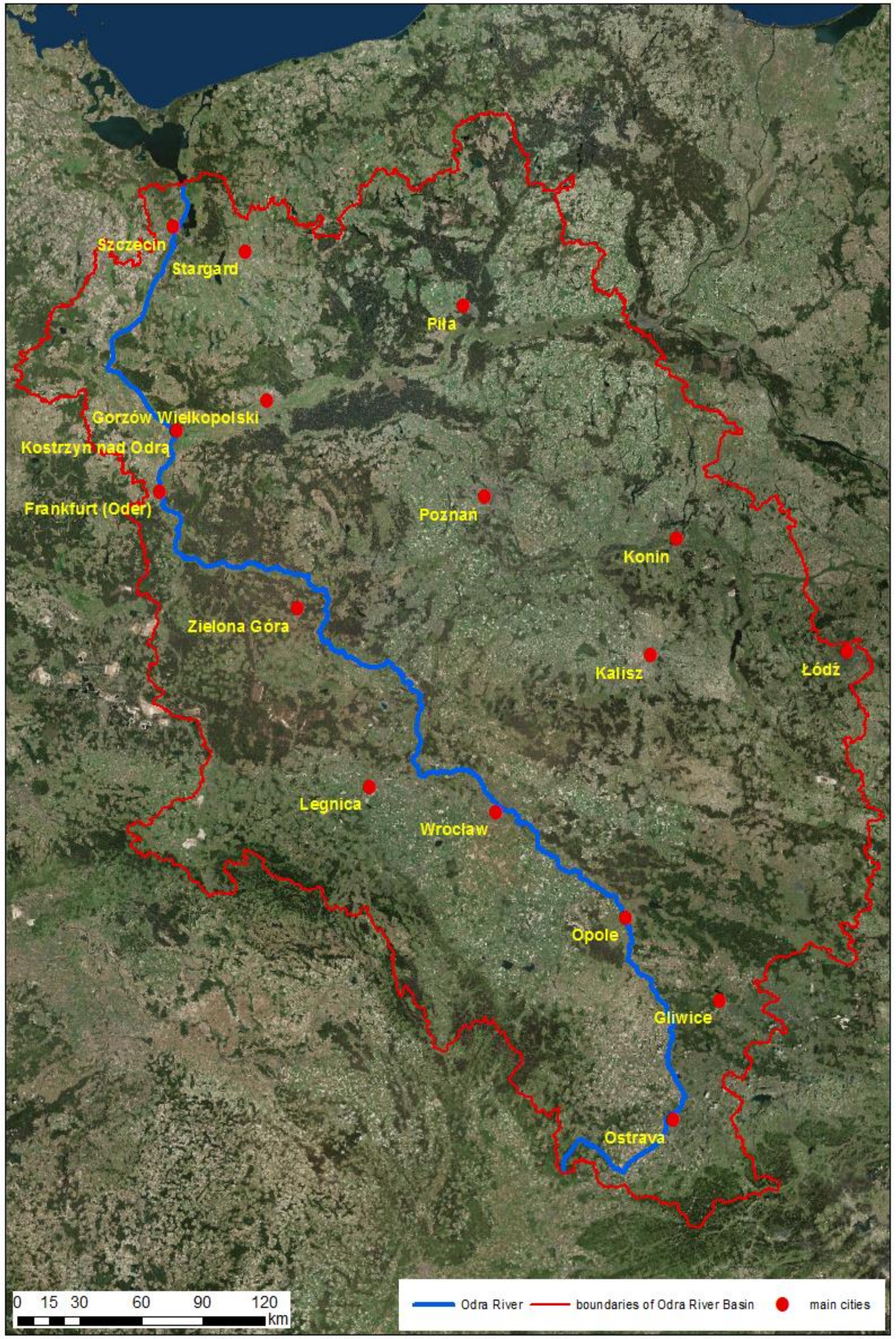
- Easy to be increased,
- Difficult to be managed
- Inexpensive
- Basis for sustainable water management and agriculture

Artifical water retention

- Easy to be increased
- Easy to be managed
- Expensive
- Unsustainable

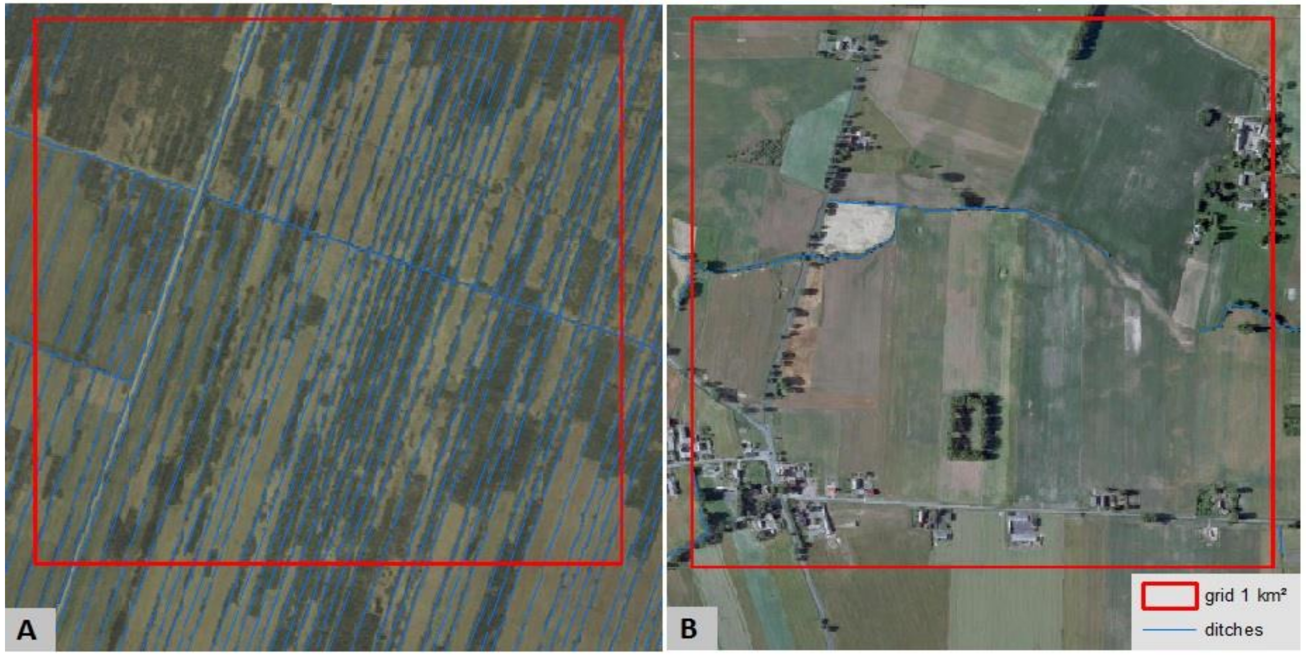
Water retention – the issue of scale

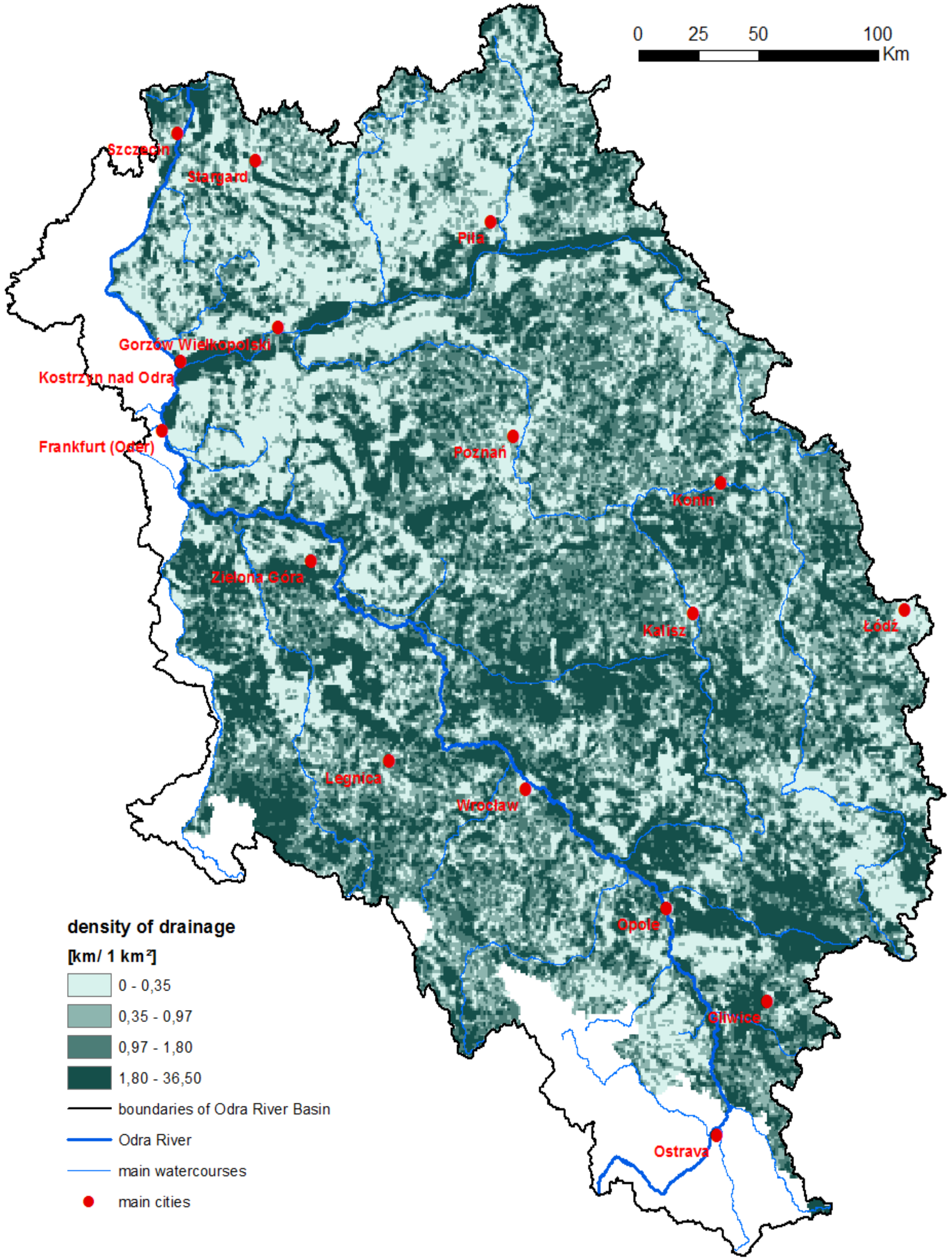
1) Water retention is responsible for floods and droughts
2) Has to be considered in space
3) There might be different forms of water retention that remain synergic one to another (e.g. natural water storage of rewetted peatlands and flooded river valleys – an issue of top-down approach to natural flood and drought protection measures)
4) As such, has to be considered in a holistic manner



Natural-artificial?

Land reclamation systems remain feasible solution to inexpensive and quick increase of water retention in the catchment scale!





ELSEVIER

Ecohydrology & Hydrobiology

Volume 15, Issue 3, August 2015, Pages 150-159

Original Research Article

A simple model to quantify the potential trade-off between water level management for ecological benefit and flood risk

Charlie Stratford [a], Phil Brewin [b], Mike Acreman [a], Owen Mountford [a]

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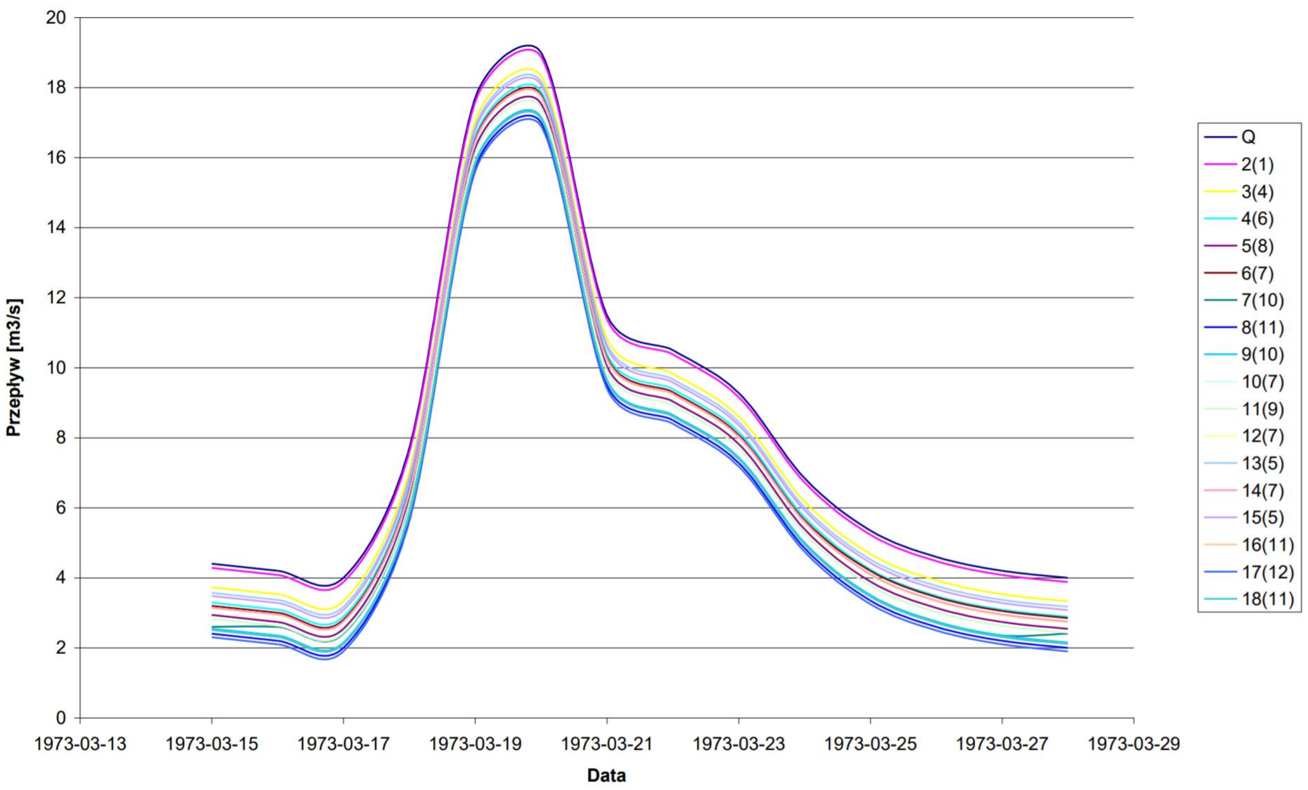
https://doi.org/10.1016/j.ecohyd.2015.06.002

- Water storage in land reclamation systems is efficient in droughth mitigation actions,
- Efficiency of land reclamation systems in mitigating flood risk is lower than in the case of the risk of droughts.



Rys. 17 Hydrogramy wezbrania za okres 15.03-28.03. 1973, rzeka Świder, profil Wólka Mlądzka dla analizowanych wariantów funkcjonowania systemów odwadniająco –nawadniających.

- The role of water storage in land reclamation systems on runoff generation was quantified in the catchment of the Middle part of Vistula.

Pierzgalski, E., Jeznach, J., Baryła, A., Brandyk, A., Stańczyk, T., Szejba, D., Wiśniewski S., 2012. Weryfikacja systemów melioracyjnych pod kątem znaczenia dla bezpieczeństwa powodziowego w regionie wodnym Wisły Środkowej. Mat. SGGW. URL: https://www.mazowieckie.pl/download/1/21639/weryfikacjasystemow.pdf

Research questions

1) Which areas of Oder catchment remain important for flood and drought mitigation?
2) What is the possible theoretical volume of water storage in land reclamation systems?
3) Could water stored in land reclamation systems mitigate low winter flows of Oder?
4) Which areas of the Oder catchment should be assigned with high priority and high potential of water retention capacity?

Methods

1) Analysis of surface runoff in the catchment scale – CN SCS methodology (Hawkins, 1979)
2) Standard hydrological analysis of water levels, discharges, cross-sections and depths of Oder in a selected profile (Gozdowice)
3) Specific methodology was developed for quantification of the role of damming water in ditches in the increase of water retention capacity in land reclamation systems
4) GIS-based approach

Hawkins, R.H., 1979. Runoff curve numbers from partial area watersheds. J. Irrig. and Drainage Div., ASCE, 105, 375-389.

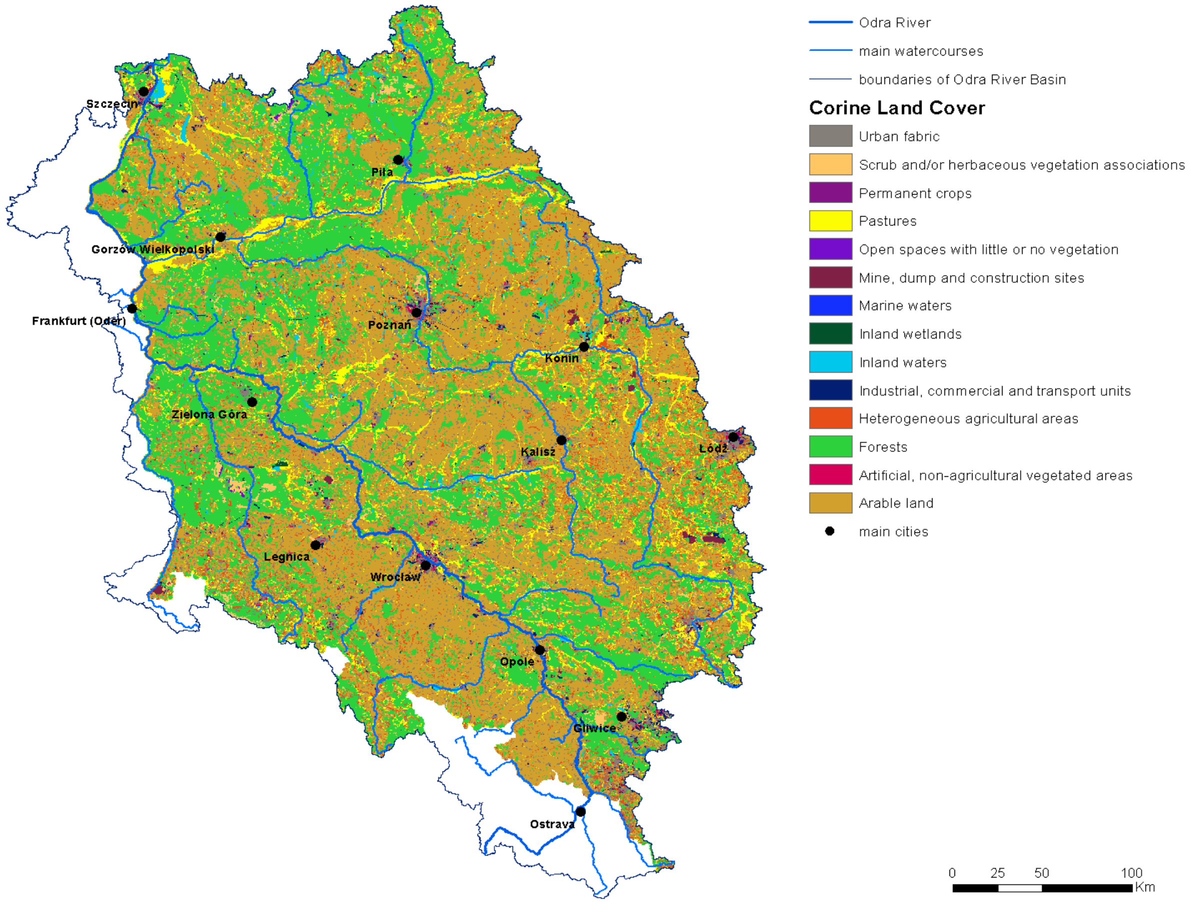
Materials

1) Land cover – Corine Land Cover
2) Water courses – MPHP 1:50000
3) Soil data – Geological Map of Poland 1:500000
4) Data on hydrology – IMGW[1] and literature
5) GIS analyses - QGIS
6) Research presented is based on the results of scientific research submitted for publishing in Agricultural Water Management (Grygoruk et al., 2018)

Grygoruk, M., Osuch, P., Trandziuk, P. 2018. Wise use of land reclamation system as a possible measure for improving water management in a catchment scale. Example of Oder, Poland. (Submitted to Agricultural Water Management Journal).

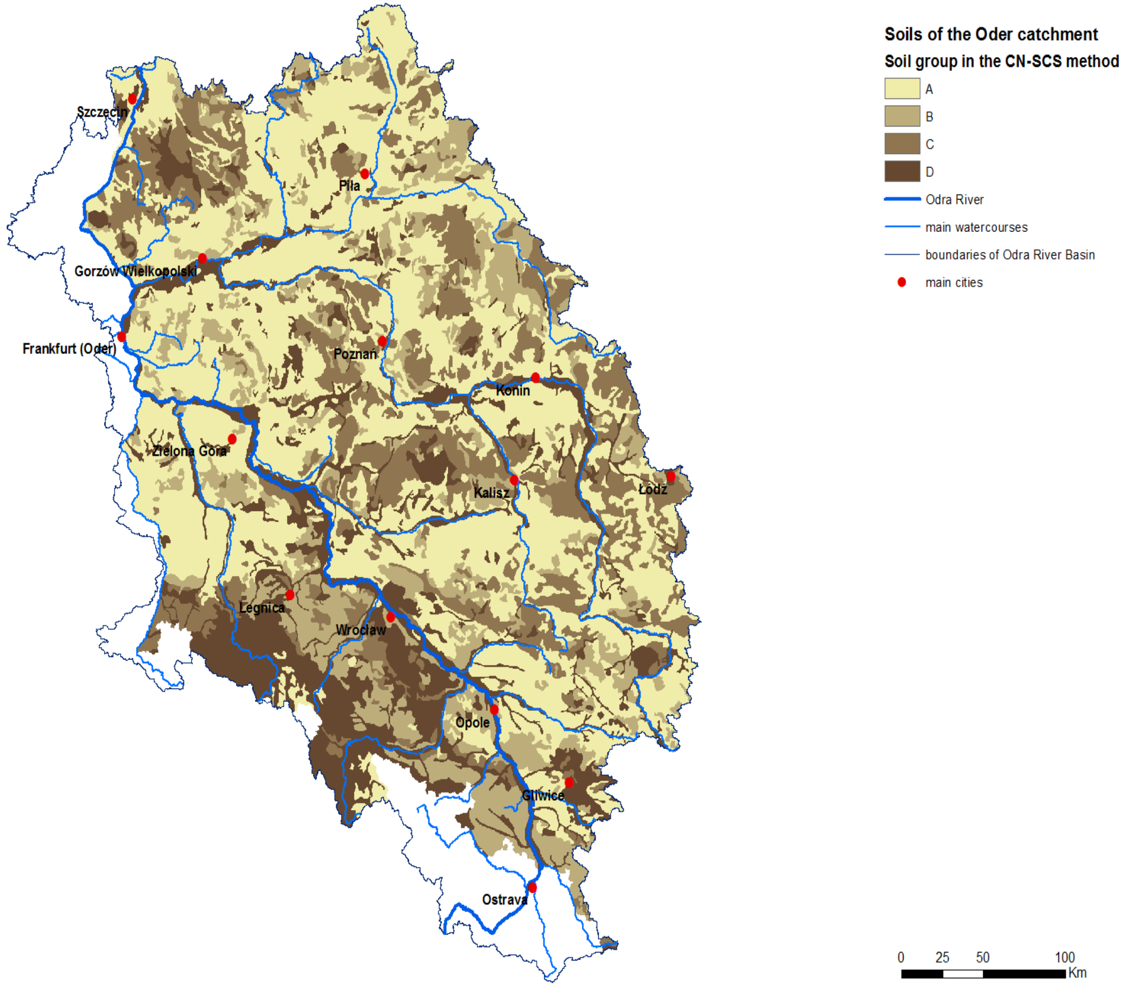
[1]Institute of Meteorology and Water Management – National Research Intsitute (IMGW-PIB). URL: http://dane.imgw.pl

Materials – CN calculation



Land cover

$$S = \frac{25400}{CN} - 254 \text{ [mm]}$$



Soil map

CN Parmeter classes

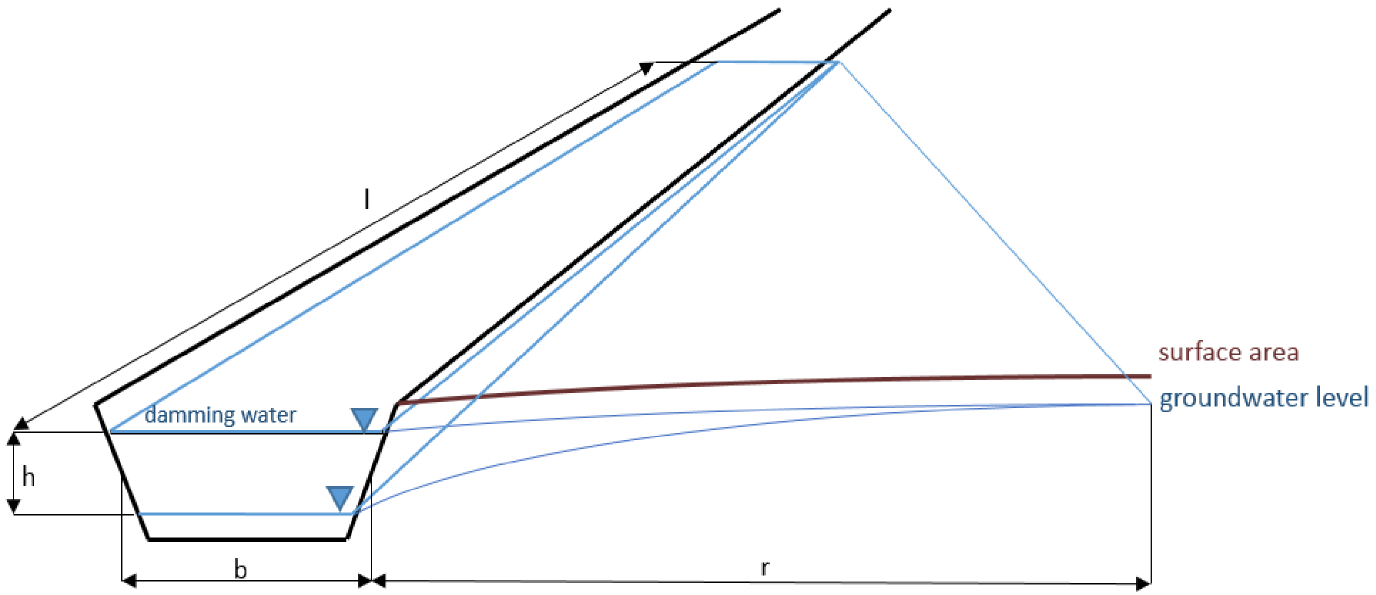
$$S = \frac{25400}{CN} - 254 \text{ [mm]}$$

S – maximum potential water storage capacity of the given area

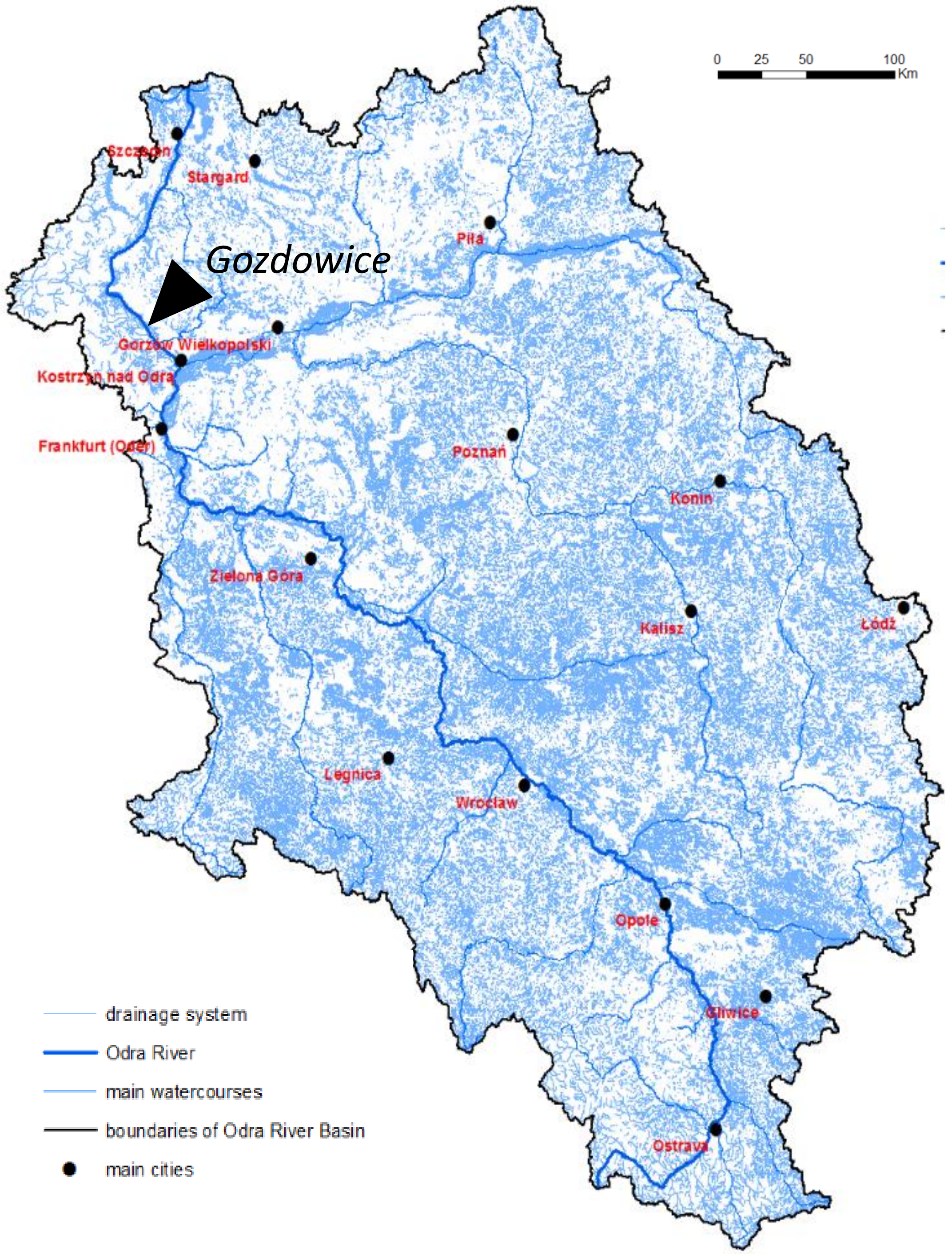
No.	Corine Land Cover code	Land use classes	CN Parameter for soil group in the SCS-CN method			
			A	B	C	D
1	242	Heterogeneous agricultural areas	62	73	81	85
2	231	Pastures	49	69	78	84
3	313	Forests	36	60	73	79
4	243	Heterogeneous agricultural areas	62	73	81	85
5	211	Arable land	67	77	83	87
6	121	Industrial, commercial and transport units	89	92	94	95
7	132	Mine, dump and construction sites	89	92	94	95
8	312	Forests	36	60	73	79
9	112	Urban fabric	98	98	98	98
10	324	Scrub and/or herbaceous vegetation associations	62	73	81	85
11	111	Urban fabric	98	98	98	98
12	311	Forests	36	60	73	79
13	142	Artificial, non-agricultural vegetated areas	68	79	86	89
14	122	Industrial, commercial and transport units	89	92	94	95
15	511	Inland waters	100	100	100	100

Retention capacity of a ditch

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



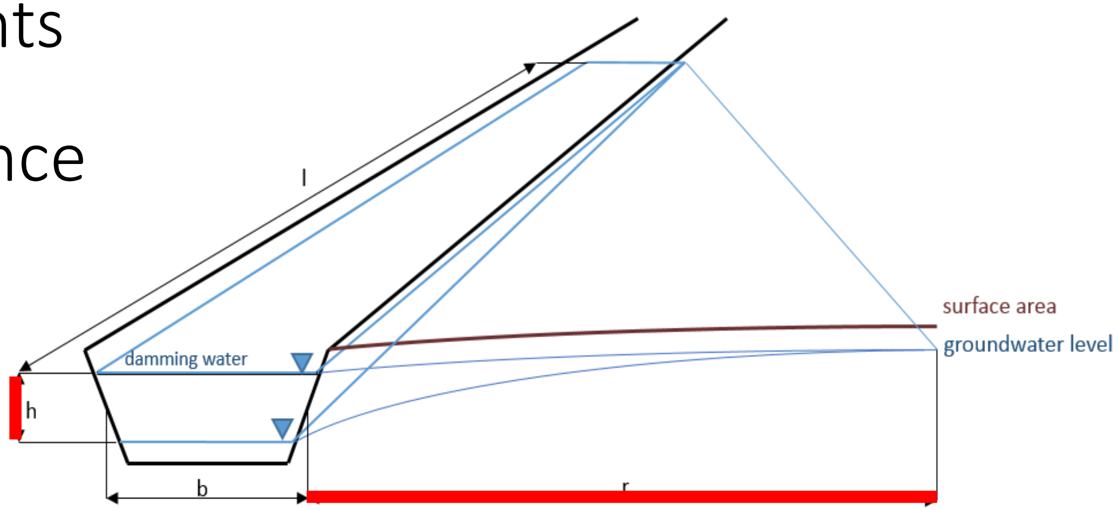
V - water retained due to damming up on ditches [m^3],
a - coefficient correcting the actual damming capacity on the ditch [-],
p - average soil porosity [-].



Retention capacity of a ditch – 6 scenarios

h – different damming heights

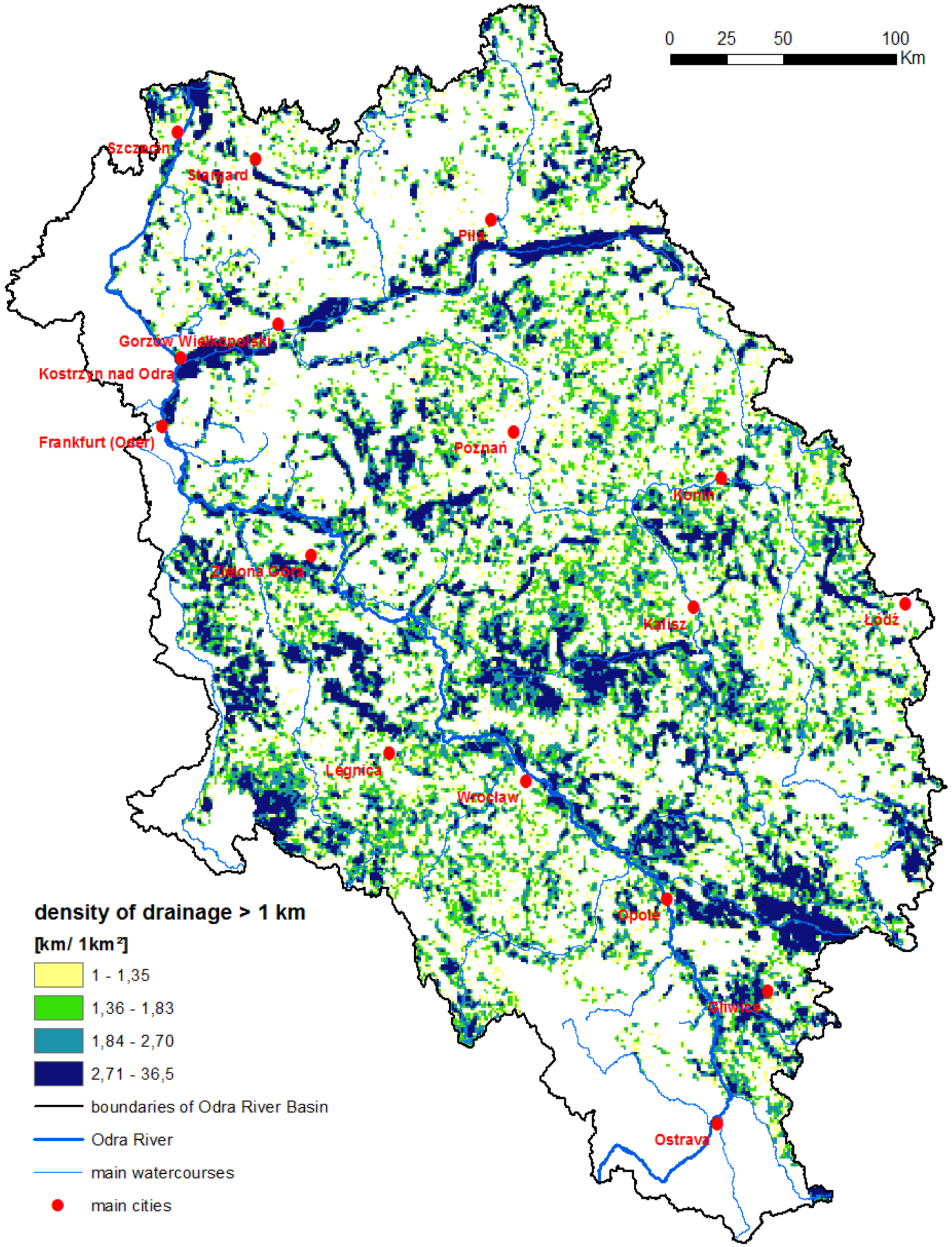
r – different radius of influence



Parameter		Value					
a	Correction coefficient	0,8	[-]				
b	Width	2	[m]				
p	Porosity	0,4	[-]				
	Scenarios:	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
h	Damming height	0,1	0,3	0,5	0,1	0,3	0,5
r	Range	50	50	50	20	20	20

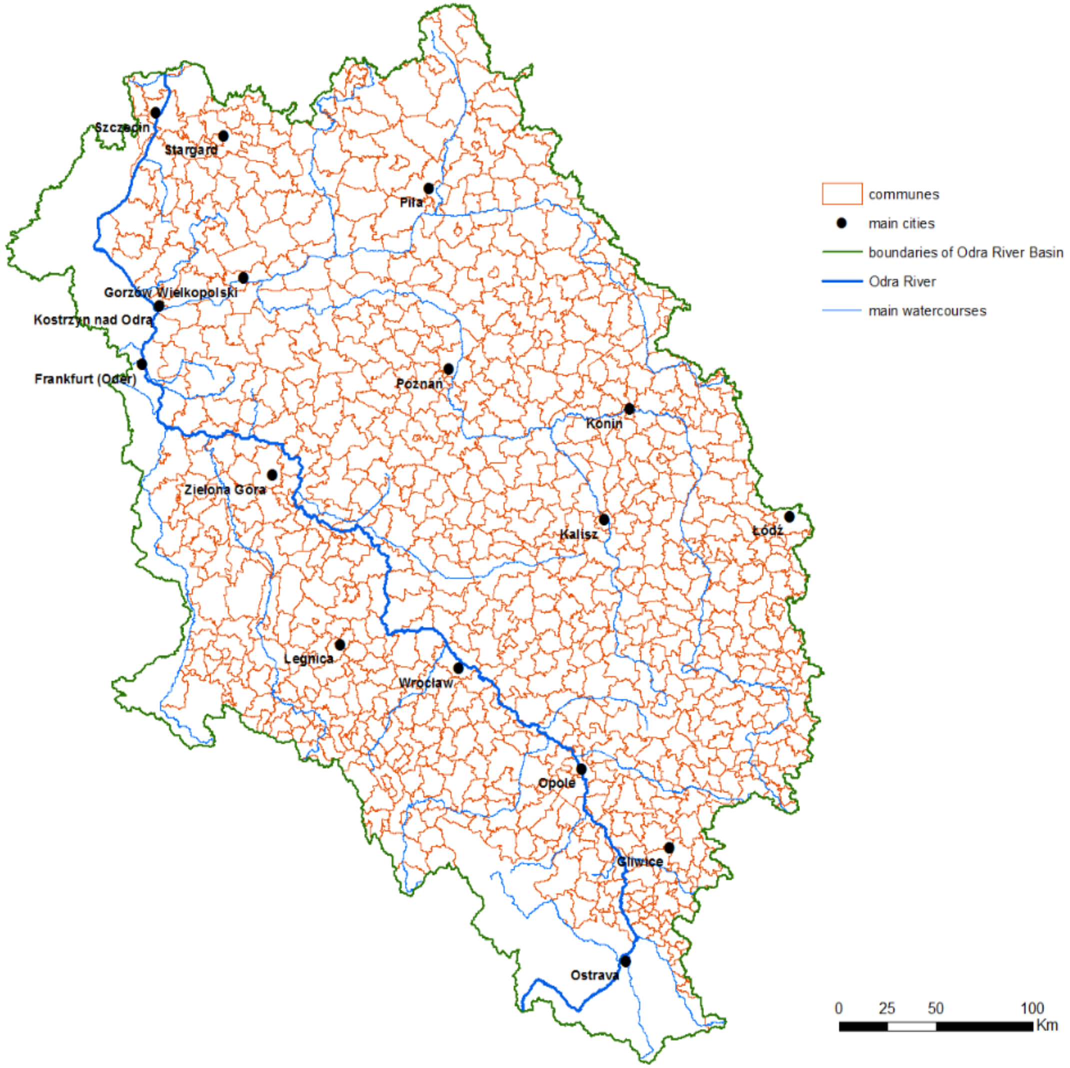
Areas of analysis

Only there, where density of a drainage network exceeds 1 km of ditches per 1 km^2 of the area.
Mainly – river valleys (close to the river – managing water in these systems is likely to influence discharges of main rivers, incl. Oder.
Vast majority of the areas located upstream of the Stretch No. 2. of Oder.

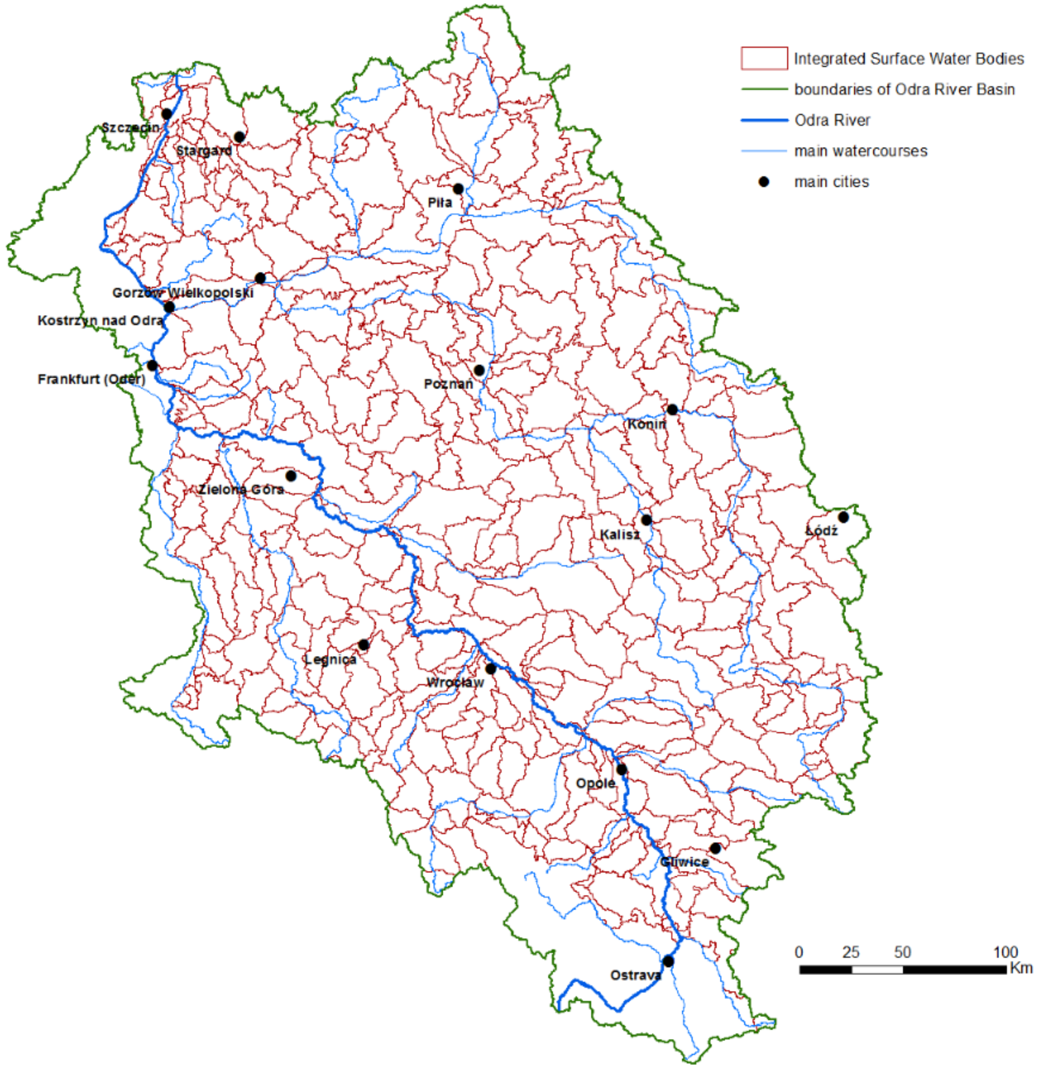


Priority for action in water retention enhancement

Comunes



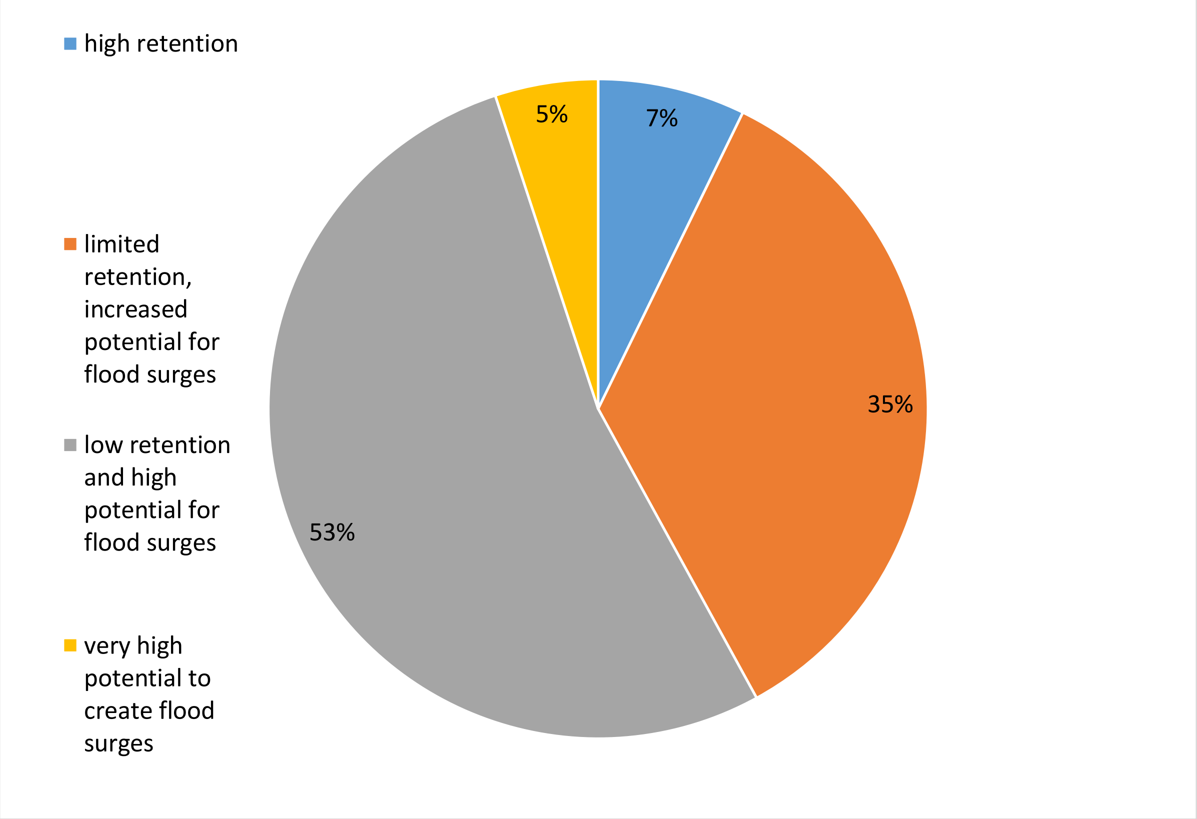
Integrated Surface Water Bodies

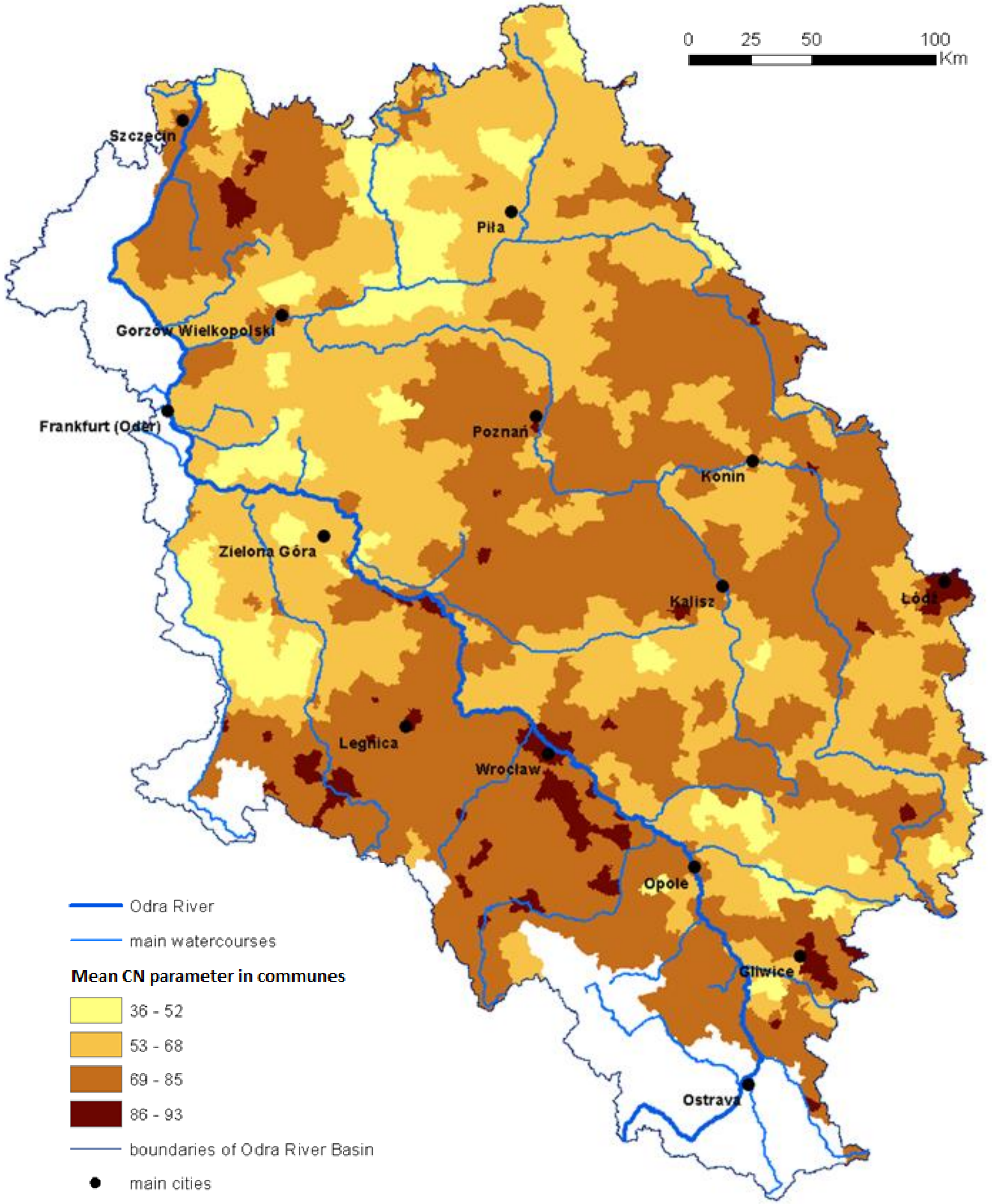


Hydrological analysis – Gozdowice profile (Oder)

- Verification, whether potential release of water from previously dammed land reclamation systems may allow to keep at least the average depth of 1.8 m in this cross-section in 90 % of the year.
- Navigation authorities in Poland and Germany state that this depth of 1.80 m (during 90 % of the year downstream of River Warta mouth) would be necessary in order to operate ice breakers on Oder River along the joint Polish-German border.
- Keeping river discharge of 250 m^3/s (which is the minimum water discharge being achieved during 90 % of the year) downstream of river Warta mouth.

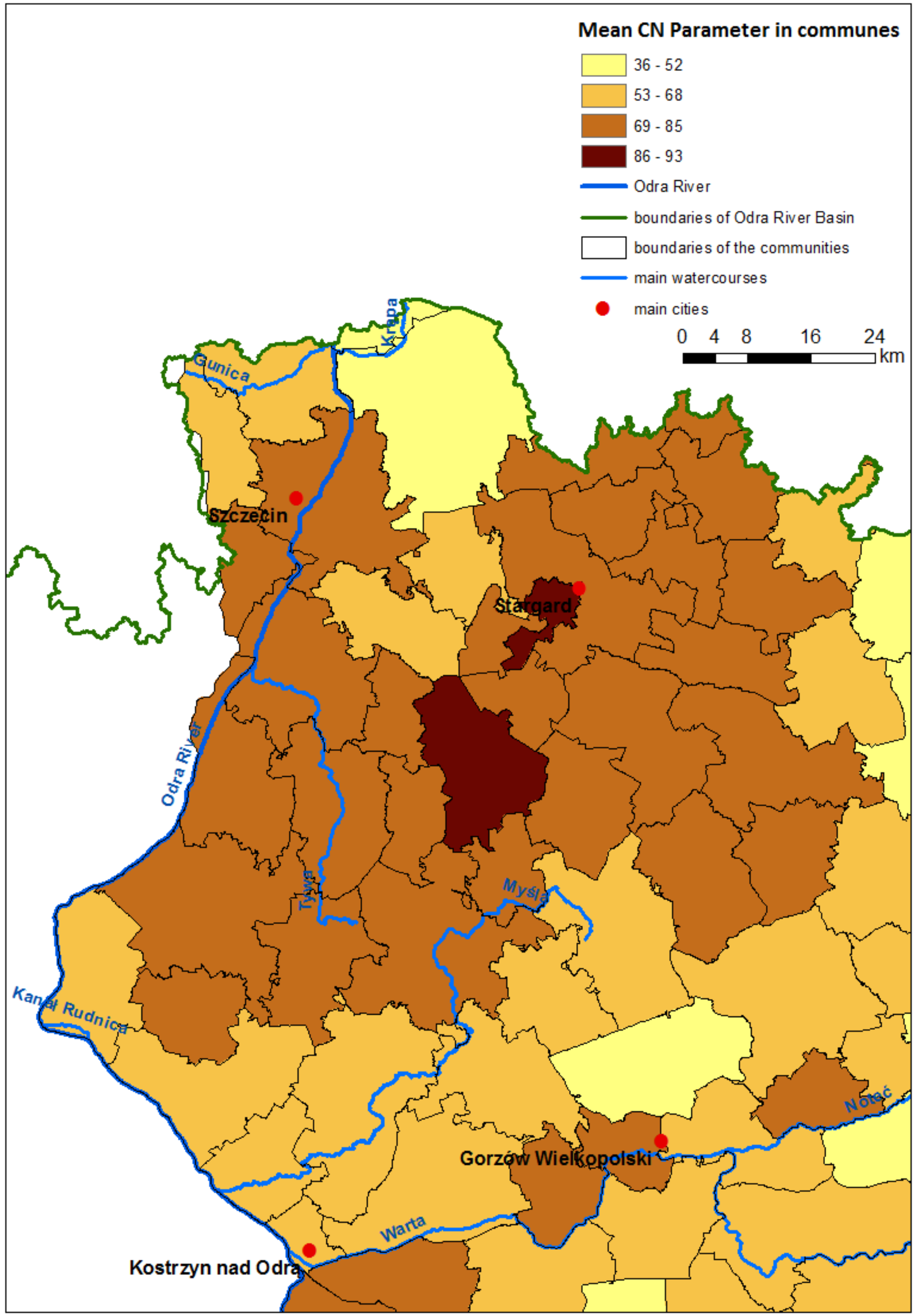
Results – water storage requirements in communes



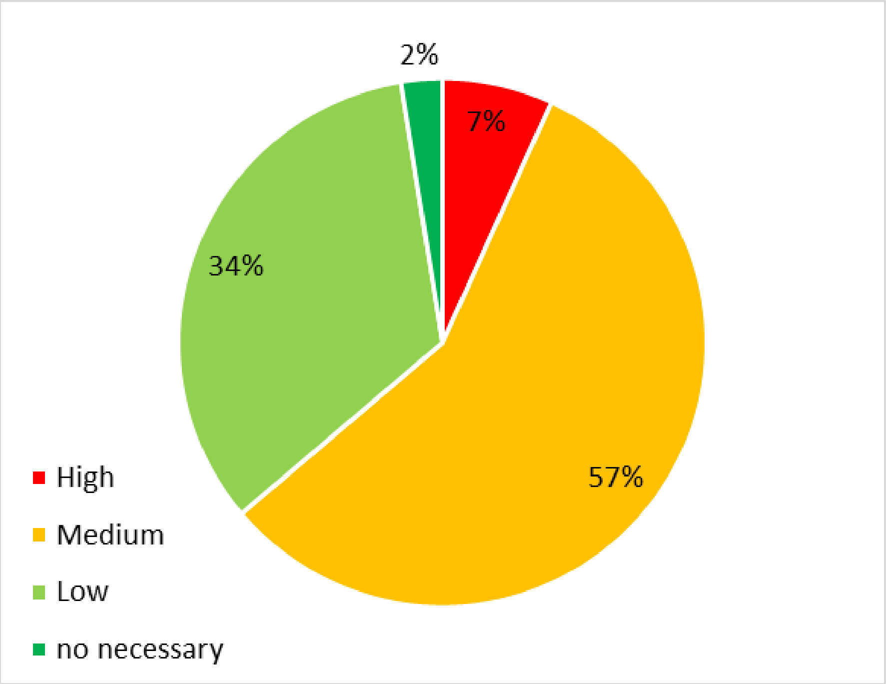


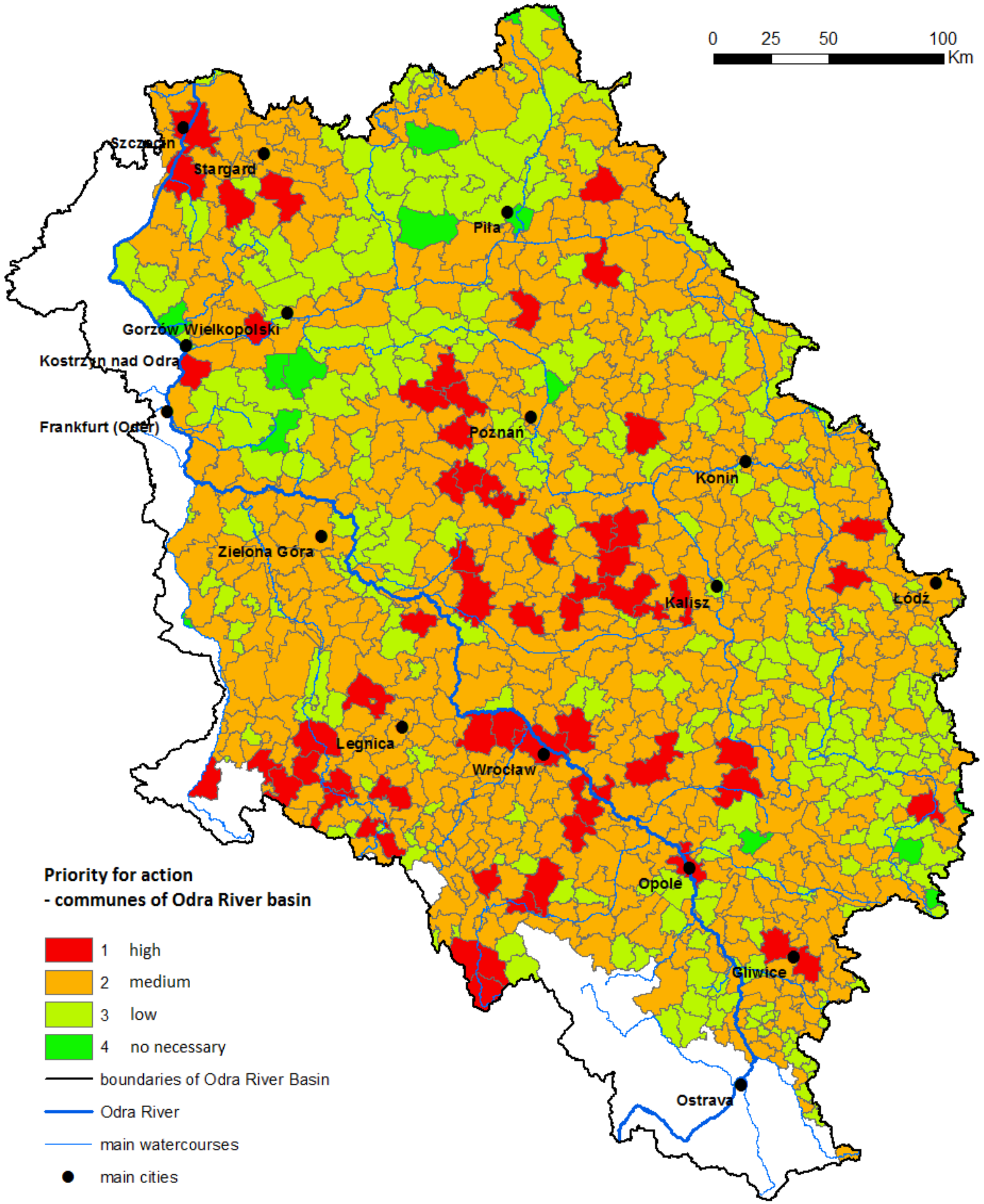
Results – water storage requirements in communes

- Random distribution of the communes,
- Independent from the map of rain, which present spatial patterns and remain variable (field of precipitation, rain intensity and duration),
- Indication, which areas contribute the most to local and regional-scale floods ,



Water retention – requirements vs. possibilities





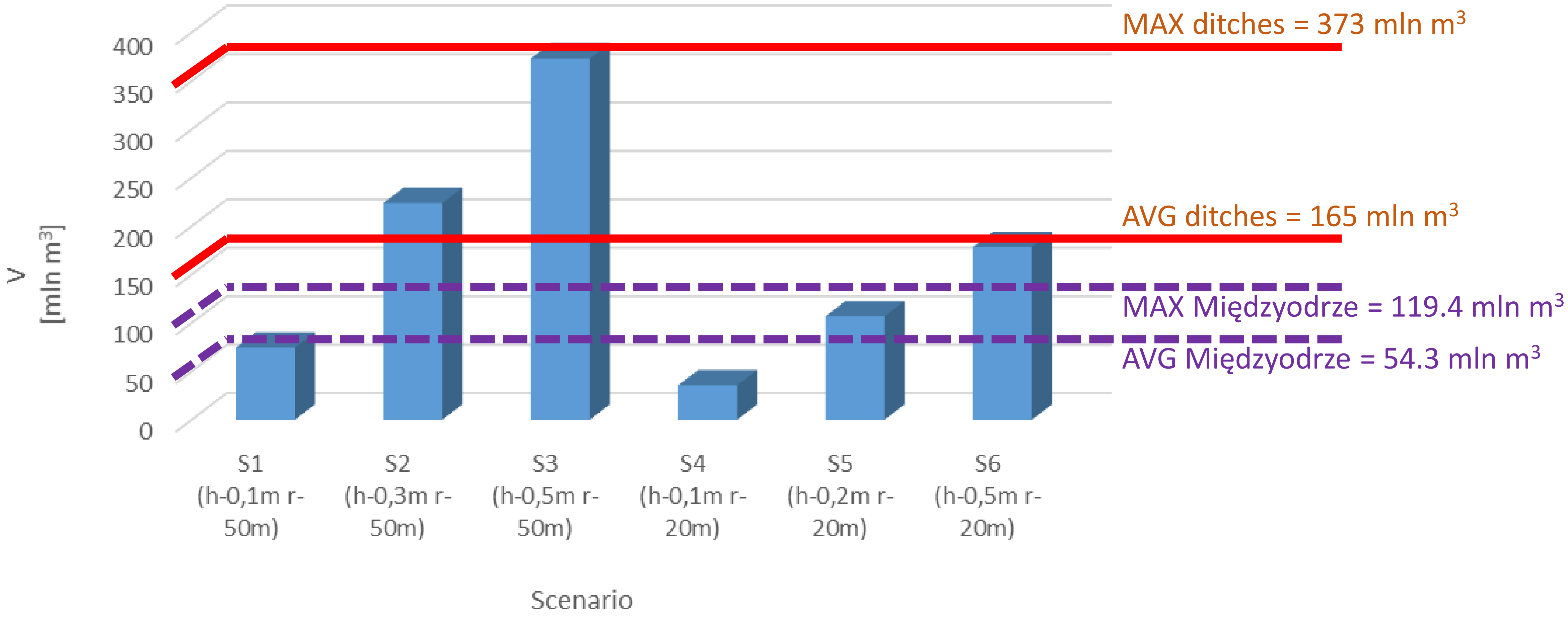
Nearly 2/3rd of the communes present considerable potential and requirements for the increase of water retention potential

Water retention – priority for action in water retention enhancement

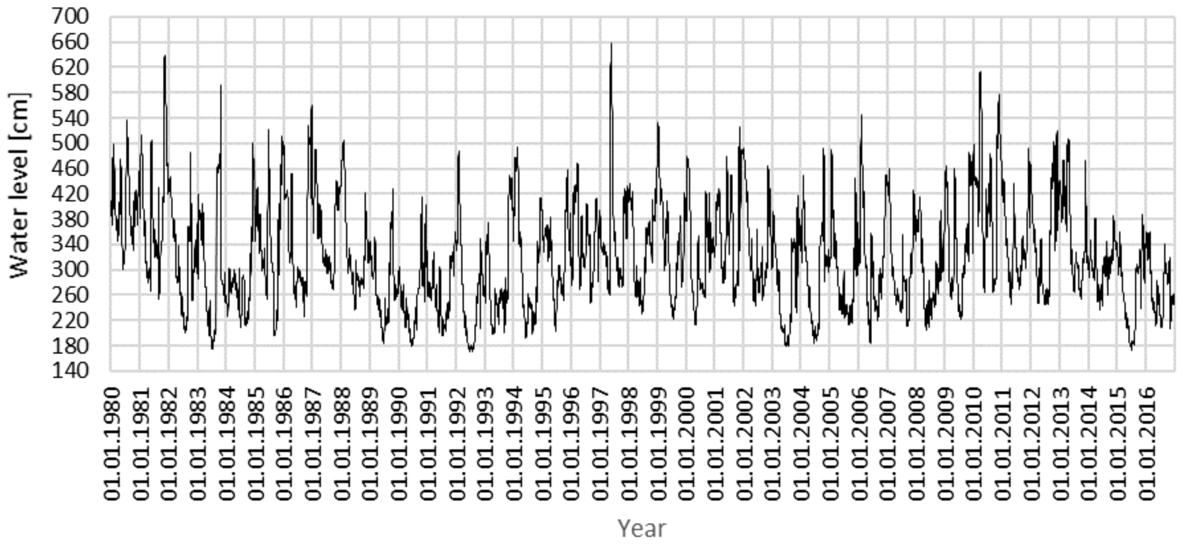
No	Name of commune	Average CN parameter value [-]	Potential catchment retention S [mm]	potential volume of water in ditches [thou m^3] for scenarios						Priority for action
				S1	S2	S3	S4	S5	S6	
135	Dobryszyce	61	159	27	82	136	13	39	65	Low
136	Dobrzany	72	98	46	137	228	22	65	109	Medium
137	Dobrzeń Wielki	65	138	73	219	365	35	105	175	Medium
138	Dobrzyca	81	58	89	266	443	42	127	212	Medium
139	Dolice	72	97	135	404	673	64	193	322	High
140	Dolsk	64	141	60	181	301	29	86	144	Low
141	Domaniów	86	40	20	61	102	10	29	49	Medium
142	Domaszowice	67	122	64	191	318	30	91	152	Medium
143	Dominowo	69	113	30	89	149	14	43	71	Low

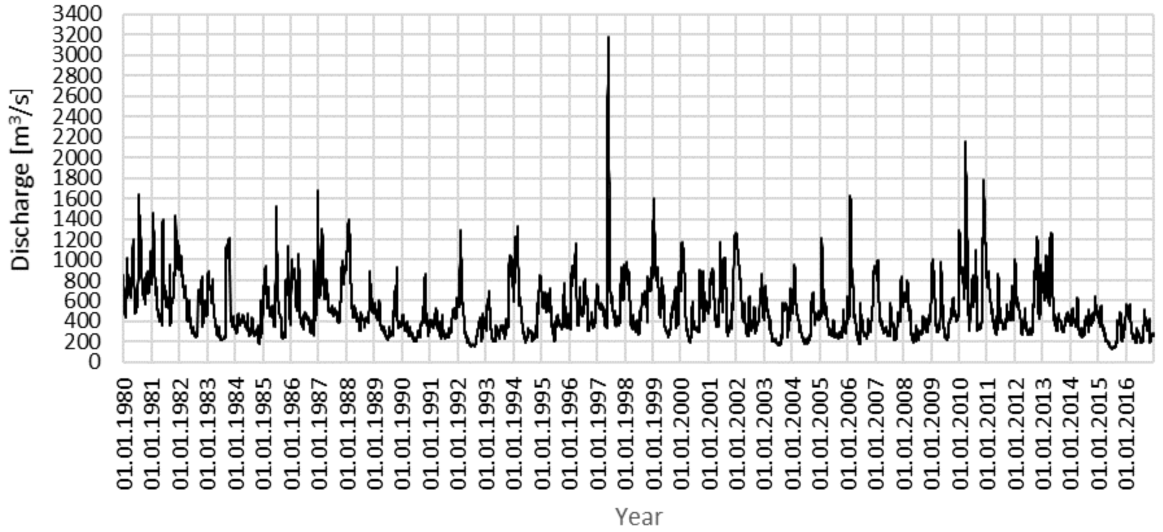
Every commune has been assigned with a priority for action.

Results – water retention in land reclamation systems in the Oder catchment



Results – Hydrological analysis in the Gozdowice profile[1]

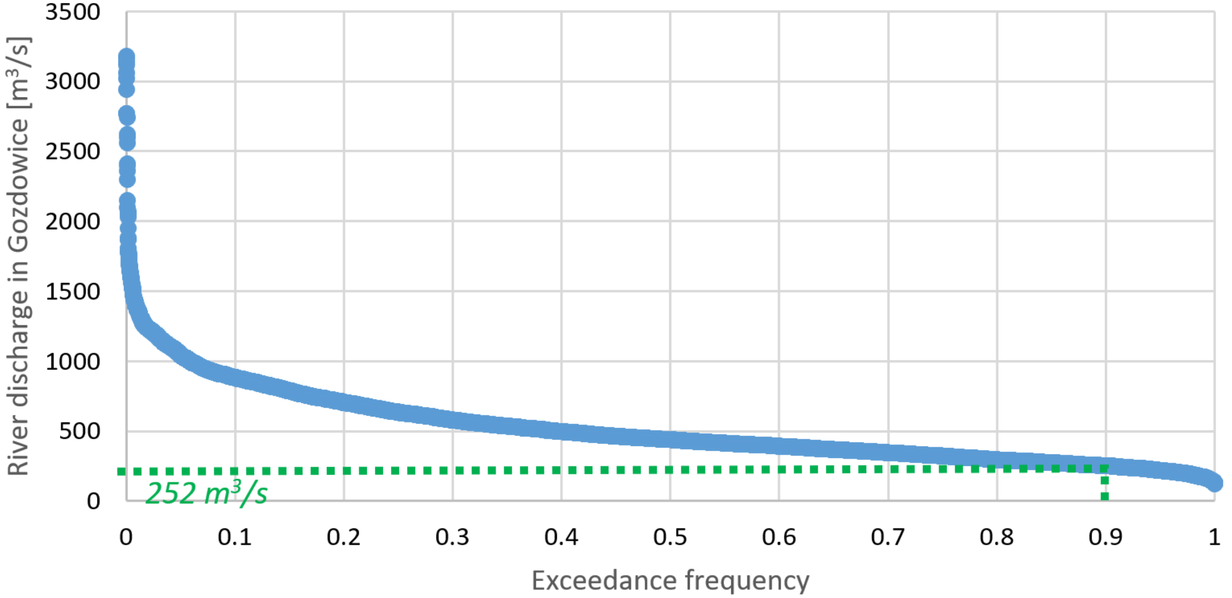


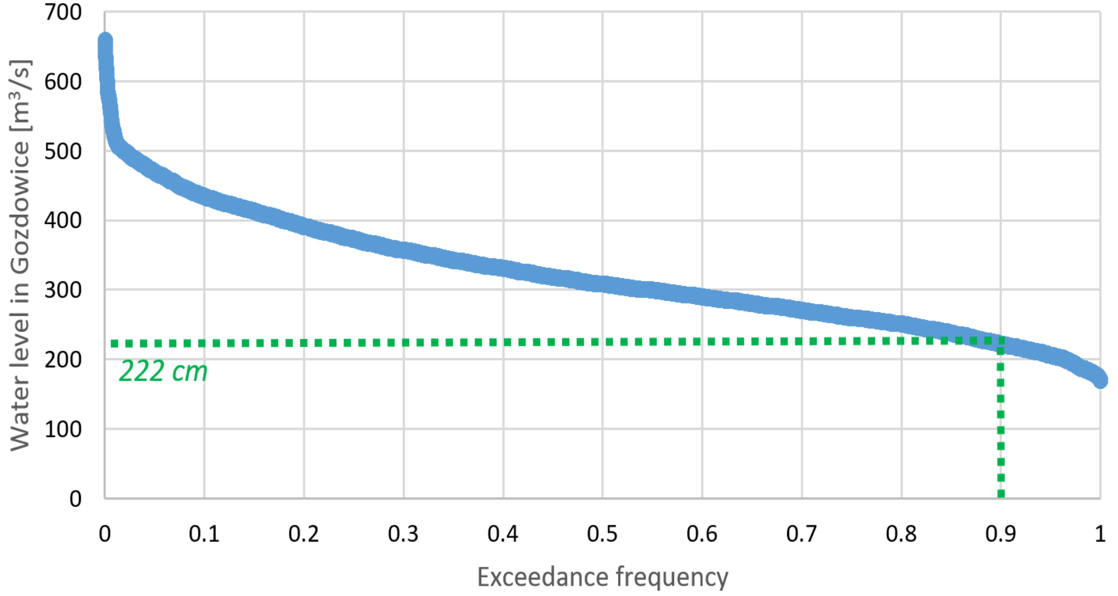


[1]Grygoruk, M., Osuch, P., Trandziuk, P. 2018. Wise use of land reclamation system as a possible measure for improving water management in a catchment scale. Example of Oder, Poland. (Submitted to Agricultural Water Management Journal).

Data: Institute of Meteorology and Water Management – National Research Intsitute (IMGW-PIB). URL: http://dane.imgw.pl

Results – Hydrological analysis in the Gozdowice profile



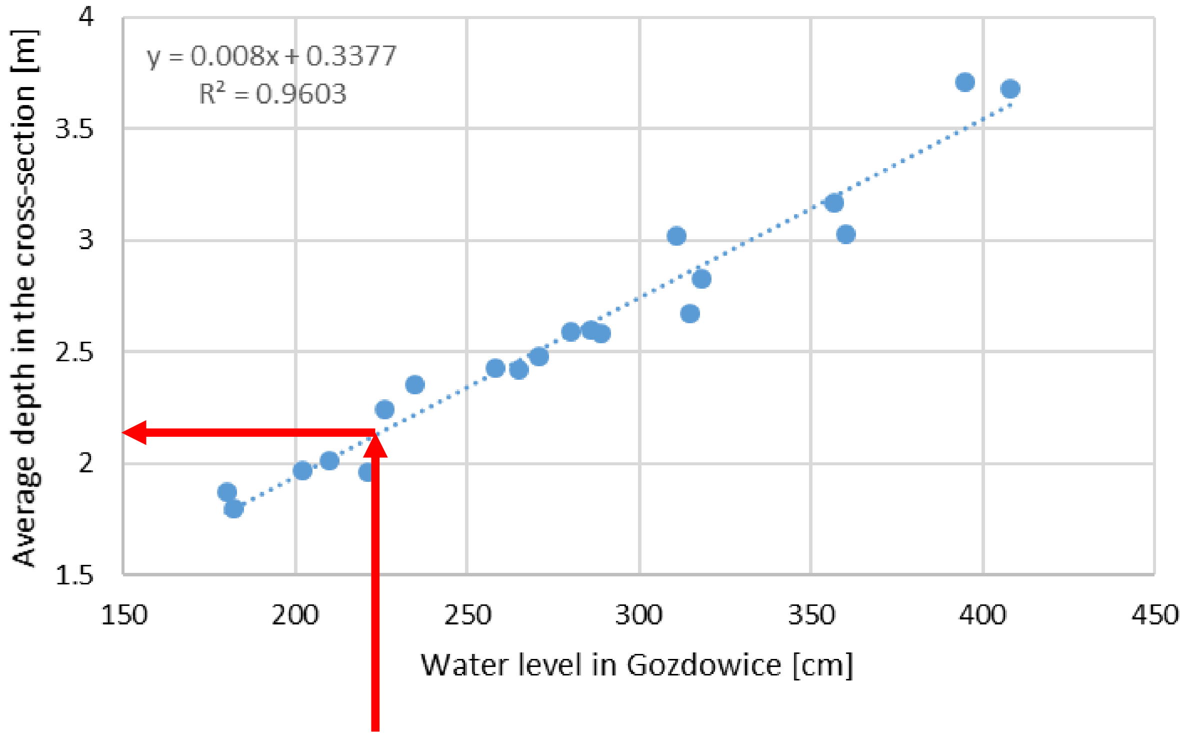


90% discharge – 252 m^3/s

90% water level – 222 cm

90% depth – ???

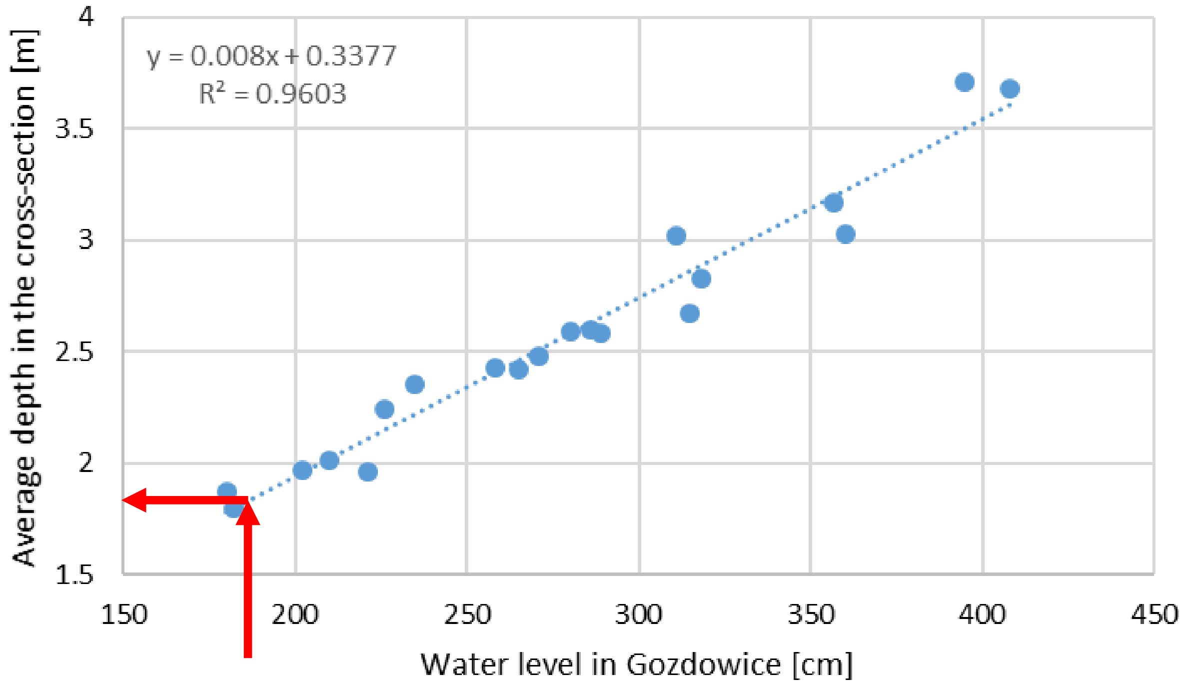
Results – Hydrological analysis in the Gozdowice profile



Historical data used

Average depth in the Gozdowice profile that corresponds to the 90% water level is higher than 2 m.

Results – Hydrological analysis in the Gozdowice profile



Average depth of the cross section falls below 1.8 m (required for navigation and ice breaking) only when water levels fall below some 180 cm

In the case of Gozdowice profile, the criterion of appropriate water levels for navigation was met in 1980-2016 and does not require any additional actions!

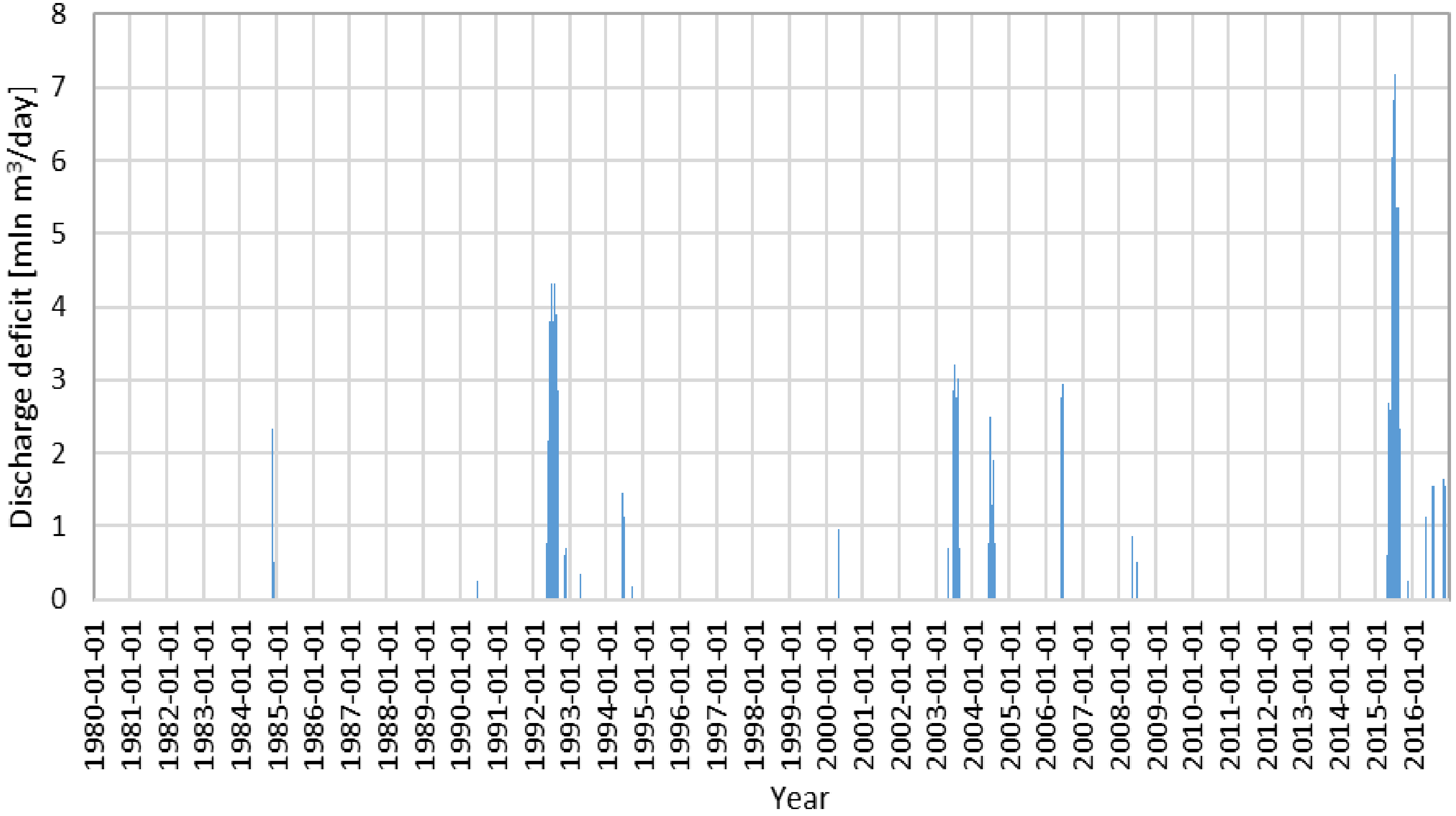
Results – Hydrological analysis in the Gozdowice

Bearing in mind the uncertainty of estimation and the fact that Gozdowice is not the shallowest profile in the Lower Oder, we assummed that the threshold criterion for the navigation reaches 200 cm (water level).

We analyzed hydrograph in order to calculate the discharge deficit during all continuous periods, when water levels in Gozdorice kept lower than 200 cm.

River discharge related to 200 cm water levels was assumed as 207 m^3/s (basing upon the rating curve in Gozdowice)

Results – Hydrological analysis in the Gozdowice



Amount of water required to keep water levels in Gozdowice at the level of 200 cm on a daily basis.

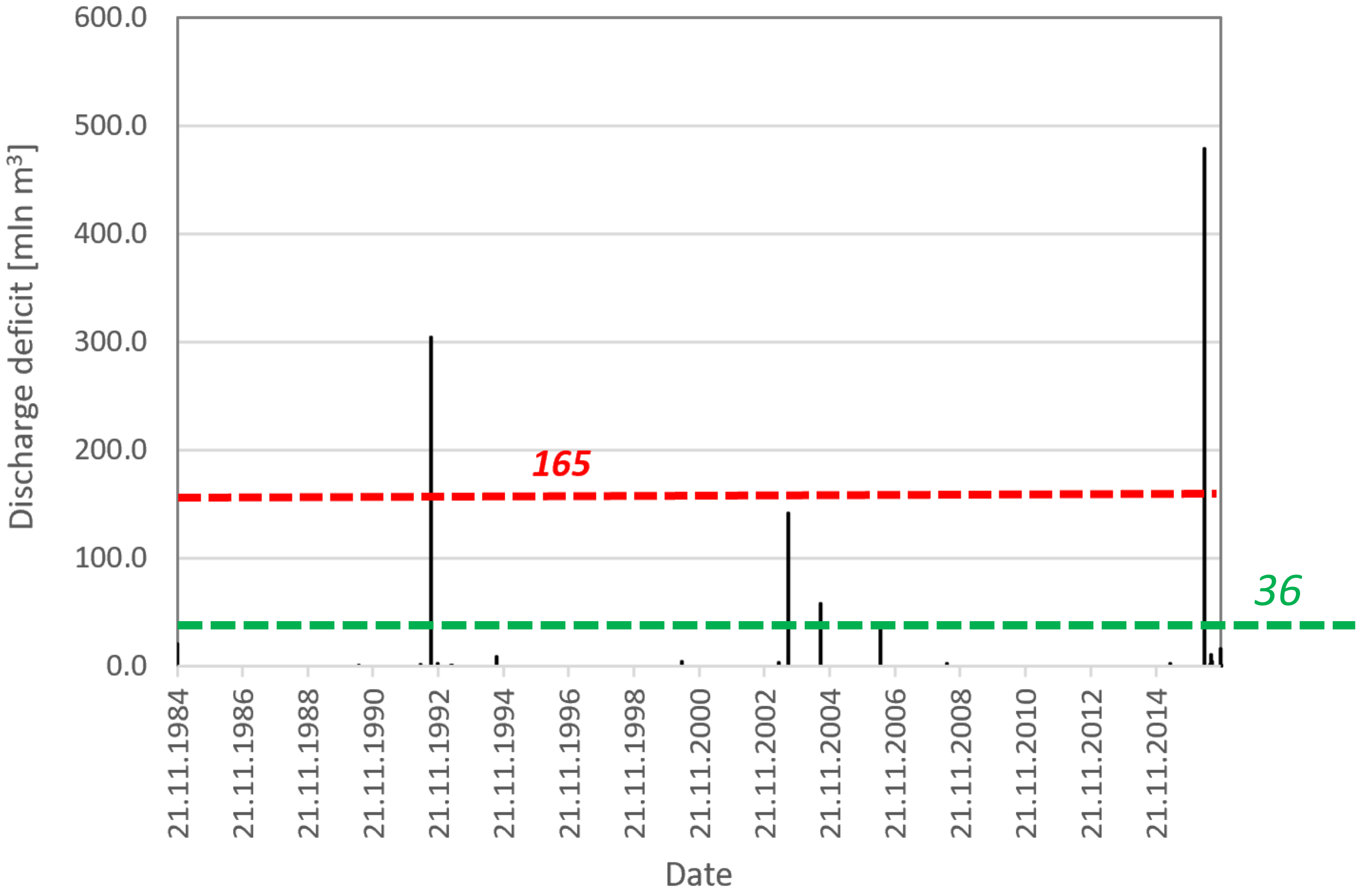
Results – Hydrological analysis in the Gozdowice profile

In the analyzed period, there were 23 individual discharge deficit periods of the total volume from 0.1 up to 479 mln m^3 that lasted from 1 up to 130 days.

Among these discharge deficit periods, 4 occured in Winter and the remaining 19 in periods with no risk of ice phenomena.

No.	Date of the end	Duration [days]	Discharge deficit [mln m^3]	Season
1	21.11.1984	*14*	*21.3*	*Winter*
2	15.06.1990	2	0.4	Other
3	05.05.1992	2	1.6	Other
4	30.08.1992	103	304.3	Other
5	12.11.1992	*6*	*3.2*	*Winter*
6	11.04.1993	1	0.3	Other
7	15.04.1993	1	0.2	Other
8	19.04.1993	2	0.5	Other
9	03.09.1994	11	8.8	Other
10	06.05.2000	9	4.2	Other
11	22.04.2003	1	0.2	Other
12	01.05.2003	8	3.7	Other
13	11.08.2003	61	142.0	Other
14	02.08.2004	51	58.0	Other
15	10.06.2006	19	37.8	Other
16	16.06.2008	5	2.6	Other
17	25.04.2015	8	2.9	Other
18	16.05.2016	130	479.0	Other
19	14.07.2016	6	2.1	Other
20	25.07.2016	10	11.3	Other
21	05.08.2016	9	4.6	Other
22	13.11.2016	*13*	*16.4*	*Winter*
23	15.11.2016	*1*	*0.1*	*Winter*

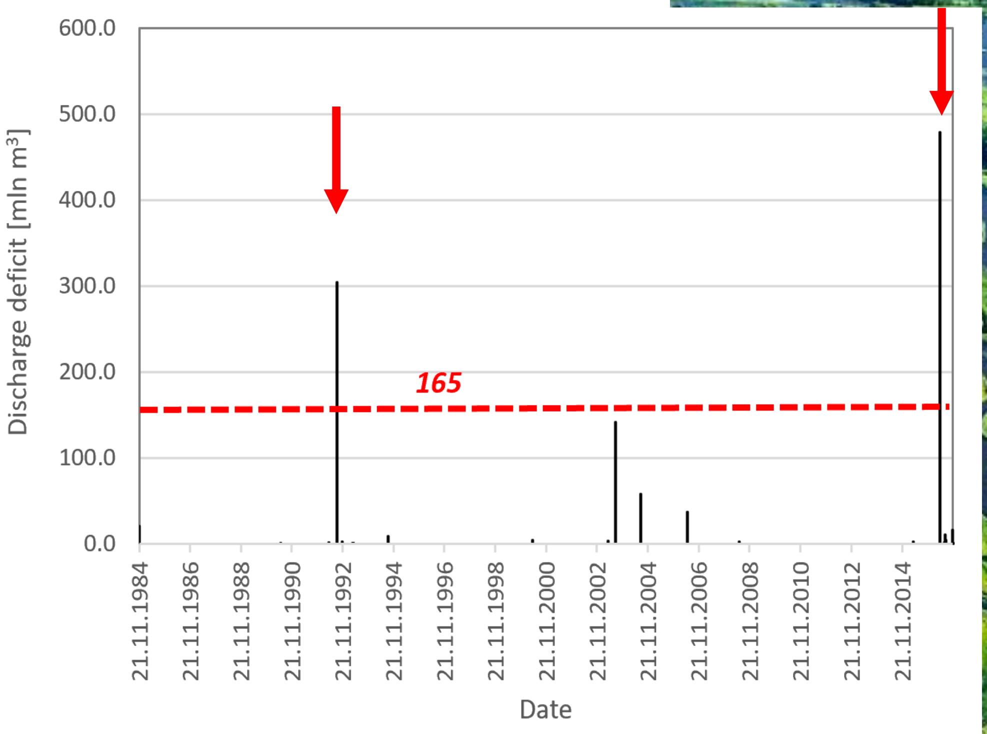
Results – Hydrological analysis in the Gozdowice profile

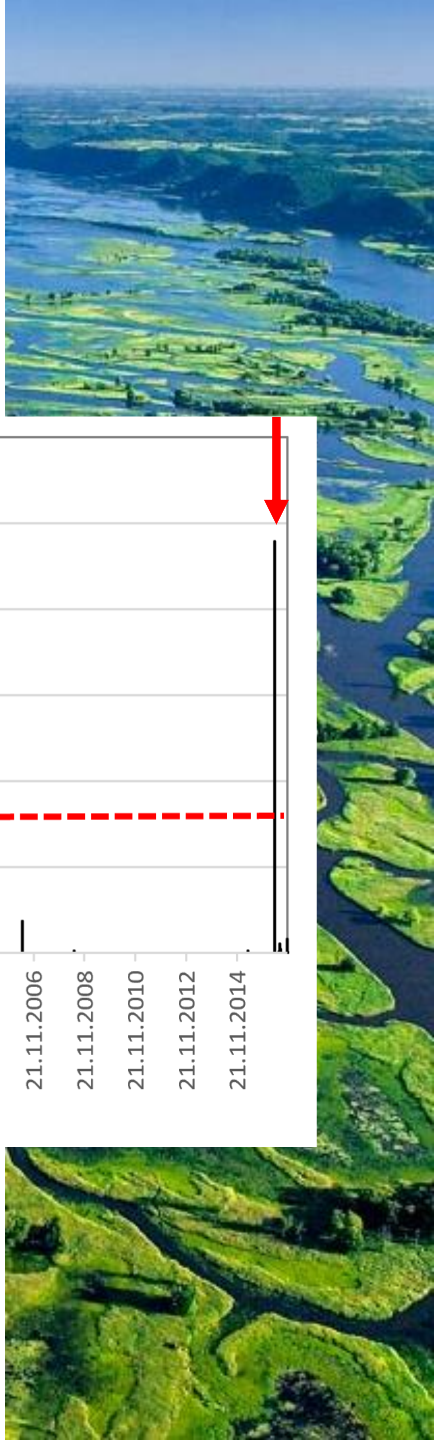


Maximum discharge defict that occurred in Winter (21.3 mln m^3) is significantly lower than the most conservative water retention scenario.

Results – Hydrological analysis in the Gozdowice profile

Volumes of two of the biggest discharge deficit episodes (namely 479 mln m^3 and 304.3 mln m^3) that ocurred in Gozdowice in years 1980-2016 are so large that they could hardly be mitigated with any technical or nature-based measures – however, these discharge deficit episodes did *not* occur during winter.





Water retention vs. discharge enlargement

Our results indicate that if properly managed, land reclamation systems can increase the water level by 25 cm and the related average water depth by 22 cm:

- in the most conservative water storage scenario of 36 mln m³ for around 8-9 days when the stored water is released from the land reclamation system,
- in the average water storage scenario of 165 mln m³ for around 37 days when the stored water is released from the land reclamation system,
- in the most optimum water storage scenario of 373 mln m³ for around 83 days when the stored water is released from the land reclamation systems.

Technical limitations

- How to control water levels in ditches in a catchment scale?
- For those very few parts of the river being shallower than 150-160 cm average water depth, where our approach could not secure an average water depth of 180 cm (or secure an average water depth of 180 cm only for a very short time period) – single construction solutions could be applied, if shipping shall be improved (for ice breaking, this is not necessary, since there do exist alternatives such as the Amphibex which can break ice also at big rivers with very shallow depths; Schnauder and Domagalski 2018). However, even at some of these very shallow parts of Oder River there does exist a fairway which offers sufficient water depth

But…

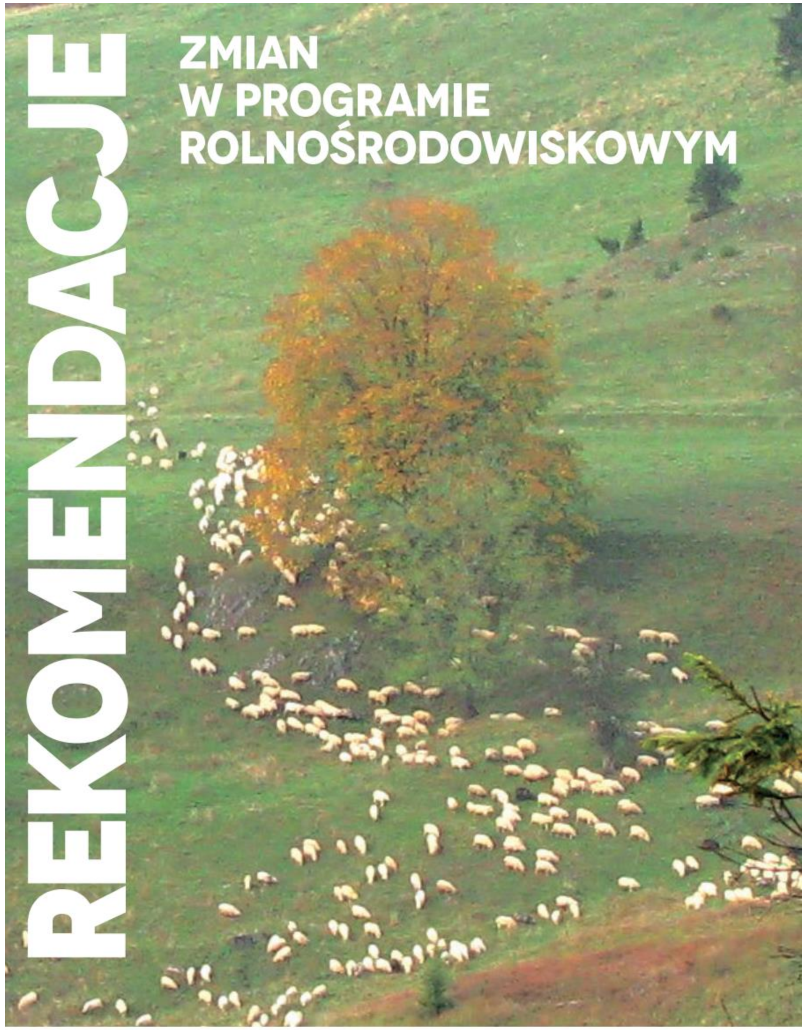
- We calculated the volume only in the areas of highest concentrations of ditches,
- We used conservative assumptions,
- We talk about the average depth in the cross sections and not about the maximum depths, which are 30-50% higher,
- Any other measures are always a subject to uncertainties and risk
- Nearly no environmental risks!
- Other benefits, such as water retention subsidies…

We aim at the real problem – the catchment

Why to use semi-natural water retention measures?

- The main drivers of low flows (both in Summer and in Winter) originate from the fact that the majority of the catchment is drained/modified, so the outflow is quick,
- Increase of water retention according to the proposed methods addresses contemporary and prospective needs of increase water levels and promote sustainable farming,
- Traditional hydrotechnical measures planned to be applied along the Lower Oder seem to mitigate low flows for the navigation remain incomparably invasive, costly and negative for water management in the catchment scale and as such have to be reconsidered.

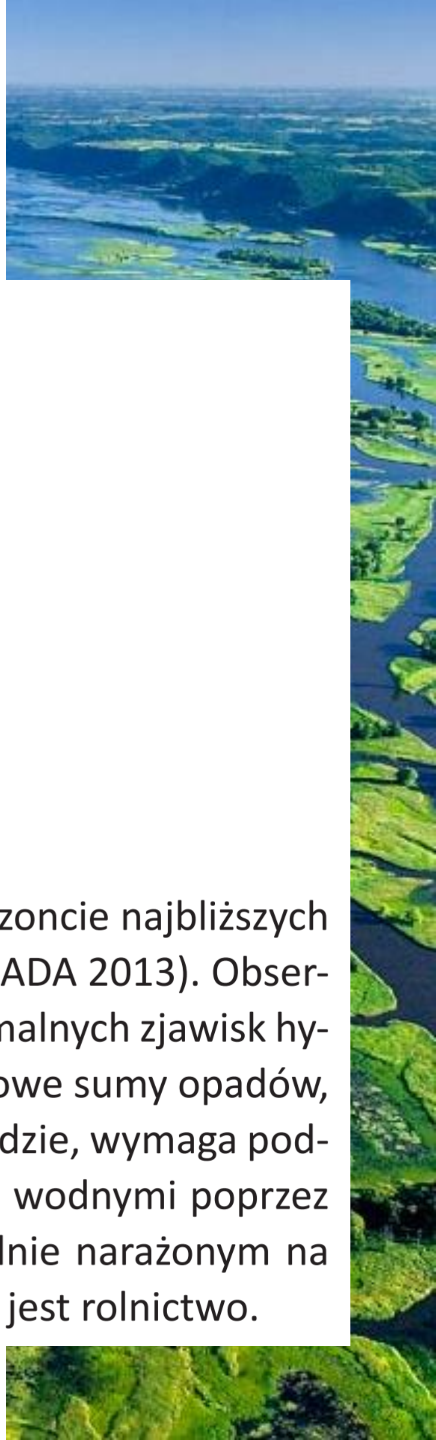
Agricultural water retention as a measure benefitial for farmers and land owners?



4.5. Pakiet retencyjny

Mateusz Grygoruk

Ograniczone zasoby wodne Polski, zarówno obecnie jak i w horyzoncie najbliższych dziesięcioleci, wymagają efektywnej ochrony (KZGW 2010; KLIMADA 2013). Obserwowana i prognozowana rosnąca częstość występowania ekstremalnych zjawisk hydrologicznych i meteorologicznych, tj. rosnące maksymalne dobowe sumy opadów, wydłużające się okresy suszy rolniczej i hydrologicznej oraz powodzie, wymaga podjęcia działań mających na celu efektywne zarządzanie zasobami wodnymi poprzez spowalnianie odpływu ze zlewni. Sektorem gospodarki szczególnie narażonym na niekorzystne skutki zjawisk hydrologicznych i meteorologicznych jest rolnictwo.



SWISS CONTRIBUTION

AgroProNatura

Thank you for your attention!

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