Quick Scan of Natural Water Retention Measures in the Osownica & Cienka river catchments in Poland

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1. Introduction

The Osownica and Cienka river catchments are located in central Poland, around 50 kilometres North-east of Warsaw. The catchments are increasingly vulnerable to climate change, especially intense summer droughts. This desktop study provides an overview of the present situation and the potential of Nature-Based Solutions (NBS) such as Natural Water Retention Measures (NWRM).

The results are presented at an interactive website: https://media.stroming.nl/poland/#

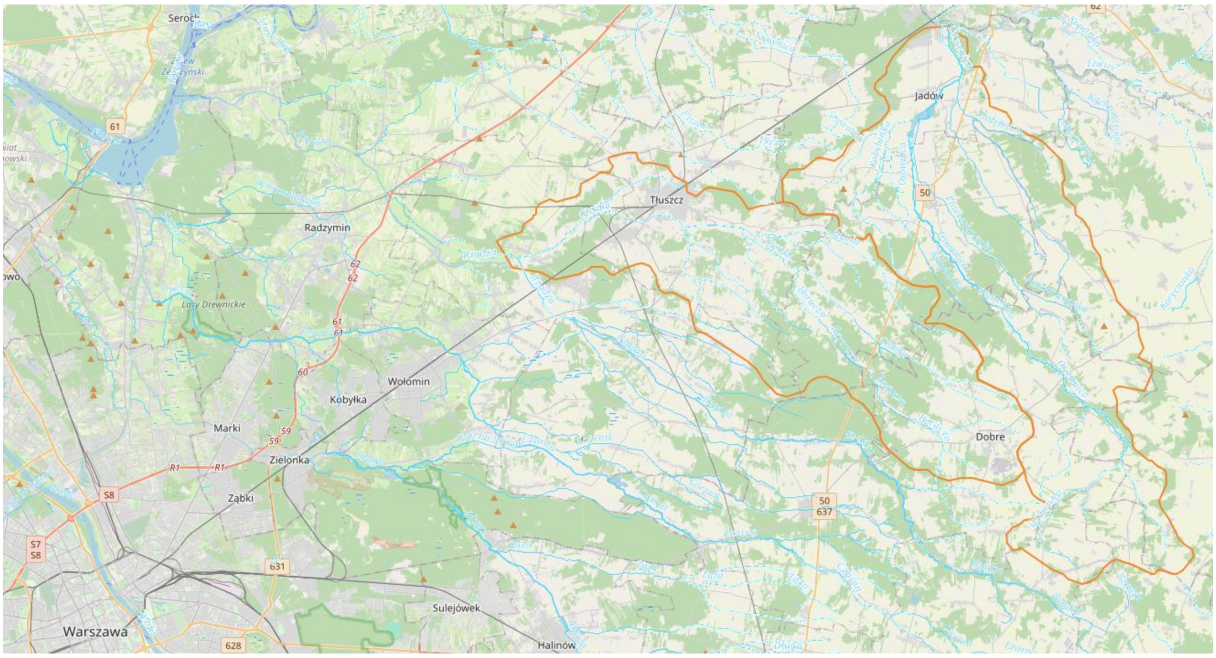


Figure 1: The catchments of the rivers Cienka (left) and Osownica (right), situated North-east of Warsaw.

2. Catchment analysis

1.1. Osownica river:

The Osownica river (40 km in length) drains a catchment area of 234 km2. It originates near the town of Wiśniew and flows Northwest through the Kałuszyńska Upland and the Wołomin Plain. The Osownica discharges its water in the river Liwiec north of Jadów town. The mean discharge of the Liwiec river is 12 m3/s. The Osownica is regulated in many sections and connected to a system of drainage ditches and fishponds.

Land use

The land use consists of cultivated agriculture and forests, both deciduous and pine forest. Especially the upper and lower part of the catchment are cultivated. The centre of the catchment is covered by forests and is defined as an ecological corridor (see map 'Nature'). A quick scan of the surface areas shows that the land is covered by 28% forest, 2% urban area and 69% rural areas. The rural area consist mainly of farmland, farmyard, meadows, and orchard.

In general forests and grasslands are beneficial for infiltration rates and for the sponge function of the landscape. Infiltration in the soil is important for delayed contribution of rainwater to the discharge as it enlarge the baseflow. Especially during dry periods, the baseflow is an important source of water. Therefore, water should be able to infiltrate.

The altitude of the highest part of the catchment is 220 m (figure 2). At the confluence with the Liwiec river the surface level is 90 m. However, 1/3 of the catchment at the downstream side has roughly the same elevation height (see elevation map in appendix) . Therefore, most of the descendance occurs over the upper 2/3 of the catchment. Here, the river descends roughly 4 metre/kilometre. The flow velocity is therefore higher in the upstream part and decreases in at the lower 1/3 part of the catchment. Especially in this downstream part the streams are canalized. This is a logical result of the decrease in flow velocity which enhances the risk to floods. The 'nature' map also shows that this region is more prone to flood risk.

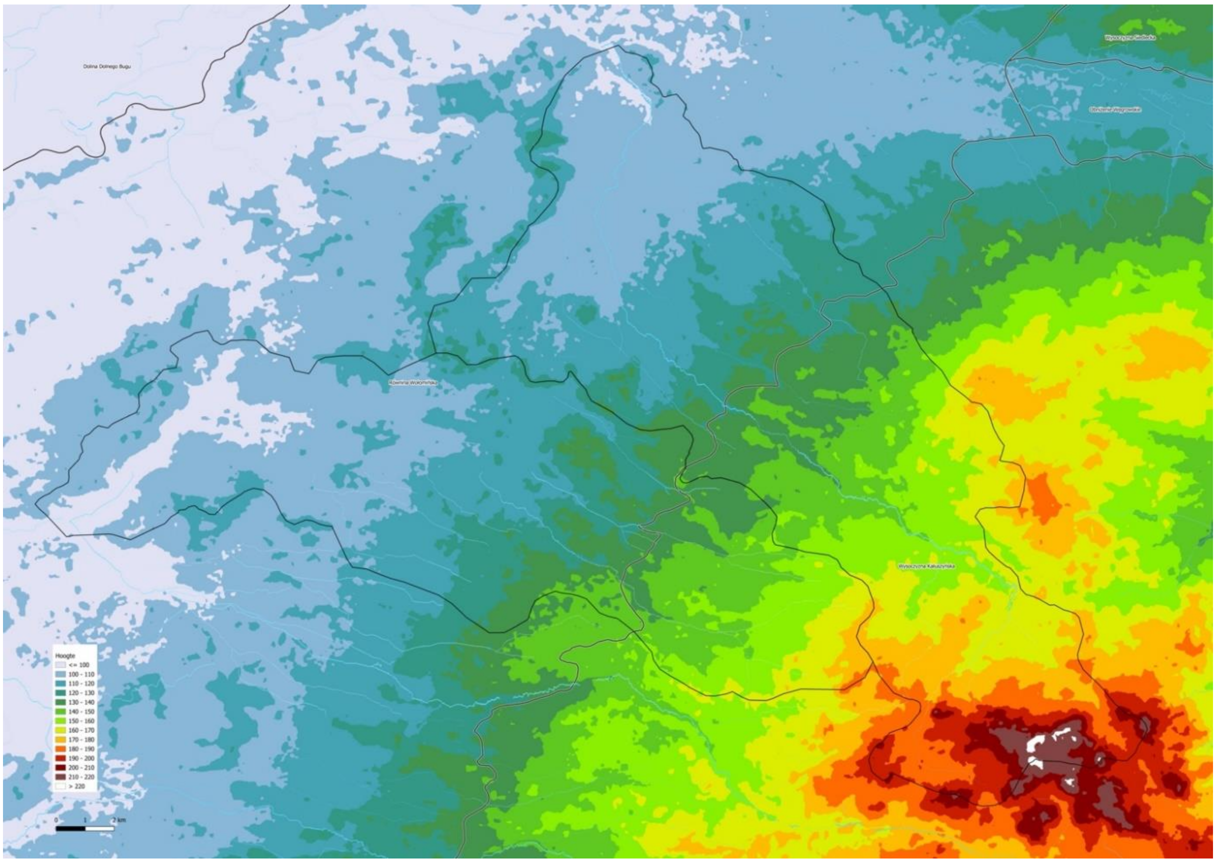


Figure 2: Elevation map of the rivers Osownica and Cienka.

Streams and riparian forests

Besides the Osowinca river the Kobylanka, Prilewnczanka and Golebinca river flows through the catchment. These streams confluence with the Osowinca. Adjacent to many of the streams forest strokes can be found. These riparian forest buffers have many water quality benefits and help to stabilize the riverbanks and decrease erosion during higher water levels.

Meandering patterns of the streams, natural valleys in combination with these riparian zones enhance the flood safety. As this is beneficial in the face of flood risk, the challenges in the catchment are more linked to the deficit of water. As the rivers and streams are mostly intermittent streams, which means that the groundwater level is located below the streambed during dry periods and the streams fall dry for a certain period of time. During these dry periods precipitation is the main source for stream flow.

Stream pattern

When analysing the stream pattern multiple characteristics can be differentiated. These are shown in the map 'Situational performance'. The yellow bullets provide information on if the stream is straightened, canalized, or meandering. In addition, information on the valley through which the streams attenuates such as agricultural, natural, or forested is given. On some occasions bever activity, man-made ponds or water basins can be found.

To structure the streams the hydrological Strahler order method is applied which helps to analyse the system by classifying the streams (see Figure 4a). Also, each stream is labelled with the corresponding flow pattern (Figure 4b). This method helps to indicate the characteristics of the streams and therefore provides the necessary information for adequate potential NBS. This Strahler method accounts for the natural water system. However, in both catchment many drainages ditches discharge are dug in order to reduce the groundwater level on the farmlands. As this drainage system needs to be taken into account in this report it is called as the 0-order.

0-order streams (drainage channels)

The topography map also shows the extensive drainage channel network. An example of this network is visualized in Figure 3. The drainage channels discharge the surplus of rain water and melting snow in winter time. This reduces infiltration and therefore drought in summer time increases. There are chances for natural water retention in areas with drainage channels by removing them.

Figure 3: Drainage channels in agricultural area

1st order streams

First-order streams are often connected to drainage channels. The streams that are not connected are dominated by overland flow or sub surface flow as they have no upstream concentrated flow. These streams are sensible to pollution and can derive most benefit from wide riparian buffers than other areas of the watershed. First-order streams are more suitable for water retention measures in the soil and for measures that reduce the runoff and improve the sponge function of the landscape. As drought issues are more relevant the infiltration capacity should be restored in these areas to improve the water storage capacity of the soil. This can be achieved by a transition of the land use to a vegetated cover and reduce the drainage system of farmlands and forests.

2nd order streams

Both the Osownica, Kobylanka and Prilewnczanka are 2nd order streams. These streams receive water from tributaries. The second-order streams distribute the water through the catchment and therefore measures that decrease the flow velocity and retain water in the landscape are most suitable. The map shows that, especially the Osowinca already has a natural meandering pattern which reduces the flow. Therefore, the opportunity to improvement is more linked to restoring water. Measures to think about are natural floodplains to improve water retention (In cooperation with beaver activity).

As drought is the main issue in the catchment natural inland wetlands could really contribute to store water. The forest in the centre of the catchment through which the Osowinca flows could be a suitable location. The part of the streams in the 2nd order that are more straight could be transitioned to a meandering pattern. This especially accounts for the downstream canalized parts. Reducing the flow in these parts will result in higher water levels during peak events. Therefore, it is important to create room for the river and its banks.

3rd order stream

The downstream part of the Osownica is defined as a third order as multiple streams collide. The centre part of the third order stream has a natural meandering pattern. The other sections are mostly straightened or canalized. In this section the same natural principles account as in the second order only the focus should be more on reducing flow velocity than on retention. Water basins downstream such south of Jadow does not contribute to the availability of water during drought. Therefore, water retention measures are less suitable in this section in the river.

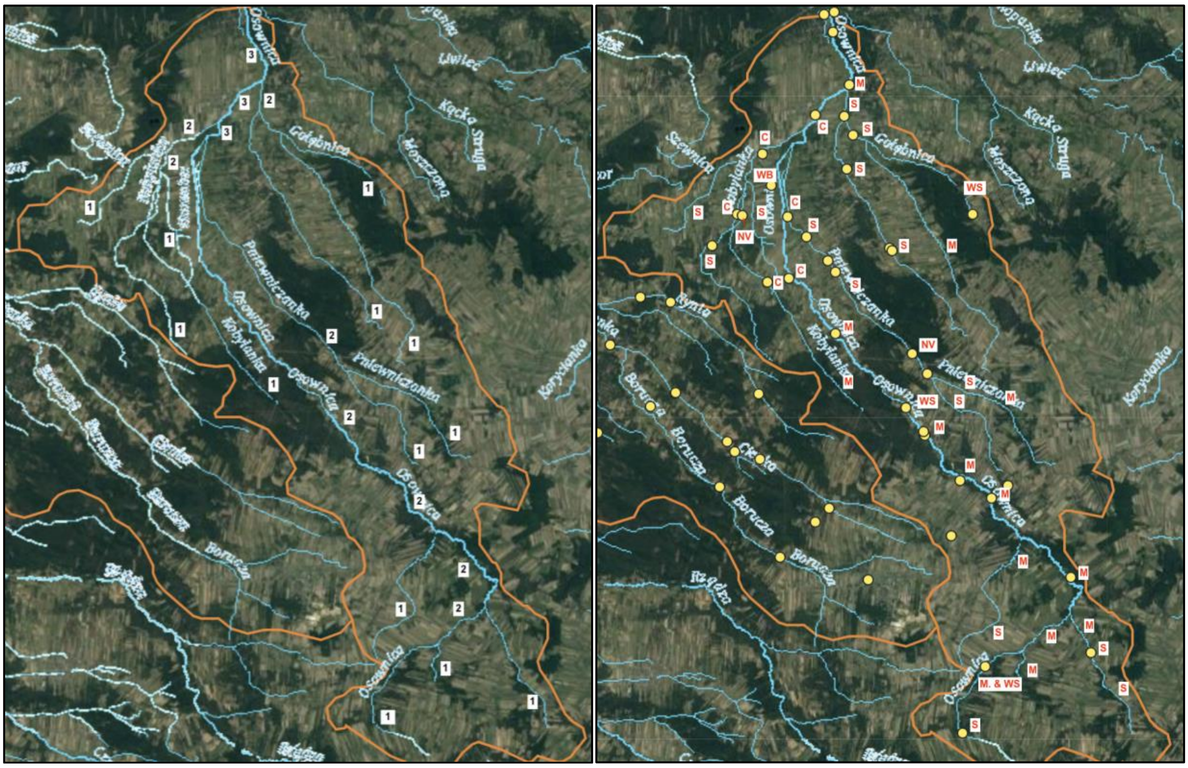


Figure 4a: Strahler method applied on Osownica catchment. Figure 4b: River pattern Osownica catchment. S = Straight, C = Channel, M = meandering, WB = water basin

1.2. Cienka

The Cienka river (30 km in length) drains a catchment area of 179 km2 and is slightly smaller than the Osownica catchment. The source of the river is near the town of Dobre and flows in to the Northeast and south of the Tluszcz town. The streams Rynia (north of Cienka) and Borucza (south of Cienka) join the Cienka river at the more downstream part of the centre of the catchment. Before Tluszcz the smaller tributary 'Jatzwie' collides with the Cienka river.

The centre of the catchment is dominated by a forest which is a broader extension of the ecological corridor mentioned in the Osownica catchment. This natural valley through which the streams flows provides good opportunities for the water flood its banks.

The catchments land cover exists of a variety of farmland and small forest patches. The area downstream is especially dominated by urban areas due to the towns of Tluszs and Jasienca. In comparison with the Osownica the Cienka and Rynia river have less forests adjacent to the river banks and flows more through agricultural valleys. The Borucza has a more natural character and remains its meandering pattern. The land cover distribution is noted in the table below with the Osownica catchment for comparison. The Cienka catchment has more forest but a larger urban area as well. The main land use is farmland.

	Cienka [km2]	%	Osownica [km2]	%
Catchment area	179	100%	229	100%
Forest	68	38%	64	28%
Urban	9	5%	5.	2%
Farmland	100	56%	159	69%

Table 1: Land cover catchments.

The Cienka originates at an altitude of 155m, gradually descending to <100 m. The descendance occurs especially over the upstream 16 km where the difference in altitude is 50 m. The slope of the riverbed is 3,1 m/ kilometre in the upstream area. The slope of the downstream part is probably in the order of magnitude of 1.5 m/ kilometre. The streams in the Cienka catchment are often straightened, canalized, and multiple drainage channels are constructed.
The last eight years the streams disappear in summertime which indicates a deficit of baseflow and the lack of infiltration to fill the groundwater storage. This lack of infiltration is partly caused by the extensive drainage network surrounding the streams.

Stream pattern
The drainage channel network is extensive in the Cienka catchment. Even forested areas are drained by a close network of channels (Figure 5). The drainage channels discharge the surplus of rain water and melting snow in winter time. This reduces infiltration and therefore drought in summer time increases. There are chances for natural water retention in areas with drainage channels by removing them.

Figure 5: Drainage channels near Rynia stream in Cienka catchment

Figure 7 shows the straight patterns of the Cienka catchment streams. The Borucza does have a long consecutive meandering pattern while only small sections of the Cienka meander. Furthermore, what stands out is the fact that the 1st-order streams are much shorter in length than at the Osownica catchment. This means that the catchment discharges its water faster and therefore the catchment retains less water upstream. For the Osownica catchment the natural measures that are suitable to the linked Strahler order are described and account for the Cienka as well. However, the opportunities for the measures are different and are related to the land use and drainage and stream pattern. In the Cienka catchment a large opportunity to maintain more water is to restore the meandering pattern of the streams. This reduces the flow and decreases the time water is lost when it enters the streams. Furthermore enlarging the areas of the riparian forest parallel to the streams would delay the flow of water.

As the downstream part is more cultivated and urbanized the potential for wetlands to retain water are present in the forested part of the catchment.

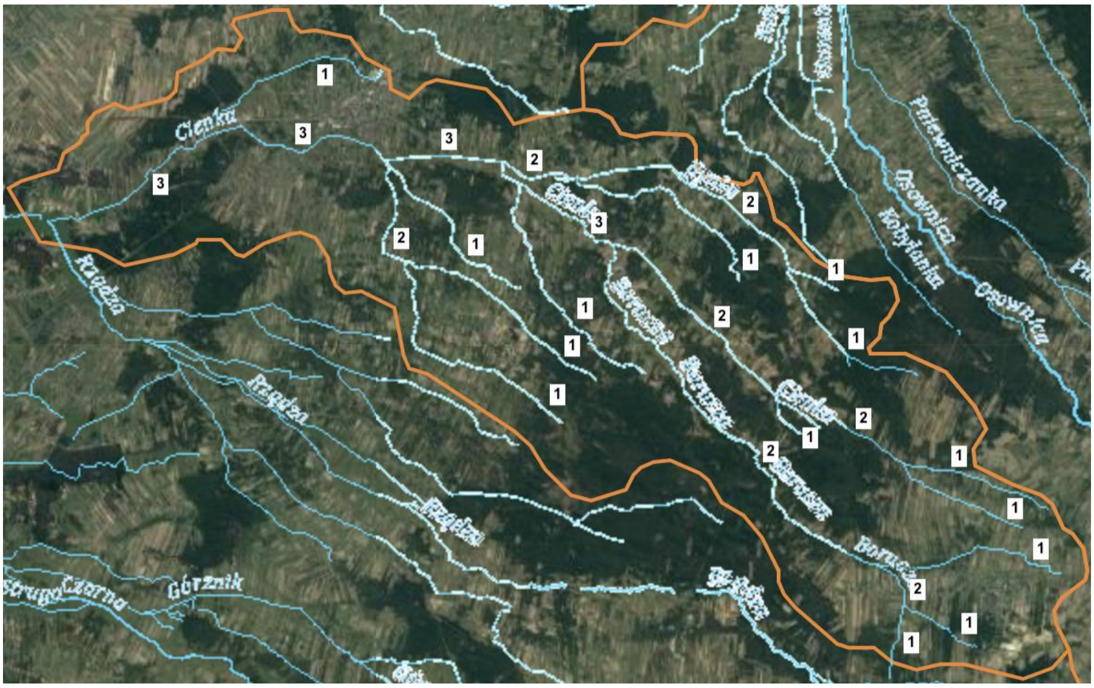


Figure 6: Strahler order method applied on Cienka catchment.

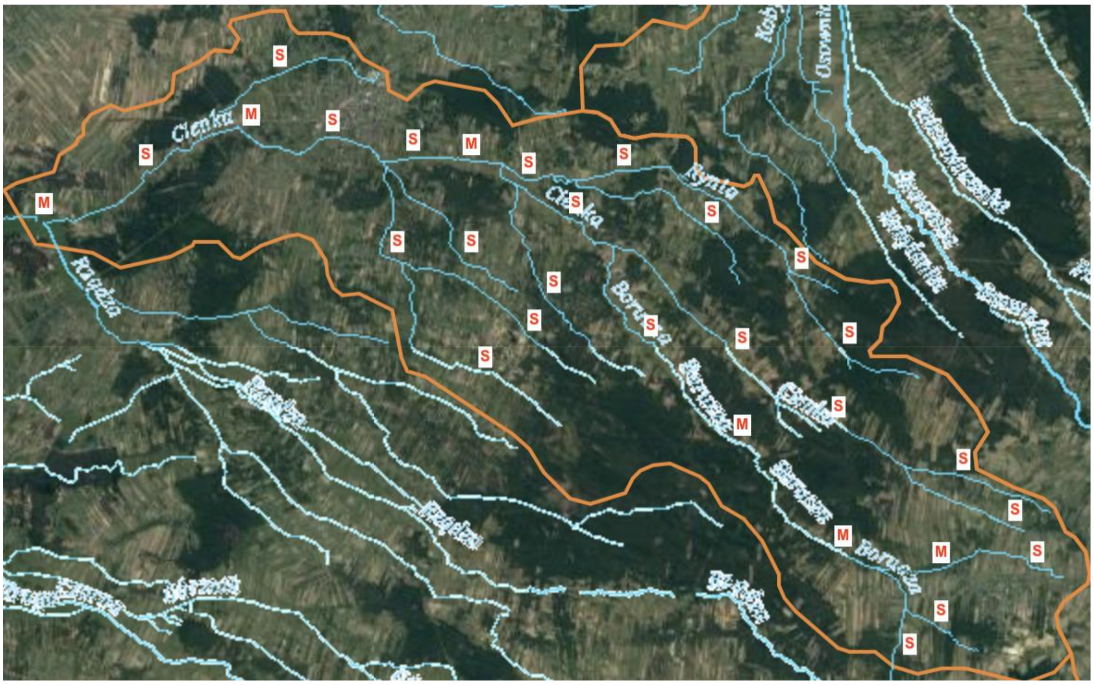
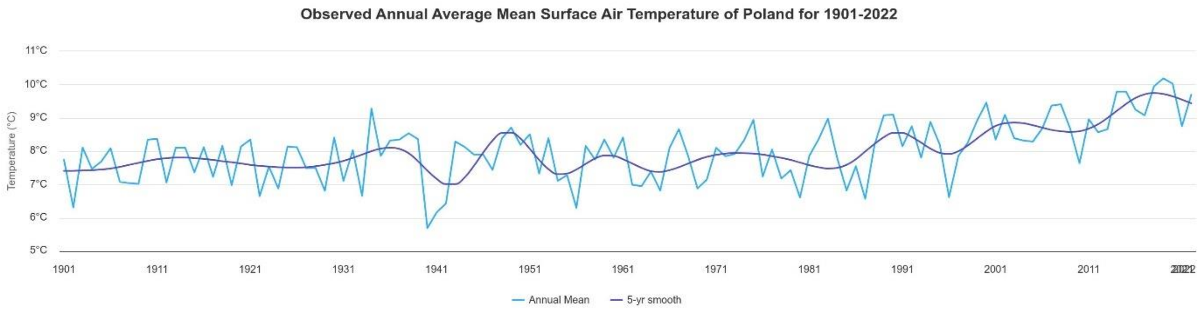


Figure 7: Pattern streams Cienka catchment.

3. Changing weather patterns Poland

Poland, in accordance with the rest of Europe, is facing warmer temperatures, more frequent and severe droughts and heavy rainfall. These shifting weather patterns are leading to an increased risk of wildfires, crop failures, and water quality and quantity issues. Research conducted by the Institute of Environmental Protection indicates that Poland will face further challenges such as shrinking water resources in the upcoming years due to climate-related factors.

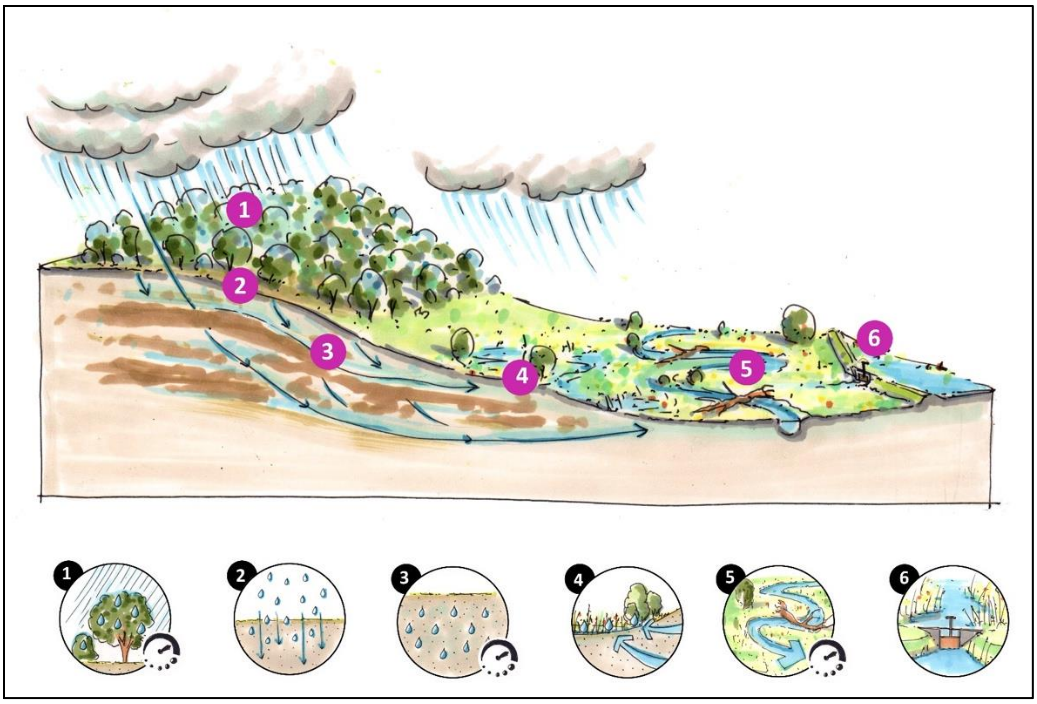
The Figure below of the Climate Change Knowledge Portal clearly shows the increasing max. temperatures over time. The observed annual average temperature increased ca. 2 degrees in the past 100 years.



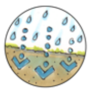
4. Potential of natural water retention measures

Chapter 1 analyses the catchments and already mentioned some opportunities for NBS suitable to the catchments. This chapter describes the principles and measures for natural water retention. Furthermore, specific locations of the catchments where these measures could be applied are shown. As some good examples can already be found in the catchments these are provided as well.

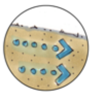
The principles for water retention are visualized in Figure 8. As the catchments have a relatively flat slope and it is unlikely to reallocate the function of agricultural land to a more vegetated landcover principle 1 is less suitable. In the 2nd and 3rd order streams principles 4 and 5 are most suitable. Most opportunities for re-infiltrating the water lies in adjustments to the drainage channels (0-order) and 1st order streams which are linked to principle 2 and 3.



1. Rain drop interception by rough vegetation



2. Rainwater reaching the surface is able to infiltrate



3. Water temporarily stored in soil layers should stay there as long as possible, otherwise re-infiltrate

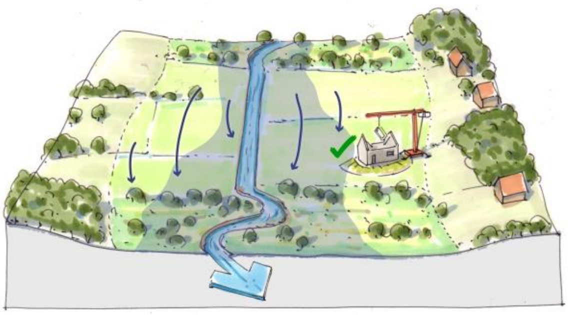
4. Sub surface water rising to the surface should be stored in rough vegetation in the valley floors

5. Once water is in the riverbed, use natural floodplains to decrease the flow velocity

Figure 8: Natural water retention principles.

4.1. Delaying water in the stream and valley

Figure 9 shows the straightened flow of the Cienka river while the old meanders patterns are still visible. In this situation the visualized concept of restoring its meandering pattern which results in a wider and shallower stream which reduces the flow velocity can be applied. Figure 8. provides an example of a more natural meandering pattern of the Osownica river which has a much more natural character. Figure 11 visualizes the natural embankments from a more detailed perspective.



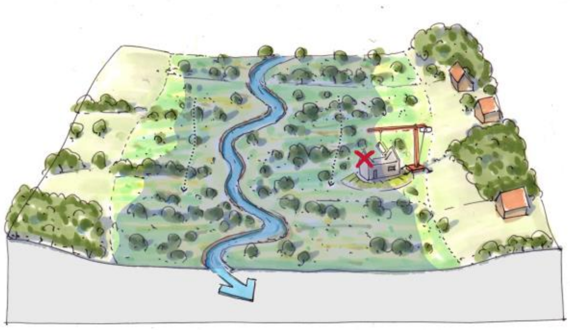


Figure 9: Straightened Cienka. 2nd order stream

Figure 10: Boruscza meandering section. 2nd order stream

Figure 11. Forested embankments and meandering Osownica.

In the more upstream sections of the stream's obstacles can contribute to water storage capacity due to the small ponds created by for e.g., bever activity and these obstacles reduce the discharge to the streams in the valley. Figures 12 and 13 visualize the aimed conversion. In Figure 13 bever activity is located and the water holding capacity is clearly visible.

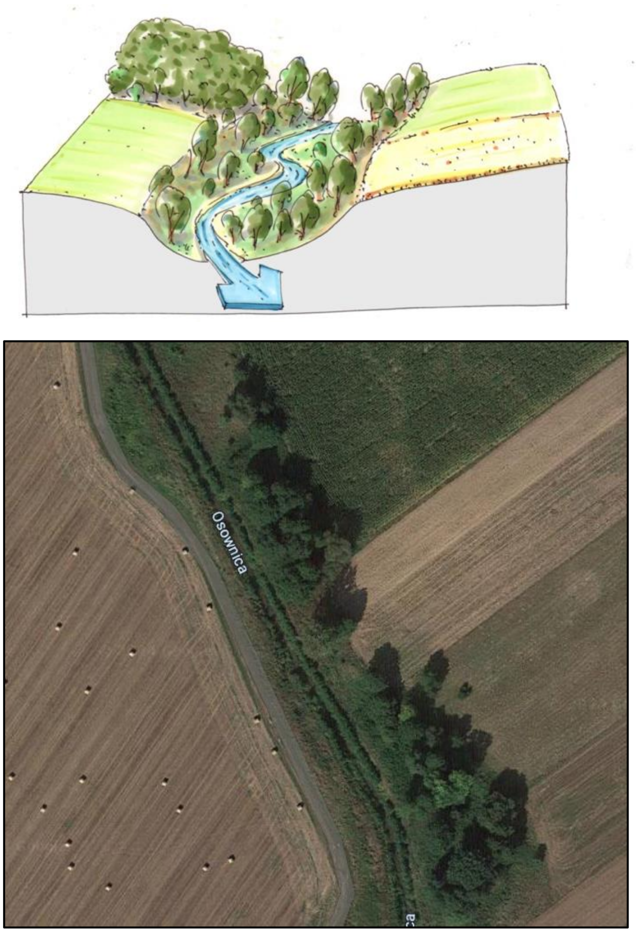


Figure 12: Osownica stream straightened.

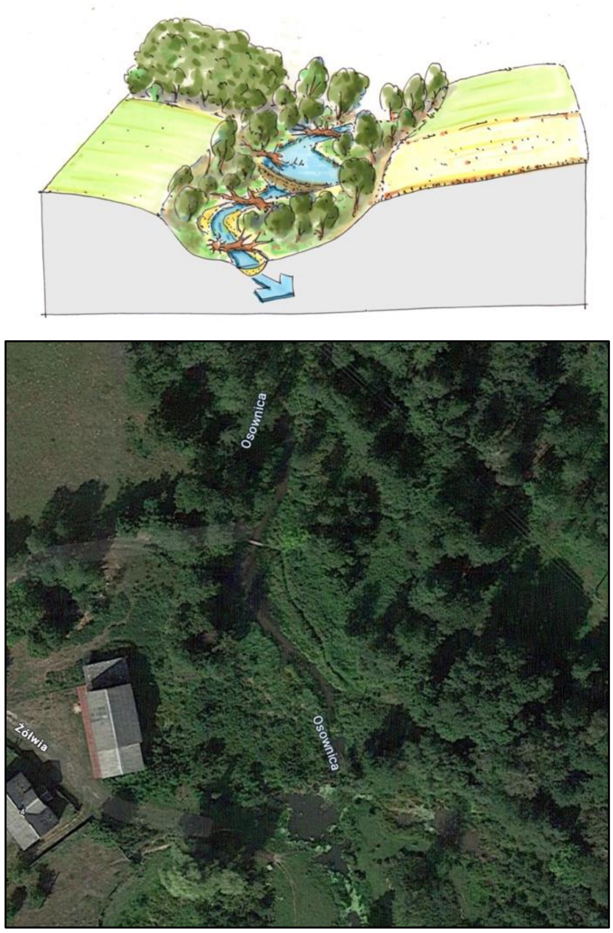
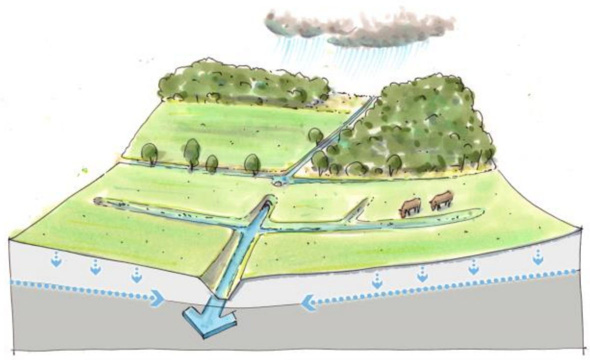


Figure 13: Bever activity in the Osownica river

3.2. Delaying water in natural wetlands

The drainage density in the catchments in quite extensive and therefore the runoff is high, and water is not able to reinfiltrate into the soil. Drainage ditches such as in Figures 14 and 15 are constructed to prevent high groundwater levels in the farmlands which makes the land more suitable for agriculture. These ditches can be converted to a more natural streams. An example of such a wetland is shown in Figure 15.



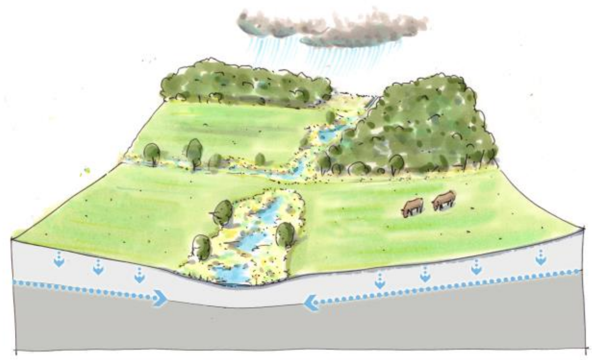


Figure 14. Cienka upstream straightened. 1st order

Figure 15: More natural landcover adjacent to stream Cienka catchment.

Figure 16. Drainage ditch in Cienka Catchment. First order stream

Figure 17. Stream in with more natural banks Cienka catchment. 1st order stream

In order to re-infiltrate drained water natural wetlands should be used to temporally store the water while discharging water at a slower pace. In the Osowinca catchment a good example can be found upstream in a 1^{st} order stream.

Figure 18. Cienka through agricultural valley. 3^{rth} order (left) Rynia in natural valley. 2^{nd} order stream (right)

Figure 19: Natural upstream wetland in Osownica catchment

5. Initial recommendations for NBS measures

Retaining more water in upstream natural sponges can create multiple benefits: reducing downstream peak flood discharges and increasing base flows of water in times of drought.
Removing drainage channels and restoring infiltration capacity in the upper catchments are effective measures to obtain these goals.

Reducing the discharge in the river valley by her-meandering streams and convert the banks to a more natural floodplains is beneficial as it increases the time water remains in the catchment.

Within the landscape, there are many possibilities to increase nature-based flood resilience in the analysed catchments.

Figure 20 provides a summarizing overview of the possibilities to convert a catchment to a water retaining catchment using NBS. In the Osownica and Cienka catchment multiple good water retention locations are already present. However, there is room for improvement. Focus points for improvement are provided in this desktop study. Furthermore, it is important to implement multiple solutions as especially a variety of adequate measures contribute to the natural water retention function of a catchment as a whole.

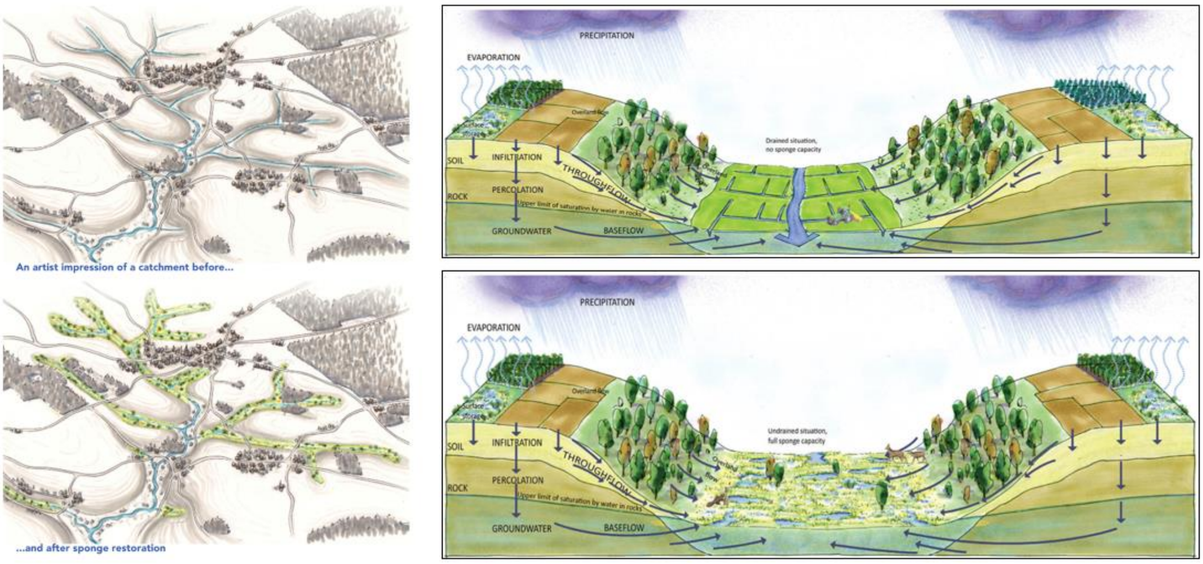


Figure 20: Illustrating the change from fast drainage in an upper catchment valley bottom (top) to a natural sponge (bottom) that retains and slows the flow of water downstream.