

## AGRICULTURE AT THE REQUIRED LEVEL

### SOIL AND WATER OPTIMISATION

Climate change means that the agricultural industry is increasingly encountering problems with a shortage or even an excess of water. Increasingly extreme rainfall alternated with long-term drought form quite a challenge for maintaining profitable business operations. 'Agriculture at the required level' is a project in which 15 agricultural companies are collaborating with the water boards from the Rhine-East sub-basin area, the provinces of Overijssel, Drenthe and Gelderland, LTO Noord and the Dutch Ministry of Economic Affairs. This publication explains the measures that may contribute to climate-proof and profitable business operations and describes potential solutions that have been developed, applied and tested in practice in the 'Agriculture at the required level' project.

[www.landbouwoppeil.nl](http://www.landbouwoppeil.nl)

## AGRICULTURE AT THE REQUIRED LEVEL



# SOIL AND WATER OPTIMISATION

PRACTICAL TIPS FOR  
HANDLING SOIL AND WATER  
IN AGRICULTURAL BUSINESS  
OPERATIONS

Landbouw op Peil



'AGRICULTURE AT THE REQUIRED LEVEL' RECEIVES FINANCIAL SUPPORT FROM THE EUROPEAN AGRICULTURAL FUND FOR COUNTRYSIDE DEVELOPMENT: "EUROPE IS INVESTING IN ITS COUNTRYSIDE"

AGRICULTURE  
AT THE REQUIRED LEVEL

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# SOIL AND WATER OPTIMISATION

PRACTICAL TIPS FOR HANDLING  
SOIL AND WATER IN AGRICULTURAL  
BUSINESS OPERATIONS

## INTRODUCTION

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Even for farmers, it has become increasingly important to think about, and to take measures against, the effects of climate change. This issue of 'Soil and water optimisation' describes the experiences and test results that fifteen farmers have acquired since 2011 whilst participating in the '**Agriculture at the required level**' project. Together with water managers, they were also on the lookout for working measures at farm or plot level.

**'Soil and water optimisation'** provides an overview of promising and practical measures that farmers can take themselves. Depending on the situation on your own farm, you can opt for one or more measures that you can implement in consultation with the water board within your own farm – either alone, or with your neighbours. The measures will help you to keep your business operations profitable, even when the climate is changing.

The selection guides on pages 6 to 13 will help you to choose from the different options. On the following pages, you will find further information about the promising measures. The colours used for situation, business operations, water supply and soil type in the overviews on the right-hand page have the following meaning:

- Green: the measure is appropriate
  - Orange: the measure is appropriate but less ideal
- The following definitions apply to the heading 'soil':
- Green: the measure is having a positive (derived) effect
  - Orange, this measure is not having or is only having a limited (derived) effect.





'AGRICULTURE AT THE REQUIRED LEVEL'

## Essential agriculture through sustainable water management

Around two-thirds of the East Netherlands consists of higher, freely draining sandy soils, without a water supply from the main water system. Climate change means that the area is increasingly encountering problems that involve a shortage or even an excess of water. Increasing extreme rainfall alternated with long periods of drought form quite a challenge for the agricultural sector.

*'Agriculture at the required level'* is a project in which all water boards from the Rhine-East sub-basin area, the three provinces, LTO-Noord and the Dutch Ministry of Economic Affairs have collaborated with fifteen agricultural companies. For agricultural companies, the project provides essential information for climate-proof and profitable business operations.

Consciously thinking about the consequences of climate change also ensures greater creativity and inventiveness, both in the agricultural sector and among water managers. The project has also provided important information for the water boards and the province about the relationship between agricultural and water management measures and how to apply them in practice.

**'Agriculture at the required level'** has turned out to be a successful project.

The project has been awarded the **Nederlandse Waterschapsbank's** prestigious CSR Award 2013. Results of **'Agriculture at the required level'** are now being used in the national Delta programme, especially when it comes to the **Hoge Zandgronden's** freshwater supply (such as in the **Zoetwatervoorziening Oost-Nederland** (East Netherlands Freshwater Supply) project.) For farmers, the experiences acquired with farm water management plans are of particular importance.

**'Agriculture at the required level'** is a typical example of what I would like to call 'do-it-yourself-water management', in which water boards make express use of the knowledge available in the area. And where each agriculturist can implement water management at plot level himself, with specific measures, which have been fully tailored to his farm's requirements.

I am therefore also particularly pleased with this publication, which outlines the solutions that have been developed, applied and tested in the **'Agriculture at the required level'** project in practice. I value sharing the knowledge and insights that the project has delivered with you in this manner.

Stefan Kuks  
Chair of Vechtstromen Water Board

**WANT TO KNOW MORE?**

See the website  
[www.landbouwoeppeil.nl](http://www.landbouwoeppeil.nl)





'AGRICULTURE AT THE REQUIRED LEVEL'

## Successful for the agricultural sector and water management

This publication concerns water management in the agricultural sector. It provides an overview of implemented and tested measures by farmers in the '**Agriculture at the required level**' project. Using practical examples, we will show you what you can do in certain conditions, such as if there is too much water or even signs of drought.

Climate change makes it quite a challenge for the agricultural sector to keep its business operations profitable. The '**Agriculture at the required level**' project helps with this. Its aim is to devise concrete measures to enable farming to continue on the high sandy soils in the future too. Within the programme, we are acquiring knowledge and sharing experiences, so that we will ultimately be able to maintain a lively agricultural sector.

Insights change. Whereas we in the agricultural industry used to just want to keep the water at bay, now we are retaining it to prevent drought. It is of course important that we can continue to manage the water. The measures in this publication show that this is certainly possible, but that it requires all parties to make changes. A striking example of this is the water manager farmer who is able to operate the dikes himself in certain areas and thereby determine the groundwater level.

I would like to emphasise this project's success factors, especially their practical side, and the acquisition and sharing of experience. The project has shown that the collaboration between farmers and the water board benefits all parties. The trick is to spread this success too, to communicate about it and to make other farmers enthusiastic. LTO Noord is encouraging its departments and managers to get going. Experiences have proven that by collaborating, you can implement things in a feasible and affordable manner. The plans in the field of water management give the farmers insight into current water management and draw attention to potential solutions.

Farmers know a lot about their own land, but experience has taught us that there is still much more to discover. '**Agriculture at the required level**' has shown us that practical and relatively simple water management solutions can deliver results that all parties benefit from and have an interest in.

The insights acquired from '**Agriculture at the required level**' are contributing to the discussion between farmers and water boards in relation to water management. The result is a water level tailored to the functions and a more balanced water management system, whereby the farmer and the water board are working together. A win-win situation! I am convinced that '**Agriculture at the required level**' is an excellent source of inspiration for the implementation of our Agricultural Water Management Delta Programme.

Siem Jan Schenk,  
Chair of LTO Noord and  
LTO Nederland portfolio holder for water

## AREA

## PROBLEM

## PROMISING MEASURE

PAGE

### WATER SUPPLY AVAILABLE

Waterlogging during rain showers

Farmers' storage

33

Domed plots

45

Poor rootability or poor infiltration

Improving the soil structure

49

Other crops

37

Removing problematic layers

47

Long pools on plot

Combined level-controlled drainage

19

Shallow narrower drainage

21

Improving the soil structure

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Dips in the plot

Smoothing and flattening

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Domed plots

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Limited soil preparation

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Poor structure, aggregates

Improving soil biology

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Other crops

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Sandy peaks or deep groundwater levels

Combined level-controlled drainage

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Irrigation and water buffering

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Increasing organic matter content

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Infiltration and flooding

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Height differences in plot

Smoothing and flattening

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Groundwater-controlled level management

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Other crops

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Soil compaction

Improving the soil structure

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Limited soil preparation

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Improving soil biology

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## AREA

## PROBLEM

## PROMISING MEASURE

PAGE

### NO WATER SUPPLY

Waterlogging during rain showers

Farmers' storage

33

Domed plots

45

Poor rootability or poor infiltration

Improving the soil structure

49

Other crops

37

Removing problematic layers

47

Long pools on plot

Combined level-controlled drainage

19

Shallow narrower drainage

21

Improving the soil structure

49

Dips in the plot

Smoothing and flattening

43

Domed plots

45

Limited soil preparation

41

Poor structure, aggregates

Improving soil biology

49

Other crops

37

Heat stress among crops

Irrigation and water buffering

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Increasing organic matter content

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Sandy peaks or deep groundwater levels

Irrigation and water buffering

23

Increasing organic matter content + green fertilisers

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Height differences in plot

Smoothing and flattening

43

Other crops

37

Soil compaction

Improving the soil structure

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Limited soil preparation

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Improving soil biology

51

## MAIN PROBLEM

## DERIVED PROBLEM

## PROMISING MEASURE

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WET

Waterlogging during rain showers

Farmers' storage

33

Domed plots

45

Poor rootability or poor infiltration

Improving the soil structure

49

Shallow narrower drainage

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Removing problematic layers

47

Long pools on plot

Combined level-controlled drainage

19

Shallow narrower drainage

21

Improving the soil structure

49

Dips in the plot

Smoothing and flattening

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Domed plots

45

Dike management/automatic dike management

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Poor structure, aggregates

Limited soil preparation

41

Other crops

37

High groundwater levels

Shallow narrower drainage or trenches

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Combined level-controlled drainage

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Dike management/automatic dike management

31

Other crops

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Insufficient drainage capacity

Dike management/automatic dike management or increasing drainage capacity

37

Farmers' storage

33

Soil compaction

Improving the soil structure

49

Limited soil preparation

41

Improving soil biology

51



## MAIN PROBLEM

## DERIVED PROBLEM

## PROMISING MEASURE

**DRY**

Little moisture-retaining ability

Temporary sprinkling ban

Sand drift and erosion

Heat stress among crops

Poor structure, aggregates

Sandy peaks or deep groundwater levels

Height differences in plot

Soil compaction

Increasing organic matter content

Groundwater-controlled level management

Water management involving farmers' dikes

Combined level-controlled drainage

Water buffering

Increasing organic matter content

Other crops (mulch)

Extra water supply

Irrigation

Infiltration and flooding

Improving soil biology

Other crops

Irrigation and water buffering

Increasing organic matter content and green fertilisers

Infiltration and flooding

Smoothing and flattening

Other crops

Improving the soil structure

Limited soil preparation

Improving soil biology

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## MEASURES

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PRACTICAL TIPS  
FOR HANDLING  
SOIL AND WATER  
IN AGRICULTURAL  
BUSINESS  
OPERATIONS



**Ormel:** "It's true that you can do an awful lot with dikes, but there's only one thing that's in control, and that's the weather. You can retain the water for longer, I've seen that. If we hadn't have had the dikes, we would have had the stress of drought weeks earlier. It is very difficult to estimate how much earlier. My basic assumption is: the longer you are able to maintain the groundwater level, and prevent it from dropping quickly, the longer you are able to do something about it. I am a visual manager and use my instincts and the experience I have acquired."

#### SUPPLY

Retain additional 10-20 mm water per annum

Manage additional 75-100 mm water per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Additional crop yield

#### INVESTMENT

€1000-€5000/dike

#### OTHER SIMILAR MEASURES

Barriers for culverts

Raising of ditch soil

Adapting of ditch profile

Barriers

Level-controlled drainage

## WATER MANAGEMENT WITH 'FARMERS' DIKES'

The groundwater level in the plot can be controlled flexibly using 'farmers' dikes'. With the help of dikes, the farmer can control the surface water level himself and thereby also the groundwater level. With as high a surface water level as possible, the groundwater level is held constant for as long as possible and water is retained in the area for longer. The control depends on the weather situation or forecasts, groundwork or the time in the growing season. It is essential that these factors are anticipated in time for optimal usage.

The experiences acquired within the 'Agriculture at the required level' project teach us that the dike levels can be set higher than the participating farmers and water board thought. Despite the high levels, the soils maintained an excellent level of workability. During wet periods, the extra water is soon drained away, but during long dry periods without a supply of water, in time, this measure won't work anymore either.

In practice, the dike is usually operated as follows: first of all, participants only adjust the level a few times a year. In the early spring (sometimes as early as February), the dike is often raised. When it rains heavily in the summer, the dike level will temporarily be lowered, before being raised again. In the autumn, the dike will be lowered.

Combined with other measures such as shallow and narrow pipe drainage, these measures have a higher yield and improved control.

#### SITUATION

Wet

Dry

Extremes

#### BUSINESS OPERATIONS

Grass/corn

Agriculture

Horticulture

#### WATER SUPPLY

Yes

No

#### SOIL TYPE

Sand

Clay

Peat

#### SOIL

Fertility

Chemistry

Biology

#### ONLINE INFORMATION

[www.library.wur.nl/WebQuery/hydrotheek](http://www.library.wur.nl/WebQuery/hydrotheek) (enter: boerenstuw)

[www.wpm.nl/nieuws/@142757/boerenstuwen\\_werken/](http://www.wpm.nl/nieuws/@142757/boerenstuwen_werken/)

[www.zlto.nl/onderwerpen-item/15/Waarom-zou-ik-water-besparen/item/10008/Zeven-manieren-om-water-te-besparen](http://www.zlto.nl/onderwerpen-item/15/Waarom-zou-ik-water-besparen/item/10008/Zeven-manieren-om-water-te-besparen)



	Year	Total number of days			
		Too wet	Moderately able to withstand grazing	Mowing & able to withstand grazing	Too dry
Current climate	2001-2010	27	88	157	
Expected future climate	10 years	32	76	163	2.4

### Measurements 2012-2013

Year	Too wet	Moderately able to withstand grazing	Mowing and able to withstand grazing	Too dry
2012	0	101	173	0
2013	7	134	99	0
Average	4	118	136	0
Without average measure 2001-2010	27	88	157	0

Experience and measurements support the theory that in this situation, level-controlled drainage is favourable for reducing wet damage. By infiltrating surface water via the drains, drought-related damage is prevented too.



**Lerink:** "Did I allow the level to drop when it started to rain? Yes, later on I did. But initially I didn't. You ask yourself: is that a bad thing or a good thing? I was thinking along the lines of: you can allow the water to drain away very meticulously every time, but if it really is too much at any given time, that's still a possibility. You don't need to take measures far in advance. That's my thinking now."

### ONLINE INFORMATION

[www.kennisakker.nl](http://www.kennisakker.nl)

[www.stowa.nl/projecten/peilgestuurde\\_drainage](http://www.stowa.nl/projecten/peilgestuurde_drainage)

[www.kennismoetstromen.nl](http://www.kennismoetstromen.nl)

[www.futurewater.nl](http://www.futurewater.nl)

### SUPPLY

Retain additional 10-20 mm water per annum

Manage additional 50-125 mm water per annum

### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-15% extra crop yield

### INVESTMENT

€1300- €2500/ha

### OTHER SIMILAR MEASURES

Combined drainage

Climate adaptive drainage (CAD)

Combined with farmers' dikes (draining into a ditch with controlled level)

## (COMBINED) LEVEL-CONTROLLED DRAINAGE

Level-controlled drainage (LCD) is pipe drainage that lies under water and from which the level can be regulated with a structure on the ends of the pipes. In contrast to conventional drainage, the pipes merge under water into a ditch from which the surface water level can be regulated using a dike, or these pipes merge into a carrier drain, whereby everything can be controlled using a control well. The latter is referred to as combined level-controlled drainage (CLCD).

Sufficient water is needed for a constant groundwater level or drainage level, such as by means of rainfall, spring or surface water supplies. We therefore make a distinction between areas of application; water supply areas and areas without a water supply. Management plays an important role.

In areas without a water supply, the effect of retaining water for longer is estimated at a one-to -two-week delay in the drop in rainwater and around 20 mm additional storage. LCD can also be used to retain extra water during the growing season following heavy rainfall (> 30 mm).

In areas with a natural water supply, the level can be regulated throughout the growing season. Calculations and practical experiences show that it has benefits for the root zone's water supply, raised and constant groundwater levels in the summer and a higher crop yield.

### SITUATION

Wet  
Dry  
Extremes

### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

### WATER SUPPLY

Yes  
No

### SOIL TYPE

Sand  
Clay  
Peat

### SOIL

Fertility  
Chemistry  
Biology



**Stamsnieder:** "When you begin to lay drainage, you can opt for shallow and narrow drainage. This form of drainage is somewhat more expensive because the pipes are laid at a distance of 8 m from each other instead of 10 m. Those low extra costs are soon recouped. It makes all the difference if you are able to apply fertiliser or collect the last of the grass at the right time, because if a cut crop is left for a time because it's too wet, there's a significant possibility that you will have to sow the land again."

#### SUPPLY

Improved drainage during rainfall peaks: approximately 1.5 times as fast

Raising/temporary raising of groundwater level: 10-25 cm in the summer

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-15% less crop damage

#### INVESTMENT

€1000- €2000/ha

#### OTHER SIMILAR MEASURES

Combined level-controlled drainage

Climate adaptive drainage (CAD)

Trenches

Small plots

Doming of plots

## SHALLOW NARROW DRAINAGE

Shallow and narrow drainage differs from conventional drainage due to laying the pipes in a less shallow position compared to surface level and a higher density and a shorter distance between the strands. This higher density drains away the excess rainfall more effectively and the plot remains more easily passable. The higher position of the pipes ensures that higher groundwater levels are achieved. During dry periods, if their level is maintained, the pipes can maintain a higher groundwater level for longer, and the crop will receive the water it needs more effectively from underneath.

Experiences with this measure in the project are positive. The inconvenience of temporarily high groundwater levels as a result of heavy rainfall and ponding will reduce. The workability of the soils remains good on average and the groundwater levels are sinking less deep compared to normal drainage. The drainage system's response speed depends on the type of soil and the ditches' drainage options.

This measure is more effective when combined with level control and water supply. Control options are increased because the density of pipes is greater.

The area of application for this measure is situated in the immediate vicinity of wet nature reserves or stream valleys or in soils that have problematic shallow layers. If this measure is used in a larger area, the groundwater level can be raised/structurally raised depending on the water supply options.

#### SITUATION

Wet

Dry

Extremes

#### BUSINESS OPERATIONS

Grass/corn

Agriculture

Horticulture

#### WATER SUPPLY

Yes

No

#### SOIL TYPE

Sand

Clay

Peat

#### SOIL

Fertility

Chemistry

Biology

#### ONLINE INFORMATION

[www.spade.nl/spadewijzer-stap.asp?KennisbankID=222](http://www.spade.nl/spadewijzer-stap.asp?KennisbankID=222)

[www.nl.wikipedia.org/wiki/Drainage](http://www.nl.wikipedia.org/wiki/Drainage)

<http://edepot.wur.nl/165292>

## Groundwater levels with irrigation

Period	GHG (cm-mv)	GLG (cm-mv)	Average number of rounds of irrigation
2001-2010	87	214	1.4
2046-2055	79	224	3.9

It is expected that in the future, the groundwater levels will drop earlier and further as a result of longer periods of drought, causing insufficient moisture to be transported by capillary action to the root zone. This makes the farmer more dependent on irrigation if his crops are to grow as optimally as possible. It is expected (based on W+ climate scenario) that irrigation will be required around twice as much.



**lemhoff:** "You take more and more measures. If you strive to achieve the maximum yield from a large number of crops, they must be watered at least every three days. If possible, I am striving to achieve a sufficient subsequent capillary supply from the soil. Just look at the lily crop: if it doesn't rain for five days, the rain system will switch on."

## ONLINE INFORMATION

[deltaproof.stowa.nl/Publicaties/deltafact/Bodemvochtgestuurd\\_beregenen.aspx?pld=14](http://deltaproof.stowa.nl/Publicaties/deltafact/Bodemvochtgestuurd_beregenen.aspx?pld=14)  
[www.wageningenur.nl/en/show/FlowAid-2.htm](http://www.wageningenur.nl/en/show/FlowAid-2.htm) [www.wageningenur.nl/en/show/FlowAid-2.htm](http://www.wageningenur.nl/en/show/FlowAid-2.htm)  
[nl.wikipedia.org/wiki/Beregening](http://nl.wikipedia.org/wiki/Beregening)  
[www.plattelandspost.nl/14457/precisie-beregening](http://www.plattelandspost.nl/14457/precisie-beregening)  
[www.projectwatersense.nl/](http://www.projectwatersense.nl/)

## SUPPLY

Expected additional moisture required for the future:  
25-80 mm

## EXPECTED ADDED BENEFIT PER ANNUM

Around 10-25% extra crop yield

## INVESTMENT

€0.15-€0.35/m<sup>3</sup>

## OTHER SIMILAR MEASURES

Droplet irrigation  
 Level-controlled drainage with water supply and infiltration  
 Level design by dikes with water supply and infiltration  
 Increased organic matter content  
 Improved rooting

Irrigation has already been used for years during persistent dry periods during the growing season. The irrigation method undergoes a development with new methods such as pivots and with "high-tech" irrigation, where the irrigation is optimised for:

- efficiency (quantity of water and location)
- limiting labour intensity
- saving water

If the water cannot be supplied through the soil (by capillary action), irrigation is a good alternative.

Irrigation comes from surface water or groundwater. In '*Agriculture at the required level*', calculations have made it clear that the importance of a good supply of moisture in the summer is becoming increasingly important. The number of rounds of irrigation is expected to increase as a result of longer drier periods. Whether the costs offset the benefits is something that the individual farm should consider. What's more, irrigation is often generally started too late to achieve optimal crop growth. Technical devices (such as soil moisture sensors or satellite images) may also help to determine the time for irrigation.

At the moment, experience is also being acquired of droplet irrigation as an alternative to irrigation. The intensive labour process is a limiting factor for starting either irrigation or droplet irrigation.

# IRRIGATION

## SITUATION

Wet  
 Dry  
 Extremes

## BUSINESS OPERATIONS

Grass/corn  
 Agriculture  
 Horticulture

## WATER SUPPLY

Yes  
 No

## SOIL TYPE

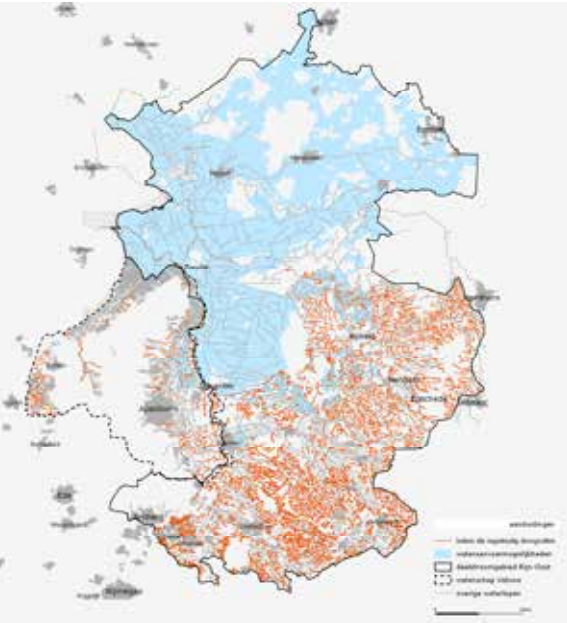
Sand  
 Clay  
 Peat

## SOIL

Fertility  
 Chemistry  
 Biology



Rhine-East water supply areas (Source: Bottleneck analysis  
East Netherlands Freshwater Supply, ZON, region East)



**Reimer:** "By supplying water with a pump, we are ensuring that all other measures really are having an effect. If you aren't supplying any water for behind the agricultural dikes, for example, you will lose the water after a while and won't have anything. A water pump isn't difficult to install and this type of pump doesn't use much electricity. Now that we are getting more and more dry summers, it is more and more important to supply sufficient water throughout the growing season."

ONLINE INFORMATION

[www.overijssel.nl/thema%27s/water/projecten/zoetwatervoorziening/](http://www.overijssel.nl/thema%27s/water/projecten/zoetwatervoorziening/)  
[www.droogtestudie.nl/droogtestudie/](http://www.droogtestudie.nl/droogtestudie/)

ADDITIONAL WATER SUPPLY

**SUPPLY**

additional 10-100 mm water per annum

**EXPECTED ADDED BENEFIT PER ANNUM**

Around 5-20 % extra crop yield

**INVESTMENT**

1.5-5000/ha  
+ water board labour

**OTHER SIMILAR MEASURES**

Water retention with dikes  
Water buffering  
Increasing organic matter content

An additional supply of water for irrigation or maintaining the water level is only possible in supply areas that have been designed for this purpose. In the freely draining high sandy soils, it isn't possible to receive a supply except with technical interventions (water the mount by pumping or use alternative sources, such as effluent from sewage water purification systems). The additional supply is provided by water boards based on the existing or new infrastructure.

The additional supply always goes hand in hand with the additional management of water/groundwater at plot and/or area level. The water can be managed using dikes, culverts, dams or barriers or a pump, using an additional supply and managing the groundwater level properly at as constant a level as possible. The level of the optimal groundwater level depends on the crop, type of soil and weather conditions. It is important to monitor the groundwater level or the moisture condition of the soil, so that it can be adjusted regularly.

The additional supply can be regulated by water courses, rivers and canals. Upstream, a sufficiently large source must be available to meet this requirement. This source may be a water course, canal, area of natural springs or nature reserve, or a sewage water purification system. Agreements must also be reached in relation to the distribution of the available water between the plots.

SITUATION

Wet
Dry
Extremes

BUSINESS OPERATIONS

Grass/corn
Agriculture
Horticulture

WATER SUPPLY

Yes
No

SOIL TYPE

Sand
Clay
Peat

SOIL

Fertility
Chemistry
Biology



#### SUPPLY

No supply: Additional 25-75 mm water per annum  
 With a small constant supply source:  
 Additional 25-100 mm water per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-15% extra crop yield

#### INVESTMENT

€0.20-€0.45/m<sup>3</sup>

#### OTHER SIMILAR MEASURES

##### WATER SUPPLY

Irrigation (ground or surface water)



**Reimer:** "The basin means that we now have the water where it's needed, close to our plots. That affects the groundwater and makes irrigation much easier. We used to have to run hoses to the water course, and the nearby campsite suffered from noise disturbance, for example. Now the water is much closer".

#### ONLINE INFORMATION

[www.waterhouderij.nl](http://www.waterhouderij.nl)

<http://publicwiki.deltares.nl/display/ZOETZOUT/GO-FRESH+-+Valorisatie+kansrijke+oplossingen+robuuste+zoetwatervoorziening>

## WATER BUFFERING

In the Netherlands, we have excess rainfall. This rainfall doesn't always fall at the right time, however, i.e. when we need it. The excess water is therefore not drained away like we are used to doing, but is buffered first for times of drought. This water buffering can be used to meet requirements in the summer.

The excess water during the winter period or the drainage during heavy downpours in the summer can be stored in the water buffer. If there is a small constant source of supply in the area in the summer too, the volume of the buffer can remain limited.

Water buffering is possible in surface water and in groundwater. Little experience has been acquired so far of the two methods for land-based agriculture in the High Netherlands. With a buffer such as this, the farmer builds up his own stock, as has already been happening in the greenhouse cultivation industry for years.

Combined with water-saving measures and/or precise irrigation or droplet irrigation, the available water can be used more efficiently.

In addition to having your own buffer on the farm, you may also consider a joint buffer or using other areas/buffer areas as stock, as per the area's function.

#### SITUATION

Wet  
 Dry  
 Extremes

#### BUSINESS OPERATIONS

Grass/corn  
 Agriculture  
 Horticulture

#### WATER SUPPLY

Yes  
 No

#### SOIL TYPE

Sand  
 Clay  
 Peat

#### SOIL

Fertility  
 Chemistry  
 Biology



**Sprokkereef:** "The measure infiltration by drainage was implemented during the course of May 2012. In the beginning, there were a few teething problems, but at the time, it was less dry than it is this year (2013), so that was already a difference. In 2013, it was extremely dry. In the past, we had many more dry years, but at the time, the corn was worse than last season. The entire plot is now in better condition, even where it hasn't drained. We have witnessed things much worse here."

#### SUPPLY

Additional 20-50 mm water per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-10% extra crop yield

#### INVESTMENT

500-3000/ha

#### OTHER SIMILAR MEASURES

Water conservation  
Climate adaptive drainage (CAD)  
Irrigation

## FLOODING AND INFILTRATION

Sufficient moisture is needed in the top layer of soil for the crop to grow as optimally as possible. The water comes from above (rain) or from underneath (capillary action). If insufficient rain falls, the moisture stock can be replenished by flooding. If the groundwater level is too deep, the moisture in the soil can be replenished again by means of infiltration.

Infiltration through drains brings water from the ditch into the plot. The water replenishes the moisture in the soil from underneath, in an attempt to maintain sufficient capillary action to the roots of the plant. Infiltration is also possible from above by infiltrating the (clean) rainwater from the yard or the farm, for example, through a drain. To make infiltration by drainage a success, drainage pipes must be underwater at all times during the dry periods. This usually requires a water supply.

Another method for replenishing the soil moisture from above is temporary flooding of the plot. This 'classic' method used to be used a lot for fertilisation and fighting vermin and pests. Temporary flooding replenishes moisture in the soil, as does rainfall. Flooding is only possible if the crop permits it and deterioration/internal deterioration can be prevented.

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

#### ONLINE INFORMATION

[www.duurzaamtelenbegintbijjou.nl/file.axd?file=2010%2F3%2FInundatie\\_in\\_de\\_bloembollenteelt.pdf](http://www.duurzaamtelenbegintbijjou.nl/file.axd?file=2010%2F3%2FInundatie_in_de_bloembollenteelt.pdf)

[www.youtube.com/watch?v=opxZnT7Ym8o](https://www.youtube.com/watch?v=opxZnT7Ym8o)



**Asbreuk:** "Climate Adaptive Drainage is very easy to control. It is quick and relatively simple to change the water level in the plot. It contains a programme that enables you to do it from home, enabling you to switch rapidly when weather conditions change. Depending on the weather forecast, you can then decide: should we raise or lower the level in the plot?"

#### SUPPLY

No supply: retain additional 10-60 mm water per annum  
Manage additional 75-100 mm water per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-10% extra crop yield

#### INVESTMENT

€1000- €6500/ha

#### OTHER SIMILAR MEASURES

Water management with farmers' dikes

## DIKE MANAGEMENT/ AUTOMATIC DIKE MANAGEMENT

Dike management of a sub-area or plot can be automated. The dike can be controlled using groundwater or surface water levels, weather data or weather forecasts, or a combination thereof. One participant in '**Agriculture at the required level**' acquired experiences with Climate Adaptive Drainage (CAD) (inventor: Future Water). Water from the nearby sewage water purification system is also used to infiltrate this form of level-controlled drainage in the plot. The dike level and thereby the groundwater levels can be regulated remotely (by PC or smartphone). Prior to heavy rainfall, the groundwater level is lowered temporarily to store water in the ground. In the event of drought or predicted drought, the dike level is raised.

The effects of this pilot are positive. Depending on the situation (supply, drainage and soil), the groundwater level is maintained more effectively, which can have a positive effect on crop growth. This method can be used in nature reserve buffer zones (high levels due to agricultural use) and in areas that have a water storage problem (storage of rainfall peaks).

At farm level, automatic dike management may increase the buffer capacity for extreme events (wet and dry) with limited use of labour. In collaboration with managing the water board's primary water courses, the effectiveness of the measures can be increased.

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

#### ONLINE INFORMATION

[www.futurewater.nl/kad/](http://www.futurewater.nl/kad/)





**Beernink:** "You can also turn it around. Then you say to the farmer: how long do you think it won't be harmful that the level in the ditch is so high. Then he will say three or four days. In the winter, that is never a problem, as you simply release all the dikes. And then you start to retain water again in the spring. If each farmer were to retain the water on his own land, that's half the battle."

#### SUPPLY

Additional 50-100 mm water stored per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

€500-€700 ha per annum remuneration

#### INVESTMENT

€1500- €2000/ha

#### OTHER SIMILAR MEASURES

Increased drainage capacity  
Retaining water at the source (at surface level)

#### ONLINE INFORMATION

[www.wgs.nl/ruimte-water/programma-ruimte/afgeronde-projecten/salland-waterproof](http://www.wgs.nl/ruimte-water/programma-ruimte/afgeronde-projecten/salland-waterproof)

[www.deltaplanhogezeandgronden.nl/best\\_practices/water\\_vasthouden](http://www.deltaplanhogezeandgronden.nl/best_practices/water_vasthouden)

## 'FARMERS' STORAGE

Everyone knows what the flooding of plots is like following heavy rainfall. It seems to occur with ever-increasing frequency. In order to prevent problems from heavy rainfall, the water board is looking for water storage areas. In the Salland Waterproof project, 'farmers' storage areas have been installed. The basic principle behind farmers' storage is to make constant agricultural use of the land. Suitable soils for this type of storage are low, usually marginal, soils. By lowering the surface level and attaching to the water course, this creates a local storage area and the problem is limited elsewhere.

Naturally this storage function involves a number of limitations for the crop and crop growth. The crop in the farmers' storage will adapt to the conditions. The storage areas have been used a number of times over the past few years, but haven't resulted in true limitations in terms of usage and processing.

In consultation with the user of the farmers' storage, agreements have been made in relation to implementation of the storage area, its use (fertilisation time and harvesting) and any remuneration (green service). We have learned from experience that the rich structure of the grass is excellent as fodder for dry cows and young stock. Other plants or crops such as cranberries or willows are also possible, but we are yet to acquire experience in this.

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology



**Luesink:** "I hadn't expected that a higher level in the ditch would have such an impact on the entire grassland. We really kept the water level high, which appeared to turn out well, because otherwise you would dehydrate. In very dry periods, you may require a water supply, otherwise the water would go down completely, and then you would have to irrigate again. But delaying irrigation ensures that you incur fewer costs".

#### SUPPLY

No supply: retain additional 10-60 mm water per annum  
Manage additional 75-100 mm water per annum  
Additional 10-30 mm water stored per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-15% extra crop yield

#### INVESTMENT

€500- €5000/ha

#### OTHER SIMILAR MEASURES

Combined drainage  
Climate adaptive drainage (CAD)  
Water management with farmers' dikes

## GROUNDWATER-CONTROLLED LEVEL MANAGEMENT

Are you familiar with the groundwater level under your plots? In '**Agriculture at the required level**', the participants have worked with groundwater level pipes in the plots, as well as learn to use them. The groundwater level is essential for crop growth and the soil structure. By measuring the groundwater level regularly (weekly), valuable information is collected that may directly result in yield increase. The information is used to manage the groundwater levels with dikes, drainage/level-controlled drainage or the water supply. After all, the subsequent capillary supply from the soil is – if not enough rain is falling – the only source of water for the crop. The soil structure and temperature is also affected by the groundwater level and structural damage is likely to occur.

By measuring the groundwater levels and relating them to the surface water level in the ditch, the rain and evaporation and the strength of the soil and crop growth can teach everyone the optimal condition for the plot. What's more, by taking soil moisture measurements, the variation in the depth of the soil moisture can be measured. Based on this information, the dike can be raised or lowered and weather forecasts anticipated.

The participants have found understanding the groundwater level to be very valuable and still measure the levels during the weekly 'Farm walk'.

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

#### ONLINE INFORMATION

[www.soilpedia.nl/Wikipaginas/Peilbeheer%20en%20drainage.aspx](http://www.soilpedia.nl/Wikipaginas/Peilbeheer%20en%20drainage.aspx)

[www.deltaproof.stowa.nl/Publicaties/deltafact/Dynamisch\\_peilbeheer.aspx?pld=6](http://www.deltaproof.stowa.nl/Publicaties/deltafact/Dynamisch_peilbeheer.aspx?pld=6)

[www.skbodern.nl/project/27](http://www.skbodern.nl/project/27)

[www.louisbolck.org/downloads/2821.pdf](http://www.louisbolck.org/downloads/2821.pdf)





#### SUPPLY

Higher groundwater levels  
(40 cm – surface level)  
Additional 10-30 mm water  
stored per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around -10% - same yield

#### INVESTMENT

€2000- €10,000/ha



**Ter Schure:** "We sowed a large number of different types of grass into strips, with and without clover. It is obvious that the clover is protruding out. Clover increases the nitrogen level in the soil and produces a higher yield. Clover disappears after three years because it has a tap root. Mowing the grass shorter helps to retain the clover, as it provides more light on the ground. But that doesn't work in practice, because when we mow, we mow everything. When grass grows, it grows most during the last week, so allow it to grow longer to obtain a greater yield."

#### ONLINE INFORMATION

<http://edepot.wur.nl/134070>

[www.agro-advies.nl/index.php?pid=16&pagename=Bedrijfsmatige%20teelt](http://www.agro-advies.nl/index.php?pid=16&pagename=Bedrijfsmatige%20teelt)

[www.inagro.be/ophalen\\_popup.aspx?lijst=Maatschappij&ID=130](http://www.inagro.be/ophalen_popup.aspx?lijst=Maatschappij&ID=130)

<http://edepot.wur.nl/201502>

## OTHER CROPS (WET)

The land's agricultural use can be guaranteed even under wet conditions. These soils require different preparation, but the disadvantages of the soils or conditions may remain limited even with other crops.

For grass land, more extensive management of the soils and a different mixture of grass or rough-stalk meadow grass is a potential solution. Structured grasses provide more prick and structure and are perfect for using in the feeding regime of young cattle or dry cows. These grasses may have a lower nutritional value, but can often be used without loss in many farm operations. The added benefit of using these grasses lies mainly in reduced stress in business operations and improved soil management. You may also want to consider converting grassland into other crops such as high forests (willows) or cranberries. Good results have already been achieved with the latter in the UK.

Wet conditions are very unfavourable for agricultural crops. Driving over crops and soil cultivation soon cause structural damage and crop growth is reduced by oxygen-related stress in the root zone. In the autumn, rewetting poses a risk of being unable to harvest crops. Of the most common agricultural crops, maize is most sensitive to rewetting, because it is sown relatively late (around 1 May) and if you choose an early variety, it can also be harvested reasonably early on (the beginning of September).

Based on the current climate scenario, it is expected that due to the changes, the growing season can be extended. This provides opportunities for other crops and, as a result, the harvesting conditions of the current crops are also different.

#### SITUATION

Wet

Dry

Extremes

#### BUSINESS OPERATIONS

Grass/corn

Agriculture

Horticulture

#### WATER SUPPLY

Yes

No

#### SOIL TYPE

Sand

Clay

Peat

#### SOIL

Fertility

Chemistry

Biology



**Ter Schure:** "The tall fescue endured the dry period better than the other grasses, which all looked poor. This is because tall fescue is more deeply rooted, as well as ensuring prick."

#### SUPPLY

10-40 mm less water  
supplied per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around -5-15 % extra crop  
yield

#### INVESTMENT

€500- €1000/ha

#### OTHER SIMILAR MEASURES

Timothy, Orchard,  
Westerwolds grass  
Japanese oat  
Sunflowers  
Alfalfa  
Rapeseed

## OTHER CROPS (DRY)

Soils that are sensitive to drought are best suited to deep-rooting crops such as grains, maize, sugar and fodder beets (up to 60-100 cm under surface level) or grass. Grains mainly grow in the spring when rainfall is less restrictive. Crops that manage water more efficiently, such as C4 crops (for example, corn is 30% more efficient with water) are sown.

As an alternative to the usual British ryegrass, you may decide to sow tall fescue because this type of grass is more resistant to drought due to its deeper rooting as the sod ages (>2 years). Tall fescue best suits an arable farming rotation (3 to 4 years), because it places higher demands on the sowing conditions; it should preferably be sown in warm and humid conditions (late summer). Under dry conditions in particular, tall fescue can easily be combined with clover, and this benefits the crop's nutritional value.

Alfalfa is a crop that roots deeply for a prolonged period. During the first year, the crop invests in the development of the root system, but then it is more productive than grass. The Alfalfa crop is beneficial to the soil structure.

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

#### ONLINE INFORMATION

[www.aquarius-nr.eu/About/The\\_Aquarius\\_Project/The\\_Aquarius\\_Project.htm](http://www.aquarius-nr.eu/About/The_Aquarius_Project/The_Aquarius_Project.htm)

[www.wageningenur.nl/nl/Onderzoek-Resultaten/Themas/Klimaat-Water/Projecten.htm](http://www.wageningenur.nl/nl/Onderzoek-Resultaten/Themas/Klimaat-Water/Projecten.htm)



**Pegge:** "Limited soil preparation, we have actually already been doing that for years. Not ploughing the grass. When we re-sow, we clear the top 6-7 cm. You can see that after all these years, the soil contains 1.5% more organic matter. Now we really do have more and more to tackle. I believe the longer we keep this up, the quicker it will go."

#### SUPPLY

Retain additional 5-15 mm water per annum  
Additional 5-10 mm water stored per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 2-10% extra crop yield

#### INVESTMENT

€200- €5000/ha

#### OTHER SIMILAR MEASURES

Dry farming (abroad)

## LIMITED SOIL PREPARATION

With limited soil preparation, the soil will be disturbed as little as possible and natural processes (soil life and plants) will do their work to the best of their ability. Soil life creates a stable and large passage system and sensitivity to soil compaction is decreased. The passage system allows the water to infiltrate more effectively, as well as improving the capillary action from the subsoil. This measure is already being applied abroad on a large scale.

Arguments made by several participants to apply this measure are: retention of organic matter content and improvement of the soil structure. Research has revealed that the organic matter content on these plots is significantly higher than in the immediate vicinity. With the new fertiliser legislation, this is therefore becoming a more and more important factor.

For water management, this measure makes a positive contribution to both wet and dry conditions. During the transition period from regular preparation to limited preparation, management is necessary and tolerated. A maximum soil coverage and the use of green fertilisers are important success factors. A new method such as undersowing also plays a role in the successful application of this measure.

The role of soil life within managing the soil of the plots effectively is a relatively new field for many farmers, but an interesting one.

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

#### ONLINE INFORMATION

[www.nietkerendegrondbewerking.nl/](http://www.nietkerendegrondbewerking.nl/)

[www.spade.nl/spadewijzer-stap.asp?KennisBankID=8](http://www.spade.nl/spadewijzer-stap.asp?KennisBankID=8)

[www.spade.nl/upload/boeken%5Cblgg0042\\_ontw\\_boek\\_w.pdf](http://www.spade.nl/upload/boeken%5Cblgg0042_ontw_boek_w.pdf)





#### SUPPLY

Additional 10-30 mm water used per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-10% extra crop yield

#### INVESTMENT

€1000- €5000/ha

#### OTHER SIMILAR MEASURES

Staged drainage



**Pegge:** "If you want to drain effectively, you must flatten the plot entirely. The plot contains half a metre difference and there's a metre difference from one point to the other. That simply won't work; otherwise you would have to install terraces. But it is too artificial and we don't want to plough, because the work will cause you to lose all organic matter. We are now at 4%, and ploughing would cause you to lose everything again."

## SMOOTHING AND FLATTENING

Unevenness in plots are detrimental to the preparation and surface drainage of water. Whenever water remains stagnant for a long time at a low point in the land, this creates oxygen-less conditions in the ground. As a result, the soil life reduces and crop roots are damaged. The soil quality in the depths will decline further over the years. This causes a difference in crop quality within the plot.

Smoothing and flattening plots reduces the problems with water that remains stagnant at specific points in the plot. This effect is reinforced even further when, instead of flattening, the plot is domed. Other disadvantages of relief in plots are the reduced effectiveness of drainage and workability. The coordination of an optimal level in the ditch is also difficult if a plot has a lot of height differences. A small proportion often benefits from capillary action from the groundwater. On plots that offer a lot of relief, you may find flat terraces with staged drainage systems.

Smoothing and flattening can be carried out by digging with a crane or ploughing. A point for attention continues to be retaining the organic matter content in the top layer. The measure can easily be combined with laying (shallow and narrow) drainage.

Depending on the subsoil (subsidence), it is necessary to repeat these measures frequently. In the event that flattening isn't possible, staged drainage systems or 'terraces' may be considered to gain better control on the plot.

#### SITUATION

Wet

Dry

Extremes

#### BUSINESS OPERATIONS

Grass/corn

Agriculture

Horticulture

#### WATER SUPPLY

Yes

No

#### SOIL TYPE

Sand

Clay

Peat

#### SOIL

Fertility

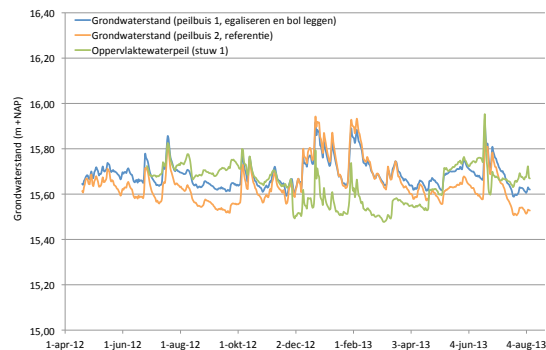
Chemistry

Biology

#### ONLINE INFORMATION

[www.kanon-kompas.nl/](http://www.kanon-kompas.nl/)

Meindert and Detri Smid's experience is that doming the plots has made a big difference. Their strength has improved and there's less water on the land compared to the plot next door. Monitoring well 1 is located in the smoothed domed plot.



**Smid:** "You can see that this plot has been domed and the plot next to it is just as low. But this year, some of the crop was left on the plot next door. This can also be seen once we have mown the plots. Traces of the crop are always visible, in those wet patches. And now it is just a beautiful green whole on the domed plot."

#### SUPPLY

Additional 10-40 mm water drained per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-15% less crop damage

#### INVESTMENT

€2000- €3000/ha

#### OTHER SIMILAR MEASURES

Drainage/combined drainage  
Improving soil structure  
Improving soil biology

## DOMED PLOTS

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

If the soil has a low infiltration capacity, the land will continue to retain water. This may be caused by problematic layers in the soil or a soil type that is difficult for water to penetrate (such as boulder clay). Another cause may be soil compaction or structural decay in the soil, which compresses the soil due to the heavy machinery that drives over it or the animals that walk across it.

Doming plots encourages rain to run off the surface quickly. Water that ends up on the plot and is unable to penetrate the ground is drained off to the sides of the plot. This encourages effective workability and creates more oxygen in the soil.

This measure can be used as an alternative to removing problematic layers. This measure is also recommended on very wet plots, such as when combined with a shallow and narrow drainage system or a combination in peaty areas with underwater drainage.

A point for attention with this measure is the water quality and the accelerated drainage to the ditch. Fertilisation of the plot must be tailored to the weather: no rain desirable within 2-3 days. The surface water system must also have sufficient storage to store the peak. This measure, combined with farmers' storage, is therefore a good one.

#### ONLINE INFORMATION

<http://edepot.wur.nl/221923>



**Enting:** "In the past, the land was sometimes too wet in the autumn - so wet that it caused me to lose 2 ha of potatoes. After removing the problematic layer, we were simply able to remove the green peas from that section. There weren't really any puddles on the land either. The soil still needs to recover from the conversion of the soil, but it provides a great deal of satisfaction to be able to harvest the crop that's there."

#### SUPPLY

Retain additional 10-20 mm water per annum  
Additional 10-45 mm moisture supplied per annum

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-15% extra crop yield

#### INVESTMENT

€400- €2000/ha

#### OTHER SIMILAR MEASURES

Digging  
Cultivation/deep cultivation  
Deep ploughing

## REMOVING PROBLEMATIC LAYERS (SOIL COMPACTION)

Natural, sharp transitions in the soil aggravate the roots and are detrimental to air and water management. Examples of natural aggravating layers are clay-on-peat soil (heavy clay with little swell and shrinkage), peat, the top layer of which has been hardened due to drying, internal blow-out in sandy soils or enrichment layers of compost and/or iron in sandy soils.

Problematic layers may also occur due to soil preparations and heavy machinery, as well as working under wet conditions (also known as soil compaction or structural decay). It takes years before these problematic layers are raised again naturally.

Most 'Agriculture at the required level' participants weren't aware of the problematic layers that were present. Who looks under the sod? Discover problematic layers yourself by digging a profile pit. Pay attention to the soil condition when digging and see what the roots are doing. Under wet conditions, you may be able to see that water is leaking where the soil is compacted, whereas the compacted soil itself looks dry.

Problematic layers can be removed by mixing layers of soil by digging, deep ploughing or deep cultivating the soil, for example. The following motto applies here: prevention is better than cure. Have patience under wet conditions and place conditions on the contractual work. It will appear as though extra costs are being incurred as a result, but the opposite is actually true!

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

#### ONLINE INFORMATION

[www.spade.nl/spadewijzer-stap.asp?KennisbankID=132](http://www.spade.nl/spadewijzer-stap.asp?KennisbankID=132)

[www.spade.nl/spadewijzer-stap.asp?KennisbankID=136](http://www.spade.nl/spadewijzer-stap.asp?KennisbankID=136)





**SUPPLY**  
Retain additional 10-20 mm water per annum  
Additional 10-55 mm moisture supplied per annum

**EXPECTED ADDED BENEFIT PER ANNUM**  
Around 5-15% extra crop yield

**INVESTMENT**  
€200- €1000/ha

**OTHER SIMILAR MEASURES**  
Improving soil biology  
Less soil preparation



**Steggink:** "It isn't just the water that's important. Our crop also benefits from composting and soil preparation, as well as the fact that we still have grains in the cropping plan. Hardly anyone has that anymore. By improving the soil, water management is also improved."

## ONLINE INFORMATION

[www.spade.nl/spadewijzer.asp](http://www.spade.nl/spadewijzer.asp)

[www.kennisakker.nl/kenniscentrum/document/effecten-van-grondbewerking-op-bodem-en-productie](http://www.kennisakker.nl/kenniscentrum/document/effecten-van-grondbewerking-op-bodem-en-productie)

[www.mijnbodemconditie.nl](http://www.mijnbodemconditie.nl)

[www.bodemconditiescore.nl](http://www.bodemconditiescore.nl)

# IMPROVING SOIL STRUCTURE

The soil structure is the extent to which soil particles are bound together (in aggregates or clods). For clayey soils, this looks like a type of card house structure at microscopic level, and for sandy or loamy soils, it looks like a pinball machine. Between the soil particles, you will find a large number of holes and pores. The 'adhesives' in the soil hold this structure in position.

Problems with the soil structure arise when the soil becomes compressed due to soil preparation, for example, under conditions that are too wet or due to the use of heavy machinery. As a result, the pores will disappear into the soil and therefore also the oxygen. Roots find it more difficult to penetrate into the soil and water doesn't infiltrate as quickly. The efficiency with which the nutrients and minerals are absorbed declines.

For a good soil structure, prevention is also better than cure. Avoid preparing the soil under wet/excessively wet conditions as far as possible. The use of wide tyres, low air pressure in the tyres and working with set paths also prevents the soil from compressing. If you want to know the condition of your soil, perform the **BodemConditieScore** (Soil Condition Score).

Other measures referred to that have a positive effect on the soil structure are increasing the organic matter content, limited soil preparation, compost, good fertiliser, grasses and grains in the cropping plan, improving the soil biology and removing problematic layers.

## SITUATION

Wet

Dry

Extremes

## BUSINESS OPERATIONS

Grass/corn

Agriculture

Horticulture

## WATER SUPPLY

Yes

No

## SOIL TYPE

Sand

Clay

Peat

## SOIL

Fertility

Chemistry

Biology



#### SUPPLY

Retain additional 10-20 mm water per annum

Additional 10-55 mm moisture supplied per annum

Improving infiltration and drainage by 10-20%

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-10% extra crop yield

#### INVESTMENT

€200- €1000/ha

#### OTHER SIMILAR MEASURES

Improving soil structure

Other crops

Less soil preparation



**Spijkerman:** "The soil life is still a relatively unknown area. Together with the soil structure and chemistry, these form the important factors for effective soil management. As an organic farmer, I have already been involved in this for some time. And with current fertiliser legislation, effective soil management is becoming increasingly important!"

#### ONLINE INFORMATION

[www.spade.nl/spadewijzer.asp](http://www.spade.nl/spadewijzer.asp)

[www.gaiabodem.nl/achtergronden/Bodemleven/](http://www.gaiabodem.nl/achtergronden/Bodemleven/)

[www.bodemacademie.nl/index.php?i=123](http://www.bodemacademie.nl/index.php?i=123)

## IMPROVING SOIL BIOLOGY

For agriculture, three aspects of the soil are important: the soil structure, the soil chemistry and the soil biology. These three aspects act on each other and strengthen each other. The agricultural industry's focus has been one-sided on chemistry for many years. More attention is currently also being paid to the structure. The soil structure and the biology in particular are long-term processes, and if renewed attention is paid to them, they will only give the desired effects in 5-10 years' time. The role of soil life in effective soil management is a relatively new field for most 'Agriculture at the required level' participants but an interesting one.

The soil life affects the structure of the soil and the cycle of water and nutrients. The organisms found in the soil are worms, bacteria, fungi and roundworms. Worms create pores etc. which encourage the ventilation and structure of the soil, and roundworms, bacteria and fungi regulate the release and allocation of nutrients. Soil life also ensures that organic matter is absorbed.

Soil life is negatively affected by a cropping plan without grass or grain, the small or lack of supply of organic matter, intensive soil preparation, soil compaction, poor drainage and dehydration. Soil life can be encouraged with solid fertiliser, crops with a good root system, keeping the soil covered, less soil preparation or the use of green fertilisers. Good soil life is characteristic of effective and sustainable soil management!

#### SITUATION

Wet

Dry

Extremes

#### BUSINESS OPERATIONS

Grass/corn

Agriculture

Horticulture

#### WATER SUPPLY

Yes

No

#### SOIL TYPE

Sand

Clay

Peat

#### SOIL

Fertility

Chemistry

Biology



**Ter Schure:** "Now I no longer constantly grow corn on the same plot, because the organic matter content must be higher there. Potatoes have now been growing on the plot for two consecutive years, so now I can continue sowing grass. After six years of grass, the rotation will start again with two years of corn."

#### SUPPLY

1% organic matter retains  
4-6 mm additional water in  
the topsoil

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 5-15% extra crop  
yield

#### INVESTMENT

€200- €1500/ha/year

#### OTHER SIMILAR MEASURES

Green fertilisers  
Producing compost  
Less soil preparation  
Catch crops and  
undersowing  
Absorbing ditch cuttings

## INCREASING ORGANIC MATTER CONTENT

The organic matter content is an important part of the soil/soil structure. Organic matter makes the soil more resilient and thereby reduces the risk of soil compaction (and the result of that soil compaction - i.e. waterlogging). Organic matter also retains water and fertilisers and thereby provides a good supply of moisture and minerals for plants. Organic matter also maintains the level of soil life and encourages the availability of nutrients. What's noticeable in practice is the number of farmers who are unaware of the organic matter content of their own plots.

To increase the organic matter content in the soil, it is necessary to add more organic matter than is being decomposed. The decomposition of organic matter depends on the crop etc.

It is possible to reduce the decomposition by means of limited soil preparation, reducing intensive crops (which demand a lot from the soil) and not cracking grassland. The supply can be increased by clippings, stable manure, compost, green fertilisers that are absorbed, undersowing of grass, or the working in of stubble and crop remnants.

When an agriculturist and a cattle farmer start working together, the grassland ensures that the soil contains a higher amount of organic matter and the rotation ensures that the soil is less exhausted. With current legislation, it is important that the organic matter content is managed carefully!

#### SITUATION

Wet  
Dry  
Extremes

#### BUSINESS OPERATIONS

Grass/corn  
Agriculture  
Horticulture

#### WATER SUPPLY

Yes  
No

#### SOIL TYPE

Sand  
Clay  
Peat

#### SOIL

Fertility  
Chemistry  
Biology

#### ONLINE INFORMATION

[www.spade.nl/spadewijzer-stap.asp?KennisbankID=117](http://www.spade.nl/spadewijzer-stap.asp?KennisbankID=117)

[www.kennisakker.nl/kenniscentrum/document/effecten-van-organische-stofaanvoer-op-bodem-en-productie](http://www.kennisakker.nl/kenniscentrum/document/effecten-van-organische-stofaanvoer-op-bodem-en-productie)





#### SUPPLY

1% organic matter retains  
4-6 mm additional water in  
the topsoil

#### EXPECTED ADDED BENEFIT PER ANNUM

around 1-7 % extra crop yield

#### INVESTMENT

€100- €4000/ha

#### OTHER SIMILAR MEASURES

Increasing organic matter  
content  
Catch crops and  
undersowing



**Steggink:** "Why does a cattle farmer use a green fertiliser? Because he has to? We, arable farmers, do things differently, however. We regard green fertiliser as a fully-fledged crop. Only then will it give you a yield too, and will you be able to improve your organic matter content and soil structure over time."

#### ONLINE INFORMATION

[www.spade.nl/upload/beschrijving%20alle%20maatregelen%20gereedschapskist%20%28definitief%29.pdf](http://www.spade.nl/upload/beschrijving%20alle%20maatregelen%20gereedschapskist%20%28definitief%29.pdf)

[www.kennisakker.nl/kenniscentrum/handleidingen/teelthandleiding-groenbemesters-welke-groenbemester-de-beste-keuze](http://www.kennisakker.nl/kenniscentrum/handleidingen/teelthandleiding-groenbemesters-welke-groenbemester-de-beste-keuze)

[www.verantwoordeveehouderij.nl/](http://www.verantwoordeveehouderij.nl/)

## GREEN FERTILISERS

After agricultural cultivation, it is recommended that you grow a catch crop. For maize on sandy soil, this is required by law to prevent nitrogen from leaking and the groundwater from absorbing too much. Green fertiliser crops are used for this, such as yellow mustard, green rye, cabbage and radishes.

These crops are able to develop lots of leaf mass in the autumn, once the main crop has been harvested. Following the agricultural crops of potatoes and maize in particular, lots of nitrogen is easily left behind in the top soil, and this is lost if not followed immediately by a new crop.

To store nitrogen away effectively, green fertilisers must be regarded as a fully-fledged crop and not as an obligation to satisfy legislation. Green fertilisers don't just save nitrogen for the next growing season - they also supply organic matter and play a part in maintaining a good soil structure. On wetter soils, this benefits the soil's ability to drain, and on dry soils, this contributes to a longer root depth. A deeper root increases the availability of moisture substantially, and this in turn translates itself into a higher crop yield. What's more, the rotation of agricultural crops places demands on the choice of green fertilisers in relation to roundworm breeding and storage in the next crop.

#### SITUATION

Wet

Dry

Extremes

#### BUSINESS OPERATIONS

Grass/corn

Agriculture

Horticulture

#### WATER SUPPLY

Yes

No

#### SOIL TYPE

Sand

Clay

Peat

#### SOIL

Fertility

Chemistry

Biology



**Zwier van der Vegte (LiveStock Research):**  
*"On the market, it has been found that undersowing is a more effective way of trapping unused nitrogen than traditionally grown green fertilisers."*

#### SUPPLY

1% organic matter retains  
 4-6 mm additional water in  
 the topsoil

#### EXPECTED ADDED BENEFIT PER ANNUM

Around 1-10% extra crop  
 yield

#### INVESTMENT

€200- €1000/ha

#### OTHER SIMILAR MEASURES

Green fertilisers  
 Less soil preparation  
 Increasing organic matter  
 content  
 Other crops

## CATCH CROPS AND UNDERSOWING

Maize is harvested relatively late in the year, certainly compared to a harvest such as grain maize or Corn Cop Mix (CCM), which needs even longer to ripen. The result of the catch crop in the form of green fertilisers therefore often leaves a lot to be desired, causing nitrogen to escape and flow into the groundwater.

The catch crop does make the land green, but the crop doesn't grow in sufficient numbers. A mixture of Italian ryegrass and rye is usually sown. To benefit more from the advantages of a catch crop, harvesting must take place no later than half way through September. This requires an early start in the spring and the use of early varieties.

To gain time in the autumn, it is recommended that grass is undersown, preferably Italian ryegrass. This means that in around mid-June, grass is sown between the rows of maize. This grass initially develops moderately through the shadow effect of the maize, however one to two weeks after harvesting the maize, you will have an enclosed crop, because the grass will be off to a flying start. On the market, as well as in the pilots of the **'Duurzaam boer blijven in Drenthe'** (Remaining a farmer in Drenthe for the long term) project, it has been found that undersowing is a more effective way of trapping unused nitrogen than traditionally grown green fertilisers. On wetter soils, the formation of a sod under the maize also provides additional strength when it comes to harvesting.

#### SITUATION

Wet  
 Dry  
 Extremes

#### BUSINESS OPERATIONS

Grass/corn  
 Agriculture  
 Horticulture

#### WATER SUPPLY

Yes  
 No

#### SOIL TYPE

Sand  
 Clay  
 Peat

#### SOIL

Fertility  
 Chemistry  
 Biology

#### ONLINE INFORMATION

[www.duurzaamboerblijven.nl](http://www.duurzaamboerblijven.nl)

<http://edepot.wur.nl/5506>

[www.archief.verantwoordeveehouderij.nl/producten/Kansen/Media/Flyer/Leaflet1Rundveehouderij.pdf](http://www.archief.verantwoordeveehouderij.nl/producten/Kansen/Media/Flyer/Leaflet1Rundveehouderij.pdf)





## SOIL optimisation

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