The Veenkoloniën
On the wave of sustainability

A report that gives a realistic view on the future development of the Mussel Aa

Wageningen, October 2009

The Veenkoloniën; on the wave of sustainability

Based on the design 'the new Peatcolonies' (Kersten, 2009) the consultancy firm 'Water & Co' carried out a feasibility assessment of the design made for the Mussel Aa area.

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This consultancy firm is specialized in integrated hydrology and landscape hydrology. The combination of specialists working at this firm guarantees a realistic view on long and short term plans.

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Executive summary

This research focused on the Veenkoloniën which lies in the northern part of the Netherlands. Our objective is to carry out a feasibility study of the plan 'the new Peatcolonies' of Inge Kersten (Master student Landscape architecture) and to give additional suggestions for the improvement of the design. The design is made to upgrade the area and to make it more attractive for recreation and tourism. This upgrade is mainly focused on the hydrological properties of the area. These hydrological measures have the purpose to make the area less dependent on the inlet of water from lake IJssel and make it climate proof.
Several methods are used in this study, such as hydrological models, interviews and literature studies to assess the feasibility of 'the new Peatcolonies'.
The outcomes of the hydrology research questions are that the retention areas are not sufficient to reduce the inlet of lake IJssel to zero, because these areas store only 67% of the storage water. Therefore it is more feasible to reduce the inlet to a certain amount instead of reducing it to zero. The reduction is estimated on 85% of the total inlet. There are two different retention areas; the temporary and the permanent. The temporary retention areas are feasible if there is a clay layer which prevents leakage inside and seepage outside. Furthermore permanent retention areas are realistic if they are excavated.
From a climate change point of view the design is feasible with an increase of 1°C if 500 mm can be stored in the retention areas. Additionally all this water should be available during summer. If temperatures will increase with 2°C and storage of 1000 mm should be created, it is not possible to store this in the retention areas.
The agribusiness is a large stakeholder in this area. The arable land that is lost due to the creation of retention areas will have the largest influence on the agribusiness. Possible fluctuating ground water levels will only occur in the winter months, so the crop production in the growth season will not be affected. The different agro-stakeholders seem to agree with each other on the dominance of agriculture in the area and that nature maintenance by farmers should be compensated. The idea of implementing intensive animal husbandry is proposed by some stakeholders (LTO and Agenda voor de Veenkoloniën), but other stakeholders disagree on this (e.g. the province of Groningen).
The implementation of retention areas creates the opportunity to build houses on water which is technical and policy-wise attractive. However, housing gives more demands on the design of the retention areas, because it needs to be a beautiful and safe living environment without mosquitoes and a poor water quality. Another issue is that it is necessary to have a unique living environment to compete with areas such as Blauwe Stad Groningen. According to the real estate agents there is currently no demand for such houses due to the financial crisis. However, they expect a demand when the crisis is over.
There is potential for recreation in this area. However, this can only be realized if several measures are implemented and investments are done to make the area more attractive. The inhabitants of the area can benefit from the recreation by using it themselves or by earning money of tourists. Governmental institutions have to play a supporting and initiating role.

Preface

Throughout the last years, the imminent climate change has gained importance. An increase of the overall temperature and change in precipitation and evapotranspiration has been predicted for the Netherlands by KNMI (Royal Dutch Meteorological institute). There are four different climate scenarios for the Netherlands; however it is clear that the upcoming change will have an influence on the water level. In order to forestall any severe consequences on the water provision for in the Veenkoloniën, measures has to be taken.
At the moment the water system in the Veenkoloniën is dependent on the inlets of lake IJssel. To make the water provision more secure in the future, water management should be made more self sustainable.
The water board Hunze & Aa's is planning to implement water storages in the landscape at the Mussel Aa in the West of Stadskanaal. As the design for retention areas is already made by the landscape architect student Inge Kersten, the goal of this research is to carry out a feasibility study of these plans. While looking at the hydrological feasibility of the retention areas, we are also looking at the impacts on agriculture, housing and recreation near the Mussel Aa.

First of all, special thanks are directed to the commissioners Patrick Bogaart and Cees Kwakernaak of Alterra. The weekly meeting was useful for the process, because their feedback helped us with the content of this report.
Further we would like to thank our coach Joost Jongerden. His advises guided and supported us throughout the process, as a team and individually.
Also we would like to acknowledge our expert Rudolf van Broekhuizen for helpful discussions and explanations. Moreover, we would like to thank Hans van Hilten and Huub Schuurman from the province Groningen as well as they were willing to share their expertise with us. We are also very grateful for the information and input given by Paul Hendriks and Wilfried Heijnen from the water board Hunze & Aa's. Furthermore we express gratitude for the advices given on the modeling from Erik Querner. Also we thank all the interviewees such as Ko Munneke (Agenda voor de Veenkoloniën) and Jakob Bartelds from the LTO as well as the Bruggers family that gave us useful information.
We hope that this report will contribute to the further development of water management the Mussel Aa region.

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1. Introduction

The Veenkoloniën is a region in the north of the Netherlands; located in both provinces Groningen and Drenthe. An overview of the region is found in Appendix A. In this area, water management plays an important role as it has an impact on socio-economic and agricultural issues. However, the region is facing changes in the climate in the future. According to the KNMI (KNMI, 2009) the climate change will result in more extreme weather conditions such as more droughts in summer and more rain in winter. That is why a well-designed water balance in this area is needed to cope with such changes.

Currently, the water management of the Veenkoloniën is dependent on the inlet of water from lake IJssel. This inlet can be reduced as the water system is quite manipulative (H+N+S, 2005). In order to have a sufficient water supply, water storages could be implemented in the region. This results in a lower dependency on external water and a more sustainable water management system (Deltacommissie, 2008).

Compared with other regions of the Netherlands, the economy in the Veenkoloniën still has room for development. The population size is shrinking, public transport is poorly organized and the average income is below national average (Ministerie van LNV, 2009). One of the main sources of income is agriculture, but this is declining as farmers continue on abandoning. About 2084 hectares of land will become available from farms, which close down between 2005 and 2012 (Kersten, 2009). This causes a transformation from small- to more large-scale farms. Therefore, the consequences of a change in water management could have an impact on the farms in this area.

In the past, this region was a rich peat area. This changed in the 17th century, when a large part of the Netherlands had been deforested and fuel became scarce. The need to exploit the peat increased in these years. By now, almost all the peat is mined. The mining left a monotonous landscape behind, which is not very attractive as a living environment neither for recreation. (Kersten, 2009).
Thus, a new design is desired. It should mainly improve the self-sustainability of the region on the one hand, and protect the Veenkoloniën against severe climate changes on the other hand. Furthermore the landscape should be changed to make it more attractive. That is why Inge Kersten designed design 'the new Peatcolonies' (Kersten, 2009).
This design suggests more retention areas as well as the broadening and meandering of the river Mussel Aa. Furthermore, the design intends to restore the peat plots in order to store more water and to make the area more dynamic.

Objective
The objective of this study is to investigate whether Kersten's measures are hydrologically feasible. The feasibility study concerning hydrological aspects will also consider expected consequences for land use possibilities in this area. The research questions for this study are mentioned below:

Main research question

Are the plans made by Inge Kersten feasible in terms of hydrology and land use? Land use concerns agriculture, housing and recreation.

Sub research questions

Hydrology

- To what extent is the retention area, suggested by Inge, sufficient to make the area independent of the inlet of water from lake IJssel?
- To what extent will these retention areas be sufficient in case of the predicted climate change scenarios?

Land use

- Based on hydrological results/measures, what changes will occur in the agribusiness?
- What are the desired changes of the different agro-stakeholders? e.g. farmers, companies like AVEBE?
- Based on the hydrological results/measures, what changes are expected to occur in housing possibilities?
- What are the long-term housing plans in the region and do they match with the expected changes?
- Based on the hydrological results/measures, what are the possibilities for recreation?
- How do the different stakeholders in the area benefit from these possibilities in recreation?

The outcomes of the hydrological studies are presented in chapter 3, in which the design of the retention areas is adjusted to the expected climate change.
Additionally, land use, which includes housing, recreation and agribusiness, should be accommodated with these hydrological measures. Concerning agribusiness, chapter 4 is about the desired changes of the agribusiness stakeholders and the changes that will occur in this sector due to the hydrological measures.
The improvement of the current water system and the development of the landscape can help to create a desired living environment. This can encourage the building of new houses, but also the reconstruction of existing houses. Such expected changes in housing and the long-term housing plans are described in chapter 5. With a more attractive landscape, recreational sites can be developed, which is described in chapter 6. This could stimulate the economy and increase the living environment in the region.
This report will end with a conclusion in which all the research questions are evaluated and answered. Finally, discussions and recommendations based on this research are given.

2. Materials and methods

In this study several methods are used to gather the information needed to answer the research question, such as models, literature studies and interviews. The models used for hydrology give a clearer view on the water management in the area and the influences of the hydrological measures in the design 'the new Peatcolonies' (Kersten, 2009). These are described in more detail in paragraph 2.1. The data input for the water balance model and the scenarios that are used for climate change is described in paragraph 2.2.
A literature study is carried out to get data for all the sub research questions, from hydrology to climate change scenarios, housing, agriculture and recreation. The last methods are interviews. Interviews are conducted with different stakeholders, the water board and the province. Beforehand a question list is prepared and these questions are asked during the interview.

2.1 Hydrological models

For the modeling of the Mussel Aa area in the Veenkoloniën two different techniques were used. First a water balance was made of the area, which could be used as a technique to get a better understanding of the Veenkoloniën. Secondly, the ground water levels are modeled to get a clear view about the influence of the retention areas on the ground water heads in the surrounding area.

Water balance

Figure 1 shows the flow chart that is used to model the water balance. All the calculations are made on a monthly base. The water balance has an input, internal processes and an output. The input of the water balance consists of precipitation and inlet as well as the output of evapotranspiration, outlet and leakage. There are also a number of internal processes present concerning storage such as ground water and open water storage. The internal relations in the water balance will determine which entries are most important and which entries could be neglected.
In the flow chart three types of connections are present, namely dotted and solid lines as well as circles.
The dotted lines indicate that a connection is present, but can be neglected because of the very small influence. The solid lines indicate one way relationships. For example the precipitation will contribute to the storage in the ground water, but this will not be the case the other way around. The last type of line is circles, which are two way relationships. In this case the first two types are connected with each other. For example, when raising the levels in the open water to create more storage, also the neighboring ground water levels will raise. This connection will also work the other way around.

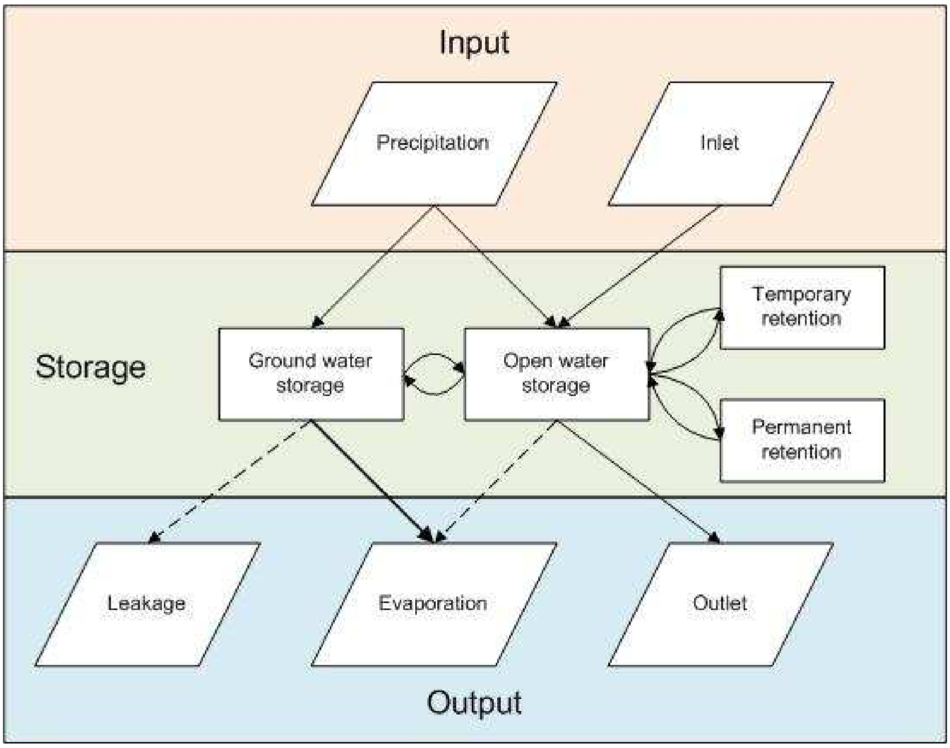

Figure 1. Design scheme of water balance, arrows indicate the internal relations. The input and output are fixed numbers/fractions. The storage depends on what is desired, so how much is stored in the retention areas and river. The dotted lines are flows that are unknown or too small to be relevant.

The different entries are described below in more detail. First the input entries will be explained, followed by the output entries and then the storage entries are described.

The input consists of precipitation and inlet. The precipitation is calculated with meteorological data from Eelde airport from the KNMI (KNMI, 2009) from 1970 till 2008. Also a calculation with meteorological data concerning climate change was done in a later stage. Eelde airport is chosen, because this meteorological station measures potential evapotranspiration is measured, which is not the case in a meteorological station more close by (Ter Apel). The calculated monthly averages are compared to monthly averages used in previously models for the Veenkoloniën in (Droogers and Immerzeel, 2005).
The inlet is calculated by using the design of the Mussel Aa of the water board Hunze en Aa's, which assumes that 0.35 l/s/ha is needed in the Mussel Aa.

The output can be divided into leakage, evapotranspiration and outlet.
The first entry is leakage. In some areas the leakage can be large, especially in the surroundings of ice pushed ridges. Because the study area is nearby the Hondsrug this could be of importance. From literature is derived that the leakage in the area is not more than 0.11 mm per month (Droogers and Immerzeel, 2005). This number is significantly low if compared with the area more towards the Hondsrug in the west. In this area the leakage is up to 14 mm per month (Droogers and Immerzeel, 2005). The leakage is neglected in the water balance, because it is only 0.11 mm per month.

The evapotranspiration is calculated by using the meteorological data from Eelde. KNMI calculates the daily potential evapotranspiration using the Makkink formula for a reference crop. Using crop factors (Bruin and Lablans, 1998) the reference evapotranspiration can be transferred into a potential evapotranspiration which can be used in the water balance. Winter crop factors were hard to find, so only an estimation of crop factors from (Bruin and Lablans, 1998) could be used for the water balance. Reduction is not included in the calculations to compensate for water shortage, in the case of drought for example. The unsaturated zone is assumed to be above wilting point throughout the year.
The outlet is difficult to calculate, because the Mussel Aa area has a very complex hydrological construction. The Mussel Aa is not a lumped system with only one outlet. Therefore the data of a sluice is used to estimate this entry.

The last part of the water balance is the storage, which can be divided into two different types, namely open water storage and ground water storage.
The open water storage is the storage present in the open water of the area. The retention areas belong to this type of storage. The retention areas designed were divided in two different types, based on the duration that it contains water. The temporary retention areas contain less than 50% of the year water, while the permanent retention areas are covered with water for more than 50% of the year. These retention areas will be filled with water from the Mussel Aa in case of a precipitation excess.
For the open water storage also the water present in the Mussel Aa is calculated. This is because water levels can be raised or lowered in the Mussel Aa.
The other storage type is the ground water. This is the entry which closes the water balance to have equal in- and output of water. All the water, which is not in or output via one of the other entries, is denoted as ground water storage.

Ground water model

This paragraph describes the model based on the mesh centered principle which is shown in figure 2 (Bier, 2007). The elements and nodes together are representing the Darcy equation and the continuity equation. Elements are the square blocks and contain information about the conductivity (k in m/d), the amount of water that can flow through it per time unit. The nodes are the dots and contain information about the head (H), external fluxes e.g. precipitation and a water balance.

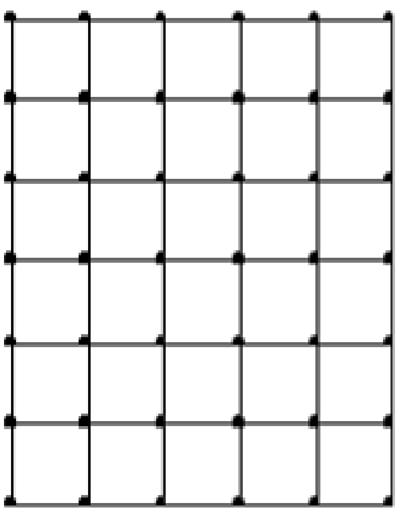

Figure 2. mesh centered principle with elements and nodes.

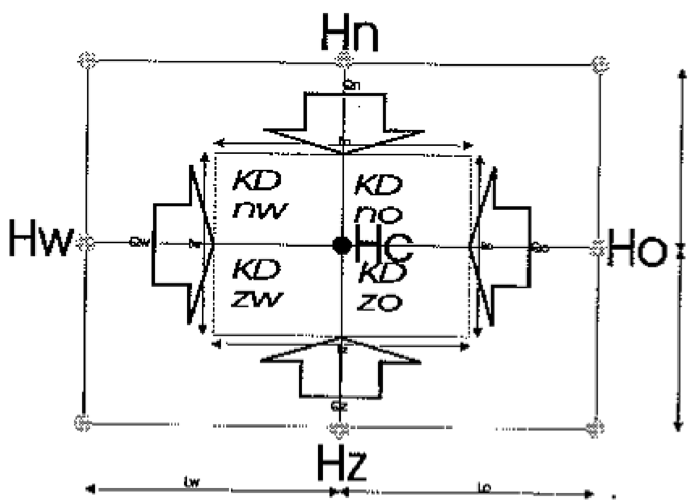

Figure 3. flux scheme for the central node with the relative contribution of several factors: kD, dimensions.

With this structure a water balance can be made assuming a stationary condition: $q_W + q_N + q_E + q_S + q_{EXT} = 0$. q_W is the flux that comes from the west and q_{EXT} is the external flux such as precipitation. In figure 3 it is visible how the value for the central node is calculated based on the relative contribution of the elements and the nodes e.g. H_W the head in the west towards the H_c, the head of the central node. The formula for this flux is:

$q_W = k * B_W * \frac{(H_W - H_C)}{L_W}$ in which:

- $k = \frac{(k_{NW} * L_N + k_{SW} * L_S)}{(L_N + L_S)}$ and
- $B_W = \frac{(L_N + L_S)}{2}$

q_W is the flux (m^2/d) that comes out of the west with the relative contribution of the conductivity (k) and element lengths L_N and L_S; often these lengths are the same because of the regular grid.

When calculating all fluxes from the north, east, west and south as well and in addition with the external input, the water balance is complete for this node. In the model that is built there are numerous nodes which are calculated consecutive and with this information the head is calculated over the whole cross-section in this case. A positive head means that there is a pressure by which the water can flow upwards and a negative head means that the water is infiltrating; hereby the influence of the retention area can be calculated. Differences in heads between the nodes cause a movement of the water from high heads to lower heads.

2.2 KNMI scenarios

How climate will change in the Netherlands depends on the worldwide increasing temperature and on changes in atmospheric circulations in Western Europe. These two aspects determine the four different scenarios as defined by KNMI (KNMI, 2008):

G → Moderate: An increase of 1 °C world-wide in 2050 compared with the temperature in 1990. There will be no changes in atmospheric circulations in Western Europe.

G + → Moderate +: An increase of 1 °C world-wide in 2050 compared with the temperature in 1990.
+ winters will become warmer and wetter due to more western winds
+ summers will become warmer and dryer due to more eastern winds

W → Warm: An increase of 2 °C over the whole world in 2050 compared with the temperature in 1990. There will be no changes in atmospheric circulations in Western Europe.

W + → Warm +: An increase of 2 °C world-wide in 2050 compared with the temperature in 1990.
+ winters will become warmer and wetter due to more western winds
+ summers will become warmer and dryer due to more eastern winds

With the G and W scenario the precipitation will not change during summer and winter. The estimation is made for the worse case scenarios, which is the reason why it is chosen to use the G+ and W+ scenarios to calculate the future water balance for the Mussel Aa area. The G and W scenarios do not really have a high influence on the precipitation. The calculation are made for 2050 and not for 2100, because the time range of 40 years is more appropriate for policymakers than 90 years and contains fewer uncertainties.
The KNMI made an estimation about the percentage of change in precipitation and evapotranspiration that will occur in every month per scenario (see table 1).

Table 1. Average monthly changes in precipitation and evapotranspiration (%) for the climate in 2050 compared with the climate in 1990 (KNMI, 2008).

	Evapotranspiration (%)		***Precipitation (%)***	
	G+	**W+**	**G+**	**W+**
January	1.3	2.6	7,5	15,2
February	1.5	3	7,0	14,2
March	2.2	4.5	5,0	10,2
April	3.6	7.1	1,4	2,9
May	5.0	10.1	-2,6	-5,1
June	6.5	13	-6,5	-13,0
July	7.8	15.7	-10,2	-20,3
August	8.5	16.9	-11,8	-23,6
September	7.6	15.2	-9,5	-19,0
October	5	10.1	-2,6	-5,1
November	2.9	5.8	3,2	6,6
December	1.7	3.4	6,5	13,2
Year	**5.4**	**9.0**	**-1,1**	**-2,1**

It is clear that the evapotranspiration will increase in 2050 in every month of the year, with a doubling effect for the W+ scenarios compared with the G+. The largest increase in evapotranspiration will occur during the summer months (June, July and August). Besides the effect of the increase in temperature during the summer, precipitation will decrease as well as water shortage will increase.
With these numbers, calculations are made for the change in precipitation and potential evapotranspiration for the weather-station in Eelde. The average precipitation and evapotranspiration per month from 1970 till 2008 are used to calculate the precipitation and evapotranspiration in 2050 (see tables 2 and 3).

Table 2. Calculations for precipitation in the area of Eelde in 2050 for the two KNMI scenarios (G+ and W+)

	1970-2008 (mm/month)	***G+ (mm/month)***	***W+ (mm/month)***
January	70.21	75.47	80.88
February	49.14	52.58	56.11
March	59.93	62.92	66.04
April	43.68	44.29	44.95
May	56.20	54.74	53.34
June	69.49	64.97	60.45
July	78.06	70.10	62.22
August	63.23	55.77	48.31
September	74.02	66.99	59.96
October	69.58	67.77	66.03
November	78.56	81.08	83.75
December	72.63	77.35	82.22
Yearly	**784.74**	**774.04**	**764.25**

Table 3. Calculations for potential evapotranspiration (Makkink) in the area of Eelde in 2050 for the two KNMI scenarios (G+ and W+)

	1970-2008 (mm)	***G+ (mm)***	***W+ (mm)***
January	7.21	7.30	7.39
February	14.20	14.41	14.63
March	30.85	31.53	32.24
April	54.75	56.72	58.64
May	82.82	86.96	91.19
June	88.54	94.29	100.05
July	91.46	98.60	105.82
August	79.18	85.91	92.56
September	48.82	52.53	56.24
October	25.93	27.23	28.55
November	10.33	10.63	10.93
December	5.68	5.77	5.87
Yearly	**539.77**	**571.89**	**604.11**

With the reference evapotranspiration (Makkink) the potential evapotranspiration can be calculated with the use of different crop factors (Pieterse *et al.,* 1998; Bruin and Lablans, 1998; Appendix B). The precipitation excess will give the water excess or deficit per month (see figure 4).

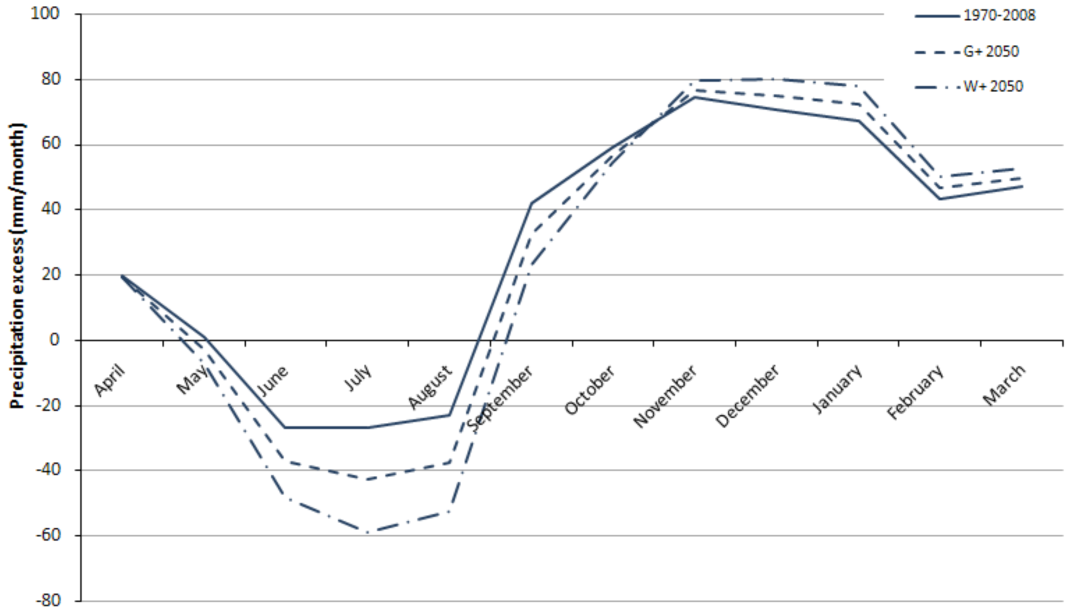

Figure 4. Precipitation excess per month. The current situation is marked with the solid line (average 1970-2008), while the regular dotted line is the predicted situation in 2050 with the G+ scenario and irregular dotted line is the predicted situation in 2050 with the W+ scenario.

3. Hydrology

3.1 Introduction

The hydrological system in the Veenkoloniën is a complex system of canals, old streams and many ditches. This water system mainly insures optimal conditions for the agriculture. The study area is (like most regions in the Netherlands (Haas *et al.,* 2007)) hydrologically not self sufficient, water from lake IJssel is pumped into the area via two different ways; Groningen (30 million m^3/yr) and Drenthe (15 million m^3/yr). Channels and ditches are leading the water to the final destination; farming land. This is done via two main canals: Musselkanaal and Mussel Aa Kanaal (figure 5). At several locations there is inlet of water from the Musselkanaal in the direction of the Mussel Aa. The area between these two canals consists of many small hydrological systems with their own water level (Appendix C).

Figure 5. The Mussel Aa left of Mussel Aa Kanaal, with changes made by Inge Kersten.
Total area = area between Musselkanaal and Mussel Aa Kanaal. The Stadskanaal is partly visible in the lower left.

Due to climate change, water management is not sufficient to avoid water shortages. In 2050 there is 10 million m^3/yr more water needed for the whole Veenkoloniën (Hunze en Aa, 2009).
In the report *Groningen, adaptation to climate change* Inge Kersten made a design for the region in the south of Stadskanaal (the new Peatcolonies) with the main goal of making this region more climate proof with the focus on water management.
The most important hydrological measures (Kersten, 2009) designed are the retention areas near the Mussel Aa (see figure 5). The re-meandering has a highly esthetic value, but does not really contribute to the storage of water. The surface area of the Mussel Aa will increase from 7.3 ha to 15.2 ha because of the meandering. The total surface of retention areas is 352 ha (11% of total), which can store a large amount of water, depending on the water depth of those areas. There is a division made between temporary and permanent retention areas. In the permanent areas (150 ha) water will be present for more than 6 months a year and the land cannot be used for other purposes. They are excavated to -0.8 m so it will be lower than the surface level (see figure 6). The average ditch

level below surface is 0.8 m which is a suitable water level for crops. Not more than 0.4 m water will be put in these permanent retention areas. These values are evaluated in paragraph 3.2.2 with the x-z model. The influence of the evaluated heights on the adjacent areas seems to be acceptable. Because these permanent areas are excavated there is no need for dykes. The temporary retention areas (202 ha) are flooded for no longer than half of the year, so it can still be used for agriculture. Water is stored on the surface level with a water level of 0.5m surrounded by dykes to keep the water inside of the retention area (see figure 7).

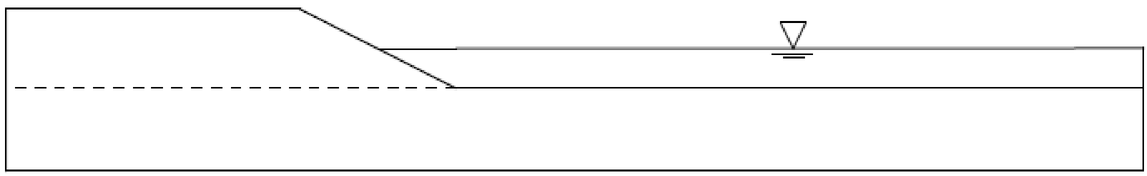

Figure 6. Permanent retention area, excavated so it is lower than surface level. Water will be present more than 50% of the year.

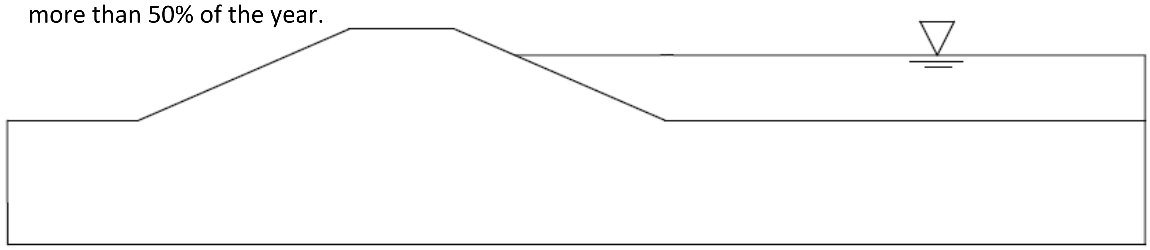

Figure 7. Temporary retention area, which lays on surface level. Water will be present not more than 50% of the year.

The areas are filled with water during the wet months in winter and this water will be used during the dry summer months to raise the water level in the Mussel Aa. The water level in the Mussel Aa influences the ground water level in the agricultural land west of the Mussel Aa. As stated before the water is flowing from the Musselkanaal via the agricultural fields through the ditches in the direction of the brook. The flow direction in the ditches will reverse when the water of the retention areas is used instead of the water from the Musselkanaal. The aim is to use constructions as simple as possible for the in- and outlet of water in these areas. Thus, a proper design for the retention areas is of high importance. When the amount of precipitation in winter is increasing, water levels should naturally get higher in the brook. This can be used to fill the retention areas, gravity then will be the main driving force behind the filling of the permanent areas. Pumps are needed for the temporary retention areas. For the use of water from the retention areas during the dry period the water can flow to the agricultural area with approximately the same elevation (see Appendix D). The functioning of these retention areas is clarified above, but the main question remains: how much water can be stored in the retention areas and is this sufficient to compensate for the changes in water availability due to climate change or to make the area less dependent on external water sources?

3.2 To what extent is the retention area sufficient

The water balance is an excellent tool to investigate the precipitation deficit in the summer months. This deficit is the amount of water, which is needed in summer to get a self sustaining water system, and is equal to the precipitation excess (precipitation minus evapotranspiration) when the water inlet is zero. The monthly precipitation and evapotranspiration values can be found in table 4.

It is clear that in the summer a small deficit of 76.41 mm is created over the months June, July and August (Appendix E). This deficit has to be compensated by for example retention areas which are filled during the periods in which the precipitation excess is large. The amount of water which has to be stored in this retention area is 76.41 mm.

Table 4. Yearly precipitation, reference evapotranspiration and precipitation measured at meteorological station Eelde airport (KNMI, 2008)

	Precipitation (mm)	Evapotranspiration (mm)	Precipitation excess (mm)
January	70.21	3.03	67.18
February	49.14	5.96	43.17
March	59.93	12.96	46.97
April	43.68	24.09	19.59
May	56.21	55.16	1.05
June	69.49	96.15	-26.66
July	78.06	104.81	-26.75
August	63.23	86.23	-23.00
September	74.02	31.98	42.05
October	69.58	10.89	58.69
November	78.56	4.34	74.22
December	72.63	2.38	70.25
Yearly	**784.74**	**437.98**	**346.76**

On a yearly base the changes in storage should be equal to zero for both open and ground water. If the change in storage is not equal to zero this will result in an deviation in the water balance, assuming that the other number are correct.

The deficit of 76.41 mm results in a deficit of ± 3.000.000 m^3 for the entire area. This water has to be stored in the relatively small area (815 ha) around and in the Mussel Aa. This will lead to an amount of water equivalent of 368 mm for the entire area of the Mussel Aa.

In the current situation the inlet from lake IJssel keeps the groundwater deficit zero, so there is no shortage of water. Reducing this inlet means creating a groundwater deficit. For the created groundwater deficit the 76.41 described above is used.

The inlet of lake IJssel is unknown at the water board. Therefore the design criterion of 0.35l/s/ha estimated by the water board Hunze & Aa's is used. This adds up to on average 2.26 million m^3/month. For the outlet data is used from a weir at Smeerling (Hunze en Aa, 2009). The data is compared with the calculated deficit on a yearly base. To have this comparison the outlet is subtracted from the inlet and this is the amount of water that is used in the Mussel Aa area. This amount should be approximately the same as the groundwater deficit. The inlet – outlet on a yearly basis is 525 mm, this compares to a deficit on a yearly basis of 456 mm.

First calculations are made in which the inlet of lake IJssel is completely stopped (see table 5). This results in 2.5 million m^3 of water that needs to be stored in the retention areas as indicated in the design 'the new Peatcolonies'. When using these areas a water level can be calculated. These levels exceed the evaluated heights (see paragraph 3.2.2) and are therefore expected to have a large influence on the ground water table in the surroundings of the Mussel Aa. When the evaluated levels are used together with the area from the design 'the new Peatcolonies' (Kersten, 2009) only 67% of the needed storage is created. This means that it is necessary to calculate how much area is needed to store the water. For this the evaluated heights and the amount of water that needs to be stored due to the reducing stopping of the inlet of lake IJssel to zero are used. These calculations show that 538 ha are needed to store the water when stopping the inlet. This is 17.3% of the total area used in the model. This can be compared to the 11.3% of retention area (202 ha for temporary retention areas and 150 ha for permanent retention areas) as calculated for the design 'the new Peatcolonies' (Kersten, 2009) (see table 5).

Table 5. Dimensions of the retention areas with an inlet from lake IJssel of 0 m^3/d

Data				
Ground water deficit	76.74	Mm	0.08	m
Total area: Stadskanaal-Mussel Aa			31155284	m2
Volume storage needed			2390856	m3
Area temporary storage	202	Ha	2020000	m2
Area permanent storage	150	Ha	1500000	m2
Needed heights in storage area[1]				
50% temporary and 50% permanent			1195428	m3
Calculated height temporary			0.59	m
calculated height permanent			0.80	m
Amount of retention with evaluated heights				
Evaluated height temporary retention			0.5	m
Evaluated height permanent retention			0.4	m
Volume temporary retention			1010000	m3
Volume permanent retention			600000	m3
Total volume of retention			1610000	m3
Percent of retention realized			67.34	%
Needed retention area with evaluated heights				
Area temporary retention	239.086	Ha	2390856	m2
Area permanent retention	298.857	Ha	2988571	m2
Percentage retention in relation to total area				
Percentage temporary retention			7.7	%
Percentage permanent retention			9.6	%
Total			17.3	%

[1] Please take into account that these are coarse estimates. This is due to the simplicity of the model used. Also the inlet numbers are estimations, not data.

Table 6. Percentage of retention area as stated in the design 'the new Peatcolonies' (Kersten, 2009).

Design 'the new Veenkoloniën'		
Percentage retention in relation to total area		
Percentage permanent retention	6.48	%
Percentage temporary retention	4.81	%
Total water	11.30	%

From the tables above, the conclusion can be drawn that the amount of water that needs to be stored, is going to take up a lot of space in the Mussel Aa area. This is due to the complete reduction of the inlet of lake Ijssel. The extra retention which needs to be created due to climate change is not even taken into account. For these reasons the groundwater deficit is plotted against the fraction of inlet of lake IJssel (see figure 8). With the use of table 6 it is possible to calculate how much inlet can be reduced if half of the deficit would be stored in retention areas around the Mussel Aa. Extrapolating the graph leads to a reduction of the inlet by 85%. This means that if 15% of the original inlet were to be pumped into the area, there should be compensation for the deficit of 38 mm.

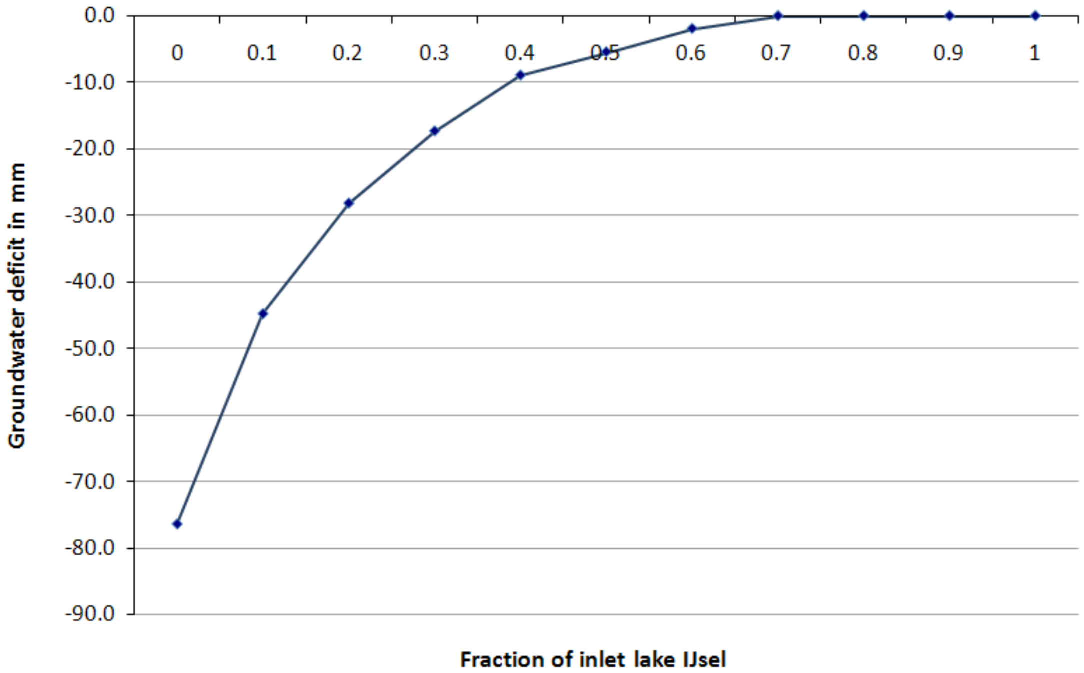

Figure 8. The groundwater deficit in relation to the reduction of lake IJssel inlet.

Further calculations were made with an inlet that only consists of 15% of the original amount of inlet. The calculations are carried out in a similar manner as previously. Looking at the results of these calculations the storage areas are sufficient to cope with this reduction (see table 7). When taking into account the evaluated heights it is possible to conclude that not all areas will be needed. This means that there is still some room left for the water shortages due to climate change. The question if this is a sufficient amount to include climate change fluctuations will be answered in paragraph 3.3.

Table 7. Dimensions of the retentions areas with an inlet from lake IJssel of 15 % of the original inlet

Data				
Ground water deficit	36.49	mm	0.03649	m
Total area: Stadskanaal-Mussel Aa			31155284	m2
Volume storage needed			1136856	m3
Area temporary storage	202	ha	2020000	m2
Area permanent storage	150	ha	1500000	m2
Needed heights in storage area				
50% temporary and 50% permanent			568428.2	m3
Calculated height temporary			0.2814	m
calculated height permanent			0.378952	m
Needed retention area with evaluated heights				
Evaluated height temporary retention			0.5	m
Evaluated height permanent retention			0.4	m
Area temporary retention	113.6856	ha	1136856	m2
Area permanent retention	142.107	ha	1421070	m2
Percentage retention in relation to total area				
Percentage temporary retention			3.649	%
Percentage permanent retention			4.56125	%
Total			8.21025	%

3.2.2 Influence retention area

In the previous paragraph the desired surface area of the retention areas are shown, but how do these areas influence the ground water table in the neighboring area? And what will be the difference in influence between permanent and temporary retention areas?

The model set-up for the project will be explained in order to clarify the theory which is presented in chapter 2 (Materials and methods). This model is used to get some insight in the x-z cross section of the retention areas next to the brook Mussel Aa. The x is the direction from the brook to the farmland for a distance of two kilometers. The z-direction is modeled for 38 meters below surface level because this depth is deep enough to have an overview of the water flows. In figure 9 the red line gives an example location of the cross section for which this model is build. A couple of calculations are done for the elements and nodes.

Figure 9. Red line indicates an example location of the cross section with permanent retention area (Kersten, 2009)

- The head (H) is calculated in the x-z dimensions that have a Δx of about 20 meters and Δz of 1 meter between nodes; this head is calculated for each node.

- The conductivity (k) values are dedicated to each element and give an impression about the amounts of water that can flow through the soil. The conductivity of the sandy soil is 25 m/d (de Vries, 1994).
- The water balance show all fluxes from the different wind directions.

The assumptions for this model are that the modeled cross section has a uniform conductivity, one aquifer and no aquitards. In reality in the upper soil could be compacted which would result in a lower conductivity. Also some peat or aquitard layers could influence the conductivity and thereby the water flow through the soil. With these assumptions the results of the model could still give insights because the soil mainly consists of sand (Haas *et al.,* 2007, figure 5.2).

Temporary retention area with dyke

The head distribution is shown in figure 10. At length zero the retention area with a water level of 0.5 meter above surface level is present. As a result of gravity the water tends to flow to the lower area adjacent to the retention area. The line in the graph tends to assemble to the ditch level of 0.8 m below surface level. With the quite significant conductivity of sand (25 m/d) the higher water level has a large distance over which the groundwater level tends to increase. Up to 150 meters from the retention area there is a positive head which means that the water can flow to the surface level. For the arable land this seepage flux will cause a water table near to surface level in case there is no extra drainage between the ditches. The implementation of the small dyke will not make a difference because the water will flow through the sandy soil beneath the dyke. In figure 11 the seepage flux is visualized with respect to the distance from the retention area. At 20 meter distance the seepage flux is the highest namely 8.6 mm/d (one bucket of water per square meter per day). The reason for this specific distance is that closer to the retention area the overall flux is still downwards and further away from the 20m. In this case the resistance is increased by the longer flow route and will thereby be lower. When implementing this system the retention area would be emptied really fast and the adjacent farm lands will be flooded. In the next part some measures are taken to prevent these high seepage fluxes.

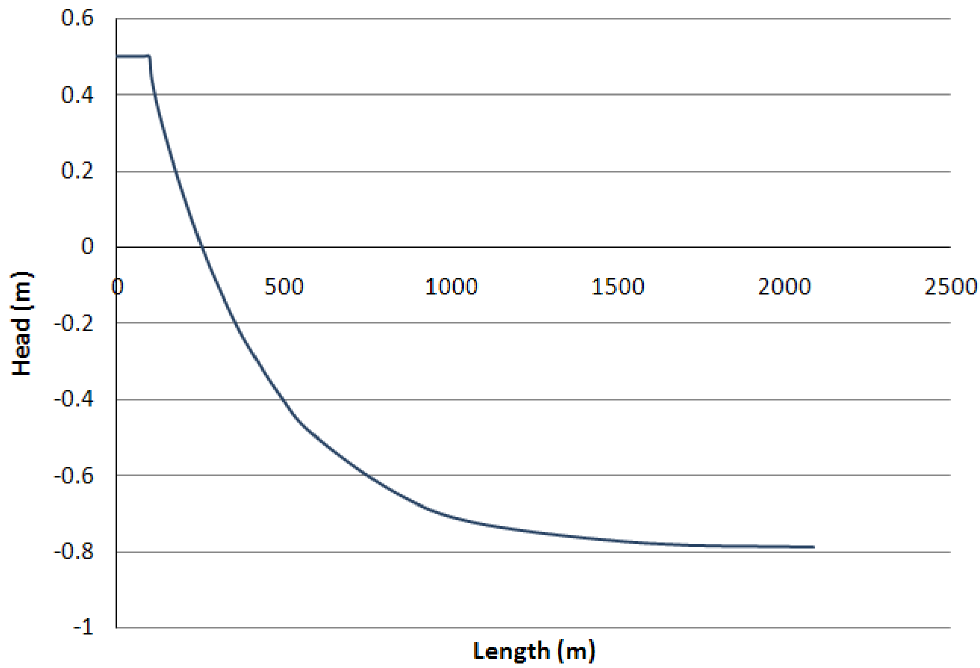

Figure 10. Head distribution of temporary retention area with a water level of 500 mm.

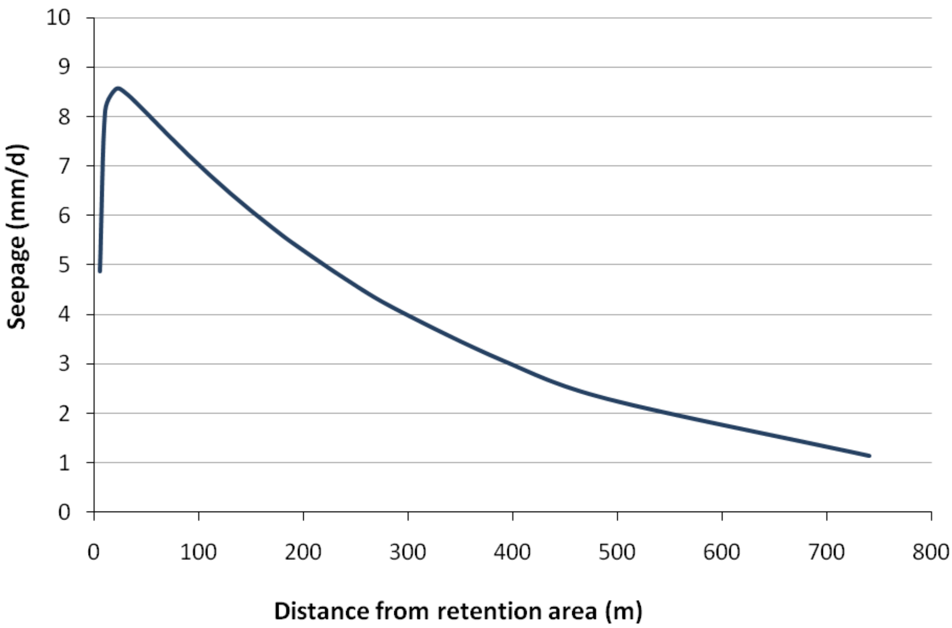

Figure 11. seepage fluxes with distance from the temporary retention area.

Temporary retention area with clay layer and dyke
In order to decrease the amount of leakage water from the retention area to the farm land, a clay layer is needed on the bottom of the retention area. The conductivity of the clay is 0.001 m/d and the modeled thickness is 0.1 m. Figure 12 shows the head distribution at surface level (0), just below surface (0.1m) and at a depth of 38 meters. The line starting at

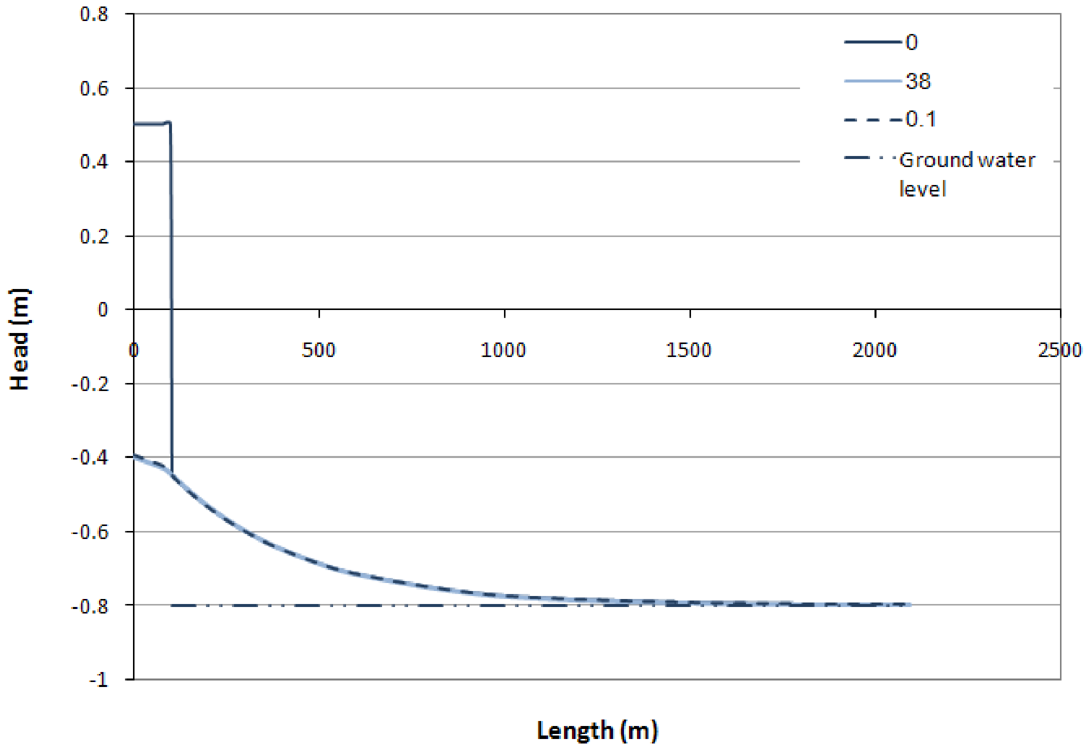

Figure 12. Head distribution of temporary retention area at several depths, with dyke and clay layer.

the retention area with a water level of 0.5 m continues along the 100 m length of the retention area and then drops very fast because of the dyke and clay layer. In the dyke cross section the head steeply descents from 0.5 m to -0.45 m. Just beneath the surface level (0.1 m) till 38 meters below surface the head starts at -0.4 m under the retention area and decreases further to the fixed ditch level of -0.8 m. This head distribution shows clearly the influence of the clay layer; in this way the adjacent land is protected from seepage fluxes but do have a slightly higher groundwater level till 500 m from the retention area. This can be solved by implementing a drainage system, but the disadvantage is more water draining out of the retention area.
In order to fill the retention area the water has to be pumped out of the Mussel Aa. This is done by using some mobile pump installations, e.g. tractors. When the water is needed in the summer the water can flow again into the Mussel Aa and agricultural land by making use of the gravitational force.

Permanent retention area
For the permanent retention area the situation is somewhat different because the water is stored from -0.4 till -0.8 meters below surface level (figure 13). The head does not become

higher than -0.4 so there is no seepage in the adjacent land. The heads will get lower over distance, and will be -0.7 m from surface level at a distance of 500 m.

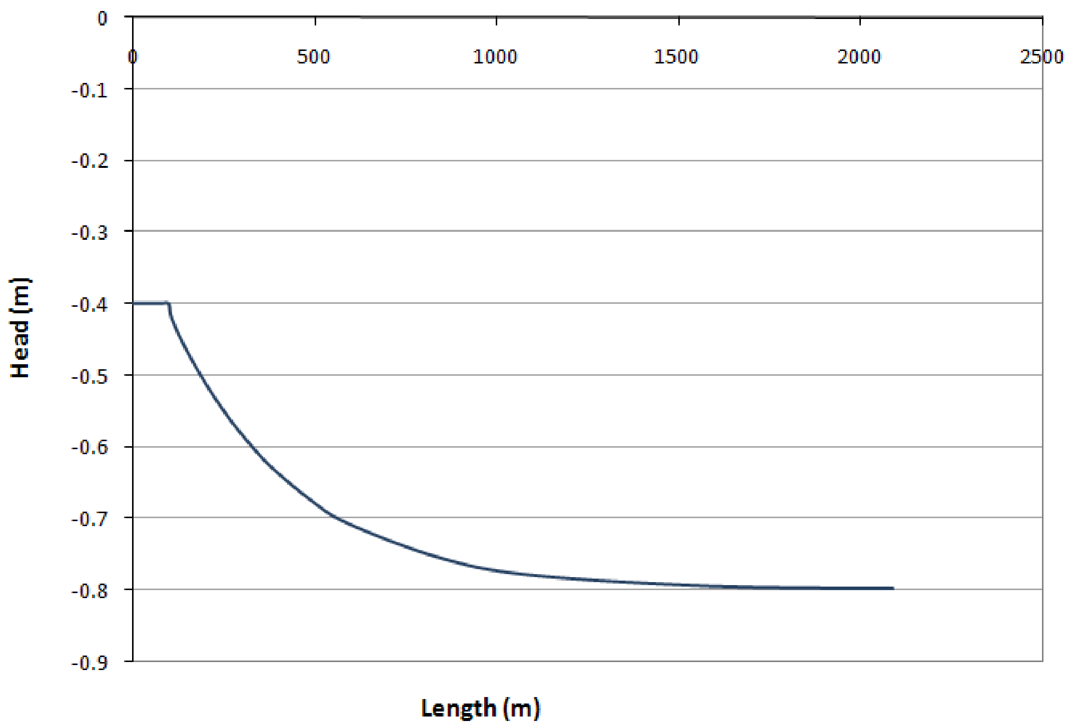

Figure 13. head distribution of permanent retention area.

3.2.3 Conclusion

Areas as taken from the design of 'the new Peatcolonies' (Kersten, 2009) are not sufficient to deal with water retention if the inlet of the lake IJssel is put to zero. If these areas are in use, only 67% of the needed water storage is realized. Therefore it is feasible to reduce the inlet of lake IJssel rather than to stop it. It is very difficult to calculate and decide on how much the inlet should be reduced. With figure 8 a plausible choice is made to reduce the inlet by 85%. However, reductions cannot be realized based on these calculations. These numbers only give a quantitative estimation and are not to be taken as definite amounts. There are two major reasons for this. Firstly, the model used is a simple model. Secondly, the inlet date from lake IJssel was unknown, so all these calculations are based on an estimation. This means the accountability of calculations is not very high. Looking at figure 8 it appears to be coarsely overestimated.

The calculations are not conclusive enough to state that it is impossible to stop the inlet of lake IJssel. We for instance only calculated the volumes using the evaluated heights. Storing the water in the ground during the winter was not investigated. At the moment the calculations do not include a deep lake, but only a shallow one.

More detailed conclusions, with the help of the x-z model, have to be made about the feasibility of the proposed retention types. The two different retention types do have a different influence on the adjacent land. For the temporary retention without a clay layer the water would be lost due to significant seepage and the adjacent area would be wet. A clay layer prevents both the leakage inside and seepage outside. Complication with this clay layer is that it is vulnerable and crop production is not possible anymore. Therefore, the overall conclusion for the temporary retention areas is that it is only feasible with a clay layer, a dyke and it is not used anymore for farming as it is nowadays in the area.

The permanent retention areas have to be excavated by 0.8 meters below surface level and could be used then for storing water. This excavation could face the problem of encountering archeological valuable objects and thereby delaying the implementation.

3.3 Sufficiency of retention areas in case of climate change

3.3.1 Climate scenarios

Almost all climatologists agree: climate is changing. Due to CO_2 emissions the temperature is rising, with all kind of consequences. The IPCC (Intergovernmental Panel on Climate Change) produced a report in 2003 with all findings about global climate change. It describes which areas will become more humid or will face dryness and what consequences can be expected. The effects of climate change differ much between regions. Based on the IPCC findings, four scenarios for the Netherlands were made by the KNMI in 2008 (see figure 14). For detailed explanation of the four scenarios, see materials and methods (chapter 2.2).

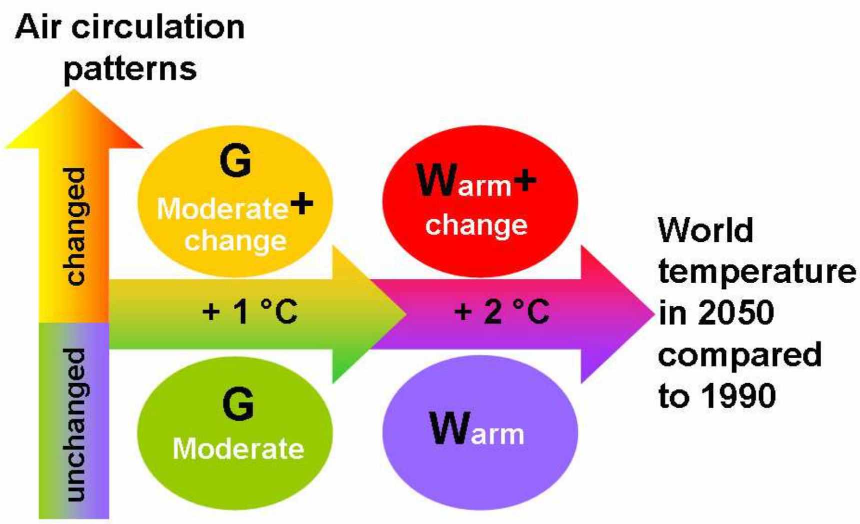

Figure 14. Schematic overview of the four KNMI scenarios, made in 2008.

The predicted increase/decrease of precipitation and evapotranspiration from the G+ scenario and W+ scenario are used to calculate the future water balance of the study area.
There is always a negative precipitation excess (precipitation minus evapotranspiration) during the summer and a positive one during the winter. With climate change this will become more extreme. To compensate the water shortage due to climate changes, retention areas are designed by Inge Kersten (Kersten, 2009) to store water and use it in times of water scarcity. The precipitation excess will decrease with 42 mm for the G+ scenario and 83 mm for the W+ scenario. The measures described are taken into account, to see if these are sufficient to compensate the change in water availability in the future.

3.3.2 Results

The water balance model (as described in chapter 2.1) is used to determine how much water is needed to compensate the climate change effects and thus how high the water level should be in the retention areas.

Table 8 shows the possible heights in the retention areas for the G+ scenario. At the moment the water level in the Mussel Aa fluctuates in an unnatural way. In winter the inlet of water in the region is reduced, while in summer the water level is higher despite less precipitation and more evapotranspiration. This is because in summer the water from lake IJssel is pumped into the Veenkoloniën. The numbers as shown in table 8 for the water levels in the Mussel Aa are estimated, but actual and expected numbers may differ for the current situation and especially in the future. The fraction says something about the amount of hectares that is used. So if the fraction is 0.5 and H = 400 mm, then 50% of the retention areas are filled with a water level of 400 mm and 50% with a water level of 0 mm. In these figures, the inlet from the lake IJssel is not taken into account, only the precipitation excess.

Table 8. Water balance design for the G+ scenario. The water level in Mussel Aa, permanent and temporary retention areas are showed per month. H is the water level in the retention area, S is the storage for the whole area in mm.

	Mussel Aa	***Permanent retention***			***Temporary retention***		
Month	*Water level (mm)*	*H (mm)*	*fraction*	*S (mm)*	*H (mm)*	*fraction*	*S (mm)*
April	400	500	1	19.2	500	1	25.7
May	400	500	1	19.2	430	1	22.1
June	500	400	1	15.3	400	0.7	14.4
July	500	300	1	11.5	0	1	0
August	500	0	1	0	0	1	0
September	400	200	0.5	3.8	0	1	0
October	400	400	1	15.3	0	1	0
November	300	500	1	19.2	0	1	0
December	300	500	1	19.2	0	1	0
January	300	500	1	19.2	500	0.3	7.7
February	300	500	1	19.2	500	0.7	18.0
March	400	500	1	19.2	500	1	25.7

The permanent retention areas are refilled from September till November, the temporary from January till April. At the beginning of the growth season (in May) the temporary retention areas are emptied so they can be used for other purposes. After the use of water in the temporary retention areas (in June), the permanent areas will be emptied.

When the permanent as well as the temporary retention areas are at least filled with 500 mm and it can all be used for the summer months, the water precipitation excess of -118 mm during the summer can be compensated. In that case the deficit into groundwater during the summer will be -77.02 mm. This is almost the same as the current deficit (-76.41 mm), so it will be sufficient to compensate climate change as predicted with the G+ scenario. In this case the inlet of the lake IJssel is not taken into account.

Table 9. Water balance design for the W+ scenario. The water levels in Mussel Aa, permanent and temporary

	Mussel Aa	***Permanent retention***			***Temporary retention***		
Month	*Water level (mm)*	*H (mm)*	*fraction*	*S (mm)*	*H (mm)*	*Fraction*	*S (mm)*
April	400	1000	1	38.3	1000	1	51.4
May	400	1000	1	38.3	850	1	43.7
June	500	700	1	26.8	380	0.7	13.7
July	500	300	1	11.5	1000	0	0
August	500	0	1	0	1000	0	0
September	400	100	1	1.9	1000	0	0
October	400	200	1	7.7	1000	0	0
November	300	400	1	15.3	1000	0	0
December	300	600	1	23.0	1000	0	0
January	300	800	1	30.6	1000	0.3	15.4
February	300	900	1	34.5	1000	0.7	36.0
March	400	1000	1	38.3	1000	1	51.4

This does not count for the W+ scenario; there will still be 47 mm deficit more than in the current situation.
To compensate for a temperature increase of 2 °C in 2050 1 m water column in all the retention areas is needed (see table 9). The question will be if this is a realistic water level, because the permanent retention area cannot be totally empty, especially when it is also used for recreation. Despite that, if there is 1 m difference between ground water level and water level in the retention areas, the water table will be 20 cm above surface level and leakage will increase with water height.

In the outcomes as described above, the inlet of lake IJssel is not included. If it is included, the inlet will be 2.8 million m^3 per month. This estimation is probably too high (see chapter 3.2.3). The inlet of 2.8 million m^3 ensures enough water for the whole area during the summer months. Concerning climate change, in the future there will be a shortage of 6.05 mm for the G+ scenario and 21.03 mm for the W+ scenario. This can easily be compensated, only one third of the permanent retention areas (50 ha) is sufficient to store all the extra needed water for the G+ scenario if the water level is 500 mm and all water can be used. No temporary retention areas are needed then. For the W+ scenario twice as much retention is needed (about 100 ha). So with the water inlet of 2.8 million m^3 per month, water shortage due to climate change can easily be compensated with the measures (Kersten, 2009) made.

3.3.3 Conclusion

The surface of the retention areas as designed by Inge Kersten is sufficient if the water level in all the retention areas is 500 mm and all the water can be used during the summer. This only holds for the G+ scenario. If the temperature is not increasing by 1 °C but by 2 °C, twice as much water need to be stored, so the water level in the retention areas should be 1000 mm. It is unlikely that this could be feasible, because of leakage and the water level will be above surface level. When inlet from lake IJssel will be included, climate change can easily be compensated with only the use of the permanent retention areas. With an inlet of 2.6 million m^3 per month, 50 ha of retention area is needed for the G+ scenario and 100 ha for the W+ scenario.

To deal with the climate problem, other ways than only water storage near the Mussel Aa should be explored. The agribusiness can adapt by investigating what kind of crops grow better with a lower ground water table or switching to cattle breeding. Also a more efficient use of water can be part of the solution, by for instance, storing water on agricultural land or using more efficient irrigation techniques. Local or provincial policy can promote a more sustainable way of water use for the whole area.

4. Agriculture

4.1 Introduction

The agribusiness plays an important role in the area, not only for now, but also in the future. Therefore it is important to look at the changes in agribusiness if the hydrological measures are implemented. These measures have several influences on agribusiness, such as the crop production, the loss of arable land and the more fluctuating water level of the Mussel Aa. These three influences will be described below in separate paragraphs.

Furthermore, in this chapter the different wishes and desired changes for the future of the different agro-stakeholders will be described. When the desired changes of these stakeholders are known it is possible to see how the hydrological measures affect the different stakeholders. The 'agro-stakeholders' described here are farmers, they seem to be the most important one, companies like AVEBE (Aardappelmeel Verkoop Bureau), LTO Noord (Landelijke Tuinbouw Organisatie) and the Agenda voor de Veenkoloniën.

4.2 What changes will occur in the agribusiness?

4.2.1 Crop production

The current crop production consists mainly of starch potatoes, sugar beets, maize, grassland and cereals (Strijker, 2003). In table 10 the distribution of the crops compared with the total arable land is shown. They also calculated the distribution in 2020 if the current trend continues. It is visible that starch potatoes and sugar beets will have a smaller percentage of the arable land in 2020 compared with 2000. This is mainly due to EU regulations and quotas. Therefore grassland, cereals and other crops have the chance to gain more land such as hemp and rape seed.

Table 10. The distribution of the arable land in the Veenkoloniën (Strijker, 2003)

Description/Year	2000	2020
Arable land vs. total area (%)	95	87
Starch potatoes vs. arable land (%)	32	25
Sugar beets vs. arable land (%)	14	11
Grassland and maize vs. arable land (%)	17	20
Cereals vs. arable land (%)	27	34
Cereals and other crops vs. arable land (%)	35	41

The influence of the retention areas is probably negligible. It is already described in a previous chapter that the ground water level near the dyke will be 40 centimeters below surface level and at a distance of 500 meters already 80 centimeters below surface level. Therefore it is expected that the hydrological measures will not have a large influence on the crop type that is being used. Especially if the grassland is gaining more area, it is possible to put these next to the temporary retention area. However, then it is necessary to think about the use of the grassland, if it is for the grass itself or for grazing. In case of grazing the farmer wants to live next to it. Because the influence on farmers is small, the consequences for the companies who are the next chain after the farmers is also small.

4.2.2 Adaptations to the Mussel Aa

The implementation of the measures for the Mussel Aa brook itself will need some room. These measures consist of creating meanders, broadening brook banks and constructing retention areas.

The first two measures will cause an enhancement of the length of the brook, and the area of the brook will be increased. Most of the land besides the brook is arable land so there is some need to change the land use next to the brook if necessary. Although these plans are made for implementation before the year 2050, farmers should be consulted to execute these plans. During these tens of years the farmers have to be voluntarily involved in the process of selling part of the land for the meandering brook.

When all retentions areas are in use by 2050 the agribusiness and mainly the product processing companies will have fewer products to process. This is due to the fact that there is less arable land for crop production.

4.2.3 The fluctuation of the Mussel Aa

In order to fill the permanent retention areas the water level in the Mussel Aa has to be temporarily increased to the level of at least 0.4m beneath surface level. For the description about retention areas in the introduction hydrology see 3.1. This measure will also temporarily raise the groundwater levels in the neighborhood of the ditches next to the brook. This higher brook level will mainly occur in the winter (October - January) when there is precipitation excess so the arable land is not intensively used for crop production. Therefore the fluctuating water level will not be a problem for the crop cultivation due to the normal water levels during growth season.

4.2.4 Conclusion

The fluctuating water levels will only occur during the winter months and will therefore not affect the crop production in the growth season. Although the most thoroughly measure will be the putting in the use of the retention areas. This costs arable land and will diminish the crop production and slightly affect the agribusiness.

4.3 Desired changes of the different agro-stakeholders?

4.3.1 Farmers

The opinions of farmers about the desired changes in the future were gathered using interviews. However due to time constraints only two interviews could be held. In this paragraph first an overview of the history, current activities and important legislations is given. In this way it is clear where the agriculture came from and where it is now. Also trends and perspectives for the future can better be identified. Additionally it serves as input for the interviews with farmers.

History

Until the end of the 15th century the Veenkoloniën was a large and monotonous marshland area. It lies between the clay in the province of Groningen and the sandy soils in the province of Drenthe. For the civilized areas in the neighborhood the Veenkoloniën were difficult to reach. However, when the city of Groningen developed they decided to mine the peat. By then the Veenkoloniën became better organized and the accessibility of the area improved. In the beginning of the 19th century the agriculture in the Veenkoloniën became more important and especially after 1840 the production of potatoes increased. This resulted in the starting up of AVEBE around 1970. This is a cooperation for the processing of starch potatoes. In this way the production of starch potatoes became better organized which gave the Veenkoloniën positive economical impulses. (Stichting Innovatie Veenkoloniën, 2004). Parallel to this development the dairy farm industry in the country declined. This was due to the specialization in arable farming and the implementation of quota in 1984 (DLG, 2008).

During the 20th century the production of starch potatoes and sugar beets were the main source of agriculture. However, the production of grass and maize increased in the last years. Also the horticulture developed, especially in the province of Drenthe. But the Veenkoloniën are still perceived as monotonous and the production of starch potatoes, grain and sugar beets are still the main source of agriculture. (Strijker, 2003)

Current situation

Most farms in the Veenkoloniën are specialized in arable farming (59%) but there are also farms (14%) who have a sideline (Du: gemengd bedrijf) like rearing pigs or poultry (intensive animal husbandry) (Strijker, 2003). Ten years earlier there were more farms which only had arable farming and the mixed farms (arable farming and animal husbandry) were less represented. Only 17 % of all the farms in the Veenkoloniën consist of dairy farms which is a slight increase. The amount of farms which are specialized in animal husbandry (pigs and poultry) is small but increased the last ten years (15 farms of the 175). In the area near Stadskanaal between the Mussel Aa and Pagediep, 41 farms are present. The area has a surface of 2437 hectares which contains for 65% of arable land.

Around half of the arable land (47%) in the Veenkoloniën is used for the production of potatoes and sugar beets. However, this amount decreased the last years. This decrease is due to European regulations which implemented quotas which are slightly decreasing every year.

The land in the Veenkoloniën area is also used for other purposes than potatoes and sugar beets. Several forms of horticulture, such as all kinds of flowers and trees grow in the area. However, this is all on a small scale mainly concentrated near Emmen (260 hectares) and Sappemeer (60 hectares) (Strijker, 2003).

The amount of farms specialized in rearing poultry or pigs is minimal. The last ten years, four new intensive animal husbandry farms set up in the area. However, there are also farms that have pigs or poultry as a second branch (Du: bedrijfstak). These farms are not expected to expand the coming years because the province does not allow new intensive animal husbandry farmers and expansion of these companies (Province of Groningen, 2009). Currently there are 15 to 20 farms with pigs or poultry as a substantial branch or main branch (DLG, 2008).
Striking in this area is that the farms which have more than 100 hectares of land are mainly located outside the stream valleys. Also in the area near the Mussel Aa and the Pagediep there are hardly no expanding farms. So the large and expanding farms are situated in the inlands near Stadskanaal.

Next to agricultural activities there are farmers who also carry out other activities. However, most farmers stick to their current activities. Only 27 of the 175 farms do have a second branch which are activities in trading, hunting, culture, recreation and the food industry (produce and prepare local foods)(DLG, 2008).
The current situation of the arable land could be improved. Mainly dairy farmers face this problem, because they have less equipment to transport on long distances. There has been some land allotting carried out in the past (Du: ruilverkaveling) however there are some problems with the availability of exchangeable land. In the future, the expectation is that there will become 3835 hectares of land available. This will be bought mainly by current farmers and partly used for nature, recreation and/or water retention. Especially in the area in the west of Mussel, a lot of arable land will become available (DLG, 2008).

The current price of land is high, compared to other years. In 2008 the price per hectare was € 35.208 while in 2007 this was more than € 10.000 less. The expectation is that the price in 2009 and 2010 will decrease slightly but will become stable around € 30.000 (DLG, 2008).

Farmer policy for the coming years

The GLB (Gemeenschappelijk Landbouw Beleid) is one of the most important regulations for agriculture in Europe. In 1958 this policy was set up to ensure that there was enough food in the world and that farmers received a reasonable price for their products. During the last years, this policy changed and became more market-oriented instead of protecting farmers and consumers. In 2008 there was a mid-term review and the conclusion was that after 2013 subsidies, which are based on historical production numbers, from the European Union (EU) to farmers will (partly) stop. In return the farmers will get a sort of fee for different activities. These activities are related to the protection of the environment, food safety and sustainability. This system is also called cross compliance (Province of Groningen, 2009 (a)).

Current producers of starch potatoes get a fixed subsidy (Du: hectaretoeslag) from the EU in return of activities which are mentioned above (cross compliance). When these subsidies will be uncoupled from the production in the coming years, farmers get a fixed income, based on historical production numbers, without the requirement that they produce starch potatoes anymore. In this way they are free to choose which kind of product they will produce. Mostly this will be the most profitable products. Research carried out by LEI (Landbouw Economisch Instituut) predicts that many producers will switch from starch potatoes to e.g. grain. By this the amount of potatoes in the Veenkoloniën area will drop to 20% of the arable land or even less (Strijker, 2003). This could have enormous influences on the economical situation in the Veenkoloniën.

In case of uncoupling the subsidies, AVEBE will get less influence in the agricultural sector in the Veenkoloniën. This is also predicted by the European Committee. Furthermore they expect that AVEBE will concentrate more on derivatives (Smit *et al.,* 2005).

Another aspect of farmer policy is the restriction for intensive animal breeding and husbandry in the area. In the Provinciaal Omgevings Plan (POP) the following regulation is implemented: “Building new farms with intensive animal breeding and husbandry will not be allowed in the province of Groningen, neither as a sideline next to arable farming of dairy farms”. Existing farms can only expand in case of an exemption which should be arranged in collaboration with the province. When existing farms cannot expand anymore in the area, in case no exemption could be made, resettlement will be the solution.

Concluding can be said that the future for intensive animal breeding and husbandry (pigs, poultry and veal calves) in the province of Groningen becomes less promising in the future.

Furthermore regulations concerning the environment become more and more important (Kloos, 2009). Especially regulations about minerals and protection of plants will have a large influence in the future. This could give conflicts with plans to create more nature in the Veenkoloniën. When agriculture will be leading in the future, the creation and location of nature should be carefully investigated.

4.3.2 Interviews

After an interview with two farmers (Bruggers, 2009; Bartelds, 2009) it became clear that they were satisfied with the collaboration between the farmers and the water board. When there is a need for more water for their land they contact the water board and the next day the sluices will be opened a bit. However, concerning the policy for the coming years the farmers are not involved in this at all while it is about their land and their property which will be used. This involvement is something the farmers want to achieve in the future. Furthermore, the farmers were positive about the current amount of nature but more nature is not desired. This was a clear statement made by both farmers. Agriculture has to decrease for the creation of nature and the farmers are not willing to decrease the size of their farms. Furthermore the interviewee stated that this is the overall opinion of the farmers in the area.

A suggestion made by Bartelds is that farmers at the edge of the area, near Mussel Aa or Pagediep can sell land for nature and involve in nature conservation. Additionally the farmer is willing to cooperate with the province or municipality to conserve the current nature. Examples of this are mowing of road verges, ditches, let plot edges grow etc. (Bruggers, 2009) However, they should get paid for this which is not the case at the moment. According to Bartelds, farmers should watch out that there will not be small pieces of nature in the whole area because that could negatively influence their activities. That is because these small parts of nature in the whole area will costs a lot of land and possibly influences the surrounding arable land because of smell and manure problems.

4.3.3 AVEBE

AVEBE is a company which has a large influence on the area, especially when looking at the agriculture. Most of the farmers are highly dependent on the decisions made by AVEBE because they buy their products. Decisions made by AVEBE are for example which products to produce, which raw materials to use, where to buy these raw materials, etc.

Currently, a large part of the supply of starch potatoes is supplied by farmers in the Veenkoloniën.

This is mainly because the soils are of good quality for starch potatoes and the distribution lines to AVEBE are very short. This makes it easy for a company like AVEBE to import their raw material from an area like this. The company has distribution channels to Germany, but prefers import of potatoes from the Veenkoloniën because of lower distribution costs.

This is an important message when looking at the plans from the EU. In 2013 the financial support for farmers from the EU will decrease or disappear and in return farmers will get money for certain activities (cross compliance). This probably will lead to farmers who quit or reduce there activities. However AVEBE expects that the import from starch potatoes by AVEBE will not decrease (de Zeeuw, 2009). In that case the company should have a broader range of suppliers of starch potatoes.

The company is more focused on the production of high-tech deliverables to deal with the coming changes. These innovations can make the production of starch potatoes more self sustainable. This can be very helpful to deal with all the changes in the GLB. They also can lead to extra financial support for the products made by AVEBE and the farmers who produce for AVEBE.

Another issue is that AVEBE can use their waste streams to produce bio-energy. However the company itself will not take initiative for producing such products as mentioned by Ko Munneke (Munneke, 2009). The company waits for the province and/or municipalities to make decisions and take initiatives. This is probably done because taking initiatives and doing research themselves costs money.

Concluding, the changes which will occur in the future will have no or small influence on AVEBE (de Zeeuw, 2009). That is why this company does not have a clear opinion about the desired changes concerning the hydrology in the area. They believe that they will continue their production and will focus more on sustainability and the production of bio-energy.

4.3.4 LTO

LTO stands for the Land en Tuinbouw Organisatie, which is a Dutch organization that advocates for Dutch farmers. To find out what their opinion is about the Veenkoloniën there has been contact with Jaap Haanstra and Jakob Bartelds. The latter is farmer in the Veenkoloniën, member of the water board, president of the project group starch potatoes and member of the Dutch LTO department.

The organization sees the agriculture in the Veenkoloniën as a strong sector. They expect that large farms will expand further. However, smaller farms without a successor will decrease the size of their farms or even quit their activities. Furthermore, dairy farms are implemented in the Veenkoloniën which LTO thinks is positive for the diversity of the landscape. The expansion of current intensive animal husbandry farms is prohibited although LTO thinks that this could be a chance for the sector. Intensive animal husbandry can be done next to arable farming because these farms (almost) do not need land (Bartelds, 2009).
LTO does not expect that the development of recreation and other forms of expansion on the farm (e.g. zorgboerderij) will increase. The area is not attractive enough for such activities. In the surrounding areas the landscape is more attractive for such activities so why stimulate recreation in this area? (Bartelds, 2009).
Furthermore, LTO thinks that farmers are willing to conserve nature but only if they get something in return which is also the wish of LTO.

After 2013 the direct support from the EU will decrease because of the changes in GLB. However LTO wants a sort of basic premium for the farms because without any support, the agriculture in the area will collapse. Furthermore, LTO proposes that Brussel will give the farmers ten years to prepare before the support will be decreased until zero.
These subsidies will be replaced by a fee paid in return of the attention and effort of social values (Du: maatschappelijke waarden) by farmers. However, the farmers should be supported by citizens because they also can profit from the care of social values by farmers (Bartelds, 2009).

LTO is aware that AVEBE has a large influence on the area now and will have in the future. LTO want AVEBE work more innovative on the creation of more value out of the products. Examples are the extraction of amylopectin (sort starch) out of potatoes. The company is working on this by developing a potato which only contains amylopectin instead of both amylopectin and amylose. This is called Eliane (AVEBE, 2009). Unfortunately due to the economical crisis this development slows down. By this development there could be made more profit out of the starch potatoes which could positively influence the agribusiness. LTO also thinks that AVEBE should be supported in these projects by the government and farmers because they have a stake in this (Bartelds, 2009).

The use of waste streams by AVEBE to produce bio-energy is perceived as a positive development by LTO. However currently there is no support for AVEBE from other stakeholders.

4.3.5 Agenda voor de Veenkoloniën

The 'Agenda voor de Veenkoloniën' (AvdV) is a collaboration between nine municipalities, two provinces and two water boards. This AvdV is set up to bundle and create plans for the future. The aim is to get a shared vision about how the Veenkoloniën should develop in the coming years to overcome the economical threats which this area is facing.

The AvdV consists out of three major components: a social, economical and spatial component. These three components include topics like: aging in the area, creating more jobs in the area, improve housing conditions, broadening of the agricultural sector, landscape, nature etc. The major objective of the AvdV is to "preserve and boost the inhabitants' quality of life" (Veenkoloniën, 2009).

Agriculture is one of the main issues in the AvdV. The desired changes of the AvdV concerning agriculture are e.g. that dairy farmers will settle in the area (Munneke, 2009). By this the diversity of the landscape will increase. The aim and desired future perspective of the AvdV is that the agriculture will become a modern, innovative and sustainable sector. There should be room for large dairy farms up to 1500 cows to give this sector a real chance.

Landscape is another important issue in the AvdV. The aim is to create an interesting and attractive landscape. Important are the traditional characteristics of the landscape in combination with water and housing. Examples of these projects are: "Ruimte voor water" and "Landschappelijke en recreatieve verbindingszones met een woonfunctie" (Veenkoloniën, 2009) .

Other spearheads of the AvdV are a well-developed infrastructure (improve roads, train routes etc.), increased tourism by creating recreation on water and built high-quality houses.

4.3.6 Conclusion

In conclusion, the desired changes of different agro-stakeholders are quite similar. As stated by the province (POP), agriculture should stay dominant and this is confirmed by the AvdV, farmers, LTO Noord and AVEBE. The opinion of farmers according to nature is that nature is good, but enough. This is in line with the fact that agriculture should stay dominant. Also there should be paid a fee to the farmers in return of nature conservation.

Innovation should take place like amylopectine distraction out of starch potatoes by AVEBE. As expected, the climate change will result in more droughts and heavier rainfalls which have an influence on the products which grow in the Veenkoloniën. However farmers are pro-active in producing other crops in order to cope with both climate change and changing market situation. This shows the motivation of the farmers to innovate. LTO is in favor of these kinds of innovations.

As the AvdV proposes, the agriculture should be more diverse. The implementation of dairy farms in the area is a good example of this diversity. Additionally intensive animal husbandry could increase the diversity which is stimulated by LTO. Unfortunately, the province does not allow the implementation or expansion of animal husbandry farms in the Veenkoloniën.

According to the change of the GLB, farmers should react on changes by looking how they can broaden or scale up their activities as current subsidies for the farmers will (partly) disappear. LTO wants a period of 10 years in which farmers can prepare for this change in the GLB.

5. Housing

5.1 Introduction

According to the design 'the new Peatcolonies' (Kersten, 2009) there will be three types of housing in the Veenkoloniën, namely land houses, communities and houses that are build on water.

The land houses will be large luxurious houses with much land. The communities are build from old farms, which will be reconstructed for several households to live in. The last type is housing in temporary and permanent retention areas. The first two types of housing are independent from the hydrological measures that will be taken in this area. A dry spot can be chosen and houses can be built there. However, the third type is dependent on these measures, because they are build on water. Houses on water are implemented due to climate change as more water retention will be needed near the Mussel Aa. This means that the area around Mussel Aa needs to be adapted and will therefore change into extensive grasslands, little dykes and storages of water. This will make the landscape more diverse and attractive, which makes it a pleasant area to live in. This chapter concentrates on the expected changes that occur in housing on the basis of hydrological measures. First, research on the current situation living in water is carried out. The technical abilities in housing on water are described here. Also the current legal situation for living in a water-rich area is examined. Additionally the demands of future residents and also the design demands needed for the combination of water and living. After this, the long-term housing plans in the region are described. For this, several references are used. By the use of several references, all the plans/ideas for housing in the Veenkoloniën are summarized. Afterwards in the conclusion of paragraph 5.3 the expected changes in housing will be discussed and the combination between the housing plans and expected changes is made.

5.2 What changes are expected to occur in housing possibilities?

5.2.1 The current situation

Technical abilities

It is important that the future residents have a house that is safe and protected from the water. Therefore the construction of water housing needs to be technically feasible. There are several housing types, which can be build in this area. These are described below and visualized in figure 15:

- Wet proof home, a house in which water can be stored in the basement if necessary;
- Dry proof home, a house which stays dry when the water level is above the ground level of the house;
- Column home, a house which is built on pales;
- Floating home, a house that is floating but not adapted to the weather and the change of water level;
- Amphibiotic home, a house that is adapted to the weather and the change of water level.

Figure 15. The different housing types on water. Top, from left to right: Wet proof, dry proof and column home. Below: floating and amphibiotic home. *(Sources can be found in literature list)*

In general, all the housing types are suitable for the temporary and permanent retention areas, but it is possible to describe some differences. The dry proof home has the advantage that it stays dry throughout the year, while the wet proof home can have a temporary wet basement or be permanently wet. Probably, there is a maximum water level, so it is also possible to build a column home. The advantage of an amphibiotic home over a floating home is that it is adapted to different water levels. Another advantage of the amphibiotic home is that it does not require extra space to combine water retention and housing in the area.

In some areas it is already proven that is possible to build houses near or in the water, for example de Gouden Ham in Maasbommel (the amphibiotic home of figure 14) and the Marina – Olderhuuske in Roermond (figure 16). In these areas amphibiotic houses are built along the river (VROM, 2005).

Figure 16. Amphibiotic houses in Roermond (Roermond, 2009)

Furthermore the housing prices are higher when the house is situated next to the water as proven by Brouwer (Brouwer *et al.,* 2007). They state that a house next to the water can be worth € 6,500 more than a house situated at 600 meters from the water, based on an

average housing price of € 225,000. If the houses are built in rural areas and have a beautiful view, the housing price will be even higher. Luttik (Luttik, 2000) conducted a similar research and has similar results. In this research housing prices are 8%-10% higher when inhabitants have a view on a reasonable sized lake compared with similar houses that do not have such a panorama.
Thus it could be a good investment for future residents, but also for companies, the province and the municipality as building houses in nature is more profitable then building them near Stadskanaal.

Policy
In 1993 and 1995 the water level of the rivers in the Netherlands was high, almost higher than the dykes. Therefore the government decided to give the rivers more space and they implemented a law called 'Ruimte voor de Rivier (Room for the river)' in 1997 (VROM, 2005). In 2005 they evaluated this law and came up with an improved version called 'Grote rivieren (large rivers)' in 2006 (Ministerie van Verkeer en Waterstaat, 2006). These laws state that only activities, such as building on banks, can take place under certain conditions. Fortunately, as it is planned to build houses in temporary and permanent retention there is no direct contact with the river.
The legislation for building these kinds of houses is the same as for houses on land, so probably there will be no problems with the law, as long as there is a dyke between the houses and the river (Baarsma *et al.,* 2007).

5.2.2 Demands for combination retention and housing
When houses are built in a retention area, several requirements are demanded. These demands are described firstly from the view of future residents and secondly from a point of view with regard to the design.

Demands for the future residents
The demands from the future residents are a good water quality, a safe environment, a pleasant atmosphere and a well-developed infrastructure, which are described below in more detail.

The water quality is important because the houses and the future residents will have contact with the water. In the retention areas the water does not flow naturally. To solve this problem there will need to be installations like water pumps combined with helophyte filters. To guarantee the water quality more research need to be carried out.
Another demand is the safety. Living next to water is always a danger. Residents that are living in houses built on water would like to use the water. Looking at similar retention areas in the surroundings, like the Rietplas in Emmen and the Ermerzand in Erm, the conclusion is that swimming, playing with boots and fishing are just some of the activities future residents will undertake here.
This means that this needs to be taken into account in the design of the retention areas. The two main issues when designing a safe retention area are flood control and safety of the people using the retention area. This will be further explained in the design demands.

The next demand is the atmosphere of the area. The landscape around the Mussel Aa must be perceived as beautiful. The region should be attractive for future residents. Right now the area is not perceived in this way and even described as monotonous (the new Peatcolonies 2009). Therefore there must be a new impulse given to the landscape in order to make it special and beautiful. The plans to give the Mussel Aa a meandering slope and develop natural grasslands can be a step in the right direction.
Another demand is the prevention of mosquitoes. Mosquitoes like shallow water, which is not flowing and warm. Thus the retention areas are well suitable for them. However, they are very annoying for future residents and therefore measures need to be taken to prevent or reduce the amount of mosquitoes (Provincie Noord-Holland, 2002).
The last demand is a well-developed infrastructure. The future residents will most likely not all work in the Stadskanaal region, but in cities like Groningen and maybe also in Emmen and Zwolle. The connections need to be fast and robust. In the current situation there are three highways, namely the A7, A28 and A37 (The highways take an average of 30 minutes to reach from Stadskanaal). The large cities in the neighborhood of Stadskanaal are Groningen, Emmen, Assen, Hoogeveen and Zwolle. Table 1 illustrates how long it will take to travel to these cities by car and public transport. It is clearly visible that the area has no convenient connections to the large cities. Therefore the infrastructure must be upgraded to improve the attractiveness of living here.

Table 11: travel distances and time from Stadskanaal to the large cities

City	**Distance from Stadskanaal (km)**	**Travel time car (min)**	**Type of public transport (-)**	**Travel time public transport**	
				Amount of busses/trains (/hour)	**Average time (min)**
Groningen	55	50	Bus	5 busses	70
Emmen	30	30	Bus	3 busses	60
Assen	40	50	Bus	3 busses	60
Hoogeveen	60	90	Bus/train	2 bus-train connections	90
Zwolle	100	60	Bus/train	4 bus-train connections	120

Design demands
The design demands distinguish between temporary and permanent retention areas.
The houses in the temporary retention areas must be able to cope with a fluctuating (ground)water level. As described above, this is technically possible. However, there is another very important aspect of this temporary retention area, namely the vegetation. The vegetation in the area must also be able to cope with the fluctuating water levels. The danger is that the vegetation will not survive and the houses will be standing in a mud field which makes the house less attractive, because the future residents are not only buying the house, but also a view on the landscape.
For permanent retention areas the demands are similar. When combining permanent retention with housing the fluctuation of the water level will be limited. This is because the future residents cannot live in a mud field. Another limitation is the pumping system that

will ensure the water quality. The system must be able to keep on working and guarantee the water quality. Furthermore, future residents buy a house in a permanent retention area, because they want to live next to water. These two demands constrain the water availability for agriculture, because a minimum water level is required.
There are also some design demands following the safety issues as described above. First there is the flood control. There must be extra space taken into account in the retention areas for unexpected fluctuations.
Secondly safety of people must be ensured while recreating in the retention area. This can for example be done by warnings or safety measures around weirs and pumps. If future residents want to swim, the swimming area should be deep enough, but also a part should be shallow for younger children. Therefore, a division between these two should be indicated for the safety. Furthermore there must be a rescue team present to ensure a safe swimming environment. This can be done by either the Stadskanaal police or a team of volunteers.
Some spatial measures should ensure the beautiful atmosphere of the area. The amount of buildings and water needs to be in balance. This means that there will be a limitation to the amount of buildings in order to hold on to the atmosphere which is created. This can be extracted from a spatial analysis.

5.2.3 Conclusion

Living next to or in the water is not a problem. Technically it is feasible and it has already been constructed in Maasbommel and Roermond. The preferred housing types are a column home and an amphibiotic home. Especially the latter one is often used. Furthermore, the presence of water has a positive influence on the housing prices. There are also no problems expected with the policies. However, there is also a down side to this type of housing. Building houses in these areas ask more requirements for the retentions areas, which need to be taken into account when designing these areas. The water quality and the atmosphere need to be good and the environment needs to be safe. Furthermore, the attendance of mosquitoes needs to be prevented as much as possible to create an attractive living environment. It is also important to think about the vegetation type in the temporary retention area, because residents do not want mud around their house.
Furthermore, there is much competition from areas such as the Blauwe Stad Groningen. To compete with these areas, the new houses need to be very special, original and attractive. This can be achieved by creating a beautiful landscape and a good living environment. There also needs to be a well-developed infrastructure.

5.3 Long term housing plans in the region

5.3.1 Provinciaal Omgevingsplan (POP)

The ambition of the province, according to the POP, is to contribute to a better living environment for all the citizens in the area. The expectation is that aging will take place in the Veenkoloniën which has influence on housing. Several services and facilities should be available and accessible for all the people living in this area, especially the elders. These are also named as the vulnerable citizens and the province expect that the amount of vulnerable people will increase by 10% in the next decade (Provincie Groningen 2009 (a)). These people mostly prefer apartments without gardens in the centre of Stadskanaal (Renses, 2009).
The role of the province concerning the long term housing plans is facilitating and financing. Contacts with municipalities will intensify to share their view with them, to see what the housing plans are and how the province can contribute. The provinces want to see plans from the municipality and concerning eastern Groningen this will mainly concerns the reconstruction of old houses (farms) into new ones. Their vision is: not the quantity but the quality of housing needs attention.

Concerning housing plans in the outlying areas, the provinces will only allow the building of:

- Second houses for farms;
- Large and luxurious land houses (e.g. KrommeWijk);
- Building new houses in existing villages only when it contributes to the quality of the living environment in the village;
- Building or reconstructing houses on abandoned arable land.

Prerequisite for the land houses is that it includes more than five hectares of land which should be partly accessible for other people like recreationists. Further, the area near the house should be integrated in the landscape according to its function such as agriculture, recreation etc. Such houses could be placed near the landscape developments zones like Ruiten Aa and Westerwolde but also the Pagediep and Mussel could be suitable for land houses. The target group for these kinds of houses are rich people that wish to build a house with a lot of room at an attractive price compared with other regions in the Netherlands. Also the province wants to have not more than 10 of these kinds of houses in this area (Van Hilten, 2009). Another aspect is that the province wants more sustainable housing. This can be achieved by producing solar energy which will be subsidized by the province.
Furthermore, the province also has the plan to build recreation houses in the Veenkoloniën. These houses cannot be used for permanent housing but only for people having their holidays.

5.3.2 De Verscholen Bron

In this report (H+N+S, 2005), several future plans for the Veenkoloniën are described. This project is a so called 'denktank' in which all kinds of ideas are gathered. Regarding housing there are plans to create five different housing environments:

- Buurtschap (townships);
- Lommerrijk wonen (villa's);
- Residenties (residence);
- Wonen aan of achter het lint (ribbon housing);
- Onzichtbaar wonen (invisible housing).

A township is a community with less than 300 houses around an existing road. The density of houses will be around 20 houses on one hectare of land. This community will rely on the public services of the villages in the area. Villa's means creating large houses in the outlying areas near e.g. woods. The density will be around 10 houses on one hectare.

Residences are large houses which contains multiple apartments. The density will be around 25 houses on one hectare. Living on or behind the housing ribbons means a higher density or a doubling at the existing ribbons. The density will be around 30 houses on one hectare. The last plan of the Verscholen Bron is invisible housing. This means living next to a wood or living on the land of a farmer, etc. The density of this housing concept will be maximum five houses on one hectare.

5.3.3 Strategische plananalyse MUST

The strategic plan analysis for the Veenkoloniën is a report carried out by MUST (2007). This report will function as input for the next Provinciaal Omgevings Plan (POP). Representatives of the province, the municipalities Veendam and Stadskanaal, the ministry of LNV, AVEBE and Grontmij were involved in this analysis.

In this analysis several ideas for housing in the future are proposed. First of all housing in the outlying areas will be combined with water and new landscape features. There will be room for large and luxurious houses, residents, lommerrijk wonen etc. (see de Verscholen Bron). These kinds of houses should be placed in the brook valley.

Furthermore, to maintain the image and strengthen the cultural-historical identity of the Veenkoloniën, new houses can only be built in new housing ribbons. In this case the focus should be on the quality of the houses instead of the quantity. In this way the villages will become more open because people will go from the village to houses at new ribbons. This creates interesting opportunities for the people living in the existing villages (MUST, 2007).

5.3.4 Rural estate agents

For the long term housing plans and expected changes, rural estate agents are a useful source because they give an estimation if the proposed design is feasible. According to Nieboer Makelaars land houses will not be the future in the area near Stadskanaal (Renses, 2009). However there are 5 of these land houses built near Stadskanaal which is called plan KrommeWijk. So in the past there was some interest for these houses but currently there is hardly any demand due to financial crisis (Schut, 2009). According to Nieboer makelaars land houses will be built near e.g. Ter Apel where there is a more diverse landscape with water and woods. In such an environment it is more attractive to built land houses. Near Stadskanaal this will not be the case (Renses, 2009). So if there should be land houses in the area of Stadskanaal, the area should be adapted with more woods and water.

Outside Stadskanaal small reconstructed farms are most popular. Those people prefer more space outside their house with gardens up to 600 or 700 m^2 (Renses, 2009). Inside Stadskanaal the current demand is focused on relatively cheap houses for starters and duplex buildings until € 200.000.

Aging does take place in the area and both rural estate agents are aware of this. This results in a higher demand for apartments in the centre of Stadskanaal however; there is enough supply of these kinds of houses also for the future.

According to the trend in the future, both rural estate agents are a bit unsure but they do have an opinion about the future trends. It is published that the outlying areas will get less inhabited but Nieboer Makelaars (Renses, 2009) does not see this trend. Schut & Lambers makelaars (2009) believe that living next to water will be the trend for the future. Of course these houses will be expensive but as soon as the economy will recover, housing next to water will become more popular.

5.3.5 Conclusion

The housing plans of the province aim at a small target group. As it is planned to have approximately ten of the land houses described in the previous paragraphs, the plans are at a small scale. Due to the fact that the population in the region is aging (Provincie Groningen, 2009 (a)), those persons aimed at could prevailingly be older people. However, not only new buildings, but also reconstructions are wanted. These houses should then be arranged in such a way that they are accessible for handicapped people. Unfortunately, there is neither a study on the demand of such houses, nor on the kind of people that are willing to buy such a house. However, according to the experience of the rural estate agents, there is currently no demand.

The likelihood of the realization of the housing plans depends on several aspects. As agriculture plays an important role and is one of the main sources of income, the plans will depend on the future prospects of farming. If agriculture stays dominant in this region, then extra land will not be available to the housing suggested by the Verscholen Bron. However, the plans of the POP are still partly feasible as they aim at reconstructing old buildings, so that no new land has to be purchased from farmers. In that case land prices will be higher than they would be if farmers themselves sell their business and land. It should also be considered that with a strong agriculture less nature and recreational sites are present. That could have an influence on the attractiveness and quality of the living environment and thus on the demand on housing in this area. Self-evidently, if the landscape stays monotonous and lack variety, the prices and also the value of luxurious houses will decline. Moreover, the success on the housing plans depends partly on the buyer's preferences on landscape features and type of houses.

However, if agriculture will decline in the upcoming years, then more land will be available for houses. Apparently, this will result in a lower land price per hectare. According to the POP, old farm houses can then be reconstructed to land houses. By implementing more retention areas near the Mussel Aa, recreation sites can be developed. Further, more nature will take place, which will give the landscape a more varied image. The possibility of having recreation sites nearby - such as biking and hiking paths - could improve the demand for such houses. The plans of the new water storages at the Mussel Aa could be combined with water housing such as promoted by MUST.
Also, the housing types, such as invisible housing and Villa's, can be combined with the recreation design of the planned retention areas. The building of land houses as well as vacation accommodation is already planned at the Pagedal (Bosch, 2009). If the concept is successful and the demand is high enough, then similar housing can be implemented at the Mussel Aa, too.
However, currently the agriculture is the main source of income in this region. When agriculture will become less dominant the economy could decline and the population would shrink. Then such houses are more suitable for vacation purposes.

However, there are projects such as Terra Mater, which are promoting the economical potential of the region. With the realization of such projects, agribusiness and other business branches could thrive and create a better economical climate. In such business parks also housing possibilities can be found. Here it would be possible to implement buildings such as land houses, where agricultural endeavor is feasible. However, for these projects financial support is vital and at the moment investors still need to be found.

Another factor that plays a major role on the feasibility of the housing plans is the attractiveness of the region itself. People, which are working in this area, need to get to their work everyday. When having a house in a more remote area a good infrastructure and/or upgraded public transport is necessary. At the moment there is no sufficient public transport in the Pagedal and near the Mussel Aa.
With the implementation of recreational sites near the Mussel Aa, the attractiveness of the region increases for both type of houses: permanent and vacation houses. However, the availability of civil services such as hospitals, supermarkets and school has a much stronger impact on the demand on permanent housing, which is promoted by the Verscholen Bron and MUST. Further, new houses in the villages would enhance the growth and thus importance of the village. However, they are in particular the most vulnerable type of housing if infrastructure and services are bare.
It is thus recommended to implement a survey to find out which type of houses is demanded by whom.

6. Recreation

6.1 Introduction

The current recreation possibilities at the Mussel Aa are quite moderate. The river is situated among agricultural fields, while at the neighboring areas such as Pagedal and the area around the Ruiten Aa diverse recreation has been developed. However, with changes in the landscape, which take place when implementing the suggested hydrological measures, recreation could thrive. In connection with the retention areas, several outdoor activities on or next to water could be developed. Therefore, the possibilities of recreation are further examined in the following paragraphs.
Afterwards the influence of recreation at the Mussel Aa on the stakeholders is shortly assessed (paragraph 6.3). In this way the advantages of recreation for the area will become clearer. The stakeholders which are mentioned are local businesses, inhabitants, governmental institutions and farmers.

6.2 What are the possibilities for recreation?

6.2.1 Existing recreation facilities near the Mussel Aa

The Mussel Aa and its surroundings are embedded between Stadskanaal and the area around the Ruiten Aa. In those areas, recreation facilities have been developed in the last decade. Each region, however, offers a different type of recreation.
At Pagedal, in the west of Stadskanaal, a holiday park has been built (Pagedal, 2009). In this park diverse sports such as tennis and squash are offered while it is equipped with fitness and swimming possibilities. Further, the park has several accommodation facilities such as bungalows and apartments. The recreation park offers also possibilities for business meetings. Further, this park consists of small nature areas that are artificially build within its borders.
The area around the Ruiten Aa is characterized by many biking and hiking paths that follow both the slope of the river and/or through the scenery around the river. Opposed to the Pagedal, in the area of the Ruiten Aa is no such recreation park. However, due to the network of paths in this region, sports such as riding, canoeing and biking over longer distances are possible. Accommodation possibilities are offered at a smaller scale such as Hotels and Bed & Breakfast (B&B).

6.2.2 Future plans for recreation

The ministry of Agriculture, Nature and Food Quality (LNV, 2009) introduced the Ecological Main Structure (Du: Ecologische Hoofdstructuur, EHS) in 1990. This structure creates a network of nature areas to conserve and develop nature. In this way many species and ecosystems have a higher vitality and are thus more preserved.

The province of Groningen made a plan for all the EHS areas in the province. They did this in cooperation with a lot of stakeholders, mostly with organizations like LTO, Dienst Landelijk Gebied (DLG, agency of ministry of LNV for planning) and Informatiepunt Landelijk Gebied (cooperation of five organizations for nature and environment management in Groningen).

About 2238 hectare of new nature should be developed by private nature management in Groningen in 2018; this is 180 hectare per year.

The province did not include the Mussel Aa in the EHS. At the Northern site of the Mussel Aa there is the Pagediep which will be functioning as an Ecological Connecting Zone (Du: Ecologische Verbindingszone) to the Ruiten Aa. More nature development is planned and all kind of recreation will be created. The province is willing to consider to make the Mussel Aa a Ecological Connecting Zone as well (Provincie Groningen, 2009) to connect Westerwolde and Hondsrug via the Pagediep and Mussel Aa and to see if the Mussel Aa is useful for storage of water considering climate change

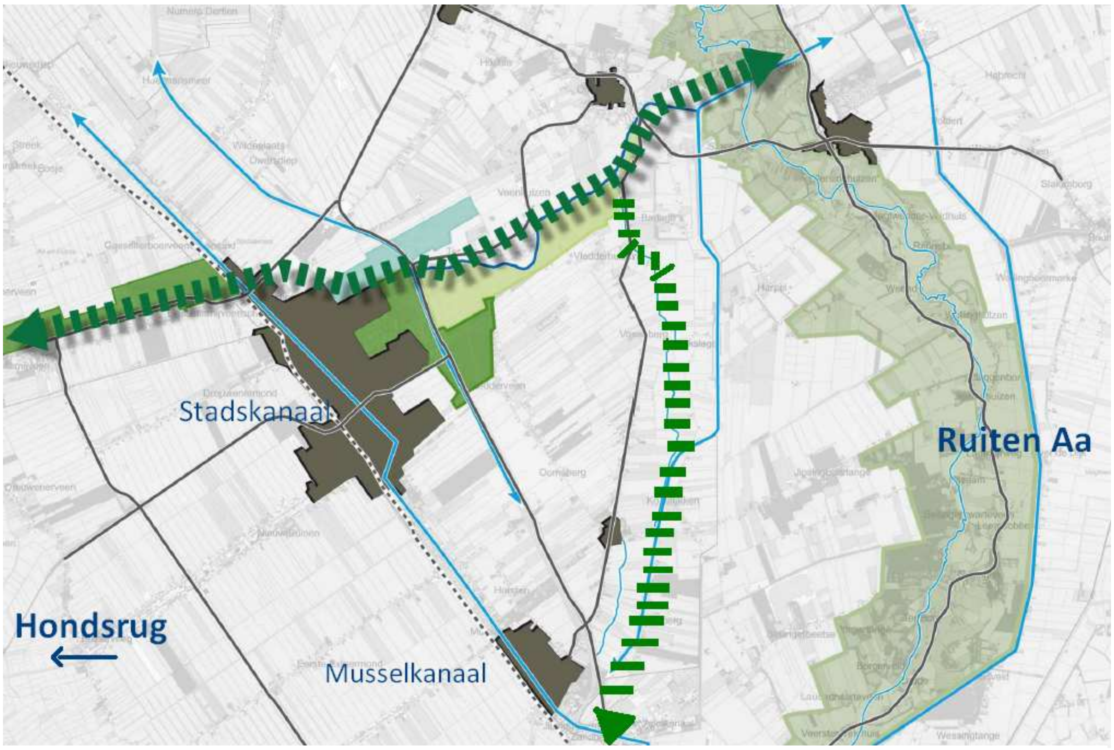

Figure 16. Overview of the study area, *Adjusted from: Bosch Slabbers*

This project is called "Gebiedsopgave Veenkoloniën – Zuid" (Provincie Groningen, 2009 (b)). The main objective within this endeavor is the development of the landscape in order to make it more attractive for recreation. By converting these regions into an EHS-zone, the province of Groningen covers legal requirement for reconstructing the area. The project is split into two parts: the development of the area around the Pagediep and of the Mussel Aa. The construction at the Pagediep started already in July 2009. Depending on the experience and success achieved in this part-project, similar measures could be taken at the Mussel Aa. The start of the project at the Mussel Aa is planned in ca. 2011.

The design of the development of the Pagediep from the province, however, does not correspond with the design of the new Peatcolonies. This design visualizes a lake as water storage next to mainly grasslands, the province planned different features. Thus, the original plan had to be revised and adjusted.

Figure 17 depicts which recreation facilities at the Pagediep are planned:

- Land houses (red)
- Wellness center and hotels (orange)
- Camping (yellow)
- Riding facilities (grey)
- Horse farm (green)
- Economical used areas (Du: werklandschappen) (dark blue)
- Sheltered workshops for handicapped (violet)
- Recreation housing (light blue)

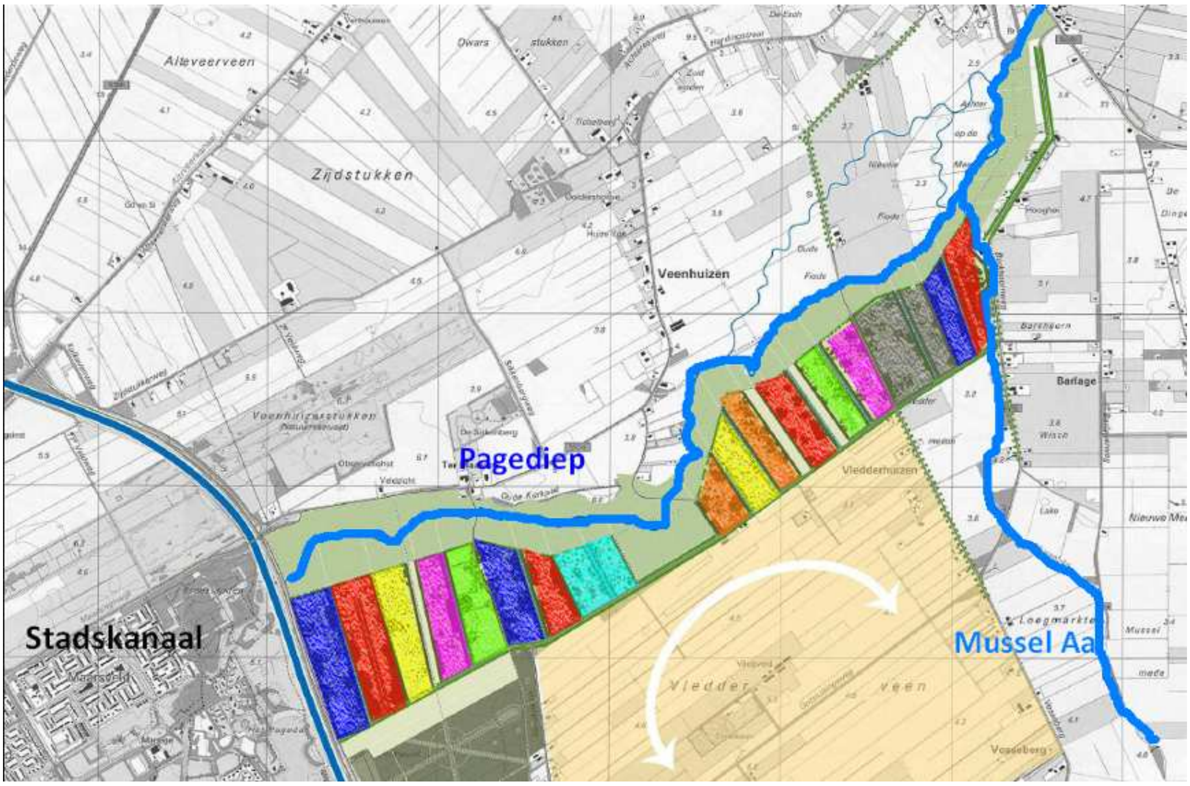

Figure 17. division of territory, *adjusted from: Bosch Slabbers, 2009.*

It should be observed, which type of recreation and facilities will be build and successfully sold. If the demand is high enough, similar measures can be taken at the recreation area near the Mussel Aa.

6.2.3 Suggestions for recreation at the Mussel Aa

By scanning the recreation possibilities in the surrounding areas, one can decide if similar recreation sites can be build near the Mussel Aa or different types of recreation should be implemented. Even though the area of the Mussel Aa differs from the Ruiten Aa, similar recreation measures can be established, such as the ones mentioned above.

Recreation on/at water

A recreation possibility on the Mussel Aa is canoeing or rowing on a rubber boat. As the river will be meandering and lined with an interesting river landscape, canoeing can be an attractive opportunity. However, landing stages near the Mussel Aa should be implemented

to allow resting. When having several stages, canoeing routes can be optionally adjusted to the recreationist's preference. Moreover, the water way should be free from water and shore vegetation.
Further, rentals for canoes and the appending equipment such as helmets, life jackets, pedals, etc. should available. The existing canoeing possibilities at the Ruiten Aa, however, could be sufficient within this region and further canoeing facilities would be obsolete. At the moment there is a rental company called " Peddel & Pedaal" that is located in villages lying along the Ruiten Aa. People can rent bikes here as well as canoes and return them in another rental office. If demand for canoeing is high, then an extension of this canoe rental in the area of the Ruiten Aa should be taken into account.

Another recreation possibility, in particular in summer time, is swimming. For that the permanent retention areas are more suitable. However, certain requirements must be ensured for the safety of swimmers (Provincie Noord-Holland, 2002). The water quality should be sufficient to make sure that no germs or toxic plants such as the blue algae can grow. Further, the swimming water as well as the access to the water should be free from any water plants. The soil should be gradational and solid, while being safe for little children to enter.

As the river and the surrounding retention areas become more natural, divers species can grow in a natural way – such as fishes. Fishing could then be promoted as a touristic activity, however, should be controlled by obliging fishers to possess a fishing license. At fishing places plants should be limited to allow fishers free access to the shore. Also such places can be next to grasslands as they positively influence the experienced quality of fishing (Provincie Noord-Holland, 2002). The requirements for fishing are that the water is at least 0.75 m deep and 5 m wide. Further, fishers prefer more standing than streaming water; therefore fishing places could be established at permanent retention areas.
Not only is the water quality vital for a good living environment, but also a diverse habitat. In some parts of the waters protected districts can be established to allow dense water vegetation for the fishes.

Recreation near water
The network of hiking and cycling paths in the region can be further extended. At the moment there are several paths along the Ruiten Aa and also near the Pagediep, but none around the Mussel Aa. Cycle paths could be built along the Mussel Aa and connected with the existing paths in the two neighboring recreation areas. Having a network of many paths offers a broader choice of varying lengths and points of interest. Cycle trips are then suitable for families, but also for experienced cyclers. Grasslands are, however, less appreciated for hiking or cycling than woods (Provincie Noord-Holland, 2002).
The permanent and temporary retention areas should be accessible for tourists and locals. While hiking paths can follow over dirt roads, cycling paths should be built on bitumen. Asphalt ways can be accessed throughout the whole year and have a solid basis even during rainy days. Additionally, bridges over the Mussel Aa can be implemented, so that people can continue their jaunt on to surrounding villages or connected paths. Preferably, trees can be planted to create shadow in the summer.

As retention areas will be flooded, paths and rest areas should lay high enough or be located behind dikes and thus be safe from inundation. Further, picnic or barbeque areas can be placed along the hiking and cycling paths. This increases the attractiveness of the area for tourism and gives the local tourism an opportunity to benefit from the new changes in the landscape.

Wet lands such as swamps can be accessed by paths (see figure 18) that surround the area or via bridges. Here a path through the swamp can be created, which can be further developed as a nature trail as a swamp can become a biotope for flora and fauna. It should, however, be taken into account that temporary retention areas can run seasonally dry. Then the appearance is less beautiful and thus less recreational.

Figure 18. swamp area with paths, *source: brec.org*

6.2.4 Technical abilities

When combining water storage with recreation, technical conditions has to be taken into account (Provincie Noord-Holland 2002). The form and the height of the shore play an important role. It has to be ensured that in time of flooding the hiking and cycling paths are still accessible and are not be damaged. When the water level is too high, some recreational activities have to be limited.

Further, a changing water level has to be considered. Some water sports such as canoeing or swimming could be established at the retention areas. If the water level is too low, those sports are not possible, if not dangerous. Therefore, temporary retention areas should be seasonally closed. Also, forest and woods are not suitable for a changing water level, in particular not if these areas are combined with housing. According to the Provincie Noord-Holland the nature types open water, wet nature areas and grasslands are the best suiting according to different kinds of recreation (see table 11).

Table 11. Best suiting nature types for recreation, *Source: Provincie Noord-Holland, 2002 .Suitability of different nature types for recreation activities*

Nature type	**Recreation in/at water**		**Recreation near water**
	Fishing	Swimming, canoeing	Biking, Hiking
Open water	+	+	[2]
Wet nature	+	[1]	- [3]
Grasslands	++	[1]	-
Forest	-/+	[1]	++
Park	+/++	[1]	-/+

[1] Recreation at water is possible if fishing and shipping water is acceptable within this nature type
[2] Open water is suitable for land recreation if the surroundings are attractive
[3] Wet nature can be attractive for bushes and grass

Moreover, it should be further investigated in how far the nutrition of the water has an influence on germs. In case of inundation, nutrients such as phosphate can be flushed out from the soil. This is most likely to occur with the temporary retention areas. The more flowing the water is the better will be the water quality. Also vegetation and animals will change according to the flowing speed of the water, to be seen in table 12.

Table 12. Change in vegetation and animal species according to stream level of water, *Source: Provincie Noord-Holland, 2002, Effects of different forms of retention areas*

	Permanent retention		*Temporary retention*	
	Standing water	Flowing water	Standing water	Flowing water
Nutrients	0/+	+	+	++
Acid	0/+	+	+	++
Turbidity	0/+	0/+	0/+	++
Algal bloom/Lemna	0/+	0/+	0/+	++
Fishes	0/+	0/+	+	+
Vegetation on shore	+	+	0/+	0/+
Land vegetation	0	+	-	-
Mammals	0	0	-/0	-/0
Plants	-?	-?	0	0

+ Growth
0 No change
\- Decrease in development

6.2.5 Peat restoration

According to the history of this region, the natural ecosystem is a peat bog. As there have been many changes to the landscape and in the region of the Mussel Aa very little is left of this original ecosystem.

The object of the design 'the new Peatcolonies' is to increase the water storage. This means more water will be in the area. Because of the future developments and the history of the area, reintroducing peat could be a way to diversify the landscape. But peat is known to be a vulnerable ecosystem. The feasibility of reintroducing peat is researched in the following paragraphs. First a clear definition on peat is given. Then the different succession stages of peat are described. The last part is about the regeneration techniques used in peat restoration.

Definitions

Peat lands (or mires); are wetland ecosystems that are characterized by the accumulation of organic substances, which are produced and deposited at a greater rate. (Paavilainen and Päivänen, 1995).

Paavilainen and Päivänen distinguish four types of peat ecosystems:

- *Bogs;* are nutrient poor ecosystems that are dependent on precipitation. The peat is predominantly Sphagnum moss peat. (Du: hoogveen)
- *Fens;* are at least slightly nutrients rich, influences by water derived predominantly from outside their own immediate limits, for instance groundwater. The peat is formed mainly from Carex and Phragmites residues.
- *Swamps*; are will-wooded, nutrient rich wetlands, where the peat layer thickness varies or can even be totally absent.
- *Marches*; are grassy wet areas, periodically inundated with standing or slowly moving water. The substratum usually consists of mineral or organic soils with a high mineral content, but there is little peat accumulation.

The definition of the term 'peat' is quite broad. Therefore, the targeted nature feature must be more specifically described, because the conditions needed for these ecosystems vary greatly.

6.2.6 Succession stages of Peat

A peat ecosystem has different succession stages. These successions stages are shortly described below (figure 19). A peat system often starts out as a swamp and slowly changes transfers into a fen or a swamp. For this, if the conditions are sufficient, the system can grow into a bog. A peat bog is a highly appreciated ecosystem. Not only because it has a high biodiversity, also because it is perceived as beautiful (figure 20).

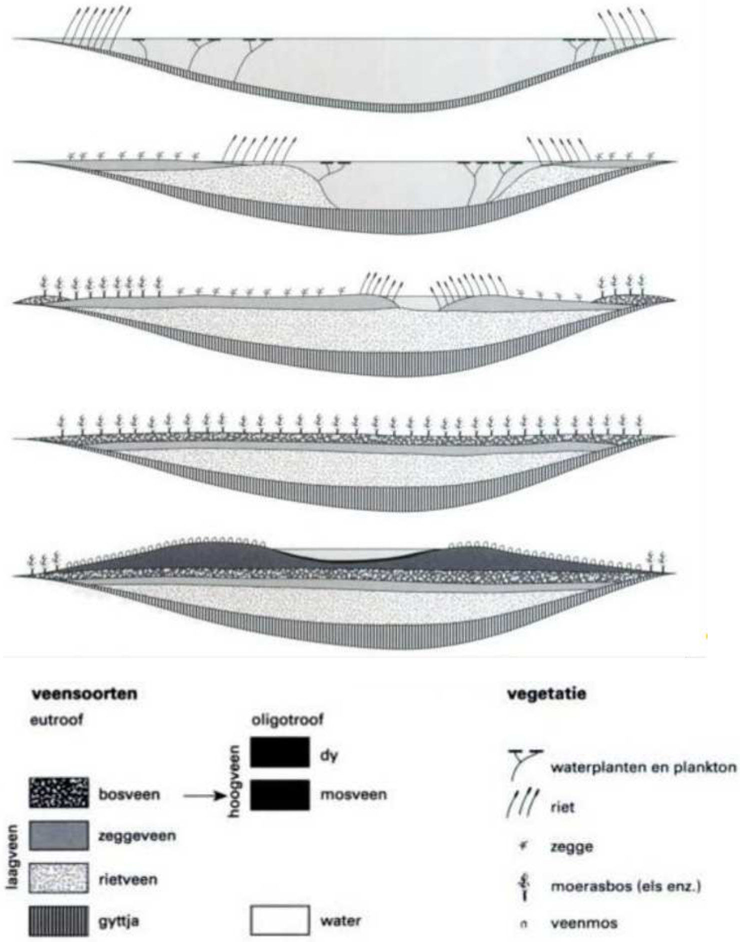

Figure 19. Succession of peat, *source: Visscher 1949*

Figure 20. Peat bog, *source: http://www.ipcc.ie/*

6.2.7 Peat growth

It is very difficult to indicate how long it takes for a peat ecosystem to grow. This is very dependent on the habitat conditions. It can take up to a thousand of years before a pond grows into a peat bog. Once the peat bog is growing it has a growth rate of 1mm/y (Rydin and Jeglum, 2006). From this, the conclusion is that the peat is a very slow growing ecosystem.

The requirements needed to get the ecosystem growing are also high. A few things that need to be considered are the nutrient state of the soil, the quality of the groundwater and the seed bank in the current soil.

There are methods available to speed up the growth of peat. These methods especially focus on the floating carpet of vegetation in fens and on the growth of bog. The development of a peat bog can occur within 20 year. But for this many measure are needed. Land needs to be filled with accumulated peat and the sphagnum moss needs to be planted (Canadian Sphagnum Peat Moss Association, 2009).

It should be known, that when only increasing the water table in an area, it does not necessarily mean that interesting and diverse vegetation will follow. The contribution of rewetting to vegetation restoration of degraded peat meadows is needed. Even if there is a seed bank in the soil, biodiversity is not guaranteed.

6.2.8 Use of peat for recreation

Figure 21. Bargerveen

Peat lands are quite common in the Veenkoloniën and thus contribute to the culture-historical landscape. Such areas are experienced as beautiful as they create a unique environment. Therefore they would be an attractive recreational site within the retention areas near the Mussel Aa. Wooden tracks on piles could lead through the peat bog while information-panels inform sightseers about the formation of peat and the flora and fauna that can be developed. Such recreational sites are already established in the neighboring areas such the peat bog Bargerveen and the fen Weerribben. However, the creation of such bogs is quite complicated, so the difficulties and preconditions mentioned above should be taken into consideration.

6.2.9 Conclusion

There is certainly potential for the area around the Mussel Aa to be a recreational place. However, this can only be realized if, and only if, several measures and investments are done. For having plentiful visitors, the region must be attractive in both landscape scenery and

activities that are offered. This would also increase the quality of the living environment and could increment demand for housing.
Besides, the recreation site should be somehow connected with rental facilities for bikes and maybe canoes. Also vacation accommodations such as hotels and camping sites should be advertised by tourist information, so that tourists have a broad choice.
Another important issue is the safety of the retention area for outdoor activities. The implementation of canoeing should underlie certain safety restriction, which should be supervised and ensured by the rental company as well as by the municipality of Stadskanaal. Also swimming may be a possibility to recreate in sunny days. For these several items that are relevant for the safety must be regularly checked. Such item could be the water quality, the presence of toxic algae, stability of the shores, etc.
Before implementing touristic activities a survey should be undertaken in order to measure the actual demand. These activities could be extended or connected to existing ones if a broader network is reasonable and increases visitors. However, an excess of recreation activities within such this region could make new implementations obsolete and the investment worthless.
The region around Stadskanaal is highly dominated by agriculture and that seems to persist in the upcoming decades. Recreation, however, can only be implemented at the expense of agriculture. Thus, if farming will stay prevailing, recreation could be developed at a small scale only.
Further, the vegetation and nature development in the retention areas should be externally supported. The technical abilities of vegetation and landscape differ among the nature types. Thus recreation activities should be either adjusted to the prevailing nature or the nature should be steered in such a way that the desired recreation can develop.

6.3 How do the different stakeholders benefit?

6.3.1 Impact of recreation on different stakeholder

The inhabitants of the region of the Mussel Aa could benefit from having recreation areas in front of their house door. However, it is unknown if more tourism is wanted by the local community.
Some local businesses besides agriculture could benefit from the new recreation areas. In particular the industry that is related to tourism profit from a higher number of visitors. Such businesses are hotels or camping places, which offer accommodations to the tourists. However, also locals in the villages near the Mussel Aa can start up their own B&B if the demand is high enough. By having more people coming to the region, the local economy could face an upswing as jobs are being created when implementing new touristic establishments. Further, the shops in the region of the river could have more customers, especially next to accommodation facilities such as camping parks. Other businesses that could potentially thrive are hiring agencies such as bike and/or canoe rental.
Other stakeholders are governmental institutions such as the DLG as well as the provinces of Groningen and Drenthe. The DLG could help to acquire and develop land for the retention areas. Further, they could give financial support or advice on potential subsidies for the execution of the project on the water storages.

As the channel of the Mussel Aa and the surrounding landscape are being restored, the province of Groningen can achieve one of the goals set in the project "Gebiedsopgave Veenkoloniën – Zuid" (Provincie Groningen, 2009 (b)).

Further, farmers should be involved in the endeavor and be accommodated as they play a major economical role in this region. Grassland near the retention areas can be seasonally used for agricultural purposes such as pasture land for animals. As usually dirt track lay along these meadows, hikers as well as riders could use them to stroll. This, however, must be done after consultation with farmers and, if adequate, outweighed with compensation.
A further measurement that can be taken in order to integrate farmers' activities into the nature is the "Blue and green services" (Du: blauwe en groene diensten). Here farmers help to sustain the nature areas and accommodate more efficient water system while maintaining their agribusiness in the first place. This is then financially compensated.
However, it needs to be considered that the existing agriculture may conflict with the development of recreational places as land is required for latter. If agriculture stays important and dominant, the realization of recreation could be less likely.

6.3.2 Conclusion

The development of new retention areas and recreation impact on the stakeholders to a different extent. Commercial recreation could experience an upswing by having more visitors in the region. From that, local businesses that are related to tourism could benefit. However, it is not known if an increased tourism is appreciated by the people living near the Mussel Aa.
Governmental institutions play a more supporting and initiating role. The development of a culture-historical landscape is wanted by the provinces. Therefore they can be a quite steering force when realizing the project. For such an endeavor, however, investors need to be found.
Moreover, farmers should be integrated in the project at all costs as the region is predominately agricultural. This could be achieved by involving them into the maintenance of nature and/or compensate them financially. Therefore it may be helpful to ask farmers for their future plans and about alternative ideas for designing the landscape more attractive.

7. Conclusion

In this research the feasibility of the design 'the new Peatcolonies' is investigated. The main research question answered is: are the plans made by Inge Kersten feasible in terms of hydrology and land use? To answer this question, first conclusions concerning the feasibility of hydrology are given and after this the conclusions on feasibility regarding land use are presented.

The hydrological measures, aiming at the storage of water, are permanent and temporary retention areas. Without the inlet of lake IJssel and the usage of all retention areas, 67% of the water needed to compensate for the deficit can be stored.
However, the feasibility also depends on the consequences of the water storage. In the temporary retention areas the water will be stored above the surface. Thus, it will be necessary to construct a small dyke and an impermeable clay layer in order to prevent leakage. The sandy soil has a high conductivity and therefore causes significant seepage outside the retention area. Placing the dyke and the impermeable clay layer will hinder the seepage. The problem with implementing a clay layer is that it will dry out when the temporary retention areas are empty in the summer. When the clay layer dries, the soil becomes permeable. Farming can then not be conducted, because ploughing will damage the clay layer.
In the permanent retention areas the water will be stored in an excavated area. Due to excavation the seepage is less likely to occur. Only there is a limited amount of space for water storage available in these areas. If the water level is increased, the seepage will increase dramatically. When the excavation is too deep, the water will be below the groundwater level. The distribution of water for agricultural purposes will then be more difficult. Also the local groundwater level will decrease near the retention area and accumulate in the retention area.
The overall conclusion for the feasibility of implementing the temporary retention areas is that it is only feasible with a clay layer as well as a dyke. Farming, however, will then not be possible. The permanent retention areas face fewer difficulties with the water storage. However, it is not possible to store a large amount of water in a small area without affecting the groundwater level or taking other technical measures like clay linings. Further, the possibility to encounter archeological valuable objects during the excavation is present and could thereby delay the implementation of the permanent retention areas.
When integrating the climate change G+ scenario, the retention areas are only sufficient for compensating the expected change in precipitation and evapotranspiration. This means that the inlet of water from lake IJssel cannot be reduced as the retention areas just compensate for the change in water availability according to the climate scenario. However, the region is then not self sustainable in terms of water. For the W+ scenario the defined water level height is not sufficient to store the needed amounts of water.

The consequences of the hydrological measures on land use are concluded in regard to agriculture, housing, and recreation.
The literature study and interviews with farmers showed that the agriculture should stay dominant, but get more diverse in the future. The 'Agenda voor de Veenkoloniën', two

farmers, LTO-Noord and AVEBE agree upon this statement. The climate change and the discharge of subsidies should encourage farmers to come up with initiatives like scaling up and using other crops in order to keep their company profitable. This will enhance the diversity of the landscape. Additionally, intensive animal husbandry can also positively influence the diversity of the Veenkoloniën. LTO wants this and also farmers do agree upon this plan. However, the province does not allow the building of new intensive animal husbandry farms. Further, expansion of existing farms is restricted by the province.
When modeling the retention areas these findings, importance of agriculture, were taken into account. The groundwater levels will not change significantly during the growth season and therefore the crop cultivation does not have to change. During the winter months the groundwater levels near to the retention areas are slightly higher; up to 0.4 m below surface level. The most thoroughly measure will be the putting in to use of the retention areas. This takes up arable land and will thereby diminish the crop production and affect also the capacity of the agribusiness.
In short, agriculture is an important sector in this area. The future plans according to the province and municipalities are to strengthen the agriculture and not diminish it. The retention areas do not have a large influence on the existing manner of farming. If the hydrologic measures do have a large influence the plans are not feasible.
The feasibility of building houses in the area near the Mussel Aa has been assessed, with a focus on housing in the retention areas. Living on the water is technically feasible and has a positive effect on housing prices. However, mosquitoes and a bad water quality can be a threat for the attractiveness of these houses. The attractiveness is also affected by competition of the existing cities on water such as “Blauwe Stad” Groningen. In order to be successful in attracting future residents, these houses need to be very special, original and attractive and there has to be a well developed infrastructure. Self-evidently, if the landscape stays monotonous and lack variety, the prices and the value of luxurious houses will decline. The province aims at a small target group and plans to have about ten large land houses. Regarding these houses the focus will lay on quality instead of quantity. The second reason for the limited housing plans is the unknown amount of land that will become available till 2050 for the retention areas. Therefore the housing plans depend on the implementation of the retention areas. In that case, new housing plans can still be developed, but the reconstruction of existing houses becomes more important.
Recreation possibilities near the Mussel Aa are limited at the moment. Coming back to the fact that agriculture will be dominant in the future, the recreation possibilities will be narrow. However, implementing recreational sites such as biking and cycling paths can improve the living environment. The recreation can be stimulated by building holiday houses, hotels, camp sites. In order to stimulate recreation in the area, both landscape scenery and recreational activities such as canoeing have to be attractive. These activities could be extended or connected to existing ones if a broader network is reasonable and increases visitors. However, an excess of recreation activities within such regions could make new implementations obsolete and investments worthless. Commercial recreation could experience an upswing by having more visitors in the region. From that, local businesses that are related to tourism could benefit. However, it is not known if an increase in tourism is appreciated by the people living near the Mussel Aa.

Governmental institutions play a more supporting and initiating role concerning recreation. The development of a culture-historical landscape is wanted by the provinces. Therefore they can be a steering force when realizing the project.

The overall conclusion on the feasibility of the design 'the new Peatcolonies' is that the plan is only partly feasible. The areas provided in the design for water retention are not sufficient to reduce the inlet of lake IJssel and compensate the climate change. The idea of temporary retention is not feasible in this area. Moreover, the area at the Mussel Aa area is not ideal for water storage because of the high permeability of the soil that causes seepage. The groundwater table is easily affected by any changes in the system.

The storage of water in the Mussel Aa is only feasible if the water table is properly managed for agriculture. As agriculture is an important sector in the region, the province and municipalities have the same opinions about the agricultural developments.

When combing the retention areas with housing and recreation, there are many possibilities and opportunities. The feasibility of building houses and recreation is fully dependent on the changes that will be made to the landscape. When the Mussel Aa area is transformed into a beautiful diverse area then the plans to integrate housing and recreation are feasible.

8. Discussion & Recommendations

Hydrology

Retention areas

The x-z model showed the results about the influence of both the temporary and the permanent retention areas. Unfortunately, implementation can give some difficulties like significant leakage. Therefore for the temporary areas it is recommended to construct small dykes and a clay layer in order to prevent leakage to the adjacent land. The construction of the dyke of 0.8 meter high will not give major problems. However the construction of the clay layer can give some problems with the suitability of the arable land. The plan is to have the land for maximum 50 % of the time in use for the water retention and for 50 % in use as arable land. Although due to the clay layer, which has to be impermeable, there cannot be any ploughing activities by farmers. So the land is not suitable for farming activities then. Another problem could be that the clay layer is drying out and therefore gets permeable in the time there is no water in it, which occurs mainly in summer. In order to prevent this it is recommended to keep a thin water layer all year through. The temporary retention area gets similar with the permanent retention area with the only difference that the permanent retention area is excavated and the temporary retention area has a clay layer.

For the implementation of the permanent retention area the problem is that there could be found some archeological valuable objects in the ground. This has to be taken into account because in Onstwedde (Bergsma, 2008), Sellingen and Ter Apel there are found some archeological valuable objects (DLG, 2008). When this is indeed the case there is a chance that the permanent retention areas cannot be excavated.

Storage capacity

The calculations about the storage capacity of the retention areas are not conclusive enough to state that it is impossible to stop the inlet of lake IJssel. For instance, the volumes are only calculated based on the evaluated heights. Also storing the water in the soil during the winter is not investigated. At the moment the calculations do not include big deep retention lakes but only a shallow lake. These are all possibilities to increase the storage capacity which can be further investigated.

When the W+ scenario will be the future situation and if the decrease of precipitation excess should be compensated compared with the current precipitation excess (or more if water inlet from lake IJssel should be compensated as well), dealing with climate change will be a problem.

When assuming the W+ scenario and reducing the inlet of lake IJssel to zero, the retention areas will be strongly needed. These can be placed along the Mussel Aa, but there are also other possibilities in increasing the storage capacity in the Veenkoloniën.

There are two main recommendations for storing more water. The first suggests to look for an even more local solution for storing water. The farmers can be put in charge for there own water retention areas. This will involves many changes, but in 2050 it may be possible to realize this. The other recommendation is the opposite of the previous. It is also an idea to look for water storages on a larger scale within the Veenkoloniën. More water can be stored in one place for a larger part of the Veenkoloniën. Moreover will the changes in the water table affect only a little area of the region. The effect on the agriculture will therefore diminish. It is then important to look for an area that can store more water naturally than the Mussel Aa area could. This can for instance be an area, which is lower in the landscape. However, for both recommendations more research is needed. It is not only recommended to store more water, it is also good to look at ways of reducing water use in the agribusiness (for instance by using other irrigations techniques).

Agriculture

Farming is dominant in this region and will play a major role in the future. However, agriculture should adjust to the imminent climate changes and economical opportunities by being more diverse. Besides arable farming, dairy farming and intensive animal husbandry is a way to diversify the Veenkoloniën. However, animal husbandry on a large scale is still prohibited by the province. Compromises should be found and the advantages and disadvantages should be outweighed.

While recreation is desired from the province, farmers do not necessarily want to extend nature areas. Also, when the new water storages are being built, land will have to be acquired from the farmers. Between those opposing forces a balance should be found. Farmers should be financially compensated for land loss. Further, farmers could receive a fee in return of nature conservation. The involvement of farmers into the maintenance of nature can be done in the framework of 'blauwe en groene diensten'. A remark is that the opinion of the farmers is based on two interviews while there are more than 100 farmers in the area working. More research should be carried out to check the cooperation of the farmers concerning nature maintenance.

Innovation can also contribute to a more diverse agriculture. That is why innovations like finding new crops to produce or the use of waste streams for bio-energy production should be stimulated by the different agro-stakeholders.

Housing

The combination of retention areas and housing demands for some requirements. The vegetation around the houses should be able to adapt to a changing water level. Thus, plants should be carefully chosen and cultivated, so that in time of a low tide no mud field will appear.

Also, dangerous sites around the houses on water should be clearly indicated. In particular weirs and pumps should be signposted. When swimming facilities are implemented at the retention areas, the swimming area should be deep enough, but partly be shallow for younger children. Also a rescue team such as the police of Stadskanaal or volunteers should patrol the swimming areas. Additionally a flood control in the retention areas should be implemented to accommodate unexpected fluctuations.

Further, the amount of buildings and water need to be in balance. Thus the amount of houses should be limited in order to hold on to the atmosphere which is created.

Because of the target group (mainly elderly people) the houses should be adapted to their wishes. However these wishes are not investigated in this research. The recommendation is to implement a survey to find out which type of houses is demanded by whom. Furthermore they should be accessible for handicapped people.

The success of selling such houses in the region should further be investigated. There are houses for both permanent and holiday purposes already at the Pagedal. If the concept is successful and the demand is high enough, then similar housing can be implemented at the Mussel Aa, too.

Recreation

For projects such as constructing recreation within the retention areas investors and financial support are vital. Therefore, the initiators of the projects should seek for interested organizations and entrepreneurs to support recreation.

Further, the area itself must be promoted. Recreation could enhance tourism and thus stimulate the local economy. Therefore, the region and recreation possibilities should be advertised on websites of Stadskanaal. Additionally, the setup of a web page designed for the recreational surrounding of the Mussel Aa would help to distribute information. Further, flyers and brochures about biking paths and hiking routes could be handed out by the tourist information (VVV).

Not only for housing, but also for recreational activities the surroundings must be regularly controlled for safety. Potential dangers could be the water quality, the presence of toxic algae, the instability of the shores, etc.

Before implementing touristic activities, a survey should be undertaken in order to measure the actual demand. An excess of recreation activities within this region could make new implementations obsolete and the investment worthless.

The most striking is the appearance of the landscape itself. The surroundings must be attractive for recreationalists. If the landscape remains monotonous, the area will be more difficult to promote as a recreation and vacation place. Therefore, the scenery should be 'face lifted'. However, this can only be realized if, and only if, several measures and investments are done. Further, the vegetation and nature development in the retention areas should be externally supported. In particular peat bogs will only develop if certain preconditions are present. The recreation facilities should suite to the prevailing vegetation types such as wet nature and grasslands.

9. Literature

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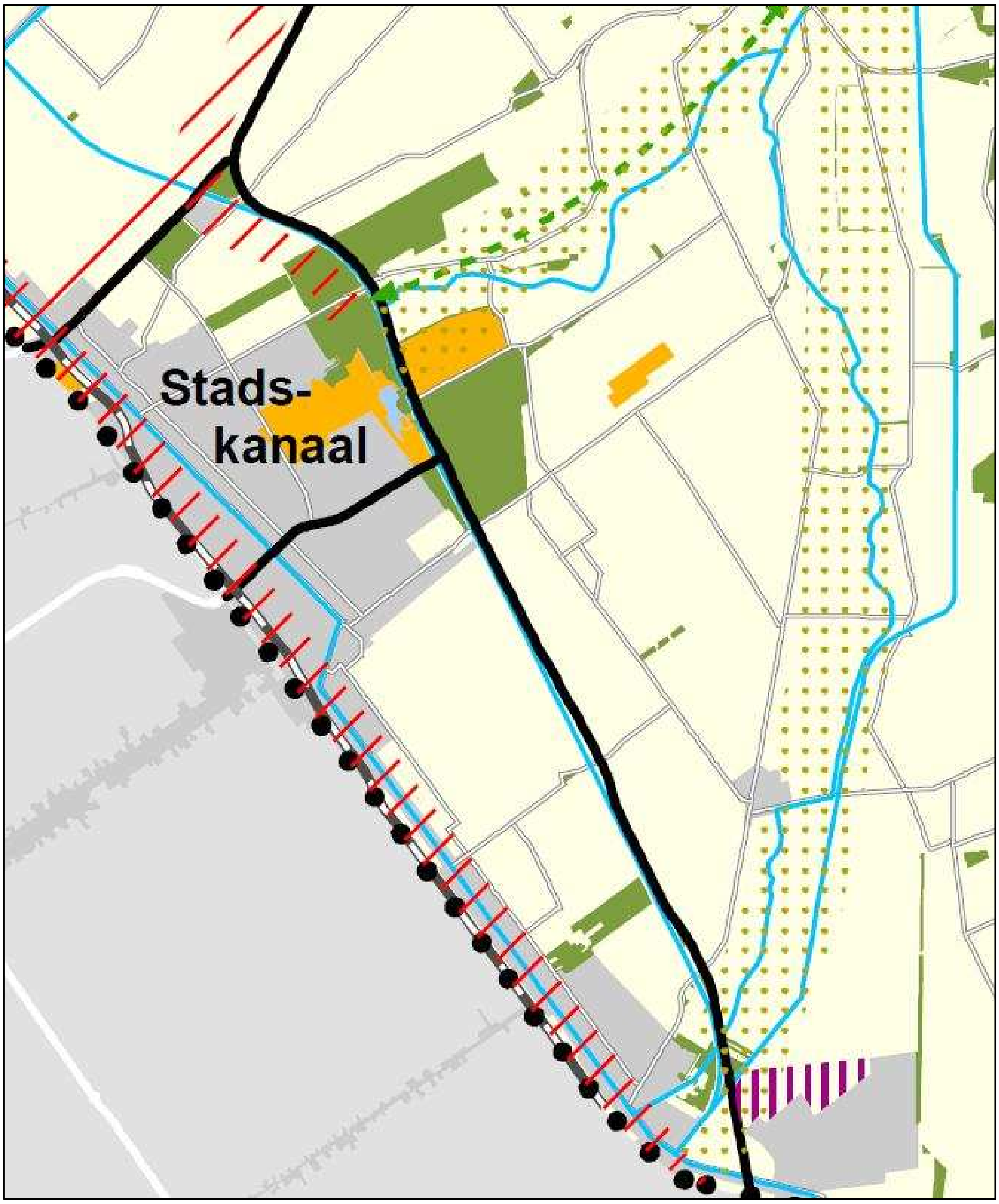
Appendix A: Overview Study area

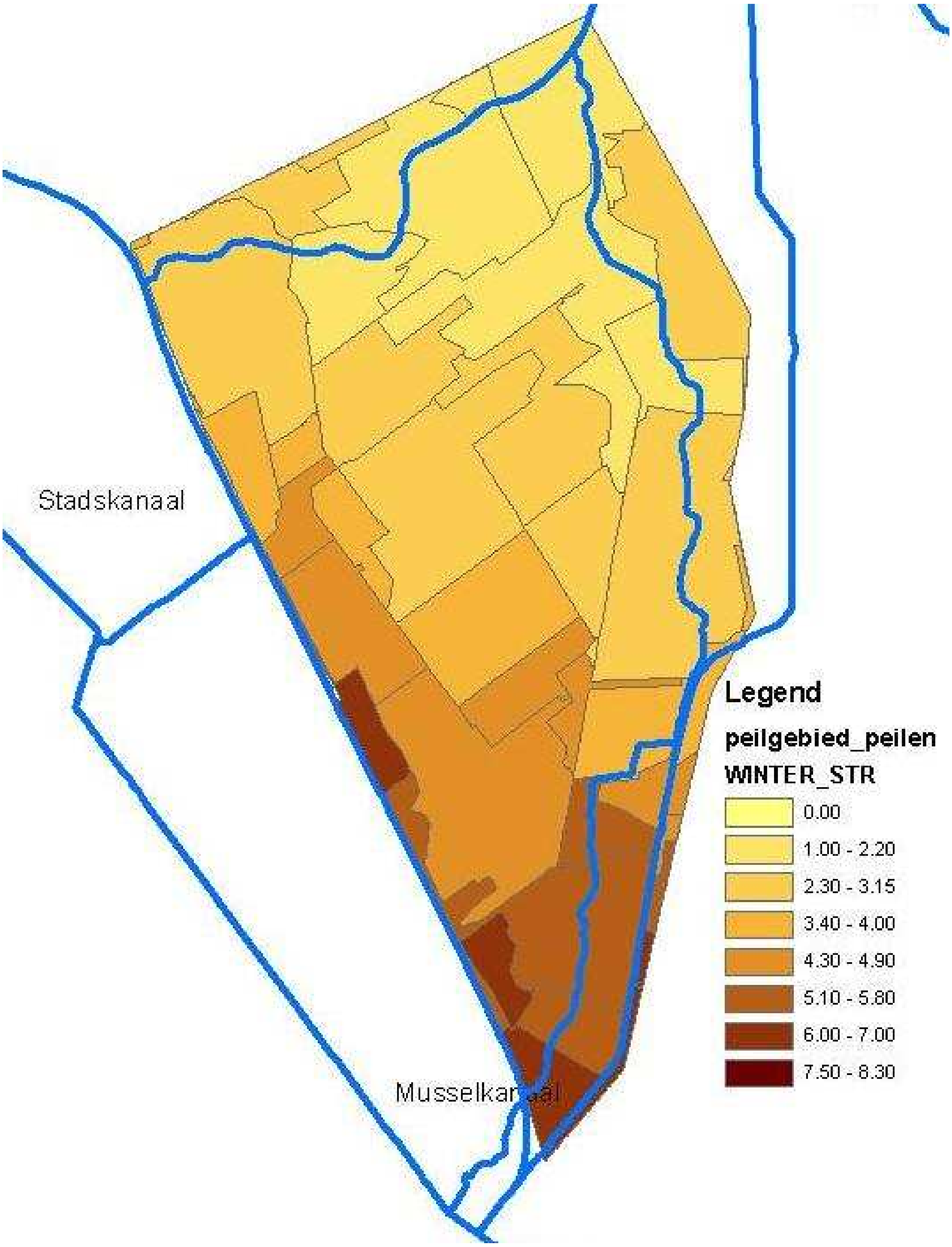


Appendix B: Crop factors

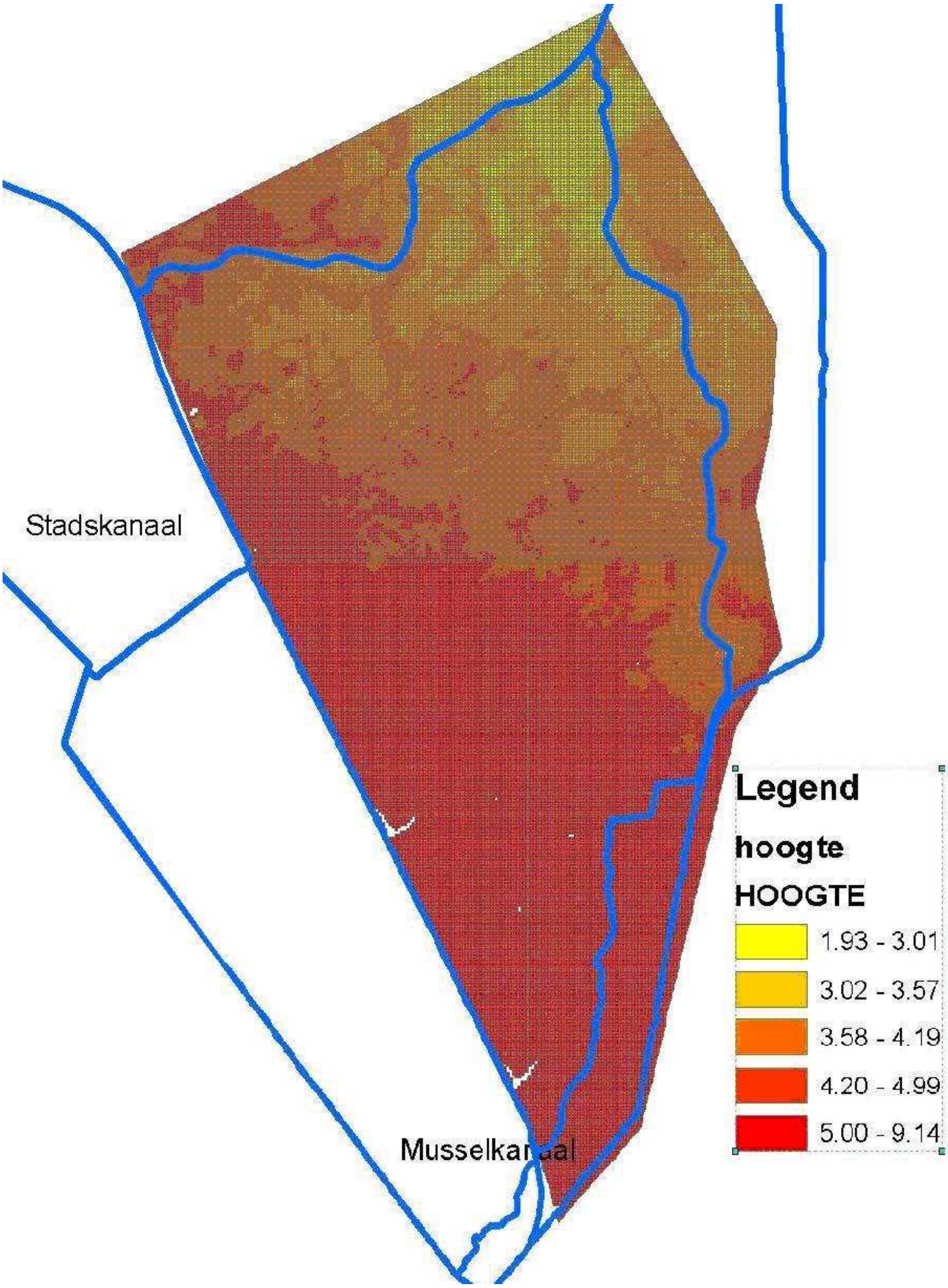
Calculation potential evapotranspiration (Makkink) with crop factors (Bruin, 1998) for current situation and future scenarios (G+ and W+ in 2050).

	Epot (mm per month)	***Crop factor***			***Reduction***	***Eact (mm per month)***		
	1970-2008	**Maize**	**Potatoes**	**Grass**		**1971-2010**	**2050 G+**	**2050 W+**
April	54.75	0.30	0.30	1.00	0.44	24.09	24.96	25.80
May	82.82	0.67	0.53	1.00	0.67	55.16	57.92	60.73
June	88.54	1.07	1.13	1.00	1.09	96.15	102.40	108.65
July	91.46	1.27	1.13	1.00	1.15	104.81	112.99	121.27
August	79.18	1.20	1.07	0.97	1.09	86.23	93.56	100.80
September	48.82	1.20	0.23	0.90	0.66	31.98	34.41	36.84
October	25.93	0.30	0.30	0.90	0.42	10.89	11.44	11.99
November	10.33	0.30	0.30	0.90	0.42	4.34	4.46	4.59
December	5.68	0.30	0.30	0.90	0.42	2.38	2.43	2.47
January	7.21	0.30	0.30	0.90	0.42	3.03	3.07	3.10
February	14.20	0.30	0.30	0.90	0.42	5.96	6.05	6.14
March	30.85	0.30	0.30	0.90	0.42	12.96	13.24	13.54

Appendix C: Overview of the small hydrologically manageable areas



Appendix D: Elevation map of the study area (3120 ha)



Appendix E: Precipitation excess during summer and winter

The yearly, summer (June, July, August) and winter (December, January, February) average precipitation excess for the current situation (1970-2008) and the two climate scenarios.

Precipitation excess			
	Current	***G+***	***W+***
Yearly	346.76	326.8	307.6
summer	-76.41	-118.11	-159.74
winter	78.67	180.60	193.86