Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
FRESH4Cs
European Regional Development Fund

Investment 4: Water storage in Kwetshage (BE)

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Date: 24/03/2023

FRESH4Cs has received funding from the Interreg 2 Seas programme 2014-2020 co-funded by the European Regional Development Fund under subsidy contract No 2S06-028.

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Executive Summary

The demo site Kwetshage within Fresh4Cs is part of larger projects at the site, part of the Kwetshage Project. In the Kwetshage Project above ground water storage is increased in order to meet Nature 2000 goals for the area. The area also serves a flood buffer area, which means that above ground storage of water inevitably results in a reduction of buffer capacity during floods. In Kwetshage a combination of water storage, increased infiltration and increasing flood buffer capacity is targeted.

Within FRESH4Cs we specifically focused on increasing water storage in the area. Additional water is brought to the site through a combination of a wind mill and weir, and local excavations allow for more storage capacity without impeding the local flood buffer capacity. Based on the expected mean flow rate of the wind water mill, mean precipitation and expected infiltration of the stored water a net storage rate of 750 m^3 per day is expected. This theoretical net capacity is confirmed by monitoring of the first operations in October and November 2022. The total net storage capacity realized in the demo amounts to 36.000 m^3. The amount of stored water infiltrating to the ground water is estimated at 20.000 m^3 per year, based on modelling results, which corresponds to 55% of the storage capacity. The water which is pumped into the demo site during winter consists of excess surface water from the adjacent part of the project area, which is otherwise evacuated to a downstream lying pumping station. As such a total volume of water of ± 56.000 m^3 per year is prevented from being evacuated outside the project area.

The water gathered and stored during winter is used for habitat development. Water level will be allowed to drop towards a minimum level in summer, primarily through evapotranspiration. A difference in water level between winter and summer level of 30 tot 40 cm is necessary for the development of reed marsh. The filling capacity is high enough to refill the site to maximum level during the following winter.

Although the purpose of the project is nature development, practice and experience in this demo serve in implementing measures for sustainable water management in agricultural areas of the Flemish polders in general.

Introduction

It is common practice in the Flemish Polders to maintain low water levels in ditches and waterways during winter period (November – March) and higher water levels during spring and summer months (April - October). Low water levels during winter are maintained by gravitational draining and pumping towards the sea. Higher levels during summer are maintained by using external water supplied by canals from inland. The low water levels in winter and early spring permit to anticipate on possible flooding during periods with high rainfall. Higher water levels in spring and summer are needed for supplying agricultural practices with enough water and for suppressing rising brackish groundwater to the upper parts of the soil.

In recent years spring and summer tend to have prolonged dry spells as a result of climate change. Under this polder water management mode this generates risks of water shortage. Yet during winter months the excess surface water is directed towards the sea. Thus retaining as much water as possible during periods with excess rainfall, such as (most) winters, seems to be the perfect solution to avoid critical low water levels in future summers. However the practical organization of this seemingly easy way to tackle problems due to climate change is less obvious. The main reason lies in the lack of any substantial difference of elevation in the polder landscape. Without risking unwanted flooding of agricultural land or residential areas, retaining excess water in winter must be confined to well defined areas. However in most cases these areas are already functional flood areas (designated for water storage in case of flooding), whose functioning will be jeopardized by storing excess rainwater. Augmenting water storage capacity and retaining buffer capacity are both important climate related measures, but the tradeoff between these two measures hampers an efficient implementation of mitigating measures for climate change.

The Kwetshage area (total area ±100 ha) is such a flood area located at the edge of the polders in Flanders. The area is designated to be transformed into a major wetland as part of Natura 2000. Retaining water in order to generate a higher water level is a necessary measure to attain the area's goals. Yet the area's function as a flood area should not be affected. For a good ecological functioning of the developing reed marsh, water level during summer should not drop below a minimum level. A minimum level can only be guaranteed if maximum levels in winter are high enough. The higher the water level in winter, the lower the buffer capacity during periods of high rainfall. In Kwetshage we have looked for an optimal combination of lowering the surface (excavations) and increasing water level, spatially differentiated within the area.

Kwetshage serves as a demo for combining water storage and retaining, or even gaining, buffer capacity. Although the purpose of the project is nature development, practice and experience in this demo can serve in implementing measures for sustainable water management in agricultural areas of the polders as well.

Technical aspects of the demo

Aim of the project

The project aims at demonstrating that the establishment of a wetland by means of sufficient storage of water in winter within a functional flood area is possible. Conditions are explored under which storage of water and retaining buffer capacity during floods can be combined.
The demo Kwetshage is integral part of the major project Kwetshage. Investments in the demo area should be considered together with measures taken in other parts of the major project area.

To reach an optimal combination of retaining water in winter without jeopardizing the area's function as a flood area the following principles are followed:

1. Spatial differentiation of water levels within the area to minimize loss of buffer capacity:
    a. Higher water levels in higher lying zone
    b. Lower water levels in lower lying zone

2. Excavations in lower lying zone to:
    a. Generate optimal conditions for habitat development
    b. Generate extra buffer capacity

3. Excavations in het higher lying zone to:
    a. Generate optimal conditions for habitat development
    b. Maximize water retention/storage capacity

This results in higher water retention and storage capacity in het higher lying parts of the project area, with however a substantial loss of buffer capacity, and the generation of additional buffer capacity in the lower lying parts. The additional buffer capacity generated in the lower lying zone must at least compensate for the loss of buffer capacity in zone with high water level.

The demo for Fresh4Cs is confined to the higher lying zone. It consists of an area of approximately 10 ha low lying grasslands (± 2 m TAW[1]) isolated by a sandy creek ridge[2] of approximately 8 ha from the rest of the project area. The creek ridge rises up to 1,5 m above the surrounded grasslands (3,5 m TAW).
Initially a combination of above ground surface water storage and creek ridge infiltration was aimed at as a means of retaining excess surface water in winter. However, due to a delay in obtaining the environmental permit the part of creek ridge infiltration had to be cancelled, as this could not have been performed within the time frame of the FRESH4Cs project.

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[1] TAW: Tweede Algemene Waterpassing is the Belgian Ordnance Datum (altitude reference level). 0 m TAW is about -2.33 m NAP which is also about average sea level for Belgium. So 2 meter TAW is located about 30 cm below average sea level.

[2] Creek Ridge: name for a sandy soil body in the otherwise clayey polders, formed by a former tidal creek. Because of the larger compaction of clayey sediments, they often coincide with slightly higher places in the landscape, hence their name.

Demo setup

The demo consists of:

1. **<u>Excavation</u>**

Figure 1 shows a plan with the area of excavation. 20.000 m^3 of ground is excavated over an area of ± 6 ha. This means a mean depth of excavation of 0,33 m. This excavation generates the necessary conditions for the development of water reed, hereby also increasing the water storage capacity of the area.

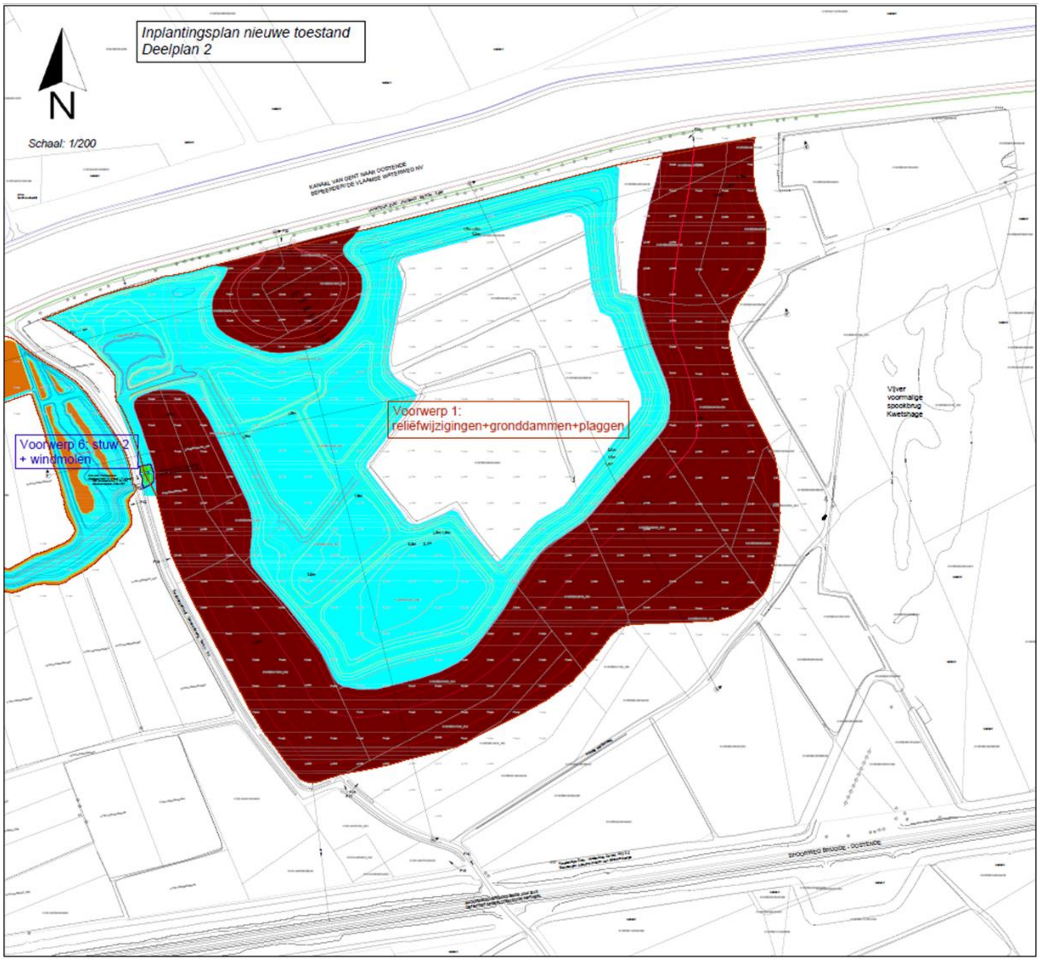

Figure 1 Plan shoing area of excavation (blue) and area elevated with the excavated ground on the surroundig creek ridge (brown). Location of the wind water mill is indicated.

2. **<u>Elevation of surrounding creek ridge</u>**

Excavated ground is used for elevating the surrounding creek ridge with 2 m on its highest points. After elevation the creek ridge will be 2,5 to 3 m higher than the reed marsh. The area which will be elevated is indicated in figure 1. Excavated ground from parts of the project area Kwetshage which are not part of the demo for FRESH4Cs will also be used for elevating the creek ridge. In the end an estimated total of 130.000 m^3 of ground will be processed.

3. Installation of a wind watermill and tilting weir

In order to store a maximum amount of surface water in winter and early spring, a wind watermill was installed. Technical details of wind watermill are presented in figure 2. Photo 1 shows the wind watermill after completion.

The combination of wind watermill and weir guarantees that a sufficiently high water level can be reached and maintained during winter and early spring in order to reach optimal conditions for habitat development. It means that in winter water level should be 40 cm higher than the minimum permitted water level in summer. The weir height is fixed at 2,30 m TAW, so a minimum level of 1,90 m TAW in summer is feasible. As in the adjacent downstream area irrigation during summer with surface water from the surrounding polders is possible, the wind watermill can be also used to maintain the minimum water level in case of very dry conditions. The main purpose of the wind watermill is however retaining a maximum volume of excess water during winter, so additional pumping during summer can be maximally avoided.

In figure 3 an overview is given of the spatial relationship between the area of the demo Kwetshage and the major project area of Kwetshage. Photo 4 gives an overview of area of the demo, on the way of being filled with water in October 2022.

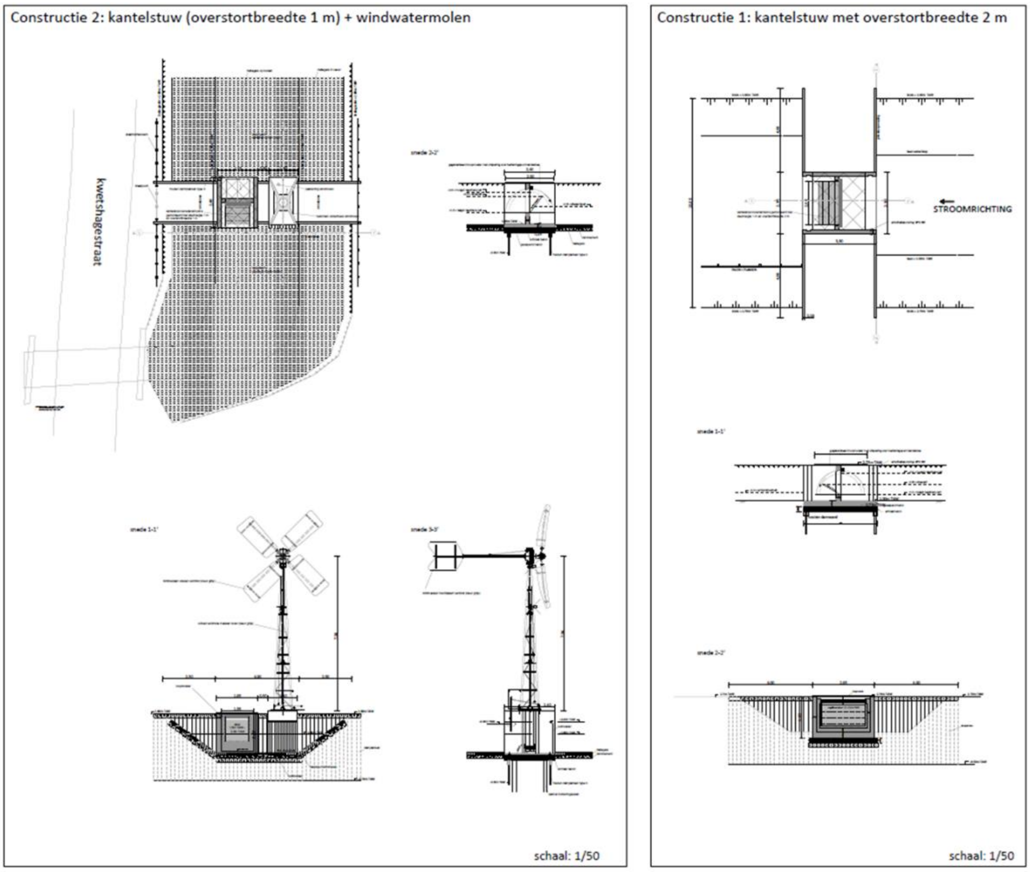

Figure 2 Technical plan of the wind watermill and weir.


Photo 1 Wind watermill after completion (Kwetshage September 13, 2022)

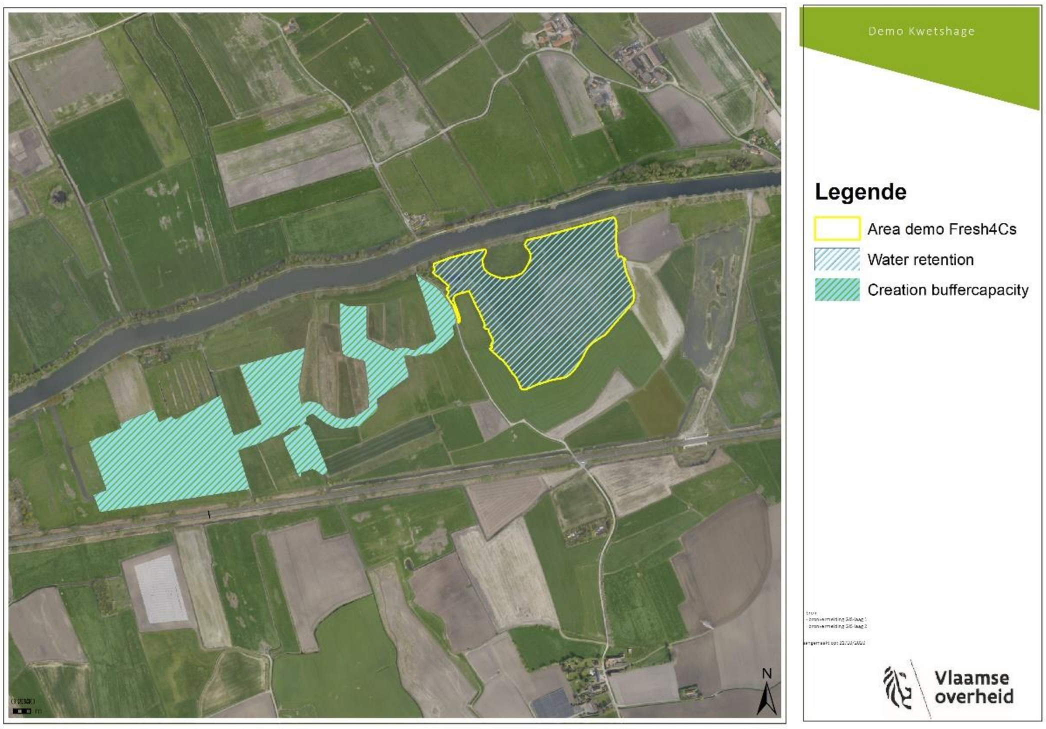

Figure 3 map of the demonstration site

Photo 2 Demo site during filling October 2022. Water level is 1,90 m TAW. At maximum level of 2,40 m TAW, apart from a few islands the entire area will be flooded.

Technical performance

Figure 4 shows the modelled water storage capacity that was generated in the demo Kwetshage in relation to the achieved water level. At maximum water level (2,40 m TW) approximately 42.500 m^3 of water is stored. The effective storage capacity is less as for habitat purposes water level in summer should not drop below 1,90 m TAW. Thus, the effective storage capacity is approximately 36.000 m^3.

The storage capacity is being filled during winter months by means of both retention of precipitation and pumping with the wind watermill. Expected mean pumping capacity of the watermill during the period December – March is ± 0,5 m^3/min (mean wind speed of 5,5 m/s), which coincides with a pumping capacity of ± 700 m^3/day. The stored surface water will experience an expected net infiltration rate towards the groundwater of 100 to 250 mm per year per m^2, depending on local soil conditions. During winter infiltration rate is expected to be around 1,4 mm/day/m^2 (*Witteveen+Bos, 2015*), which amounts to approximately 140 m^3 per day for the entire demo area. This is approximately 20% of the mean pumping capacity of the wind water mill per day. It is estimated that 20.000 m^2 of surface water will infiltrate to the groundwater annually. The infiltration will replenish groundwater on a regional scale. This must be compensated by precipitation and pumping of the wind watermill. Considering the expected pumping capacity, precipitation and infiltration, a net filling capacity of ± 750 m^3 per day is expected. Theoretically it is expected to take a mean time of 48 days to bring the area to maximal water level.

This is in agreement with observations, as between October 25 and November 17, 2022, water level has risen from 1,90 m TAW (photo 2) to 2,20 m TAW (photo 3). In figure 4 it can be seen this means that in a period of 24 days ± 18.366 m^3 of water is effectively retained in the area, which is ± 760 m^3 per day. As winter 2022 – 2023 is the first winter the area is filled with water, and conditions for development of reed marsh should be optimal, water level this winter is kept at a maximum of 2,20 m TAW.

The loss of buffer capacity of approximately 15.000 m^3 is overcompensated in the other part of the project area where buffer capacity is generated. Here an additional 30.000 m^3 of buffer capacity is generated in combination with development of reed marsh, meaning that overall a net gain in buffer capacity of 15.000 m^3 is reached.

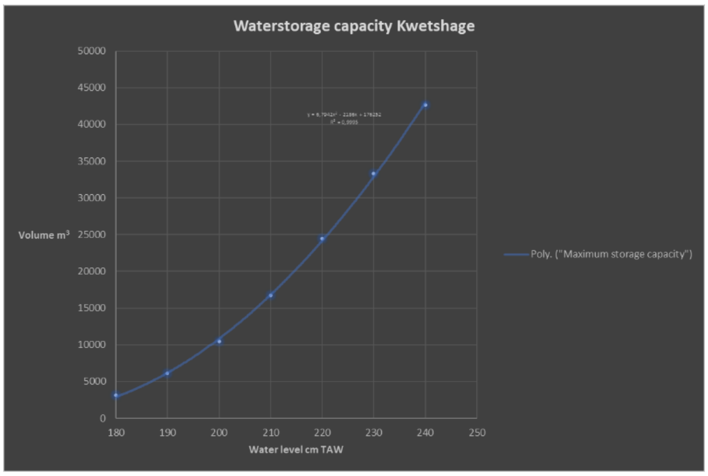

Figure 4: modelled water storage capacity of the demo area

Conclusion:

- The demo generates an effective storage capacity of 36.000 m^3
- It is expected that infiltration to the ground water will amount to 20.000 m^3 per year; which is approximately 55% of the effective storage capacity
- Overall a net buffer capacity of ± 15.000 m^3 is gained

Photo 3 The demo site after reaching a level of 2,20m TAW (November 2022)

Non-technical aspects of the demo

Regulatory framework

For constructing the demo an environmental permit was obtained. An archeological survey and an appropriate assessment (Natura 2000) were performed prior to applying for the environmental permit. Additionally, an agreement with the railway operator had to be negotiated, as a new water way had to be constructed closely to a major railway. With a peat layer in the underground all precautions had to be taken to avoid soil instability during and after finishing the works.

Conclusions and replication potential

The application of a wind water mill to differentiate in water level between adjacent parts of the same polder can be extended to the rest of the polders in Flanders. In the demo Kwetshage the wind watermill was deployed for habitat development, but it can likewise be used for agricultural purposes as well. The water board 'Nieuwe Polder van Blankenberge' is currently planning to install several similar water mills in different part of their management area, inspired by the water mill in Kwetshage.

References

Witteveen+Bos (2015). Hydrologische studie Kwetshage.