Water retention area with land use adapted to the ground water levels and flooding frequencies, at the primary sea wall (Research project 'COMTESS')

Water retention polders with adapted land use (North Sea region) (Germany)

Polder mit angepasster Nutzung zur Verbesserung des Wassermanagement (Nordsee Region)

DESCRIPTION

Water retaining polders to reduce flood risk from heavy rainfall or runoff at high tide in coastal lowlands. Alternative production systems will be viable within thesepolders.

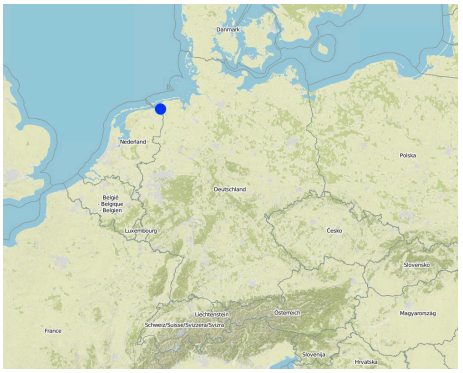
In the 19th and 20th century land was reclaimed from the sea to make use of the exposed fertile soils for agriculture through a process known as 'impoldering'. The reclaimed land is now characterized by intensive grazing and cropland. This is a region where agriculture is the most important form of land use. However, the land needs to be regularly drained. Given the expected increase in precipitation in winter due to climate change, the corresponding increase in freshwater discharge needs to be managed. Furthermore, the periods when natural discharge into the sea oc-curs are likely to decrease – because of rising sea levels also caused by climate change. Consequently, in winter and spring, greater quantities of freshwater will need to be pumped into the sea rather than discharged naturally at the low or 'ebb' tide. Specially embanked water retention polders will be required to temporarily impound water as part of a multifunctional approach to coastal zone management.

Purpose of the Technology: These retention polders could be a cost-effective alternative to expensive invest-ments in extra pumping capacities to prevent submergence of low-lying cultivated areas. The primary aim is to restrict floods to the retention polders when the drain-age network is overburdened and cannot deal with the predicted extra demands in the future. The high evapotranspiration from the open waterbody, and the reeds growing within, will also help with reducing the amount of water. During dry sum-mers, the water in the retention polder could also be put to creative use as a source of irrigation. Another potential advantage is that subsurface saltwater intrusion in the region could be prevented by the freshwater-filled polders. During extreme storm surges and in the rare case of breaches in the sea wall, the retention polders would serve as an extra line of defence by holding seawater.

Establishment / maintenance activities and inputs: An embankment enclosing approx. 3,000 ha will be able to store up to 25,000,000 m^3 of water. This will improve the drainage of an area of approx. 49,000 ha. The invest-ment for building this water retention area is high – but for the reasons stated it serves a necessary purpose at a cost which is lower than the alternative – increased pumped drainage installations. Maintenance costs will be lower than the drainage alternative as only the integrity of the embankment needs to be monitored regularly. Agricultural land use within the polders is adapted to higher water levels and occa-sional flooding.

Natural / human environment: However within the proposed retention polders – the areas enclosed by the em-bankment - a change from the current intensive grazing for dairy farming and cropland to extensive grazing, open waters and wetlands covered with reeds will take place. The reeds can be harvested for their commercial value as biomass for renewable energy generation, or for other applications (e.g. thatching of roofs or industrial raw material). According to recent investigations, natural reeds growing in brackish water produce as much biomass as maize cultivated for biogas use. In con-trast to maize, no investments in tillage, fertilizer or biocides are necessary for these naturally growing reed stands. Thus the proposed land use provides an economic alternative to the current production system.

LOCATION



Location: Landkreis Aurich, Germany, Lower Saxony, Germany

No. of Technology sites analysed:

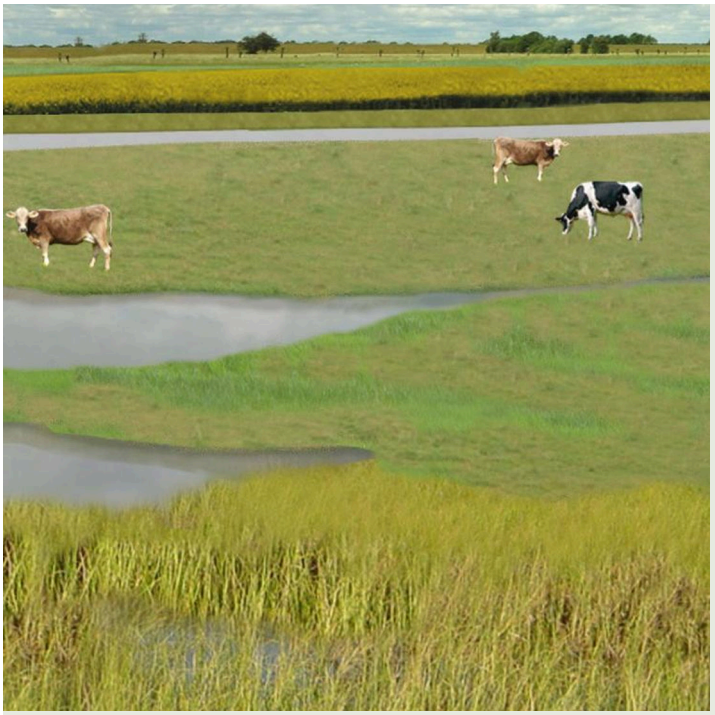
Geo-reference of selected sites
- 7.07806, 53.44667

Spread of the Technology:

In a permanently protected area?:

Date of implementation: 10-50 years ago

Type of introduction
- ☐ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☑ during experiments/ research
- ☑ through projects/ external interventions



Detailed view within the water retention area with land use adapted to the ground water levels and flooding frequencies (Research project 'COMTESS')

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- improve production
- reduce, prevent, restore land degradation
- conserve ecosystem
- protect a watershed/ downstream areas – in combination with other Technologies
- preserve/ improve biodiversity
- reduce risk of disasters
- adapt to climate change/ extremes and its impacts
- mitigate climate change and its impacts
- create beneficial economic impact
- create beneficial social impact

Land use

Land use mixed within the same land unit: Yes - Agro-pastoralism (incl. integrated crop-livestock)

Cropland

- Annual cropping: cereals - barley, cereals - maize, wheat

Number of growing seasons per year: 1

Grazing land

- Cut-and-carry/ zero grazing
- Improved pastures

Animal type: cattle - dairy, cattle - non-dairy beef
Products and services: meat, milk

Water supply

- rainfed
- mixed rainfed-irrigated
- full irrigation

Purpose related to land degradation

- ☑ prevent land degradation
- ☑ reduce land degradation
- restore/ rehabilitate severely degraded land
- adapt to land degradation
- not applicable

Degradation addressed

chemical soil deterioration - Cs: salinization/ alkalinization

water degradation - Hs: change in quantity of surface water, Hg: change in groundwater/aquifer level, Hq: decline of groundwater quality

SLM group

- water diversion and drainage
- surface water management (spring, river, lakes, sea)

SLM measures

structural measures - S5: Dams, pans, ponds

management measures - M1: Change of land use type, M2: Change of management/ intensity level

TECHNICAL DRAWING

Technical specifications

The figure shows the study region, located on the North Sea coast. The whole area is protected by a sea wall (grey). Crop fields (yellow), grasslands (green) and the drainage system (light blue) char-acterize the region. Large water bodies (blue) sur-rounded by reeds (brown) act as water retention polders. Extensive grazing and reed farming re-places current production systems within the reten-tion polders. The land around the retention area (higher parts of the landscape) profits from the retention areas as the risk of flooding is reduced and can be used for cropland and intensive graz-ing. Depending on the size of the retention polder a huge amount of excess water can be contained. Retention areas of 3,000 ha are able to store up to 25,000,000 m^3 water. The height of the dams de-pends on the elevation of the landscape but in general a height of less than 2 m is sufficient.

Author: Udo Schotten

Location: Krummhörn. County of Aurich, Lower Saxony

Technical knowledge required for field staff / advisors: high (To generate income in the retention area (without existing agricultural methods))

Technical knowledge required for Water board: high (To build a new adapted drainage system with retention areas)

Main technical functions: control of dispersed runoff: retain / trap, control of concentrated runoff: retain / trap

Secondary technical functions: increase / maintain water stored in soil, increase of groundwater level / recharge of groundwater, increase of biomass (quantity)

Dam/ pan/ pond
Height of bunds/banks/others (m): 1
Width of bunds/banks/others (m): 2
Length of bunds/banks/others (m): 30000

Construction material (earth): sand core and clay cover

Specification of dams/ pans/ ponds: Capacity 25000000m3

Catchment area: 49000ham2

Beneficial area: 49000ham2

Other specifications: size of retention area (embanked area): 3,000.00 ha

Change of land use type: Within the retention area the conditions are wetter than before. Therefore the agricultural land use needs to be adapted to hydrological conditions.

Change of land use practices / intensity level: Under the wetter conditions only a less intensitive land use is possible, e.g. no crop fields but instead extensive grazing

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated:
- Currency used for cost calculation: **Euro**
- Exchange rate (to USD): 1 USD = 0.94 Euro
- Average wage cost of hired labour per day: 100.00

Most important factors affecting the costs

n.a.

Establishment activities

1. Building of dams (Timing/ frequency: during winter months)

Establishment inputs and costs

Specify input	Unit	Quantity	Costs per Unit (Euro)	Total costs per input (Euro)	% of costs borne by land users
Labour					
Labour		1.0	21000000.0	21000000.0	
Equipment					
Machine use		1.0	9000000.0	9000000.0	
Construction material					
			750000.0		

Total costs for establishment of the Technology	30'000'000.0	
Total costs for establishment of the Technology in USD	*31'914'893.62*	

Maintenance activities

1. Control of dams (Timing/ frequency: once a year)
2. Maintenance of dams (Timing/ frequency: once a year)
3. Maintenance of drainage system (Timing/ frequency: once a year)

Maintenance inputs and costs

Specify input	Unit	Quantity	Costs per Unit (Euro)	Total costs per input (Euro)	% of costs borne by land users
Labour					
Labour			800.0		
Equipment					
Machine use			300.0		
Construction material					
Earth			100.0		

NATURAL ENVIRONMENT

Average annual rainfall
- [ ] < 250 mm
- [ ] 251-500 mm
- [ ] 501-750 mm
- [x] 751-1,000 mm
- [ ] 1,001-1,500 mm
- [ ] 1,501-2,000 mm
- [ ] 2,001-3,000 mm
- [ ] 3,001-4,000 mm
- [ ] > 4,000 mm

Agro-climatic zone
- [x] humid
- [ ] sub-humid
- [ ] semi-arid
- [ ] arid

Specifications on climate
Thermal climate class: temperate

Slope
- [x] flat (0-2%)
- [x] gentle (3-5%)
- [ ] moderate (6-10%)
- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

Landforms
- [x] plateau/plains
- [ ] ridges
- [ ] mountain slopes
- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

Altitude
- [x] 0-100 m a.s.l.
- [ ] 101-500 m a.s.l.
- [ ] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [ ] 1,501-2,000 m a.s.l.
- [ ] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

Technology is applied in
- [ ] convex situations
- [ ] concave situations
- [ ] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [ ] shallow (21-50 cm)
- [ ] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [x] very deep (> 120 cm)

Soil texture (topsoil)
- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [x] fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Topsoil organic matter content
- [x] high (>3%)
- [ ] medium (1-3%)
- [ ] low (<1%)

Groundwater table
- [ ] on surface
- [x] < 5 m
- [ ] 5-50 m
- [ ] > 50 m

Availability of surface water
- [ ] excess
- [x] good
- [ ] medium
- [ ] poor/ none

Water quality (untreated)
- [ ] good drinking water
- [ ] poor drinking water (treatment required)
- [x] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to:

Is salinity a problem?
- [ ] Yes
- [ ] No

Occurrence of flooding
- [ ] Yes
- [ ] No

Species diversity
- [ ] high
- [ ] medium
- [x] low

Habitat diversity
- [ ] high
- [ ] medium
- [ ] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] subsistence (self-supply)
- [ ] mixed (subsistence/ commercial)
- [x] commercial/ market

Off-farm income
- [ ] less than 10% of all income
- [x] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth
- [ ] very poor
- [ ] poor
- [x] average
- [ ] rich
- [ ] very rich

Level of mechanization
- [ ] manual work
- [ ] animal traction
- [x] mechanized/ motorized

Sedentary or nomadic
- [ ] Sedentary
- [ ] Semi-nomadic

Individuals or groups
- [ ] individual/ household
- [ ] groups/ community

Gender
- [x] women
- [x] men

Age
- [ ] children
- [ ] youth

- [ ] Nomadic
- [ ] cooperative
- [x] employee (company, government)
- [ ] middle-aged
- [ ] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [ ] 1-2 ha
- [ ] 2-5 ha
- [ ] 5-15 ha
- [ ] 15-50 ha
- [ ] 50-100 ha
- [ ] 100-500 ha
- [ ] 500-1,000 ha
- [ ] 1,000-10,000 ha
- [ ] > 10,000 ha

Scale
- [ ] small-scale
- [ ] medium-scale
- [x] large-scale

Land ownership
- [ ] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [x] individual, not titled
- [ ] individual, titled

Land use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [ ] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [ ] leased
- [ ] individual

Access to services and infrastructure

health	poor	good
education	poor	good
technical assistance	poor	good
employment (e.g. off-farm)	poor	good
markets	poor	good
energy	poor	good
roads and transport	poor	good
drinking water and sanitation	poor	good
financial services	poor	good

IMPACTS

Socio-economic impacts

Crop production

decreased — increased

Under wet conditions in the retention area a crop production is not possible any more.

fodder production

decreased — increased

Under wet conditions in the retention area an intensive fodder production is not possible any more.

fodder quality

decreased — increased

Under wet conditions in the retention area the optiomal fodder quality can not ensured any more.

production area (new land under cultivation/ use)

decreased — increased

Quantity before SLM: 49000 ha
Quantity after SLM: 46000 ha
For the whole catchment area a loss of approx. 3,000 ha (size of retention area).

water availability for livestock

decreased — increased

Due to reduction of saline influx

expenses on agricultural inputs

increased — decreased

Only adjusted land use takes place within retention area, therefore the expenses are reduced.

farm income

decreased — increased

diversity of income sources

decreased — increased

Due to land use adapted to the conditions the typical land use is not possible and a diversitfication will take place with reed mowing and extensive grazing in the retention area.

Intrusion by saline groundwater

decreased — increased

Socio-cultural impacts

recreational opportunities

reduced — improved

Diversification of landscape by building the retention area will increase the attractivity for recreation and tourists.

SLM/ land degradation knowledge

reduced — improved

Less intensive land use results in more diversity and conservation of regional species and habitats.

conflict mitigation

worsened — improved

Ecological impacts

water quantity

decreased — increased

Typical for the region are wet situations. These typical wet conditions are restored by cessation of drainage system within the retention area.

water quality	decreased	increased	Updwelling of saline groundwater is prevented by increased water level in the retention area.
groundwater table/ aquifer	lowered	recharge	By water in the retention are the recharge of groundwater will increase and prevent salinization.
evaporation	increased	decreased	Instead of pumping water into the sea a higher amount is evapotranspirated naturally.
soil moisture	decreased	increased	Typical for the region are wet situations. These typical wet conditions are restored by cessation of drainage system within the retention area.
salinity	increased	decreased	By water in the retention are the recharge of groundwater will increase and prevent salinization.
soil organic matter/ below ground C	decreased	increased	By wetter conditions the soil organic matter will be increased.
biomass/ above ground C	decreased	increased	Growth of reeds
plant diversity	decreased	increased	By diversification of land use the number of species will be increased, especially due to extensive land use.
animal diversity	decreased	increased	By diversification of land use the number of species will be increased, especially due to extensive land use.
beneficial species (predators, earthworms, pollinators)	decreased	increased	
habitat diversity	decreased	increased	By diversification of land use the number of habitats will be increased.
pest/ disease control	decreased	increased	
emission of carbon and greenhouse gases	increased	decreased	Modelled is the global warming potential by gas emissions. Not yet clear if it is benefit or disadvantage. Model will show.

Off-site impacts

water availability (groundwater, springs)	decreased	increased	Water from retention area.
reliable and stable stream flows in dry season (incl. low flows)	reduced	increased	Water stored in retention area can be used for irrigation during dry summer months.
downstream flooding (undesired)	increased	reduced	Measured m3 of excess water in the catchment area, leading to floods or needs to be pumped. Exact values from modelling will be added as soon as possible!
damage on neighbours' fields	increased	reduced	Retention area to tackle impact of climate change.
damage on public/ private infrastructure	increased	reduced	Retention area to tackle impact of climate change.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	very positive
Long-term returns	very negative	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	very positive
Long-term returns	very negative	very positive

The benefits will be visible in the longer time frame. There will be benefits of the investments when considering sea level rise in the upcoming 100 years.

CLIMATE CHANGE

Gradual climate change

annual temperature increase — not well at all ✓ very well

Climate-related extremes (disasters)

local rainstorm — not well at all ✓ very well

local windstorm — not well at all ✓ very well

drought — not well at all ✓ very well

general (river) flood — not well at all ✓ very well

Other climate-related consequences

reduced growing period — not well at all very well Answer: not known

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- single cases/ experimental
- 1-10%
- 11-50%
- > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- 0-10%
- 11-50%
- 51-90%
- 91-100%

Has the Technology been modified recently to adapt to changing conditions?

- Yes
- No

To which changing conditions?

- climatic change/ extremes
- changing markets
- labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- The retention area will support the drainage of the arable fields and pastures outside the retention area

  How can they be sustained / enhanced? Combine with other technical solutions for protection against flooding (including strengthening of the ditch system and in-creasing pumping capacity).

Strengths: compiler's or other key resource person's view

- Prevention of flooding during strong rainfalls and possibility to irrigate during dry periods

  How can they be sustained / enhanced? The larger the retention areas are the more water can be stored.
- Prevention of salt water intrusion in the region

  How can they be sustained / enhanced? Fresh water in the retention polders prevents saline ground water from intrusion. Build polders in areas where saline ground water intrudes.
- Endangered species might obtain new habitats in the retention area

  How can they be sustained / enhanced? Extensive land use can help to optimize the habitats for endangered species and increase attractiveness for tourism.
- Through investments in building retention areas the very expensive strengthening of the existing drainage system is not necessary anymore

  How can they be sustained / enhanced? By increasing the attractivity for touristic use in the retention area benefits for land owner can be generated and the probability to build up retention areas instead of strengthening the existing drainage system is increased.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Retention polders in an important tourism region will change the landscape and this may reduce the value of the region for tourism. Include tourism concerns in the retention area (access, infor-mation, attractiveness).
- Loss of land for agricultural production (highly productive arable land) Establish retention area in low elevated parts, where there is not a high interest for agricultural production.
- Endangered species might lose habitats when building up the retention area Do not build a retention area where endangered species live.
- Loss of livelihoods Retention areas should be planned for parts of the landscape without settlements.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- High water levels (especially with changing water levels) may generate high emission of greenhouse gas Ground water levels should kept stable near to the soil surface.

REFERENCES

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_1660/

Linked SLM data
Approaches: Stakeholder participation in integrated assessment and planning of vulnerable coastal regions
https://qcat.wocat.net/en/wocat/approaches/view/approaches_2597/

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Key references
- http://www.comtess.uni-oldenburg.de/: