Poland Water Security Outlook and Action Plan - DRAFT

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Acknowledgments:
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Index

1. Overview
2. Analytical approach
3. Vulnerability analysis
4. Intervention stoplight assessment

Current water security context in Poland

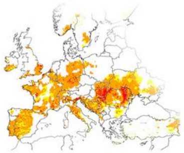
1. Severe drought across Western Europe
2. Oder fish kill caused by low water levels
3. Increased risks of floods
4. Water quality

Poland pulls 100 tonnes of dead fish from Oder river after mystery mass die-off

More than 500 firefighters deployed to haul in dead fish, using dams, boats, quad bikes and even a drone

FINANCIAL TIMES

Europe battles water shortages as severe drought sweeps the continent



Europe's driest summer in 500 years threatens crops, energy production

By Aman Bhargava and Samuel Granados

PUBLISHED AUG. 22, 2022

Over half of Poland at serious risk of drought amid heatwave, says state agency

JUL 4, 2022 | BUSINESS, ENERGY & CLIMATE, SOCIETY

Polish state auditor finds one third of treated water wasted and quality problems in 80% of units

AUG 11, 2022 | ENERGY & CLIMATE, SOCIETY

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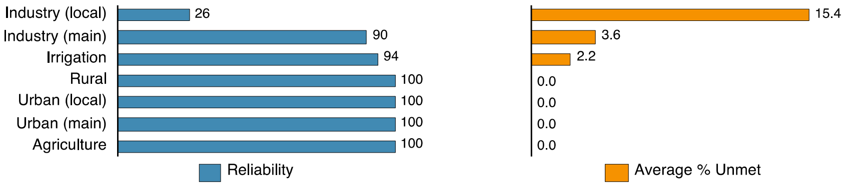
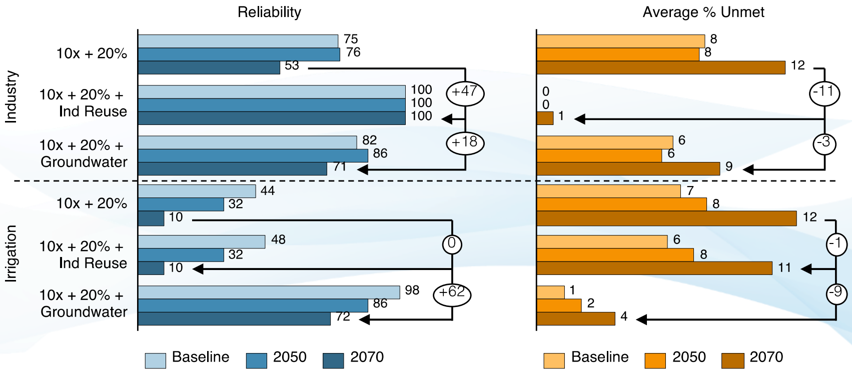
Current State of Water Security and Potential Risks

- Industry is the most vulnerable sector in terms of insufficient access to water
- Increased irrigation demand coupled with climate change could lead to water shortages
- By 2070, water reliability and unmet demand start to exhibit the negative impacts of climate change

Unmet Water Demand by Sector for Baseline Scenario



Unmet Water Demand Given a Tenfold Increase in Irrigated Area and Climate Change Impacts



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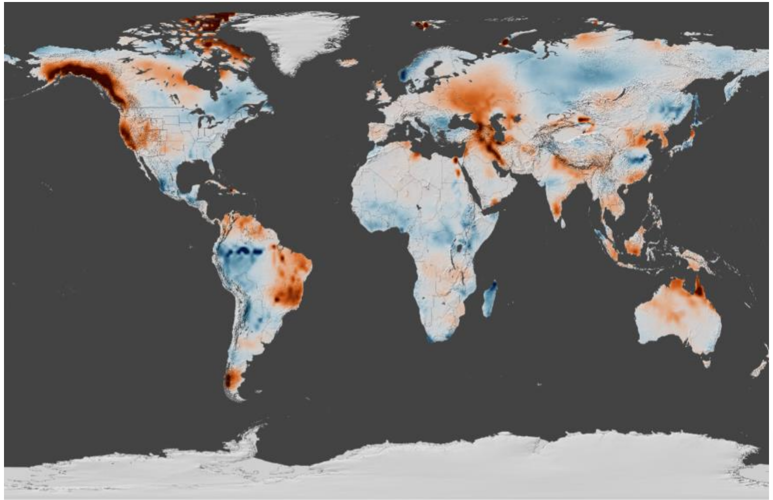
Water storage is an important tool for resilience to climate change

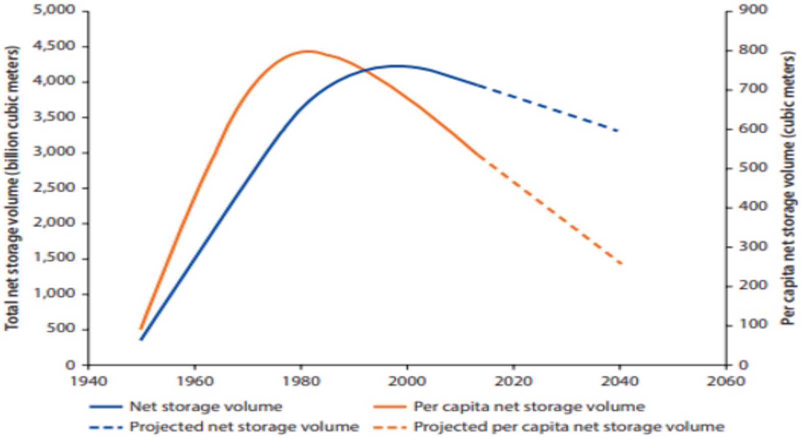
Reduction in Natural Water Storage



Source: Rodell, M et al. 2018.

Decline in Built Water Storage

Figure 3.15 Net Global Reservoir Storage Volume, Accounting for Storage Loss from Reservoir Sedimentation



Source: Annandale 2013.

… but decreased overall water storage capacity

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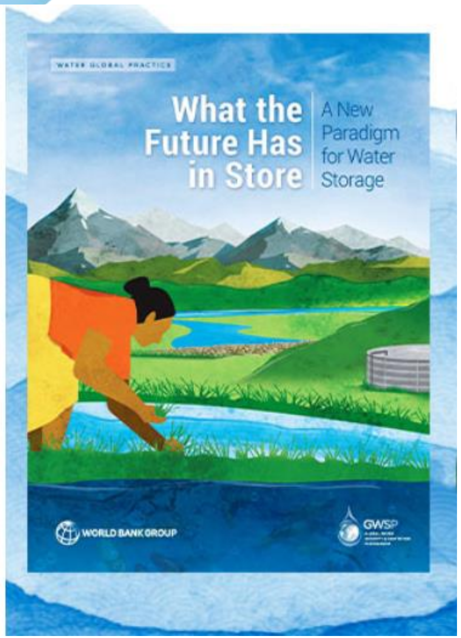
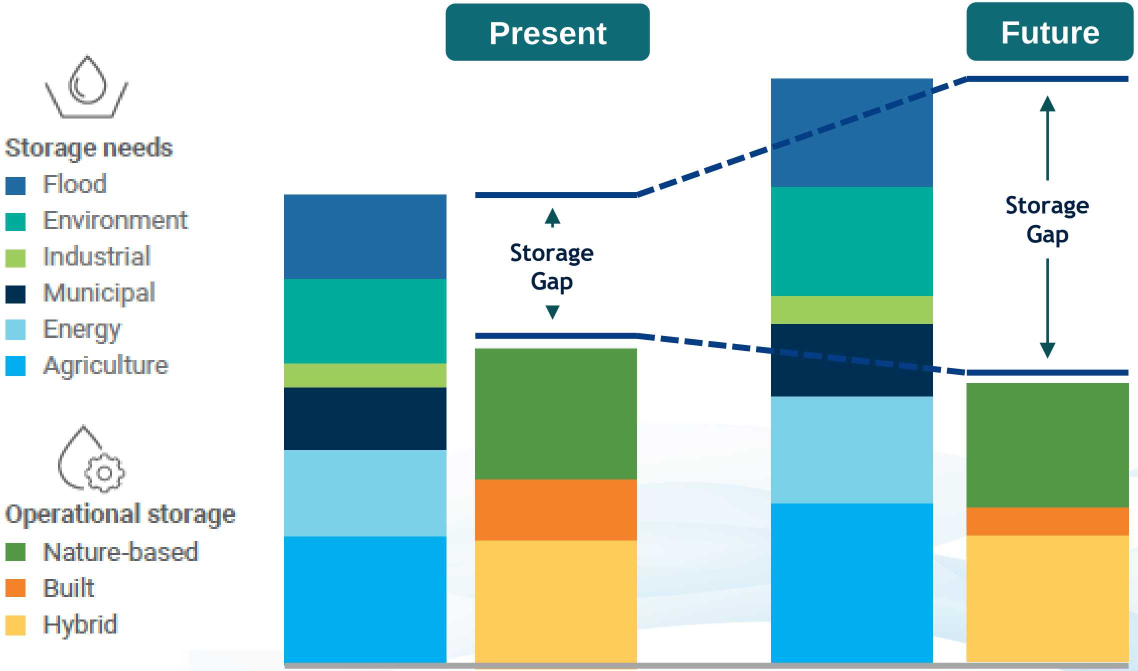
Altogether leading to an increased storage gap





https://www.worldbank.org/en/topic/water/publication/what-the-future-has-in-store-a-new-paradigm-for-water-storage

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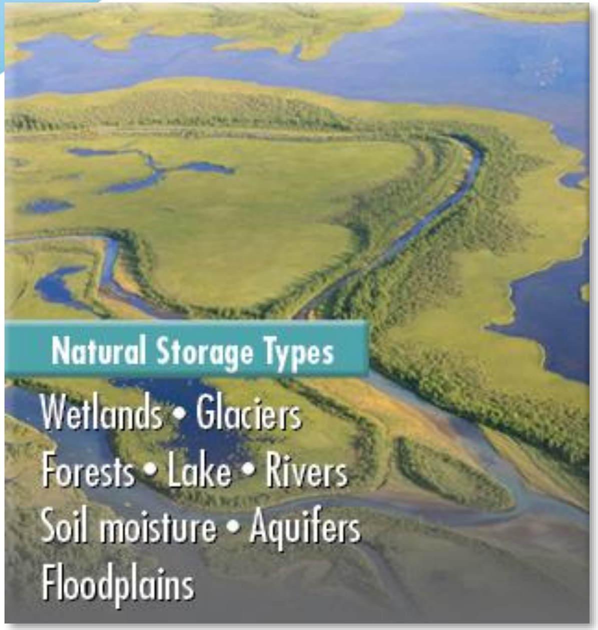
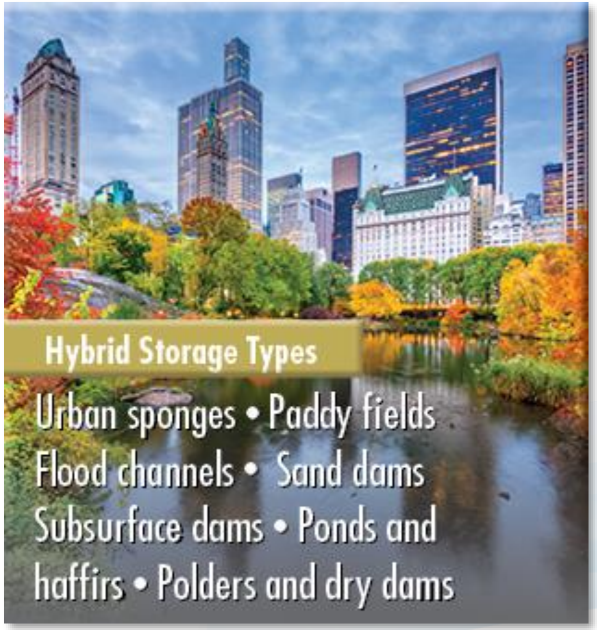
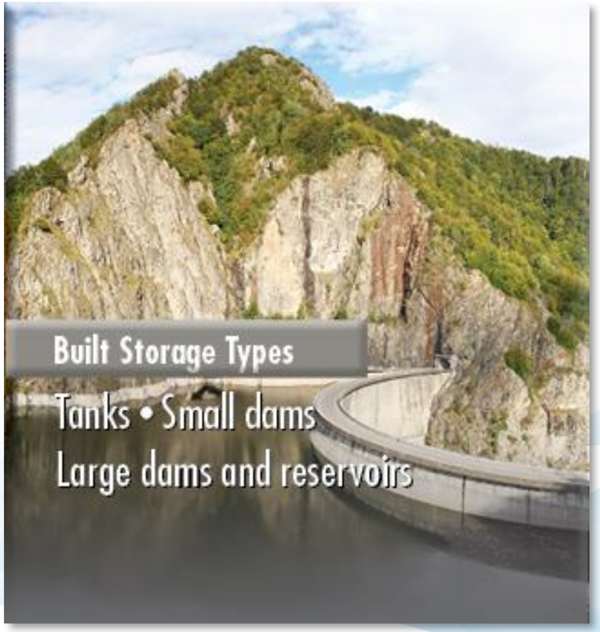
Interventions can tap into all types of storage







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… while adopting a systemic approach

- ✓Reoperate
- ✓Rehabilitate
- ✓Retrofit
- ✓Raise new

… and using existing storage more strategically

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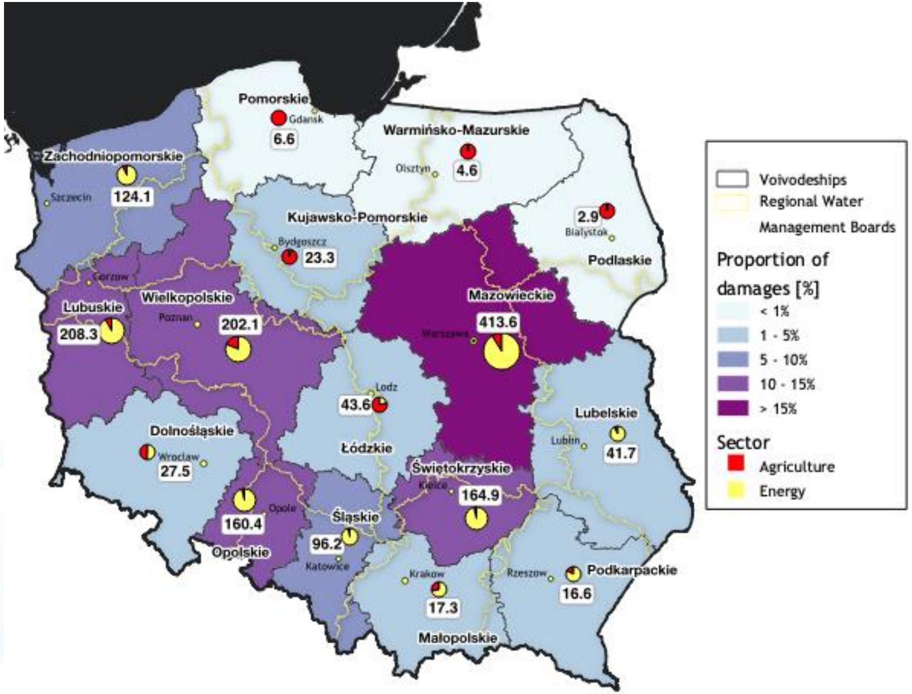
Cost of Inaction

- Recent floods in Poland have caused 4 billion EUR losses near the Odra River basin and 2.5 billion EUR in the Odra and Wisla basins
- Annual drought losses are estimated at 1.5 billon EUR for the country (3% of GDP)
- By voivodeship, Mazowieckie, Lubelskie, and Wielkopolskie are most vulnerable to energy and agricultural losses

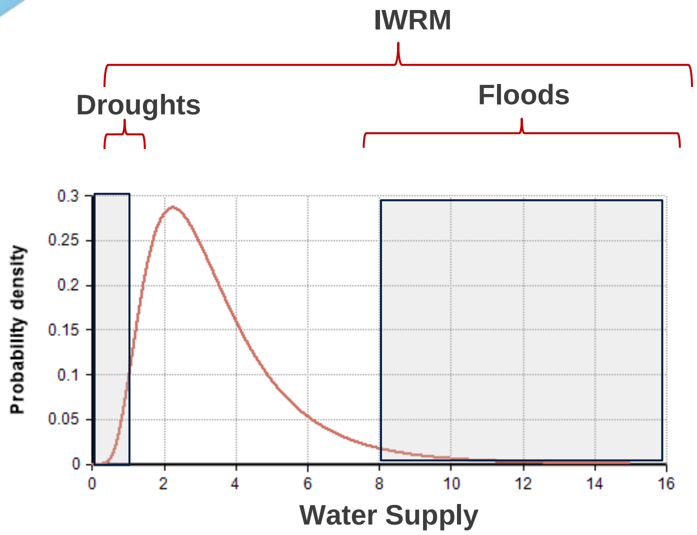
Average Annual Expected Damages from Drought



Promising interventions for water-related risks in Poland

✔ Main benefit
✓ Co-benefit

Interventions focus on 3 issues:



#	Theme	Intervention	Drought risk mitigation	Flood risk mitigation	IWRM
A	**Improve groundwater management**	1. Increase sustainable extraction 2. Artificial recharge	✔		✓
B	**Enhance soil water management and irrigation**	1. Increase irrigation 2. Agronomic practices (i.e., drought-tolerant crops, soil management)	✔		✓
C	**Expand surface water storage**	1. Large-scale storage 2. Small-scale (engineered) storage 3. Nature-based storage	✔	✔	✓
D	**Implement green urban flooding solutions**	1. Nature-based solutions & river channel systems		✔	
E	**Improve water demand management**	1. Convert coal-fired powerplants to dry cooling 2. Water conservation and reuse practices	✓		✔
F	**Water supply, sewage, and treatment**	1. Improve WSS infrastructure 2. Enhance capacities of local utilities	✓		✔

Index

1. Overview
2. Analytical approach
3. Vulnerability analysis
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Action Investment Framework

Objective:
Identify areas within Poland with the highest potential for implementing each intervention

Spatial resolution: 50 catchment management boards

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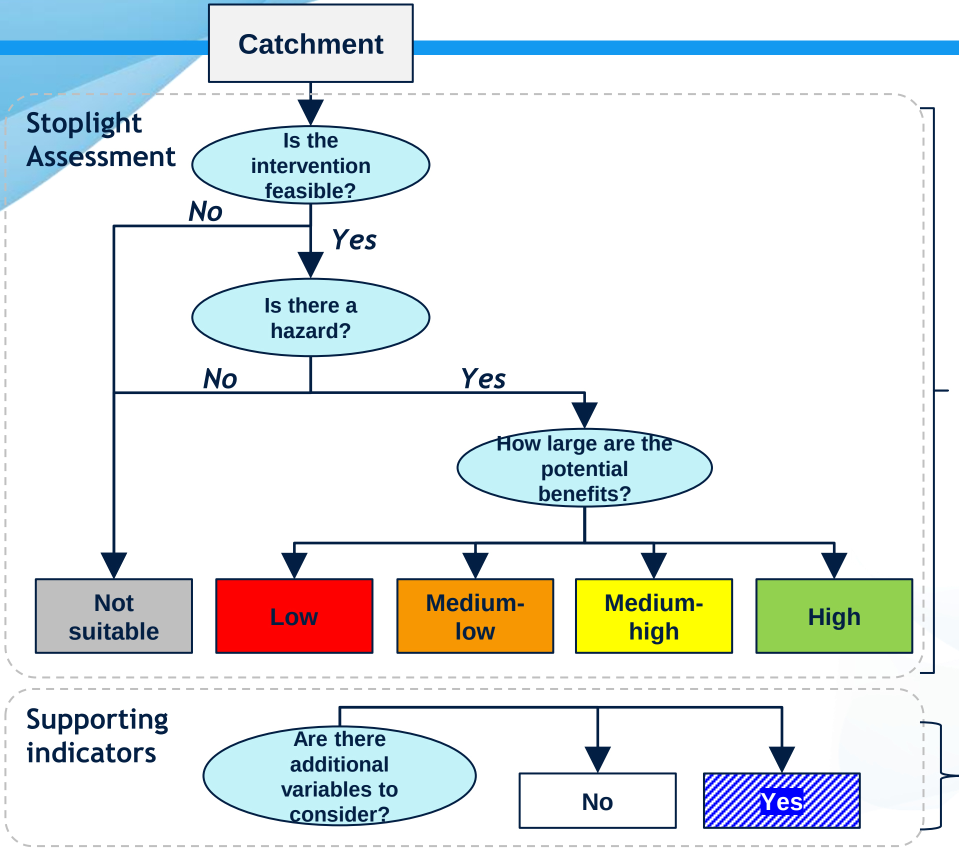
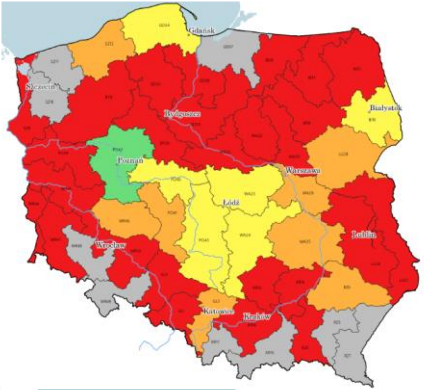
Action Investment Framework

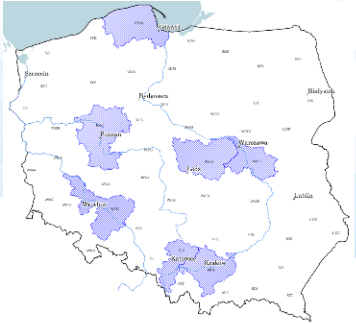


Illustrative example



Relative quantification of potential benefits

Qualitative consideration



Sources of data for analysis

Polish sources

PGW Wody Polskie:
- Drought Effects Counteracting Plan
- Flood Risk Management Plan
- Flood Hazard Maps

GUS (Statistics Poland):
- Water supply & withdrawals
- Water supply network & utilities
- Wastewater discharge and supply losses
- Population, income, asset values

Poland-specific research / data

Tarka et al. (2017):
- GW recharge
- Soil infiltration

Rzętała (2021):
- Dams & reservoirs

Walczykiewicz (2022):
- Power plants cooling

WEAP:
- Water demand (irrigation)

EEA:
- Natura 2000 protected sites

CORINE:
- Land use and land cover

High-resolution global data

FAO:
- Gridded value of agriculture

CGIAR:
- Irrigated agriculture revenues
- Evapotranspiration

EarthENV:
- Topography

NASA-Landsat:
- Impervious surfaces

HydroAtlas & HydroRivers:
- Sub-catchments & river network
- Soil characteristics

MacKnick et al. (2012):
- Cooling water needs

Index

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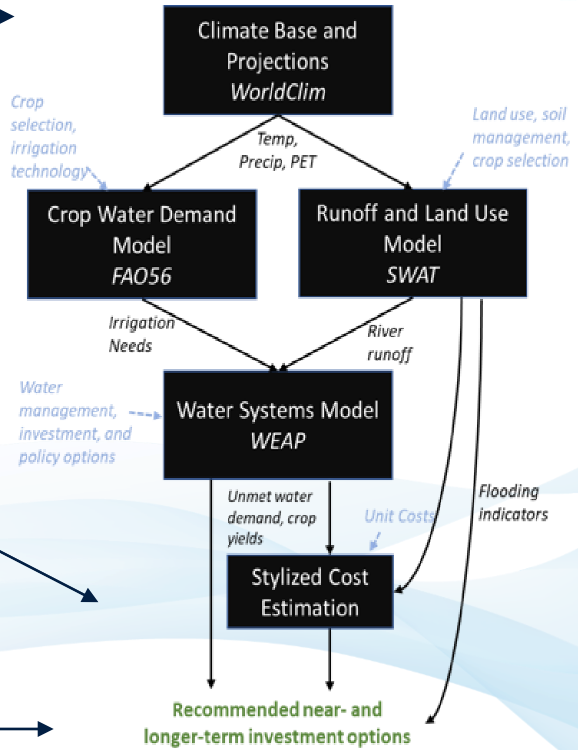
Water Security Assessment: Modeling Approach

Biophysical modeling

1. **Step 1: Establish a climate base and projections**
2. **Step 2: Model water resources vulnerability**
3. **Step 3: Evaluate the cost and benefits of interventions**
4. **Step 4: Preform a climate stress-test on potential interventions (repeat step 3 with selected scenarios)**
5. **Step 5: Develop a shortlist of promising water security options**



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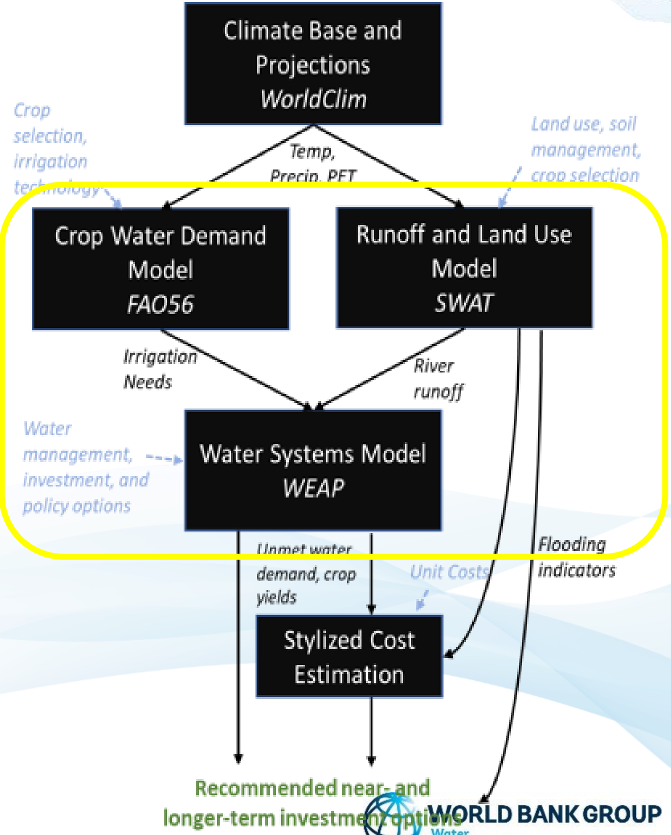
Water Security Assessment: Biophysical Models

- Biophysical models translate climate inputs from Step 1 into metric describing the state of water resources
  - *Soil Water Assessment Tool (SWAT):* A rainfall runoff model
  - *FAO 56:* An irrigation water demand model
  - *Water Evaluation and Planning (WEAP):* A water balance model

- Using these three models we calculate two indicators of water availability to assess water vulnerability
  1. Reliability (proportion of years at least 95% of water demands were met)
  2. Average percentage of unmet water demand



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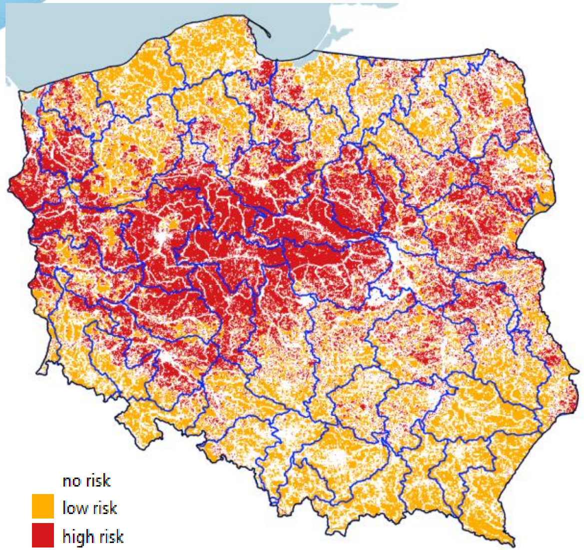
Vulnerability analysis

Hazard	Exposure
Drought hazard	**Agricultural drought** • **Crop production revenues** **Hydrological drought** • Water demand
Flooding hazard	• **Capital (value)** • **Population**
Mismanagement of water resources	• **Water supply** • **Water demand**

Agricultural drought vulnerability

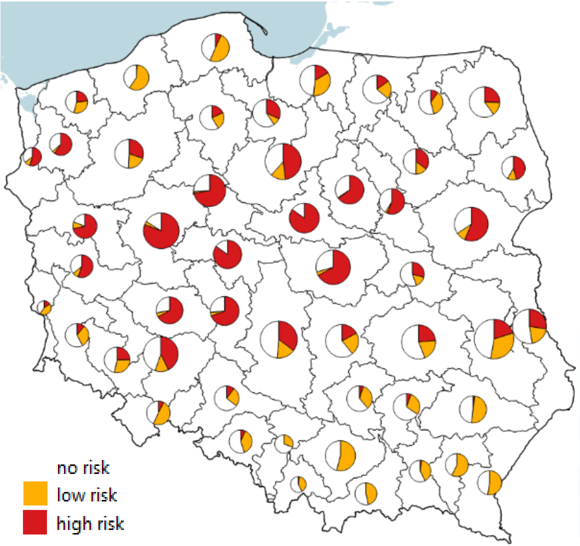
Hazard:

Agricultural drought risk

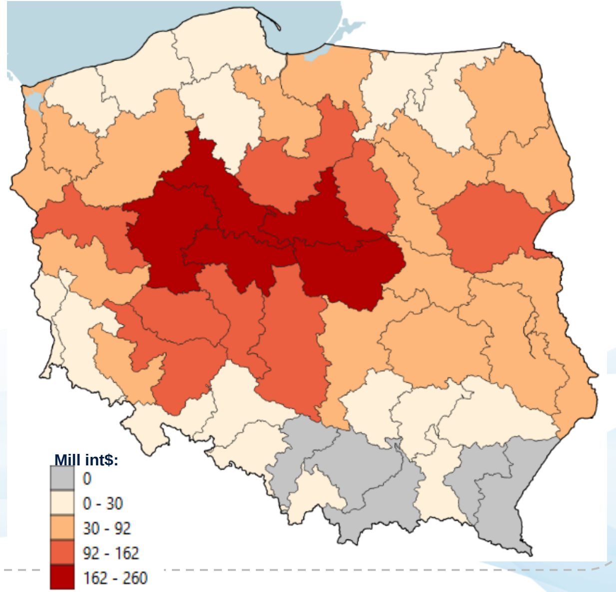


Vulnerability:

Share of agricultural revenues exposed to high/low drought risk



Production value ($) exposed to high drought risk



Sources:

- *Wody Polskie, Drought Effects Counteracting Plan (2020)*
- *FAO, Gridded Agricultural Revenues (2010)*

$int: international dollar, considering power purchasing parity adjustment

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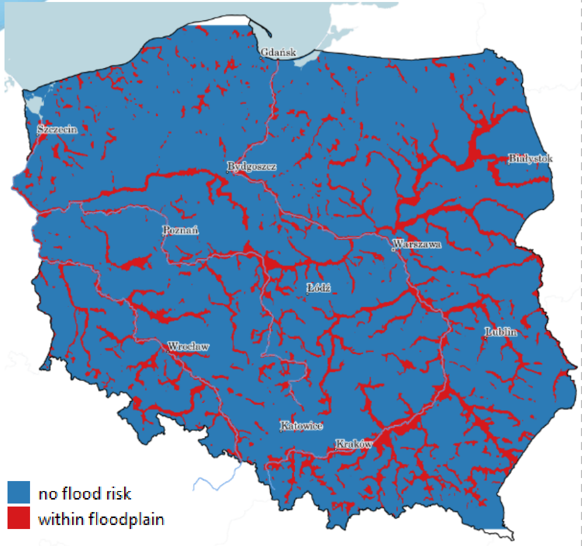
Flood vulnerability

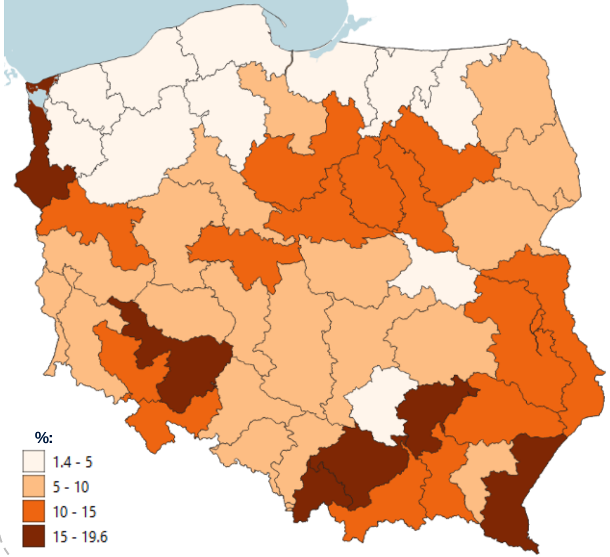
Hazard:

Riverine flooding

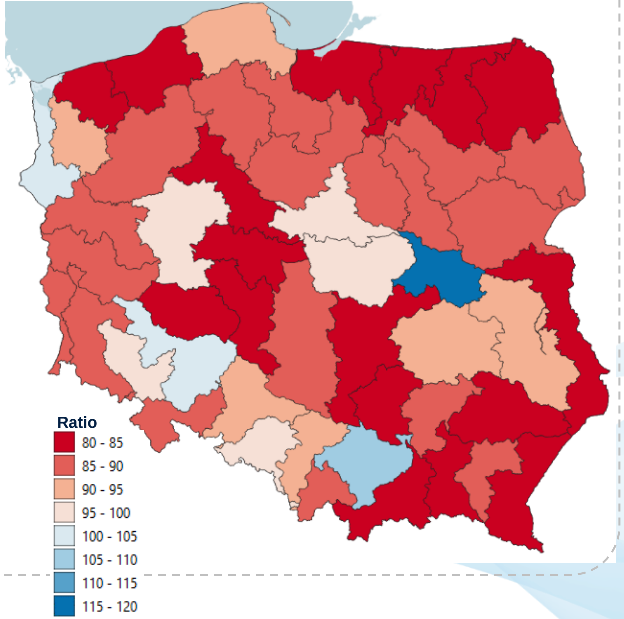


Vulnerability:

Share of population within floodplain



Mean wage (as ratio over median = 100) of population within floodplain



Sources:

- *Wody Polskie, Flood Hazard Maps (2019)*
- *GUS, Population & asset value by gmina (2021)*

Index

1. Overview
2. Analytical approach
3. Vulnerability analysis
4. Intervention stoplight assessment

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Water security interventions

#	Theme	Intervention
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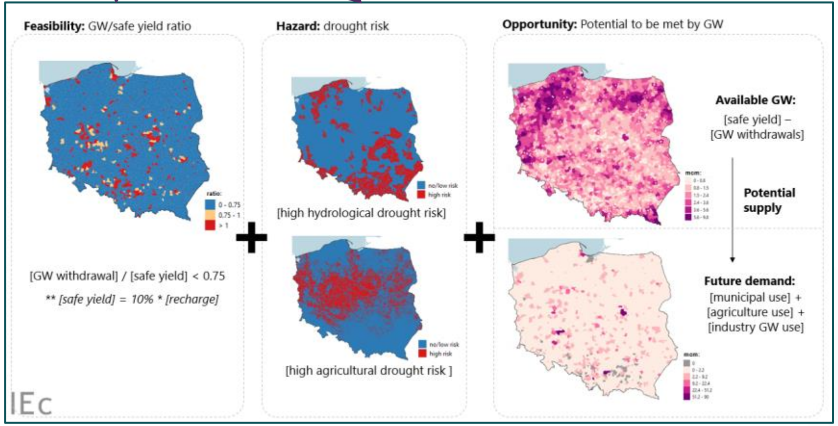
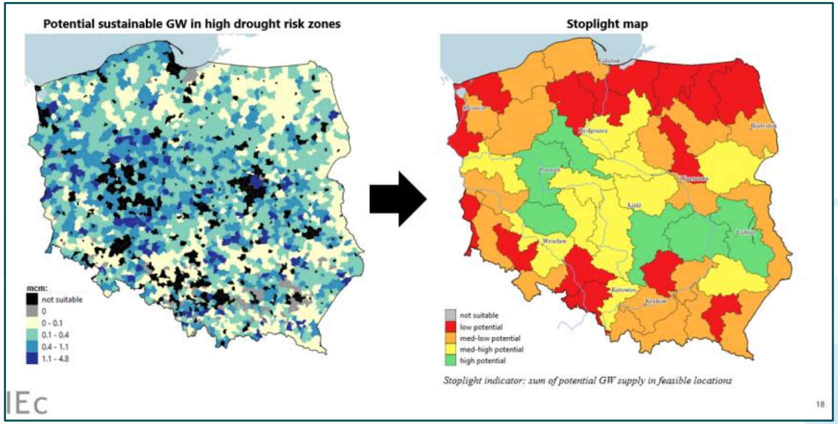
F	**Water supply, sewage, and treatment**	1. Improve WSS infrastructure 2. Enhance capacities of local utilities

For each intervention, 2 slides

Slide 1: Variables and maps used for evaluating feasibility, hazard, and opportunity (as applicable)

Slide 2:
intermediate result at highest available resolution + resulting stoplight map aggregated at 50 catchments





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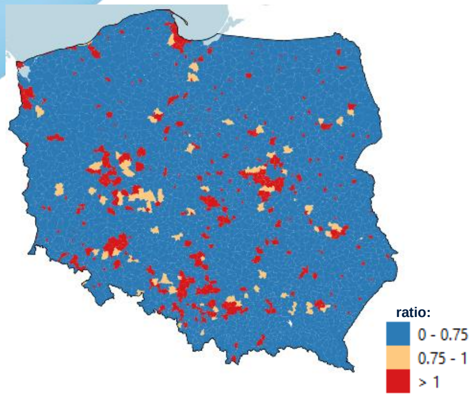
a1. Increase sustainable groundwater withdrawals

Feasibility: GW/safe yield ratio

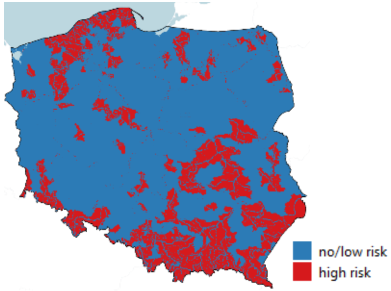


[GW withdrawal] / [safe yield] < 0.75

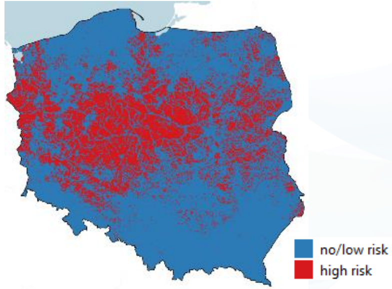
*** [safe yield] = 10% * [recharge]*

\+

Hazard: drought risk



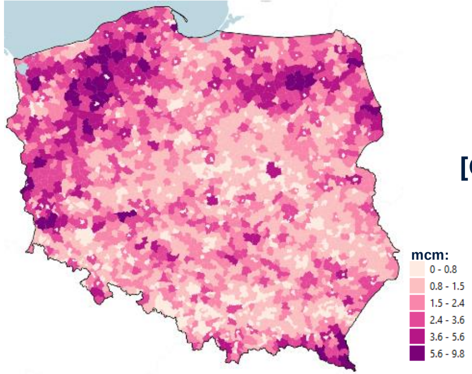
[high hydrological drought risk]



[high agricultural drought risk]

\+

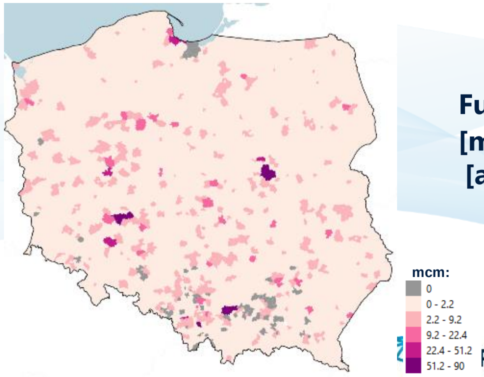
Opportunity: Potential to be met by GW



Available GW:

[safe yield] –
[GW withdrawals]

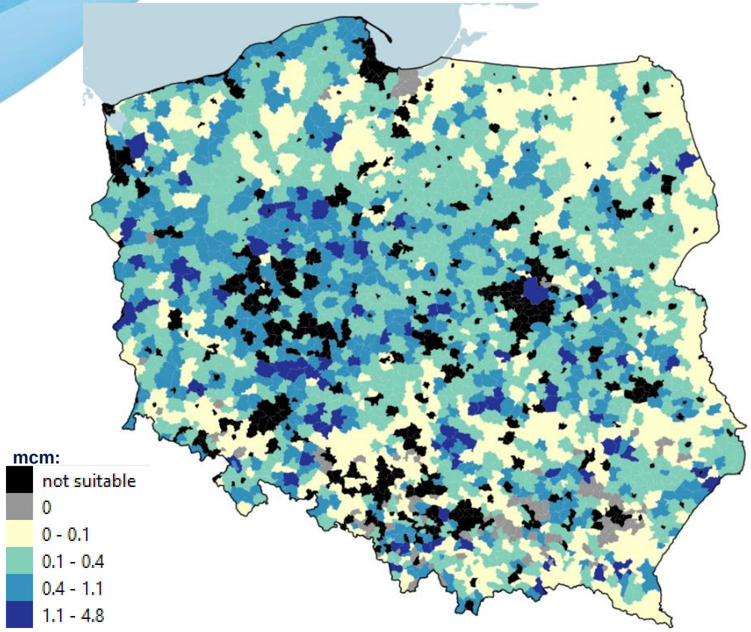
Potential supply



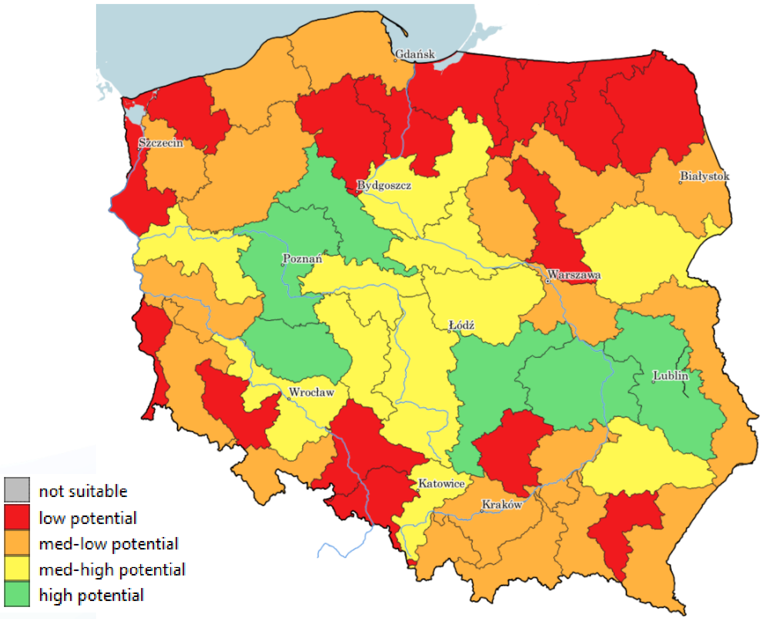
Future demand:
[municipal use] +
[agriculture use]
\+
[industry GW use]

a1. Increase sustainable groundwater withdrawals

Potential sustainable GW in high drought risk zones



Stoplight indicator: sum of potential GW supply in feasible locations

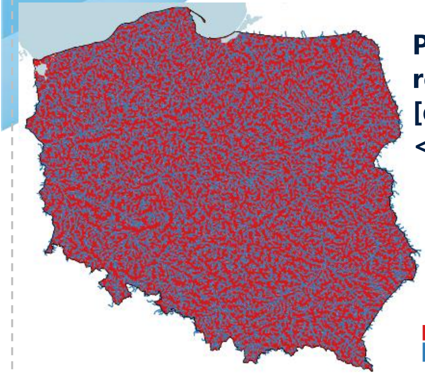


Takeaways / discussion points:

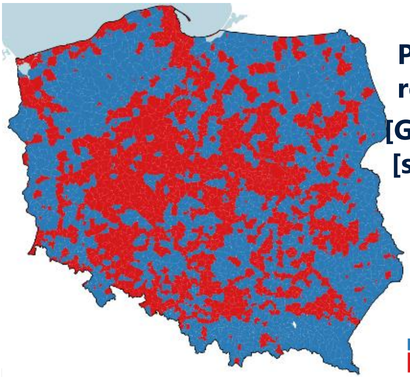
- **At a catchment scale, there is some suitability everywhere, even considering a conservative safe yield. However, there is high heterogeneity at gmina level.**
- **Highest potential in central catchments along the Warta and Wisla**
- **Limited potential in the Odra and coastal catchments**

b1. Increase irrigation

Feasibility:



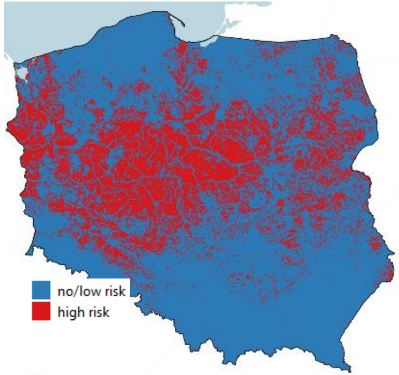
Potential SW resources [distance to stream] < 1km



Potential GW resources [GW withdrawal] / [safe yield] < 0.25

+

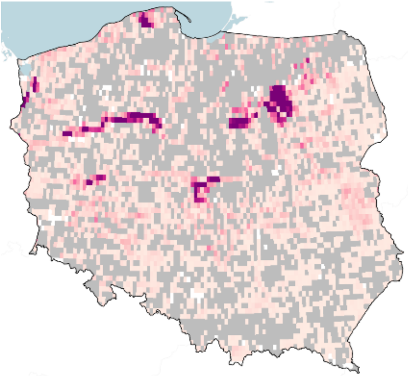
Hazard: drought risk



[high agricultural drought risk]

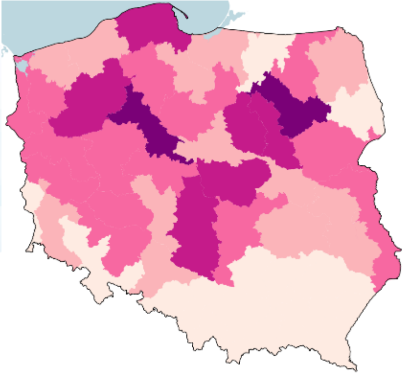
+

Opportunity: $ return per drop of water



Value within feasible/risk areas:

[value of irrigated production]



Potential irrigation demand:

[irrigation water demand]

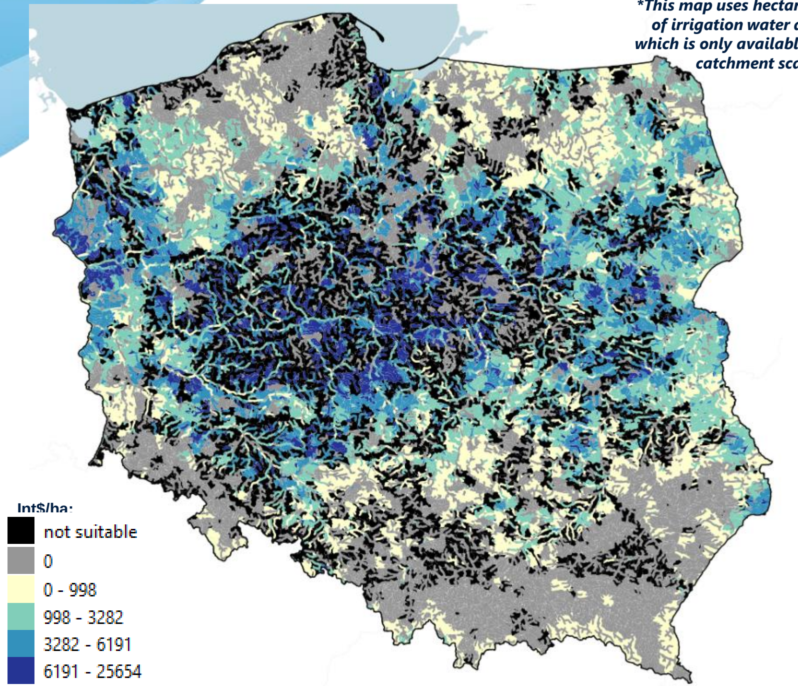
b1. Increase irrigation

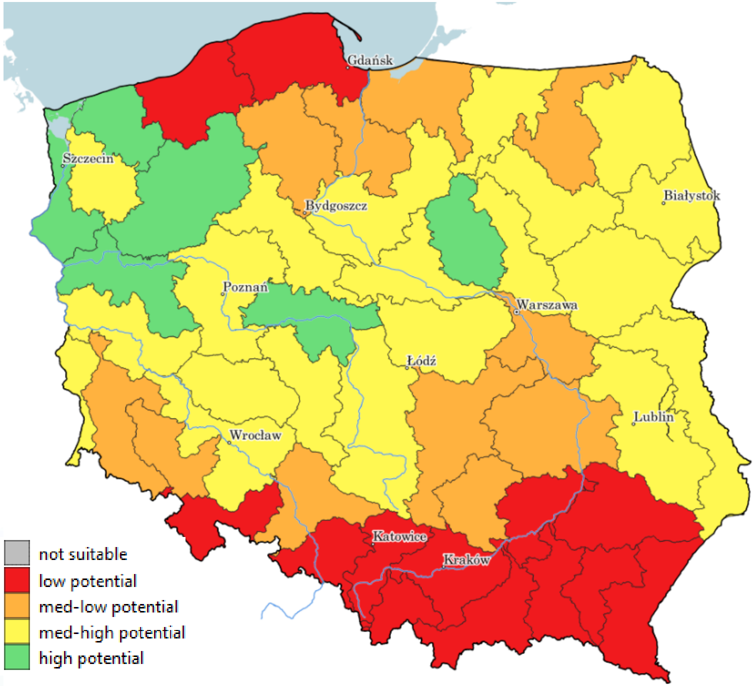
Stoplight indicator: sum of value ($) per sum of m³ of water for irrigated crops

Value per hectare of irrigated crops within feasible areas*

Stoplight map

**This map uses hectares instead of irrigation water demand, which is only available at the 50 catchment scale*



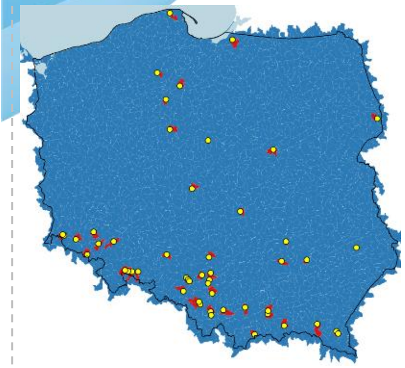


$int: international dollar, considering power purchasing parity adjustment

Takeaways / discussion points:
- **Highest potential along the lower Odra and Warta catchments, where agriculture is concentrated.**
- **Low potential in southern Poland due to lack of agricultural drought hazard and lower agricultural value.**
- **Analysis does not consider how increased irrigation could impact other uses.**

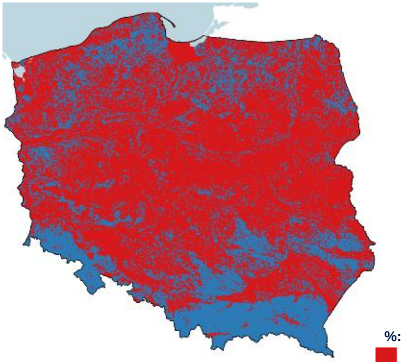
c1. Large-scale storage

Feasibility:



No existing dam in catchment

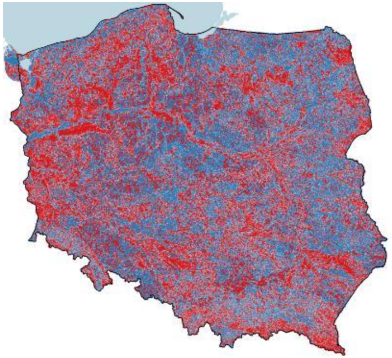
[level 12 catchment]



Slope

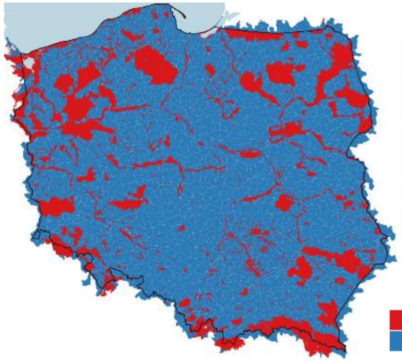
[max slope] > 1

Available land uses



[no urban / forest OR dense agriculture]

No Natura2000 protected land

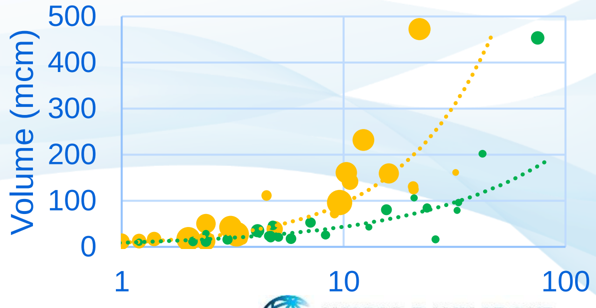


[no protected area]

+

Opportunity: maximum storage potential

Potential volume per surface area:



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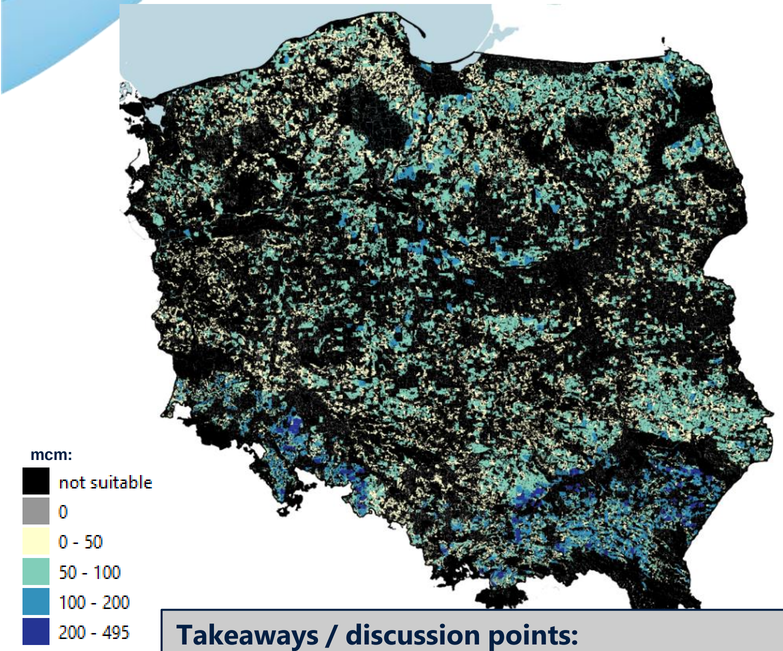
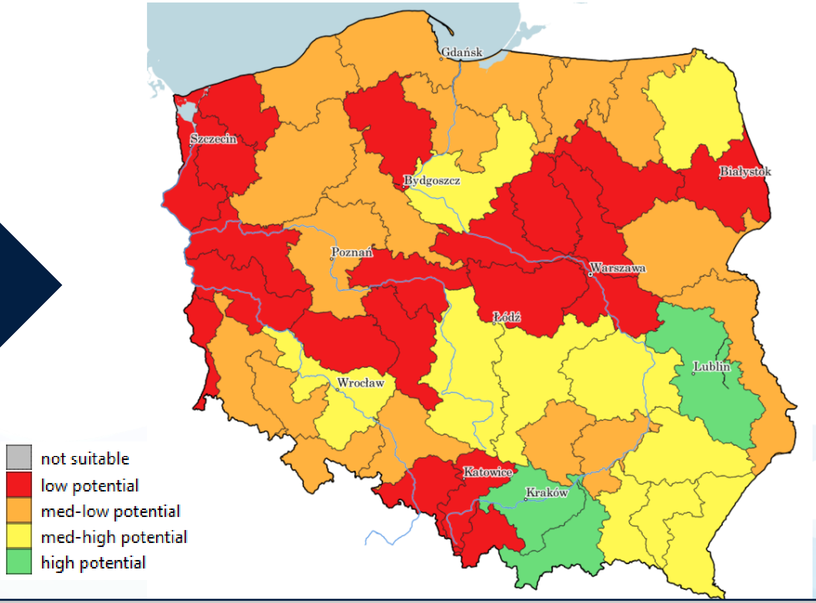
c1. Large-scale storage

Potential storage volume from large-scale reservoirs in available land



Stoplight indicator: sum potential volume from available land



Takeaways / discussion points:

- **High storage potential in the upper Wisla catchments, which could contribute to flood control / improved water supply downstream.**
- **Potential is highly localized, with a high degree of spatial heterogeneity**

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Summary and Conclusions

Our analysis has highlighted four areas where urgent action is needed:

1. **Infrastructure:** Increasing the availability and reliability of water resources will require a combination of storage and conveyance infrastructure investments

2. **Innovation:** Nature-based solutions for flood control should be piloted in areas where high economic gains could be obtained; New data-science techniques (particularly on drought management); Circular economy approaches to be more efficient.

3. **Information:** The enhancing and refinement of all data sources (including water quality) across all government agencies is an easy win.

4. **Institutions:** To achieve potential increases in irrigation, further coordination between the Ministry of Agriculture and Rural Development, Polish Waters, and other water-related ministries will be necessary.

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THANKS FOR YOUR ATTENTION!

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ANNEX

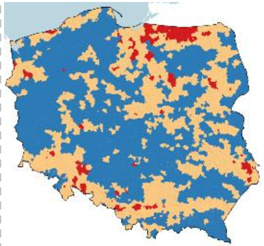
a2. Artificial groundwater recharge

Feasibility:

Storage capacity

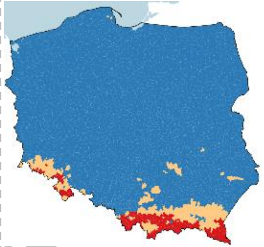
[GW withdrawal] / [safe yield] > 0.75

***** [safe yield] = 10% * [recharge]***



Good infiltration

[infiltration coefficient] > 0.2

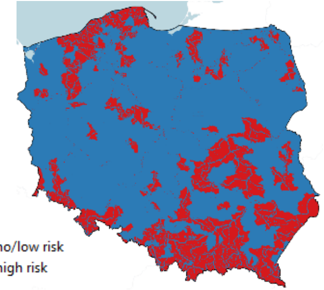


Flat area

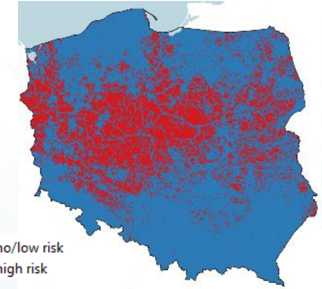
[mean slope] < 0.02

+

Hazard: drought risk



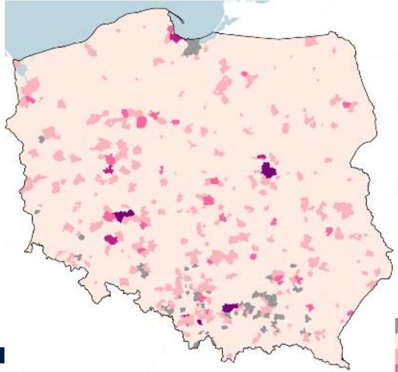
[high hydrological drought risk]



[high agricultural drought risk]

+

Opportunity: Potential GW demand

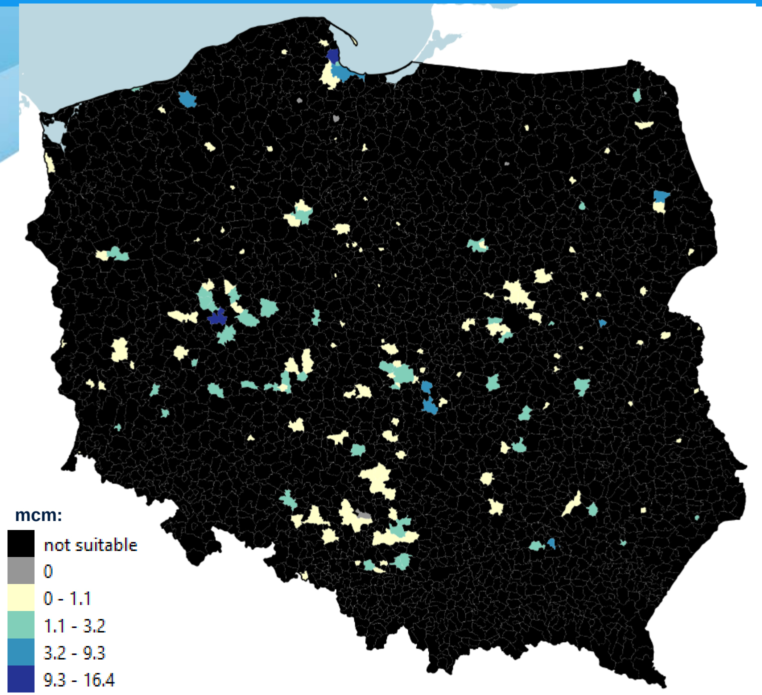


[municipal use] +
[agriculture use]
+
[industry GW use]

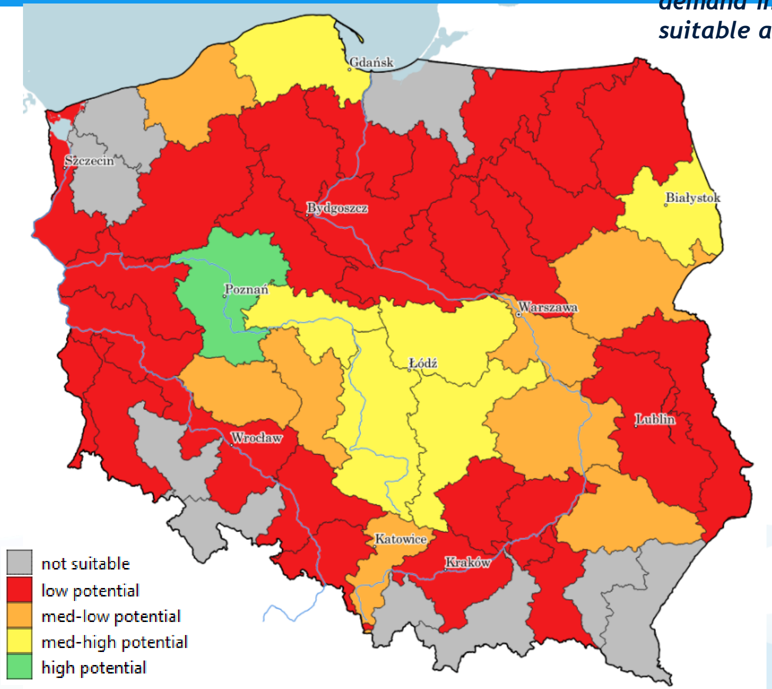
a2. Artificial groundwater recharge

Stoplight indicator: sum of potential GW demand in suitable areas

Potential GW demand in areas suitable for artificial recharge



Stoplight map



Takeaways / discussion points:

- **Limited suitability across the country primarily due to limited storage volume (from low withdrawals from**
- **Solution more appropriate for targeted locations with high withdrawals.**

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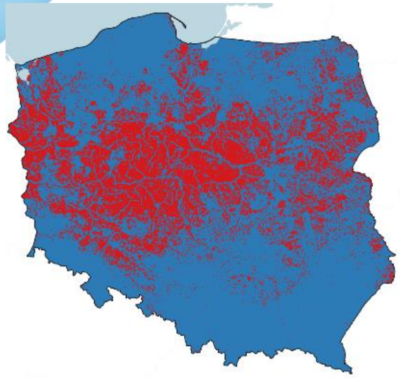
b2. Drought-tolerant crops & land management practices

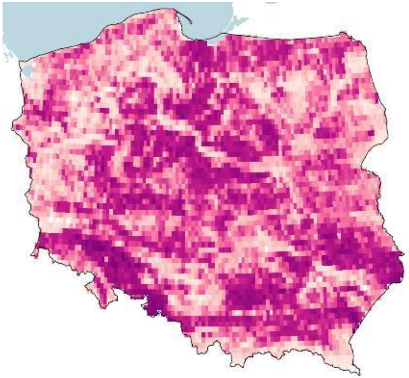
Hazard: drought risk



[high agricultural drought risk]

\+

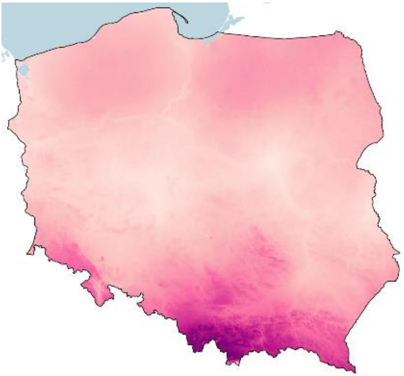
Opportunity: $ return per drop of water



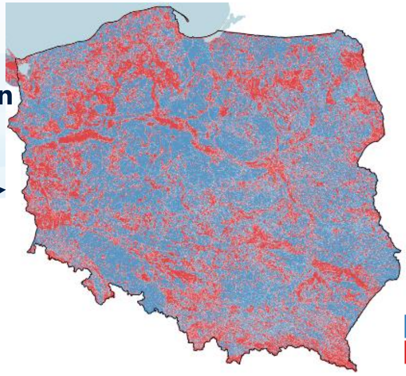
Value within risk areas:

[value of production]

Summer crop water need:



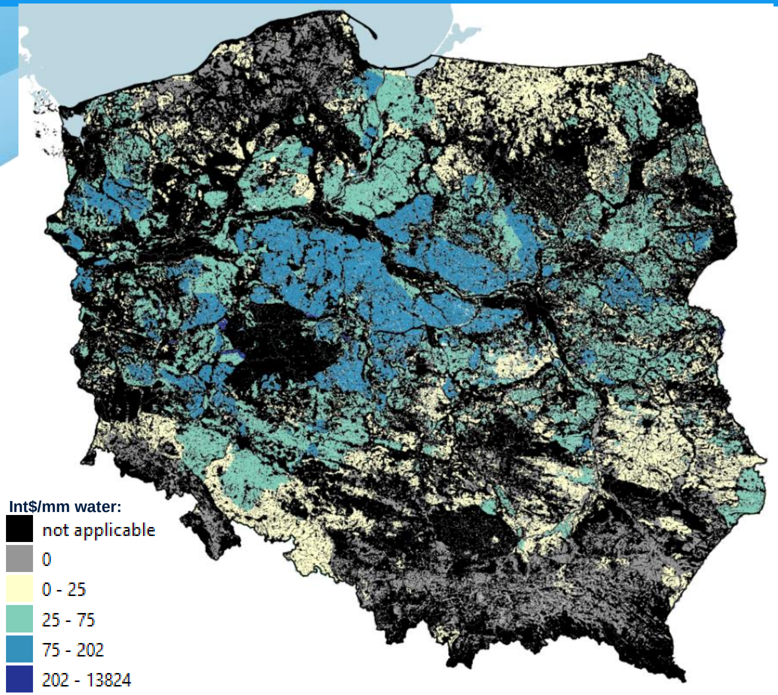
[actual evapotranspiration during J-J-A]



[within cropland]

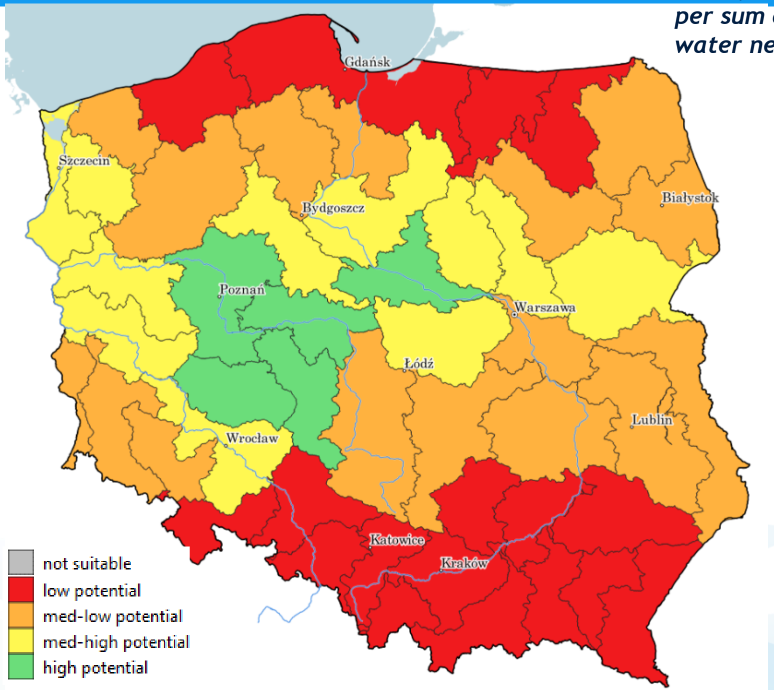
b2. Drought-tolerant crops & land management practices

Value per summer crop water need in drought zones



Stoplight map

Stoplight indicator: sum of value ($) per sum of summer water need (mm)

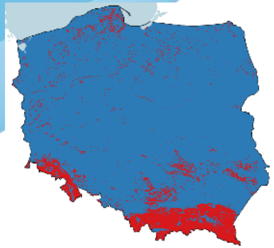


Takeaways / discussion points:

- **Maps indicate where reducing crop water requirements (period of high water requirement and prone to drought) could save the highest $ value of crop production.**
- **Solutions could consider reducing sensitivity to shortages (e.g., drought-tolerant crop, reducing demand) or improving soil moisture (i.e., supply).**

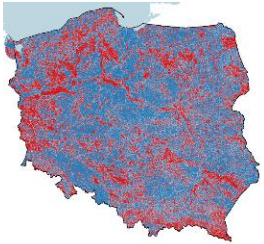
c2. Small-scale (engineered) storage

Feasibility:



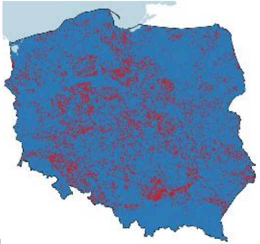
Flat slope

[slope] < 2



Available land to inundate

[no urban or forest land]

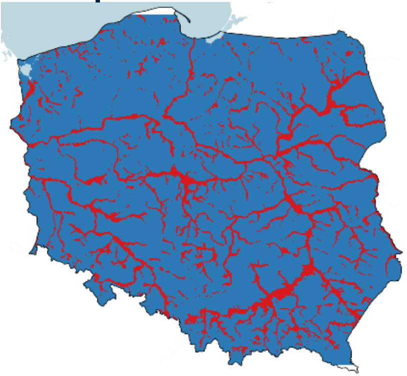


[no dense agricultural land]

+

Hazard: flood risk

Floodplain

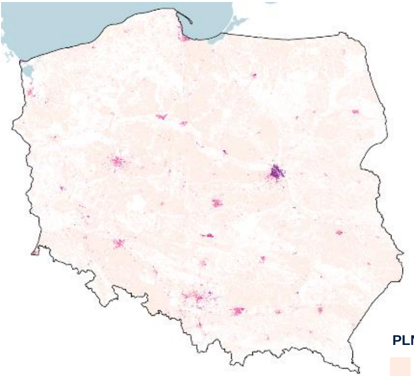


[within floodplain boundary]

+

Opportunity: capital within floodplain

Total value of capital per area



[industry capital] + [services capital] + [agriculture capital]

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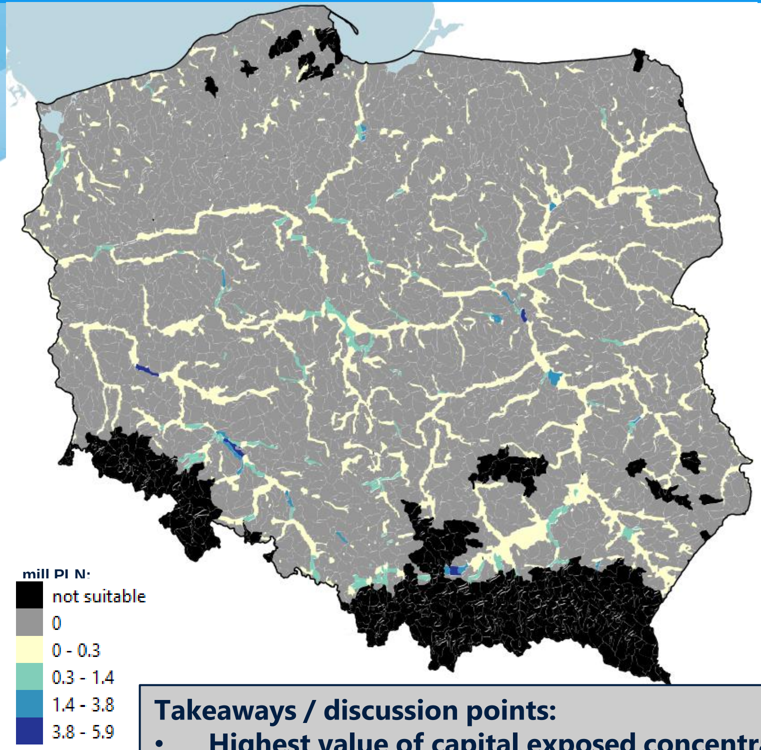
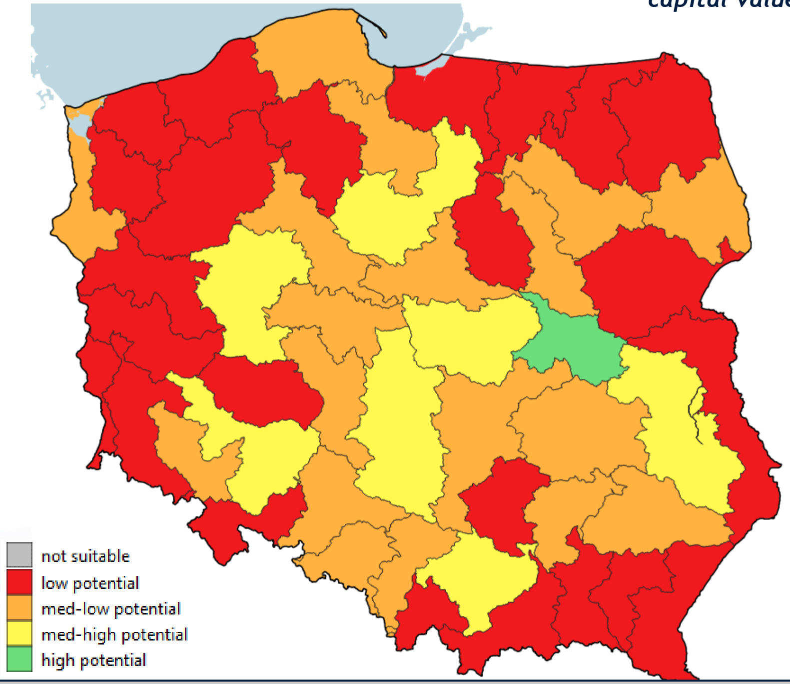
c2. Small-scale (engineered) storage

Stoplight indicator: sum of exposed capital value

Value of capital within floodplain of feasible catchments



Stoplight map



Takeaways / discussion points:

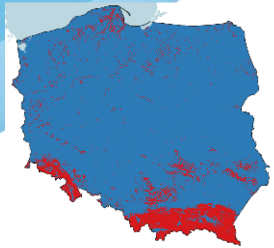
- **Highest value of capital exposed concentrated in large cities, particularly Warsaw.**
- **Intervention is feasible in most catchments except for southern mountains. However, local availability of land to inundate should be considered.**

c3. Nature-based storage

Feasibility:

Flat slope

[slope] < 2

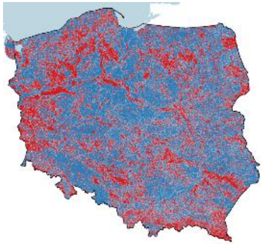


Clay soils

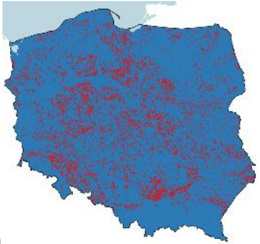
[share of clay] > 15%

Available land to inundate

[no urban or forest land] + [wetlands]



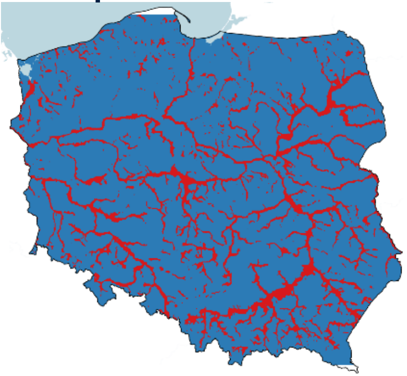
[no dense agricultural land]



+

Hazard: flood risk

Floodplain

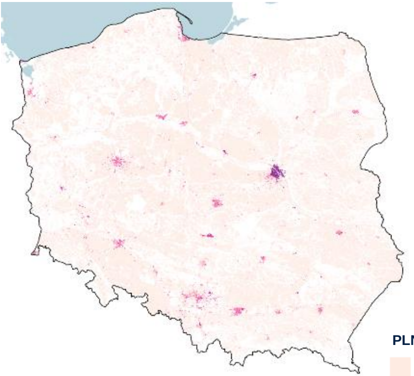


[within floodplain boundary]

+

Opportunity: capital within floodplain

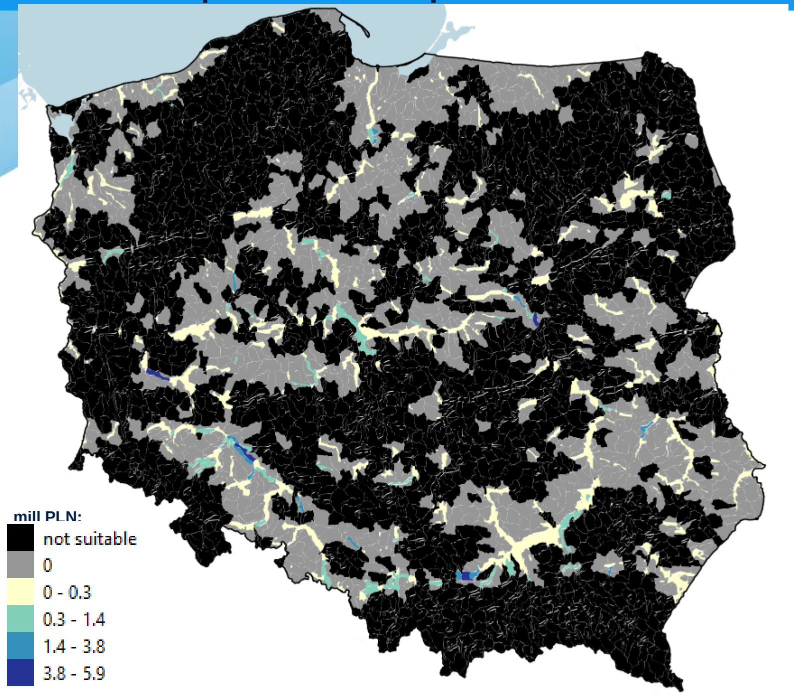
Total value of capital per area



[industry capital] + [services capital] + [agriculture capital]

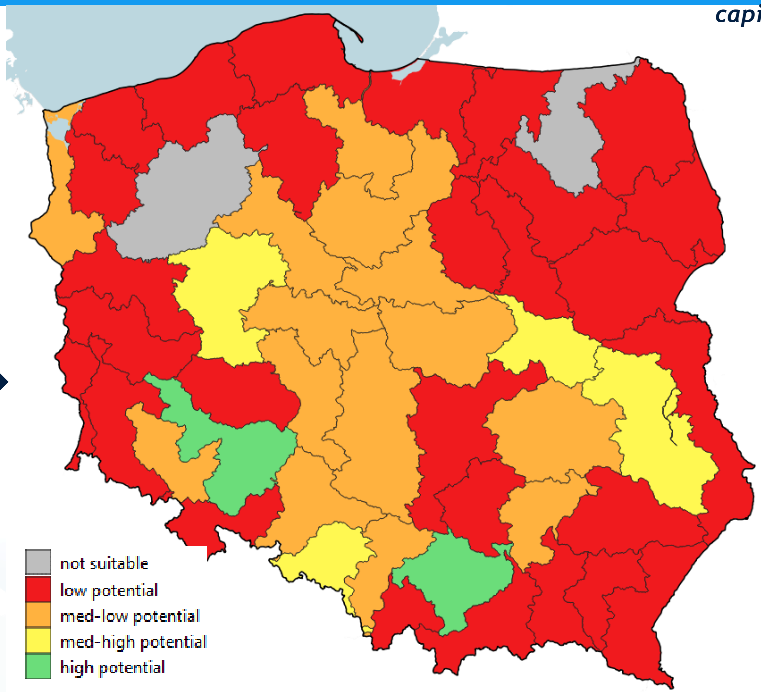
c3. Nature-based storage

Value of capital within floodplain of feasible catchments



Stoplight map

Stoplight indicator: sum of exposed capital value



Takeaways / discussion points:

- **Green storage options more limited than artificial, to areas with enough clay content.**
- **Due to high value of exposed capital, highest potential located around Wroclaw and Krakow.**

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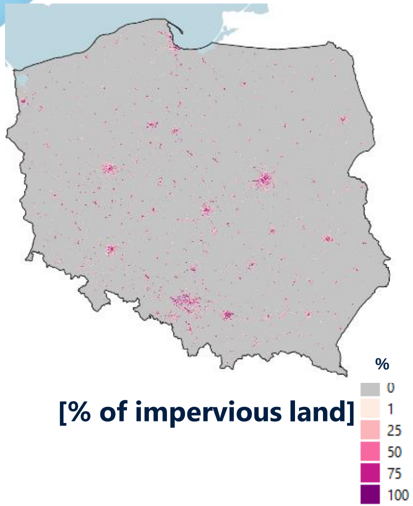
d1. Green urban flooding solutions

Hazard: pluvial flood risk

Opportunity: capital value in urban areas

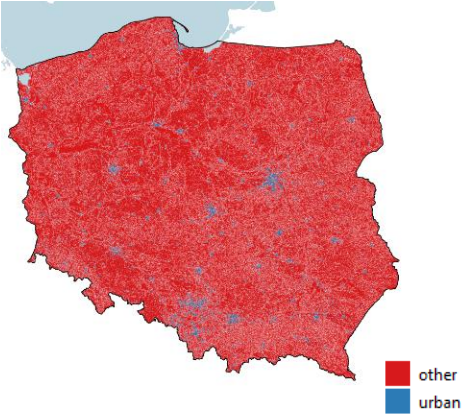
Drainage capacity in urban areas



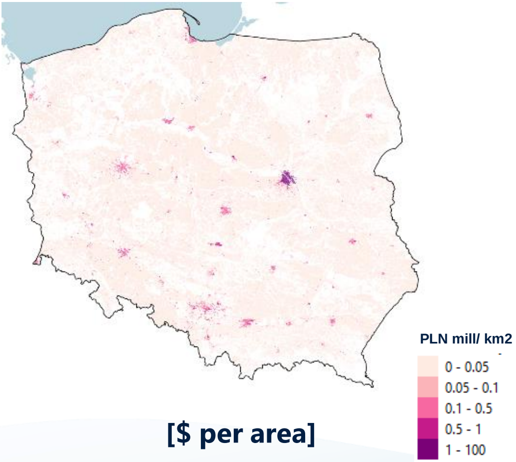
[% of impervious land]

+

Land use



Total value of capital per area



[$ per area]

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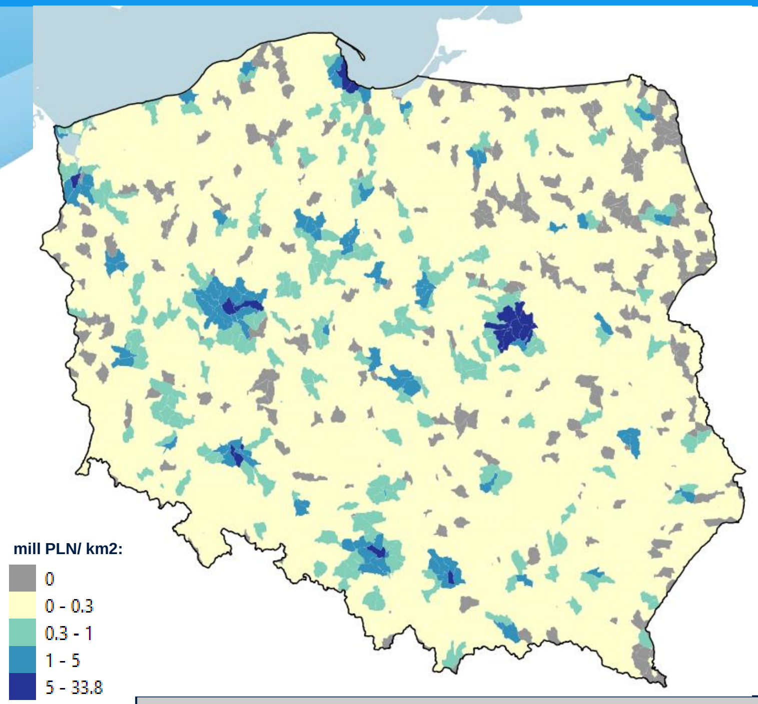
Water

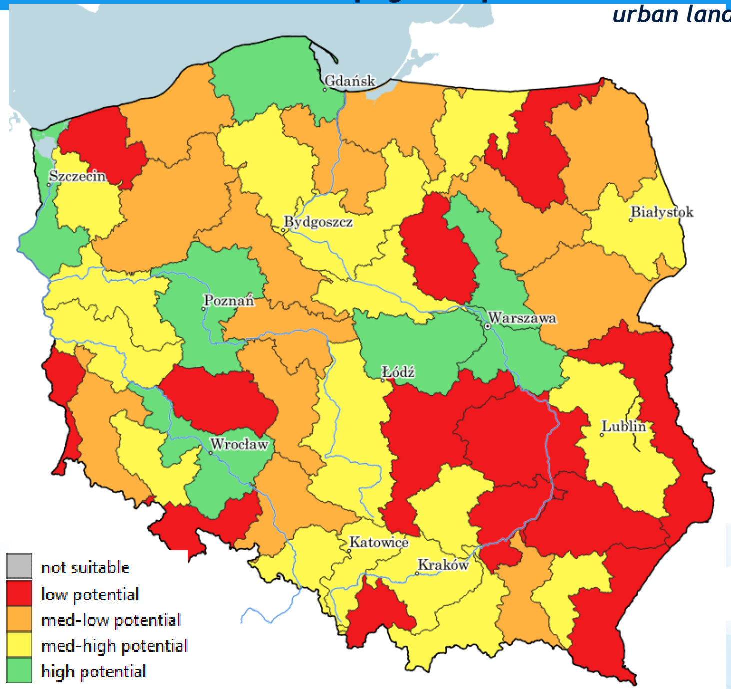
d1. Green urban flooding solutions

Stoplight indicator: average capital value per km² of impervious urban land

Value of capital per impervious urban land area



Stoplight map



Takeaways / discussion points:

- **All urbanized areas of Poland are considered exposed to urban (pluvial) flooding.**
- **Green solutions are feasible in any location, but at a local scale, land uses and values may pose trade-offs. This is not captured in this analysis.**
- **Highest potential is in largest, where there is a high concentration of capital.**

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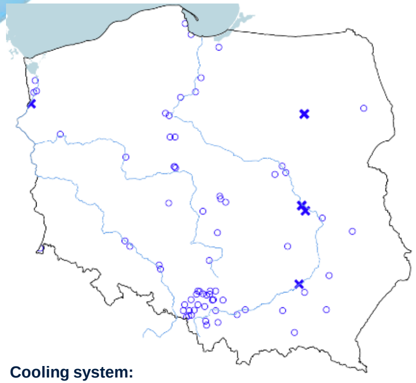
e1. Convert coal-fired power plants to dry cooling

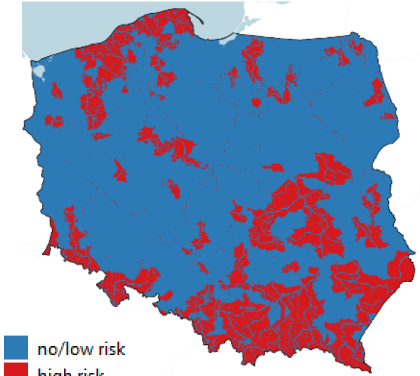
Feasibility: water cooling plants

Location of coal-fired power plants



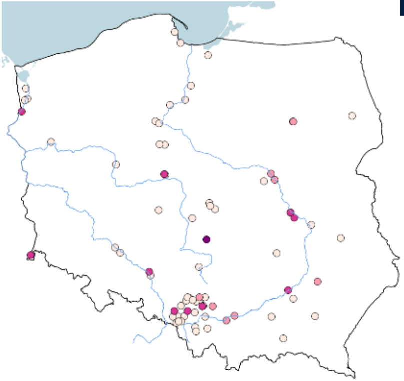
Hazard: drought

High hydrological drought hazard



[drought hazard level]

Opportunity: generation (MW) cooling water requirement



Energy generation per plant

[MWh]

Cooling water consumption per plant [mcm]

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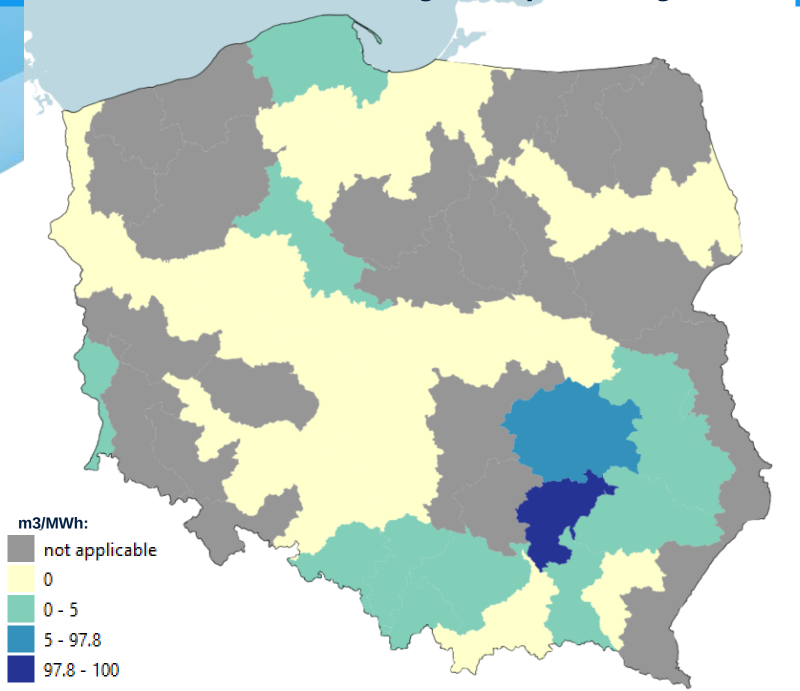
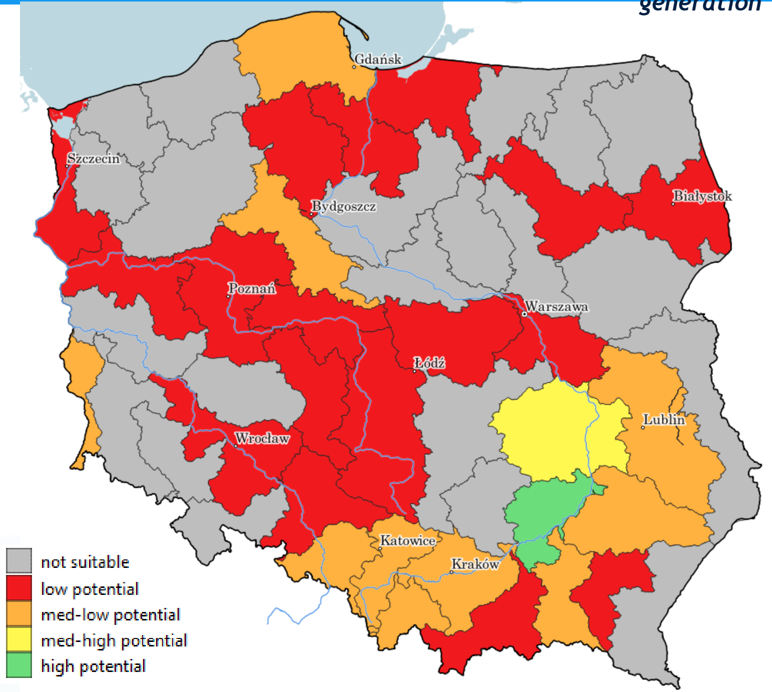
e1. Convert coal-fired power plants to dry cooling

Stoplight indicator: sum of m³ of cooling water per MWh of generation

Cubic meter of cooling water per MWh generated



Stoplight map



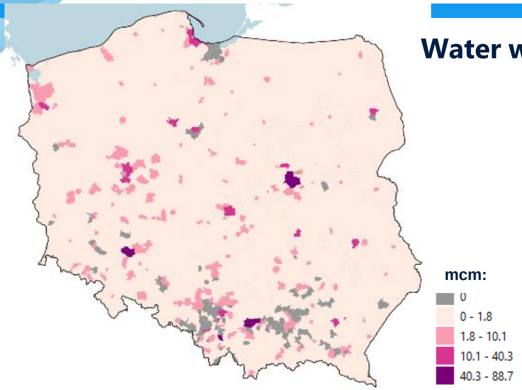
Takeaways / discussion points:

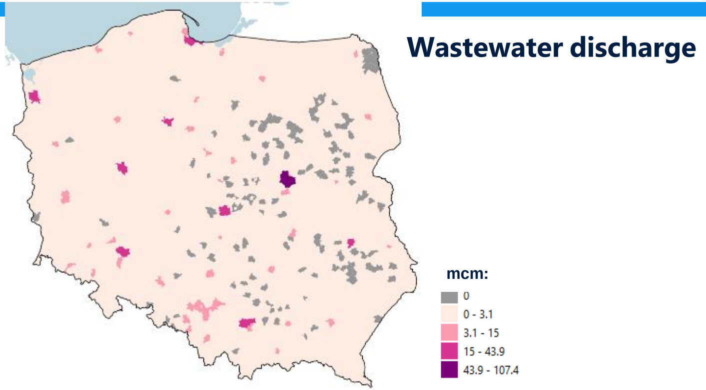
- Conversion of thermal cooling could consider more water-efficient system, as well as development of other source that do not require (as much) water cooling.
- Potential is limited to the specific location of power plants with open cooling, in the middle-upper Wisla

e2. Water conservation & reuse practices

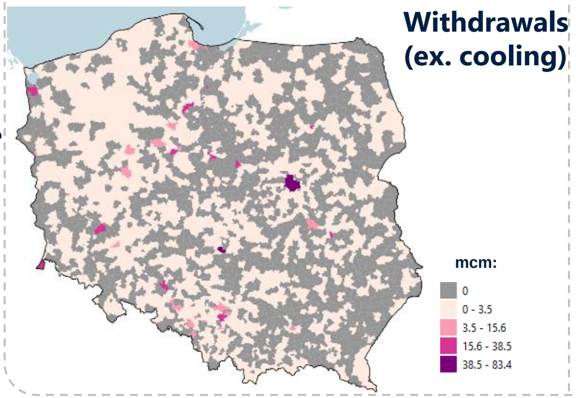
Opportunity: share of withdrawals discharged, by sector

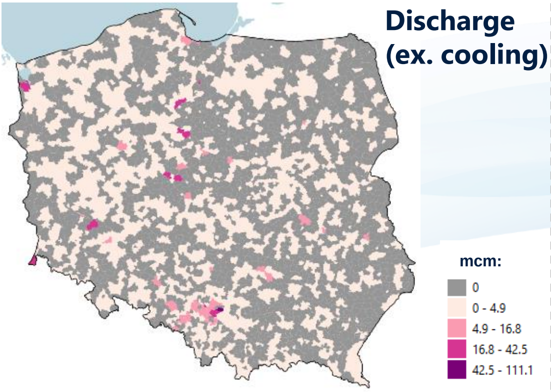
Municipal

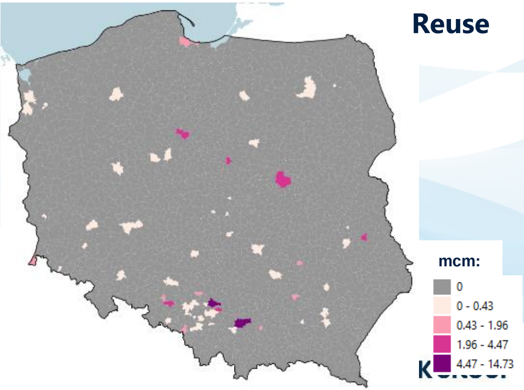




Industry







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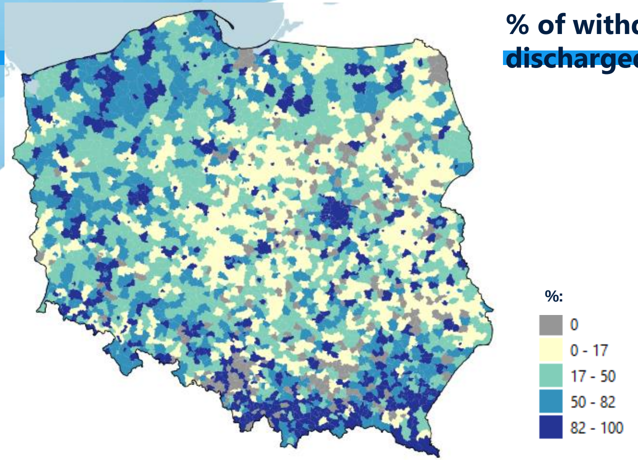
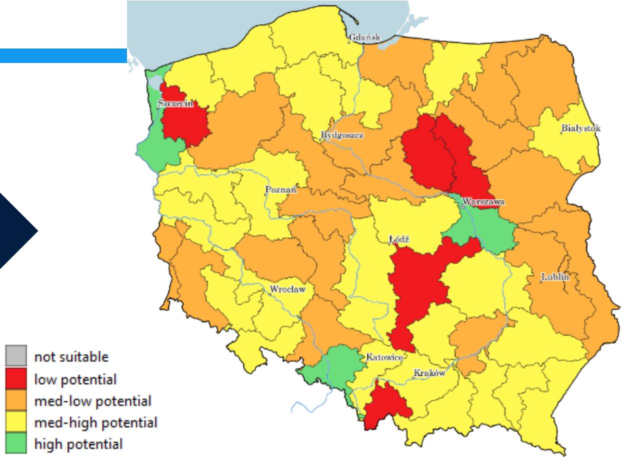
e2. Water conservation & reuse practices

% of withdrawals discharged

Stoplight indicator: mean % of withdrawals discharged

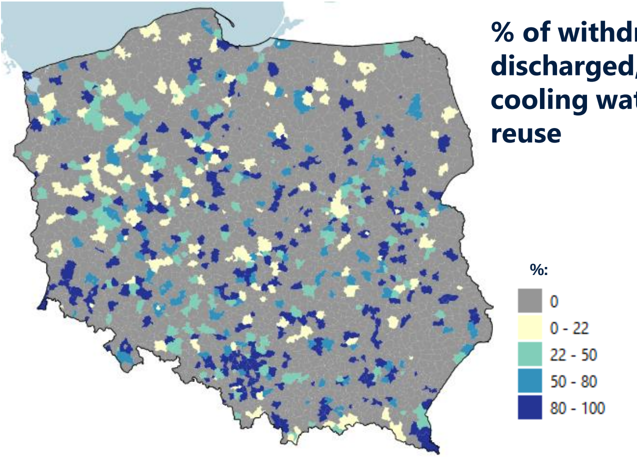
Municipal

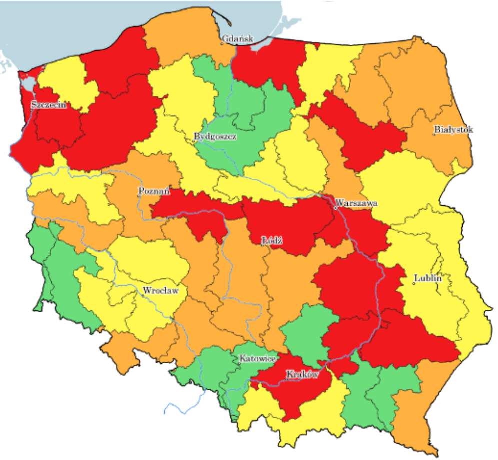




% of withdrawals discharged, excluding cooling water and reuse

Industry





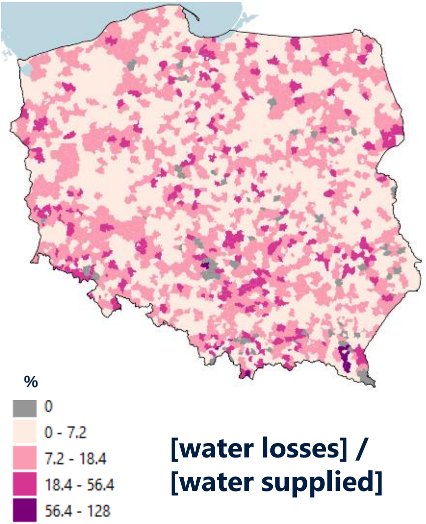
Takeaways / discussion points:

- **Indicator represents where there is higher non-consumptive use of water, which could be conserved.**
- **In addition, it also indicates where there is more wastewater that could be reused.**

f1. Improve quality of WSS infrastructure

Hazard: % of water supply lost

Proportion of water losses

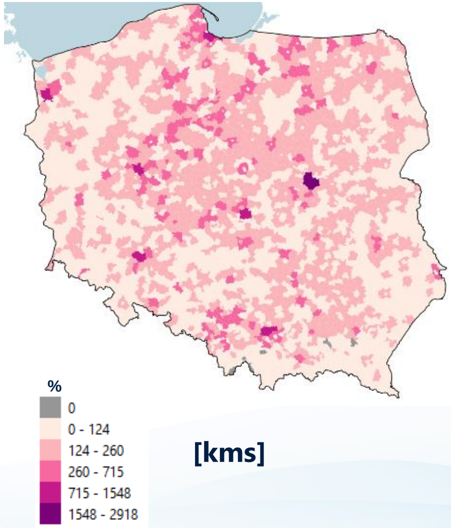


[water losses] / [water supplied]

+

Opportunity: losses per km

Water supply network length



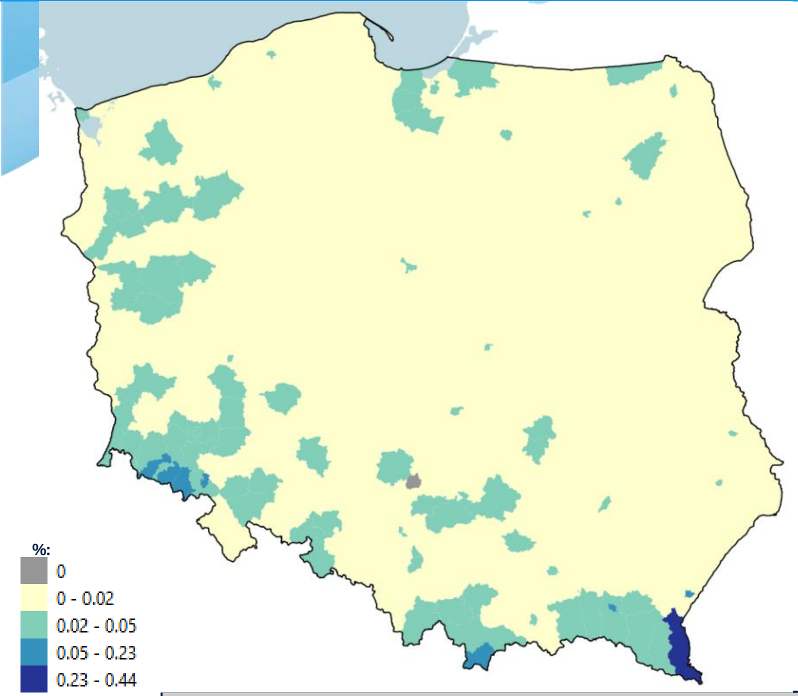
[kms]

IEc

WORLD BANK GROUP Water

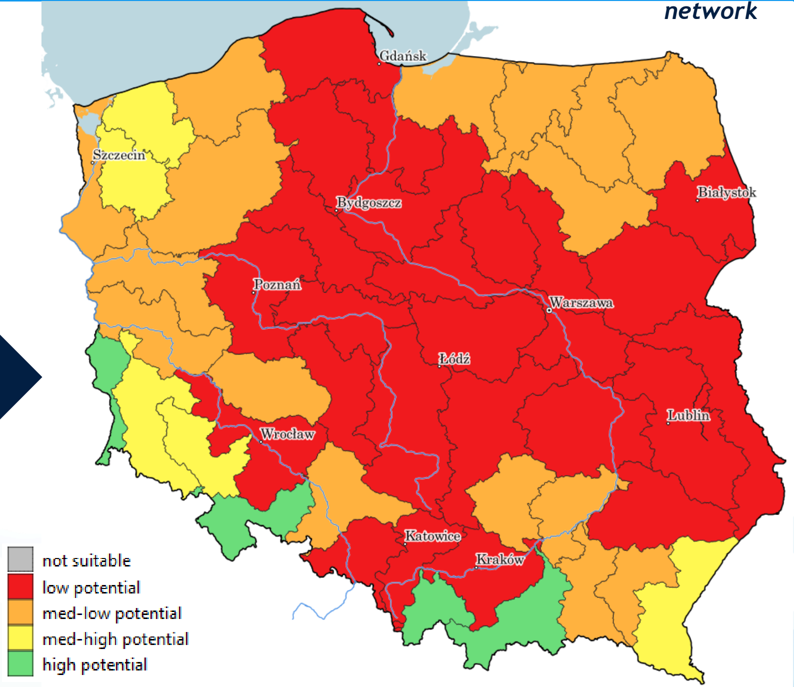
f1. Improve quality of WSS infrastructure

% of water lost per km of water supply network



Stoplight map

Stoplight indicator: mean % of water lost per km of supply network



Takeaways / discussion points:

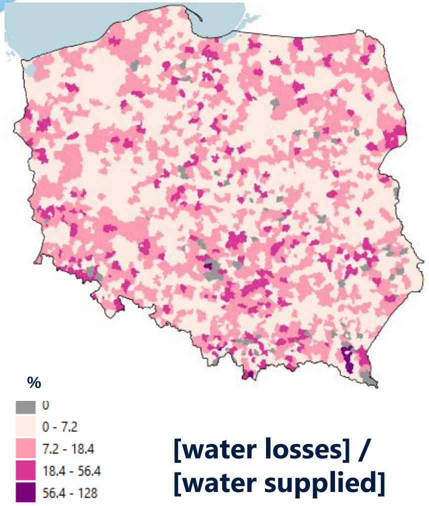
- **Highest percent of leakage in the southern and western areas of Poland.**
- **Low potential does not indicate lack of need to improve infrastructure, but rather a lower priority in terms of reducing water losses.**

f2. Enhance capacities of utilities

Hazard: % of water supply lost

Opportunity: average per capita losses by utility

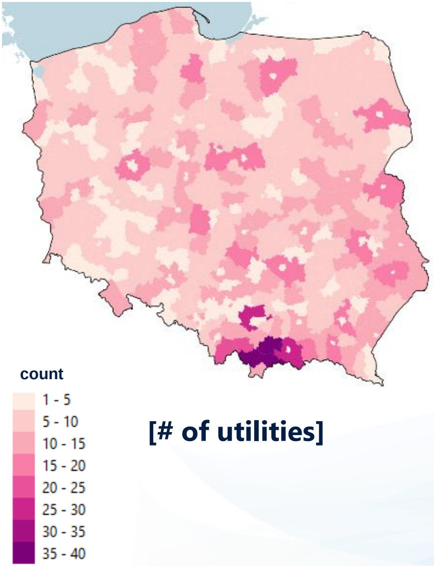
Proportion of water losses



[water losses] / [water supplied]

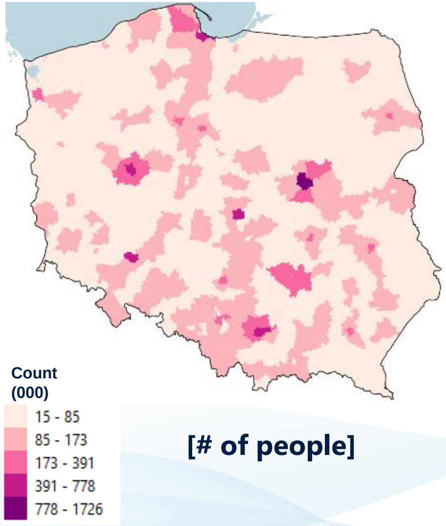
+

Utilities per powiat



[# of utilities]

Population served by public water supply



[# of people]

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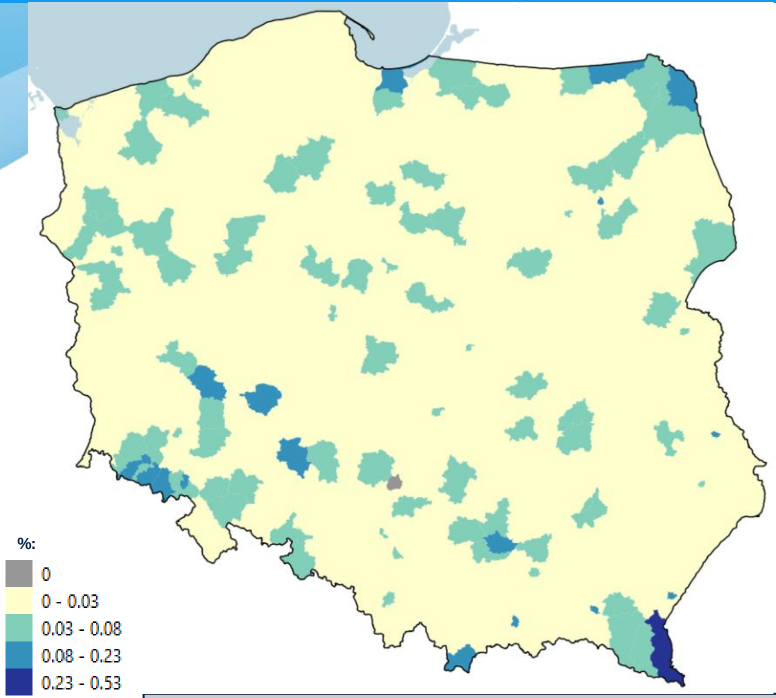
WORLD BANK GROUP Water

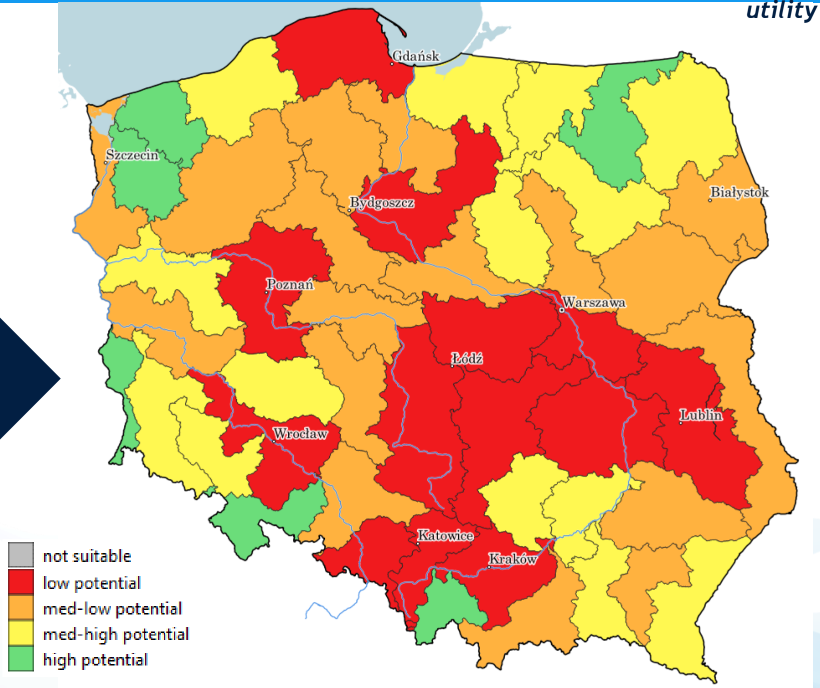
f2. Enhance capacities of utilities

Stoplight indicator: % of water lost per person served by utility

% of water that a utility loses per every 1,000 people served



Stoplight map



Takeaways / discussion points:

- **Indicator represents where the improvement of the management capacity of a single utility could result in a higher amount of water savings.**
- **Highest water lost by utility per customer is generally located outside large cities.**

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