Restoration of the Odense river, Denmark

Year of issue

2025

Summary

The Odense is a river in southern Denmark. It was channelized and deepened in the late 1940s to improve agriculture. The NWRM consists of a series of measures to restore floodplain connectivity along a 17 km section of the river. The measures will prevent flooding in downstream towns and cities. This will have a number of effects on the pressures relevant for the WFD. Reduced risk for flooding of urban environment reduces the risk for storm overflows from sewers as well as diffuse pollution resulting from flooding in general. Re-meandering reduces the pressure from previous physical alterations for flood protection and agricultural purposes. It will also potentially have a positive effect on ground water recharge in temporarily flooded areas.

Since 2004, ~12 km of Odense River have been remeandered and 350 ha of wetlands restored under LIFE REGAIN. Recent actions include removal of migration barriers, and mussel habitat restoration.

In 2024, two artificial stone reefs (4500 tonnes) were established in Odense Fjord to enhance marine biodiversity. The project was led by SDU in partnership with Odense and Nordfyn municipalities and Aage V. Jensen Naturfond. The reefs aim to improve conditions for fish fry, seagrass, and aquatic invertebrates, and contribute to the ecological recovery of the fjord.

Photo Gallery



Location

55.2196, 10.2824

Project

NWRM

National ID

Denmark_01

Sector

Hydromorphology

Installation Date

2003

Implementation status

Completed

Contact

Mats Ivarsson, Enveco

Overview

Location of the project

The Odense is a river in southern Denmark. The project consists of a series of measures to restore floodplain connectivity along a 17 km section of the river.

Country

Denmark

NUTS2 Code

Syddanmark

Sponge measures implemented in the case study

Wetland restoration and management

Floodplain restoration and management

Re-meandering

Stream bed re-naturalisation

Objectives

Regulation of the chemical status of freshwater

Flood control and flood risk mitigation

Biodiversity and gene-pool conservation in riparian areas

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
Regional / sub-national water authority	Fyn County	Implementation	The former Fyn County actually carried out the project. After the county decommissioning in 2006 the municipality took over.	Responsible
Local water authority	Faaborg-Midtfyn Municipality	Implementation	Faaborg-Midtfyn Municipality is the current responsible authority for the project.	Responsible

Site Information

Climate Zone

Cool temperate moist

Precipitation

727.00 mm

Temperature (°C)

8.20 °C

Runoff

316.00 mm

Elevation range

26

Slope range

very gentle (1-2%)

Soil type

Fluvisols

WFD Ecological status

Good

WFD Chemical status

Unknown

Design and Implementation

Project scale

Large

Project scale specifications

The area affected by flooding during extreme precipitation events was for the investigated river stretch 43,8 ha.

Project area

43,8

Project area specifications

The area affected by flooding during extreme precipitation events was for the investigated river stretch 43,8 ha. If the remaining 95% of restored river stretch behaves in the same manner, the figure only represents 5% of the entire area affected. The entire area affected by the measure consists of 78 ha.

Area subject to Land use change or Management/Practice change (ha)

125.00 ha

Basis of design

The area affected by flooding during extreme precipitation events was for the investigated river stretch 43,8 ha. If the remaining 95% of restored river stretch behaves in the same manner, the figure only represents 5% of the entire area affected.

Constraints

The land use in affected areas have to be transformed permanently from e.g. intensively cultivated land to grazed meadows. This will induce a cost to the farmer which requires compensation, either by an annual compensation based on market values for crops or some other metric, or by land aquisition. Re-meandering and creation of wetlands might also be in conflict with infrastructure and residential or commersial housing.

Favourable preconditions

The evident need to mitigate the effects of the re-occuring flooding events in the downstream towns and villages in the catchment area, together with the availability of land for the purpose of floodplain restauration and wetland creation.

Financing

Total cost

635976.00 €

Total cost information

14,520 €/ha.
The whole LIFE REGAIN project had a total eligible budget of 3,852,367 €. The more recent UC LIFE Denmark project (for mussel habitat restoration) has a total eligible budget of 2,077,261 €

Costs capital information

3 120 €/ha

Costs land acquisition

11400.00

Costs land acquisition unit

€/ha

Costs land acquisition information

In 2014 prices

Costs operation maintenance information

Not available

Economic costs, actual income loss

The average decrease in income from farm operations due to the conversion from arable land to grazed meadows of land adjacent to the river has been assessed to €11 400/ha.

Financing authorities

Authority name	Type of funding	Comments	Financing share
Danish Nature Agency	National funds	State program under the Danish Nature Agency.	~ 50 %
Odense county	Sub-national funds	As time went by, the land prices became higher and higher and in the end the County had to hold the remaining financing on top of the Danish Nature Agency.	~ 50 %
European Union	EU-funds: LIFE+	1,926,184 € for the LIFE04 NAT/DK/000022 (LIFE REGAIN) project	—

Authority name	Type of funding	Comments	Financing share
European Union	EU-funds: LIFE+	1,246,356 € for the LIFE15 NAT/DK/000948 (UC LIFE Denmark) project	—

Policy and Governance

Policy description

The measure will prevent flooding in downtream towns and cities. This will have a number of effects on the pressures relevant for the WFD. Reduced risk for flooding of urban environment reduces the risk for storm overflows from sewers (PN 1.1) aswell as diffuse pollution resulting from flooding in general (PN 2.1). Re-meandering reduces the pressure from previous physical alterations for flood protection and agricultural purposes (PN 4.1.1 and 4.1.2). It will also potentially have a positive effect on ground water recharge in temporarily flooded areas (PN 6.1).

Land ownership

Over 70 landowners involved, with grazing agreements for 150 ha.

Policy targets

Improved Biodiversity

Pollutants Removal

Peak-flow reduction

Policy pressure

Directive	Relevant pressure
WFD identified pressure	4.1.2 Physical alteration for agriculture
Floods Directive identified pressure	Natural Exceedance

Policy impact

Directive	Relevant impact
WFD identified pressure	Altered habitat due to hydrological change
Floods Directive identified pressure	Waterbody status

Requirement directive

Requirement directive

WFD-achievement of good ecological status
Floods Directive-mitigating Flood Risk

Part of a wider plan

Yes

Wider plan

Wider plan type	Wider plan focus	Name	Comments
National	Environment & Biodiversity	National action plan II for the aquatic environment	1998 plan. The objective was to restore 16.000 ha of wetlands in Denmark to retain nitrogen. The application was finaced by a state program under the Danish Nature Agency.

Public consultation

No

Has contractual arrangements

Yes

Contractual arrangements

Name	Role	Comments
Grazing agreements.	Land management based on voluntary agreements.	Signed for ~150 ha.

Impacts and Monitoring

Monitoring System

Monitoring parameters

Ongoing monitoring of flows and riparian inundation could help to validate the modelling results used to justify this measure.

Maintenance

Maintenance requirements

No maintenance required

Impact Assessment Methodology

Performance impact assessment method

Laboratory

Performance impact estimation information

Exploration of the linkages between floodplain hydraulics and in situ observed sedimentationpatterns by: (i) performing a validation of a dynamic 2D river andfloodplain model based on in situ measurements of water depth and flow velocity for a section of a re-meandered 5th order Danishriver channel and floodplain; (ii) compare floodplain flow velocities with measured net deposition of sediment, phosphorus and organicmatter; and (iii) test if simple empirical relationships between floodplain hydraulics and sediment deposition could be developed.

Biophysical impact assessment method

Biophysical impacts were assessed by a combination of modelling and observational studies. Modelling was performed to assess the flow patterns in the floodplains while observational studies were performed to assess the amount of sediment and nutrients deposited.

Cost assessment method

Cost information were provided by Claus Paludan at the municipality of Faaborg-Midtfyn No information was available on the assessment of cost effectiveness of measures.

Socio-economic Impacts

Direct benefits information

There are no monetary valuation of the direct benefits accruing from the re-meandering and wetlands available. Qualitatively, the direct benefits can be described as reduced risk for flooding in down stream villages, towns and land adjacent to the Odense Å during events of extreme precipitation.

Ancillary benefits information

The aditional benefits from this measure are connected to the reduction of nutrient leakage and consequent eutrophication in the Odense Å and in the coastal water receiving the river discharge. The riverbed restoration also bring about a strengthened biodiversity as migrating fish and benthos return to the stream. Positive effects can also be anticipated on cultural ecosystem services such as recreation in the affected areas.

Biophysical impacts: Hydrology

Hydrological effects

Wetland restoration (~860 ha total) increased water retention and restored floodplain dynamics. Overbank flooding is re-enabled in remeandered sections.

Information on retained water

At maximum water detention, approximately 3650 m3 are detained in the investigated area (%5 of the restored river stretch). Assuming that the remaing 95% of the restored river stretch behave in the same manner, the correct figure would be 72 960 m3.

Information on increased water storage

Since the storage is done in temporary wetlands formed during events of extreme precipitation and consequent flooding of grazing meadows (previously cultivated land) the entire volume can be considered to be an increase compared to the previous situation.

Information on peak flow reduction

The measure has led to a reduction in peak flow during events of extreme precipitation.

Information on Restoring hydraulic connection

Barrier removal reconnected 3.1 km of river, improving fish and Unio crassus migration. Longitudinal continuity was partially restored.

Information on peak delay effects

No overall attenuation in runoff is expected, but the timing of runoff, and hence the height of the flood peak, is altered.

Biophysical impacts: Biodiversity

Improved biodiversity

Yes

Information on improved biodiversity

Restoration of riverbeds and re-meandering are themselves measures that strengthen biodiversity in terms of improved biotopes for stream benthos. The periodical flooding of wetlands in connection to the restored river enhances this effect for a number of species, both flora and fauna.

Biophysical impacts: Water & Soil Quality

Water quality overall improvements

Positive impact-WQ improvement

Information on water quality overall

The measurzeaffected water quality insofar as it led to increased deposition of sediment, phosphorus and organic matter on the floodplain as well as removal of nitrogen in the wetlands along the re-meandered river stretch.

Water quality improvements - Nitrogen (N)

39.00

Water quality improvements - Nitrogen (N) - Unit

% reduction pf pollutant

Information on water quality Improvements (N)

An estimate of 235 kg N/ha/yr is removed in the wetlands along the re-meandered river stretch. Restored wetlands reduced nitrogen exports by ~124 t/year. Overall, a 39% N-load reduction (–377 t/year) was measured between 2000–2015.

Soil quality overall improvements

N/A info

Biophysical impacts: Others

Ecosystem impact climate regulation

Reduced energy use (farm operations)

Information on ecosystem impact climate regulation

The conversion from arable land to grazed meadows of land adjacent to the river will result in decreased energy use in farm operations.

Lessons Learned

Key lessons

Water detention through temporary flooding of wetlands can play a significant role in cutting of flow peaks, and thereby decreasing water levels and floodrisk in downstream towns and villages during incidents of extreme precipitation.

Barriers

Barrier type	Barrier role	Comments

Other	Main barrier	The main barriere was the willingness of the landowners to participate in the project. However, the "toolbox" contained several measures to overcome this problem. T

Drivers

Driver type	Driver role	Comments
Other	Main driver	The financial support of the Danish Nature Agency through the national plan for the aquatic environment together with the initiative from the former Danish Counties played a cruicial part for enabling the project.

Success factors

Success factor type	Success factor role	Comments
Specific incentives for stakeholder involvement	Main factor	The "toolbox" offered contained several measures (including land consolidation). The project succeded in establishing voluntary agreements with and among the landowners in this project.

Cost effectiveness

No “traditional / structural” methods are available to achieve the floodplain reconnectivity accomplished by the Odense measures, thus it is very difficult to make this comparison.

Flexibility / Adaptability

There may be a potential to adapt the measure to changing baseline conditions either through additional remeandering or further work on the channel bottom.

Transferability

Some elements of the measures implemented here are transferrable to many agricultural rivers throughout north and central Europe. In any place where historical channelization has disconnected rivers from floodplains, a potential may exist for measures which reconnect the river and its floodplain.

Sources

Sources

Linking floodplain hydraulics and sedimentation patterns along arestored river channel: River Odense, Denmark

Vandtillbageholdelse i vådområder: Odense Å case område

Odense Å ved Brobyværk

LIFE REGAIN Final Report

LIFE Unio Crassus Project (LIFE15 NAT/DK/000948)

Nitrogen Retention Study (2000–2015)

Stone reefs in Odense Fjord