Price formation of agricultural land in the Veenweidegebied in the Netherlands

Rients Hijma
2021

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MSc-thesis
Agricultural Economics and Rural Policy (AEP)

Preface

Dear reader,

Before you lies my MSc thesis. A thesis about the analysis of the price formation of agricultural land in the Veenweidegebied in the Netherlands. A subject I knew already something about, but this thesis gave me a lot more insights. I enjoyed working on this topic because finally I could apply my knowledge gathered in the Master Management Economics and Consumer Studies in practice.

The Veenweidegebied was not a strange environment for me, growing up in a region where there are peat soils. This is also the reason I wanted to do my thesis in this field so I could learn more about it. Writing this thesis made me clear how complex the land market is in the Netherlands and how big the challenges are for farmers who farm on peat soils.

I would like to thank my supervisor Jack Peerlings for his feedback, support and expertise. He has helped me with my reading and writing skills and to prioritise, so I could create a coherent and good readable thesis.

I hope you enjoy reading my thesis because I enjoyed making it.

Sincerely,

Rients Hijma

Abstract

The function of land is in the Netherlands determined by spatial planning. Due to spatial planning land gets a function, for example housing, industry, transport, nature or agriculture. These functions have changed in the recent years. The total amount of agricultural land has been decreasing in the recent years. Agricultural land has been changed to housing and industrial areas.
To reduce greenhouse emissions from the agricultural sector European and national legislation is in place. With the CAP, EU ETS and the EU Green Deal the European Union wants to reduce emissions from the agricultural sector. The national government has also policy in place like the new Climate agreement with the target to reduce 55% of CO_2 emissions in 2030 and legislation about the maximum allowed emission of greenhouse gasses.
In the peat soil areas measures need to be taken to reduce the emission of CO_2. In this thesis the effect of underwater drainage, high water level and land-use change is investigated. This to stop the settlement of the soil and to comply to European and national policy to reduce greenhouse gasses.
Based on the results can be concluded that investments in measures that reduce the emission of CO_2 are not profitable, so only possible with financial rewards or compensation of costs. An alternative is the inclusion of agriculture in the EU ETS.

Table of Contents

Chapter 1: Introduction

This chapter introduces the topic. First, some background information will be given. In section 1.2 the research questions are discussed. Theoretical framework and methodological design are discussed in section 1.3.

1.1 Background

The land market, especially in the Netherlands, is a complex market. In the Netherlands the land market is characterised by many regulations, submarkets because of zoning policies, a limited number of demanders and suppliers and an extremely high land price. Besides farmers, municipalities, the government, project developers, NGOs and investors are active on the land market (Segeren et al., 2005).

Supply of land is finite and it cannot adjust quickly to changes in the demand (Luijt and Voskuilen, 2009). Moreover, the demand for land is high and will grow in the future. This involves demand for agricultural land but also non-agricultural land. For example, the Dutch government needs to build a lot of houses the coming years which leads to an increase of demand for land (Rijksoverheid, 2020a).

In the Netherlands submarkets are defined and regulated via zoning policies (Wet Wro 2018). Submarkets serve different land-use functions. Submarkets are for example: agriculture, housing, infrastructure, business parks, nature and water storage. Different actors are active in these submarkets which really identifies these submarkets (Segeren et al., 2005).

Climate change is more and more battled by legislation, on a national level but also on an European level. The EU proposed the EU Green Deal and a new CAP is coming up. The Dutch government proposed the Climate agreement to battle climate change. All sectors which emit need to reduce emissions (Rijksoverheid, 2021).

Agriculture uses 2/3 of all the available land in the Netherlands. Therefore, agriculture is the most important submarket. Besides, agriculture supplies land to the other submarkets (Segeren et al., 2005). This supply goes by a change in the land-use assigned by the zoning policies. Not only supply and demand determine the price of land, a lot of other factors like the quality of land and the future land-use function of land determine the land price.

The “Veenweide gebied” is a Dutch landscape type of grassland on low lying peat soil. This type of landscape can be found in the lower parts of Holland, Utrecht, Friesland and Overijssel. In these areas the land is lowering due to the oxidation of the peat. This CO_2 emission is 2.5% of the total CO_2 emission in the Netherlands. To stop these emissions of CO_2 and lowering of the land an increase in the water level is needed (Hendriks, 2020). This has impact on the quality of the soil and thereby effects the value of the land.

1.2 Research objective and research questions

The objective of this thesis to explain the price formation of agricultural land in the "Veenweidegebied" in the Netherlands.

The objective of this thesis will be reached by answering the following research questions:

1. How does the land market in the Netherlands look like?
2. What are the current and possible future national and European policies and regulations to reduce greenhouse gas emissions in agriculture in the Netherlands?
3. How works the price formation on the agricultural land market?
4. What is the effect of measures to reduce CO_2 emissions in the Veenweidegebied in the Netherlands on the land price?

1.3 Theoretical framework and methodological design

To answer research question 1 and 2, I use a literature research. I will use micro economic theory (e.g. Kreps, 1990) to answer research question 3. I will look at the price, supply and demand and therefore micro economic theory is the most appropriate economic theory. Moreover, the land market can be seen as an institution. Therefore, I also use new institutional economics (NIE) to answer research question 3. The NIE gives the following definition of an institution: 'the rules of the game in a society or more formally the humanly devised constraints that shape human interaction. In consequence, they structure incentives in human exchange, whether political, social or economic' (North, 1990). Research question 4 applies theory to the Veenweidegebieden in the Netherlands. The required data are found in existing literature and databases of for example Statistics Netherlands and WECR. With this information measures to reduce CO_2 emissions in the Veenweidegebied can be compared with each other in terms of effectivity, costs and effect on the land price.

In Chapter 2-5 the sub-questions 1-4 will be answered respectively. In Chapter 6, the conclusion, an answer to the research questions will be given and in the discussion, I will reflect on this thesis.

Chapter 2: The Dutch land market

This chapter describes the land market in the Netherlands. Section 2.1 gives some background information. The spatial planning in the Netherlands is discussed in section 2.2. In section 2.3 the function of land is discussed. After that, in section 2.4 a more detailed description of the agricultural land market is presented. The chapter ends with section 2.5 which will give a description of the Veenweidegebied.

2.1 Background

The land market in the Netherlands is quite different from a normal market for goods and services. This follows from the unusual characteristic of land; it is immobile. This immobility has impact on the land market (Luijt, 2002). If there is for example agricultural land for sale only farmers in the close surrounding of that particular piece of land will be active on the market. Farmers far away from that available piece of land will be not or less interested to buy that land due to the high transport costs. This means that there are only a few demanders active and this has impact on the price of the land and the possibility to sell the land (Segeren et al., 2005). A reason for farmers to buy land far away from their farm could be manure regulations in the Netherlands, in this way farmers are able to at least on paper process all their manure on their own land (extensive farming). Moreover, regulations and spatial planning play an important role on the land market in the Netherlands.

2.2 Spatial planning

In the Netherlands all the land has a designated function. What the function of a parcel is regulated in the spatial planning law. This spatial planning law will be described in this section.

The special characteristic of land explains the active role the government plays in the land market (De Regt, 2003). The amount of land in the Netherlands is limited and every parcel of land has a designated function. Figure 2.1 shows the land-use in 2015. The function of the land can vary between agricultural, housing, infrastructure, recreation and nature (Tisma et al., 2019). Figure 2.1 shows that land-use differs largely between regions.
What the function of land is and how the function of land can change (i.e. spatial planning) is regulated in the spatial planning law (Wet ruimtelijke ordening). This law was first implemented in 1965. The most recent revision of the spatial planning law was implemented in 2018.

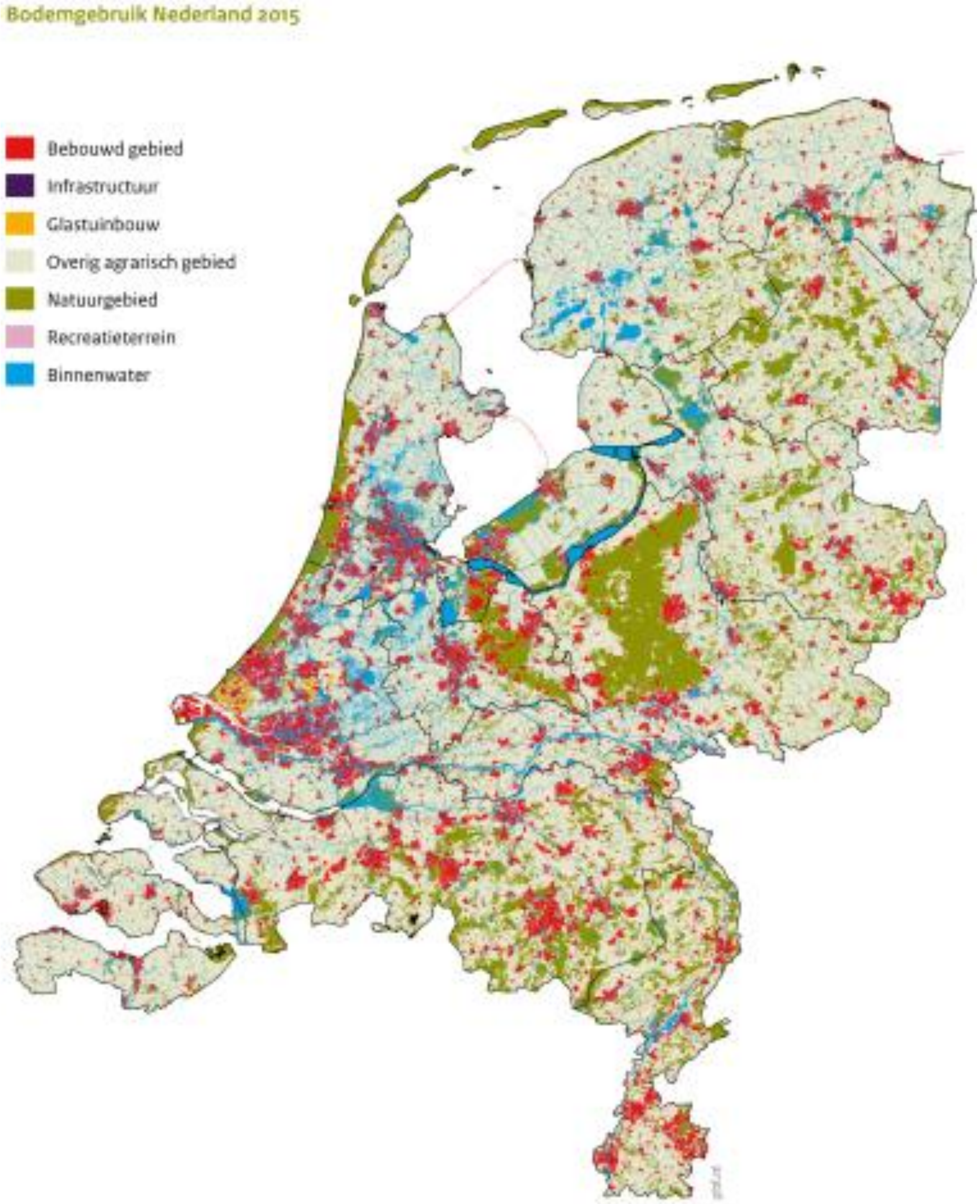
In the Netherlands it is decided that the government, from national to local has the authority to spatially plan land-use (Wet Wro 2018). In a spatial development strategy (structuur visie) the government lays out the primary spatial planning for their territory. This can be done by provinces as well as municipalities. In these development strategies the government lays out how certain spatial goals in a region will be accomplished. These goals are for example the building of new industrial areas, the building of new roads or the protection of nature.

With these spatial development strategies, the municipalities and provinces make a land-use plan (bestemmingsplan). This is a more detailed plan about the function of a certain parcel of land. Also the rules regarding the destination of the land are included in this plan. These rules are for example regulations about the use of the land and the buildings in that specific area. The regulations for a piece of land with a destination agriculture are different than that of land with the destination housing. In a land-use plan it is also included how the destination of a certain parcel of land has to be realised in case it changes (Wet Wro 2018).

In a land-use plan it is also included how the current or future destination of an area needs to be preserved. This means that it is possible that there is a section included in the land-use plan which states that it is for example forbidden to build, rebuild and demolish buildings (Wet Wro 2018).

If a land-use plan is approved by the municipality council (gemeenteraad) the land-use plan holds for 10 years. After 10 years the land-use plan can be changed or extended. An extension of a land-use plan is done by a so-called extension decision (verlengingsbesluit), if this decision is taken the land-use plan is unchanged. This means that the function of land only can change if the municipality changes the land-use plan for a certain area (Bruil, 2019).

Figure 2.1: Land-use in the Netherlands, 2015.



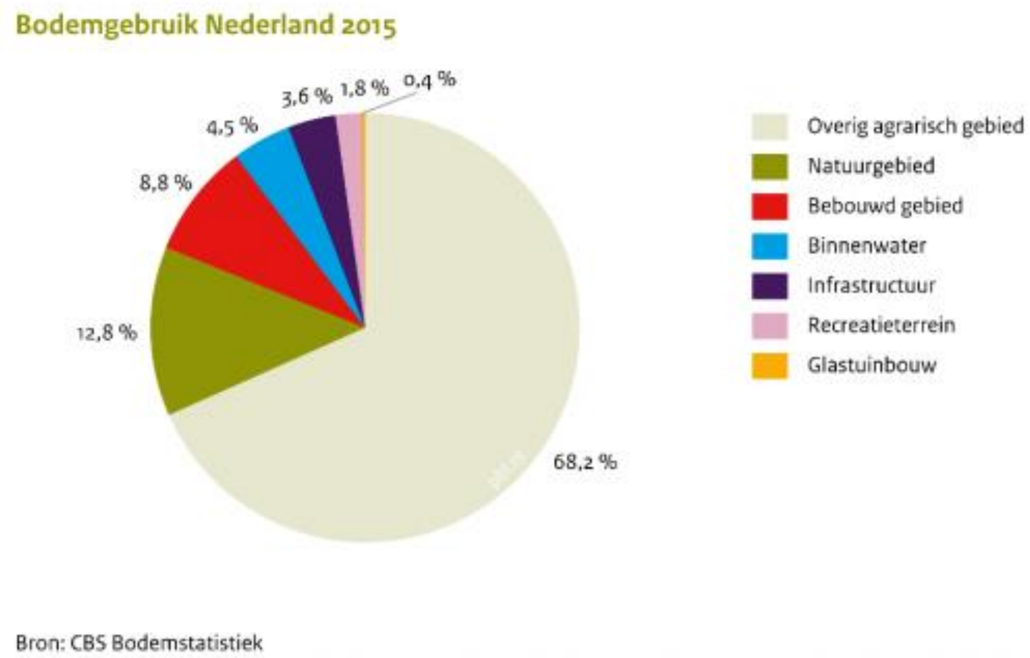
Source: Tisma et al., 2019

2.3 Function of land

As described in the previous section the function of land is regulated in the spatial planning law. The topic of this section is land-use change.

Figure 2.1 shows the land-use in the Netherlands. Figure 2.2 shows the division of land-use in in 2015 (not including seas and lakes). Agriculture uses by far the most land in the Netherlands, 68.2%. Nature is with 12.8% the second largest user of land, housing is the third user of land with 8.8%. This divisions says nothing about the submarkets but give a clear indication about which sectors use land and how much.

Figure 2.2: Land-use in percentage in the Netherlands in 2015.



Source: Tisma et al., 2019.

Table I.1 (Annex I) shows the change in land-use in the Netherlands over the last 15 years. In Table I.1 the percentages of land-use for the different functions of land differ from Figure 2.2, in Table I.1 seas and lakes are included in the total area of the Netherlands.
One thing that stands out is that the amount of agricultural land is decreasing the last 15 years. Between 2006 and 2015 the total amount of agricultural areas has decreased with almost 50,000 ha. Land used for infrastructure (verkeersterrein) was increasing before the year 2010 but is also decreasing the last few years.
This means that land-use for other functions has increased the last 15 years. These functions are housing and industrial areas, nature and recreation. The biggest increase can be seen in housing and industrial areas. Between 2006 and 2015 the total amounts of housing and industrial areas have increased with almost 24,000 ha. The land allocated to the functions nature and recreation has increased with respectively 15,000 ha and 9,000 ha between 2006 and 2015 (CBS, 2018).

The most important reason for the increase in land allocated to housing is the population growth in the Netherlands (Rijksoverheid, 2020a). New houses are built on former agricultural land. To make this happen municipalities buy land from farmers and other landowners close to a village and change the land-use plan from agriculture to housing. Private actors like land developers also develop land to build houses, these companies depend on the development plans made by the government. If they possess land they have a stronger position in the negotiations with the municipalities when is decided who can build where and what is allowed to build (Segeren et al., 2005). In the coming years more houses need to be build which will result in a further decrease of agricultural land and an increase in housing areas (Rijksoverheid, 2020a).

Table I.1. also shows an increase in nature (CBS, 2018). This to preserve the fragile nature we have in the Netherlands. People are more and more aware of nature and the problems nature has to survive. This is partly due to increases in income as nature is a luxury good. The government reacts to this movement with the increase of nature areas. Increasing incomes and population growth can also explain the increase in recreation areas.

In the future the pressure on the land market will further increase. The need to build houses, industry and infrastructure maintains and also the need to protect fragile nature will increase, which will lead to an increase in nature areas. The need to build will lead to a change in the function of land, less agriculture and more housing, industry, infrastructure and nature. In this way the functions of land are competing with each other which has big implications for the land market. It is not possible to have both agriculture and industry on the same piece of land, this means that these functions compete with each for that piece of land.
Sometimes it is also possible that two functions are not competing with each other on one piece of land. This means two functions on the same land for example nature and agriculture Two functions on one piece of land will be further elaborated in section 2.5.

Due to the spatial planning law in the Netherlands the land market can be divided into different submarkets since every piece of land has a function which cannot be changed easily. Also the characteristics of the land, e.g. the quality of the land, has impact on the land market and if there are different submarkets or not. Certain qualities of land make it difficult to change the land-use plan, for example building houses on peat soil is more difficult than on sand.

Submarkets can be connected in case buyers and sellers expect that the designated function of land will change. For example, speculators may buy relatively low-priced agricultural land because they expect that this land will get the function of high-priced housing in the future. Land markets are also regional because land is immobile. For example a farmer from the North of the Netherlands will not easily buy land in the South of the Netherlands and vice versa. This is less the case for the Dutch government they can buy land anywhere in the country if new houses or infrastructure needs to be build (Segeren et al., 2005).

2.4 Agricultural land market

As Figure 2.2 shows agriculture is the largest user of land. 68.2% of all the land of all the land in the Netherlands is agricultural land. This makes the agricultural land market an important one especially because over time agricultural land has been used for other functions like construction. The most important players on the agricultural land market are:

Farmers: They are both demanders and suppliers on the agricultural land market. If farmers want to expand their farm they need more land which means they will become active as a demander on the agricultural land market. Farmers can also be a supplier on the agricultural land market, farmers sell their land if they stop with their farm. A farmer can also be both if he moves his farm to another location. In this case he sells his land off the old location and buys land on the new location where he is going to continue to farm (Segeren et al., 2005).

Government: Next to farmers, the government is the second largest demander on the agricultural land market (Segeren et al., 2005). This can be the national, regional or local government. The reasons that the government land buys are diverse, as well as the new functions of the land. One of the reasons the government buys land is to build infrastructure, roads or railways (Segeren et al., 2005). Another reason is nature development. Most of this land is after the purchase given to nature conservation organisations (Staatsbosbeheer en Natuurmonumenten). These purchases are mostly done by the national and regional governments.
The local governments (municipalities) buy land for the construction of houses and business parks. In this case the municipalities buy agricultural land close to a village or old industrial areas. If someone does not want to sell his land the government has in this case the right to expropriate the owner. After that, the municipalities change the land-use plans for these lands (Wet WRO 2018), in this way it is possible for the municipalities to build houses or business parks. Mostly the municipalities buy the land and build the infrastructure, for example the roads and then sells the lots to private individuals or land developers. This way of building new housing areas is most common in the Netherlands. In some case the government only does the planning and developers construct both infrastructure and houses. This way the government avoids risks.

Land developers and speculators: They buy land to build houses or business parks. With the ownership of land these land developers have a strong position in the development of regions. They can (partly) control where the houses will be build and how they look like (Luijt, 2002). Speculators can also buy land close to a village. This with the hope that the function of these lands change from agriculture to housing. It is also possible that they lobby for a change in the function of the land (i.e. rent seeking). Speculators sometimes do not sell the land back to the municipalities but do the development of the houses themselves. They build the houses and the roads for that new residential area. This means that they bear all the costs but also all the profit after the houses are completed and sold to their new owners. In this case the role of the government is very limited. The only thing the government can do in this situation is set out some rules for the new build residential area, this can be for example how many houses are build and how many parks and ponds are constructed.

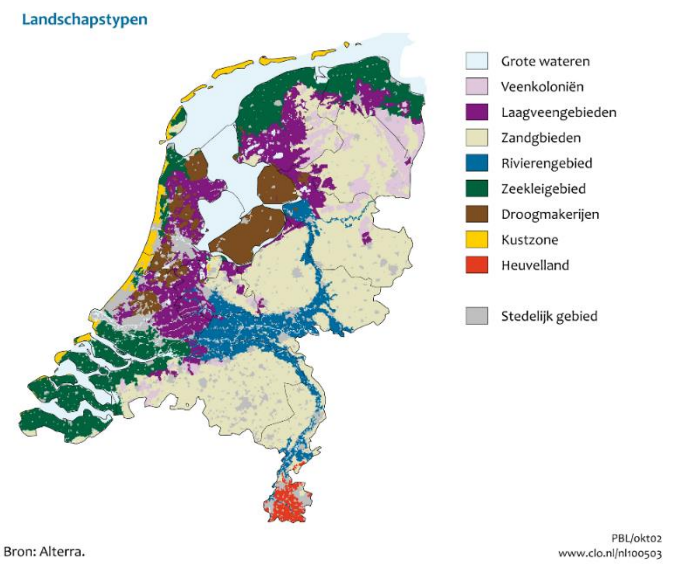
Investors: A lot of agricultural land in the Netherlands is owned by investors, these can be banks, insurance companies and pension funds. The land is rented and leased to for example farmers. These corporations see land as a low-risk long-term investment. Land is more and more a scarce resource which makes it attractive as an investment. Land mostly maintains its value and the value goes up due to the increasing demand for land. They can also benefit if the function of land changes. Agricultural land which changes into an area where houses can be build increases a lot in value, making it profitable for investors to invest in land. Moreover, buying leased land and sell the land if the lease contract ends is very profitable. Leased land is relatively cheap and when the lease contract ends you can sell the land for the normal market price which is higher, how much higher depends on the lease contract (Segeren et al., 2005 and Luijt, 2002).

2.5 Veenweidegebied

The 'Veenweidegebied' is a special land type in the Netherlands, which is characterised by peat soils. In this section background knowledge about the Veenweidegebied will be provided.

Figure 2.3 shows the different landscape types in the Netherlands. One of the landscape types in the Netherlands is the "laagveengebieden", these are the purple areas in Figure 2.3. These are the low-lying peat soils in what in the Netherlands is called Veenweidegebied. These low-lying peat soils are mostly located in the provinces Friesland, Noord-Holland and Zuid-Holland (CLO, 2020).

Figure 2.3: Landscape types in the Netherlands.



Source: CLO, 2020.

The Veenweidegebied is one of the oldest and most original cultural landscapes in Europe. In the Netherlands the Veenweidegebied is well preserved. The Veenweidegebied is characterised by peat soils and long and small parcels separated by ditches. These parcels had a standard width and length in for example Noord- en Zuid-Holland, in some cases these parcels could be several kilometres long (Cultureel Erfgoed, 2020).

To use the low-lying peat soils these lands were drained with ditches between the 10th and 13th century. Due to draining these lands became economic useful in 2 ways:

1. Agriculture: peat soils are very fertile, so particularly useful for arable farming.
2. Peat extraction: peat was dug up to be used as fuel.

This peat extraction lowered the soil, this resulted in very wet soils, unsuited for arable farming (Cultureel Erfgoed, 2020).

These wetlands attract meadow birds. These birds breed on the meadows and need the wet soil to survive. To help meadow birds to survive there is protection, the meadows are for example later mowed, in this way the young birds are protected from the agricultural machines and predators. This protection of meadow birds is done in agricultural lands which are nature inclusive, these lands are used for agriculture but these lands have also the goal to preserve and protect nature (Vogelbescherming, 2019).

If agricultural land is nature inclusive it means that there are two different functions on the same piece of land: nature and agriculture. These lands attract people who are interested in nature and birds, for example with walking roads (recreation). In this way it is possible to have 3 different functions on the same land which are not competing with each other.

For centuries the peat soils in the Netherlands had a high-water level. This ensured that the peat stayed wet and by that prevented the settlement of the peat soil. This changed 50 years ago with the deeper reclamation of the soil for modern intensive agriculture. Due to deeper reclamation of the peat soil oxygen penetrates deeper into the peat soil which leads to settlement of the peat soils (Kwakernaak et al., 2010).
Due to oxidation of the peat the total area of peat soils in the Netherlands is in the last 30 to 40 years reduced with approximately 20%. On a yearly basis the total amount of peat soils in the Netherlands is reduced by 2000 ha (Kwakernaak et al., 2010).

Due to drought and reclamation of land for agriculture, water in the upper layer of the peat soils is disappearing which results in oxidation of the peat soils. This leads to lowering of the ground level, this settlement leads to damage to houses and buildings.
But the biggest problem with the settlement of the peat soil is the high emission of carbon dioxide (CO_2) and nitrous oxide (N2O). An settlement of the peat soil of 1mm leads to an emission of 2.26-ton CO_2 per ha (van den Akker et al., 2013). Estimations show that the peat soils in the Netherlands emit 30-ton CO_2 per hectare each year. The amount of emission depends on the way of the type of agriculture, the composition of the soil and the depth of drainage.
The emission of CO_2 is higher in Friesland than in Noord- and Zuid-Holland because of the deeper drainage depth. Looking at the whole Netherlands the peat soils emit on a yearly basis 4.2 million tons of CO_2 and 1000 tons of N2O. The total CO_2 emission from the peat soils is 2-3% of the total CO_2 emission in the Netherlands. This a small percentage of the total emission but this “natural” CO_2 emission is equal to 2 million passenger cars (Kwakernaak et al., 2010).

To stop the settling of the peat soil and to reduce the emission of CO_2 measures can be taken. These measures and also the cost of these measures and the effect on the land price will be discussed in Chapter 4 and 5.

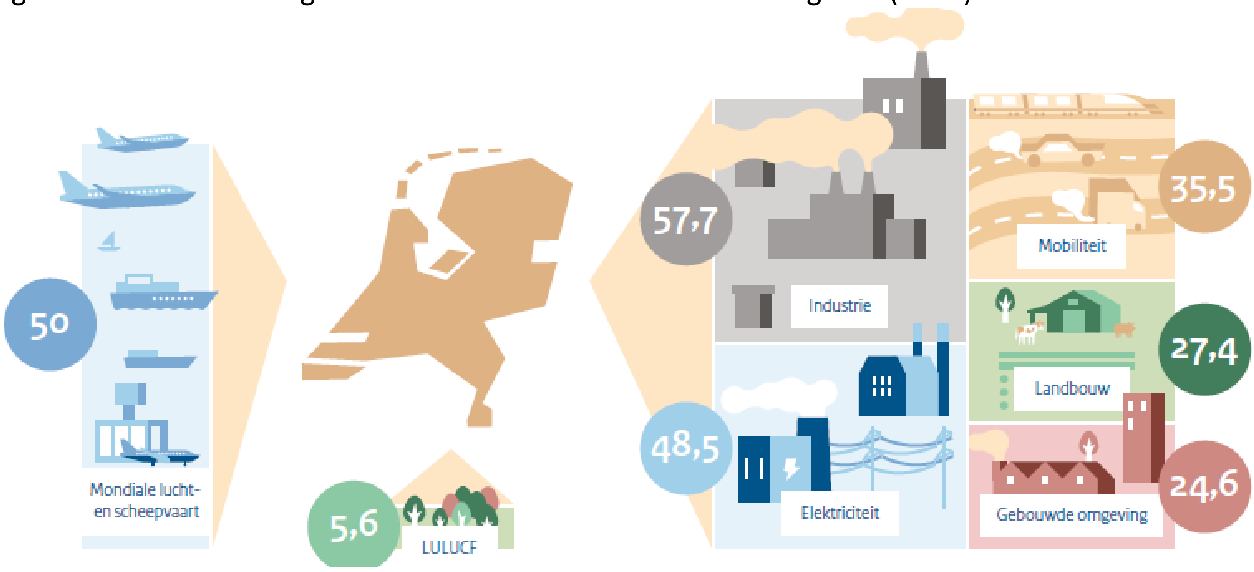
Chapter 3: Policy to reduce greenhouse gas emissions

This chapter discusses the European and national policies to reduce greenhouse gas emissions. Section 3.1 provides some background information. In section 3.2 the current European and national policies are discussed. In section 3.3 the European Union Emission Trading System is explained. Possible future regulations and incentives to stimulate emission reducing investments are discussed in section 3.4.

3.1 Background

Investments in techniques to reduce emissions are expensive and reduce the productivity of agricultural land. However, the need to reduce emissions is high to battle climate change. This need has been translated into government regulations. Moreover, it is expected that more policies will follow including potentially maximum allowed greenhouse gas emissions for individual farmers.

Figure 3.1: Greenhouse gas emissions in the Netherlands in megaton (2017).



Source: Rijksoverheid, 2020b.

Figure 3.1 shows the greenhouse gas emission per sector. It shows that industry and transport are the biggest polluters with respectively 57.7 and 50 megatons of emission in 2017. Agriculture is also a substantial contributor to the pollution with 27.4 megaton of emission in 2017.

3.2 Current national and European legislation

This section discusses the current national and European legislation and policies to reach a reduction of greenhouse gas emissions.

With almost 100% certainty science established that climate change is caused by human actions since 1850, the industrial age. The emission of CO_2 and other greenhouse gasses have increased due to the use of fossil fuel and deforestation. Climate change has negative effects like global warming, droughts, ice melting and floods. To prevent this from happening the whole world acts against climate change, on European and national level (Rijksoverheid, 2020b).

The basis of regulation for agriculture and the environment is decided and regulated on an European level. The Common Agricultural Policy (CAP) is the agricultural policy of the EU. The CAP consist of two pillars:

- The first pillar of the CAP is the income support for farmers. Farmers get subsidies from the EU as income support if they meet requirements with respect to emissions and the environment (Nitrate and Bird and Habitat directives).
- The second pillar of the CAP is the policy of the EU with respect to environment, climate and rural development. It supports rural areas with economic, environmental and societal challenges affected by climate change.

Agricultural nature conservation forms with climate measures for agriculture the most important policy area within rural development. Agricultural nature conservation is used for greening the agricultural sector (Toekomst GLB, 2021).
Members of the EU are allowed to make their own national policies within the framework of the second pillar of the CAP (Bij12, 2021).

A Dutch project within the second pillar of the CAP is a project where farmers can participate to make dairy farming in peat soils areas more sustainable. The government is actively stimulating this project with agreements on nature conservation, soil, water and nature inclusive agriculture. This is done because in the Climate agreement there is agreed to reduce the emission of CO_2 and other greenhouse gasses in peat soil areas (Water land en dijken, 2021).

Such pilots are used for to design future CAP. There is a new CAP coming up in in 2023 and these pilots are used to gain experience for the next period of the CAP. The new CAP will be explained in the next section of this chapter.

The CAP is financed by two funds form the EU-budget: the European Agricultural Guarantee Fund and the European Agricultural funds for Rural development. The first pillar of the CAP is funded by the European Agricultural Guarantee Fund and the second pillar if financed by the European Agricultural funds for Rural development.
This European Agricultural funds for Rural development is part of the Structural- and Investment funds of the EU. These funds have the goal to support economic development (EC Europe, 2021).

The European Agricultural funds for Rural development has the goal to increase sustainability in the European agriculture. With the resources of this fund national governments can fund projects which increase the sustainability of agriculture and reducing the emission of greenhouse gasses. The Dutch elaboration of this fund is the Rural development program (‘Plattelandsontwikkelingprogramma’ in Dutch). This program stimulates projects which make agriculture more eco-friendly while maintaining agriculture’s competiveness. The funds for the Netherlands were €607.3 million for the period 2014-2020. This money is allocated to farmers and/or land-users if they participate in projects which increase sustainability and decrease the emission of greenhouse gasses (EC Europe, 2021).

On top of the European legislation the Dutch government also takes on national level measures to reduce the emission of greenhouse gasses and thereby to protect the Netherlands for the negative effects of climate change (Rijksoverheid, 2021).

The Dutch administration presented in 2019 the Dutch Climate agreement. The goal of the Netherlands is to reduce the emission of CO_2 equivalents with 49% in 2030 compared to 1990. In 2050 the goal is to have 95% less emission of CO_2 compared to 1990. This is all established in the Climate law (Rijksoverheid, 2021).
Base of this climate agreement is to reduce the emission of CO_2 step by step while keeping the goals of emission reduction affordable and reachable. The burden of reduction needs to be equally distributed between civilians and companies. In the Climate agreement the governments, business and NGOs have made agreements to reduce the emission of CO_2 the next 10 years. The sectors included in the Climate agreement are electricity, industry, mobility, housing and agriculture. Each sector has his own goals and measures to reduce the emission of CO_2 (Rijksoverheid, 2021).

The goal of the agricultural sector is to reduce 6 Mton CO_2 equivalents before 2030. This 6 Mton is subdivided into 3 pieces. First a reduction of 1 Mton reduction of methane from the stables. Second, 1.5 Mton reduction by a change and improvement of land-use. The other 3.5 Mton of reduction needs to be realised with technical measures like manure storage, feed and renewable energy. Technical measures are preferred above a reduction in the total amount of animals (Rijksoverheid, 2019).

To reach these goals the sector has chosen a business-oriented approach. The farmer can choose the measures to reduce emissions himself using the measures which fits the best at his specific farm. The government and other societal organisations support and stimulate the farmer to take this measure. The exact emission reduction is monitored by the carbon footprint monitor (Rijksoverheid, 2019).

Besides policy for greenhouse gas emissions there are strict regulations on emissions of for example ammonia, methane, nitrogen and fine dust. For example, the ‘Besluit emissiearme huisvesting’, regulates the protection of nature areas by means of maximum allowed emissions per dairy farm. The maximum allowed emission of ammonia per animal place in existing stables is 12.2 kg/year. If cows are also grazing the maximum amount of ammonia is 13 kg/year. For new stables the maximum allowed emission of ammonia per animal place per year is 11 kg.
For the whole agricultural sector the maximum allowed emission of phosphate is 173 million kg per year, the maximum for nitrogen 504.4 million kg (Infomil, 2020).

The Dutch national government is actively stimulating farmers to take measures to reduce greenhouse gas emissions, reduce the emission from animals and stables, increase the sustainability of agriculture and reduce the use of natural resources.
There is a subsidy for entrepreneurs and also farmers to invest in the biobased economy (Biobased Economy en MIA/Vamil). This can be an investment in for example replacing fossil fuel for biomass and lowering the use of natural resources. Specific for farmers is that they can apply for a subsidy to invest in manure separation to reduce the emission of ammonia and methane. Another option is an investment in a sustainable dairy barn to improve the

living conditions of the animals inside, reduce the emission of ammonia and an emission free storage of manure (Besluit emissiearme huisvesting).
In this way the government stimulates and helps farmers to invest in measures and techniques to reduce emissions (RVO, 2020).
To reduce the emission of CO_2 entrepreneurs, and therefore also farmers, can apply for the 'Versnelde Klimaatinvesteringen industrie'. If entrepreneurs want to take proven measures to reduce the emission of CO_2 but the investment costs are too high they can apply for this subsidy. This is for example an investment in systems and techniques which reduce emission and increase energy efficiency (RVO, 2021).

3.3 EU ETS

In the EU European Emission Trading System companies can sell or buy permits which allow them to emit for example CO_2. Agriculture is not included in the EU ETS, inclusion could be a way to reward farmers if they reduce their emissions. In this section the EU ETS is explained.

The EU ETS was set up in 2005 as the world's first international emissions trading system. It works with a cap-and-trade system. The EU sets the cap, the maximum of emission for a certain greenhouse gas. Then the permits which allow companies to emit auctioned. If companies need to more or less permits they can trade these permits on the market. In this way the reduction of greenhouse gas emission is done in a cost-effective way. This system works without governmental intervention and is in theory the cheapest way to reduce greenhouse gas emissions (Action, 2013).

The goal of the EU ETS is a climate-neutral EU in 2050 with an intermediate target of at least 55% reduction by 2030 (Action, 2013; EC, 2021).
The system of the EU ETS focuses on a few emissions which can be measured with a high level of accuracy, this are CO_2, N_2O and PFCs.
Sectors included in the EU ETS are for example: power and heat generation, energy-intensive industry sectors like iron, metal, steel and aluminium and commercial aviation. Participation is mandatory (Action, 2013; EC, 2021).

The EU ETS in currently in Phase 4 (2021-2030): the current phase of the EU ETS focuses on the strengthening of the EU ETS but reinforcing the Market Stability Reserve, this is an mechanism to reduce the surplus of permits and thereby improve the EU ETS resilience to market shocks. Free allocating permits is still possible, this to ensure for international competitiveness (EC, 2021).

The EU ETS focuses on emissions which can be measured accurate, with agriculture this is problematic since the emissions occur from non-point sources. To be included in the EU ETS this measurement problem needs to be solved to be able to see exactly how high the emission and the possible reduction is. Another problem is the allocation of allowances to the agricultural sector, these allowances come from other industries who will not be a big favour of this idea (Brandt and Svendsen, 2011).
However, inclusion in the EU ETS has huge financial opportunities for the agricultural sector. Investments in techniques to reduce for example the emission of CO_2 are costly and have an effect on the productivity and thereby the revenue. With the EU ETS permits farmers can sell their permits which they no longer need after they invested in emission reducing

technology. In this way a reward is given to the farmers and thereby a compensation for the lost revenue. Inclusion could also be an incentive for farmers to reduce emission because they can now benefit if they reduce emissions (Brandt and Svendsen, 2011).

Inclusion of the agricultural sector is not likely to happen soon due to the measurement problems. Another problem is that the agricultural sector also emits a lot of other emissions like methane and ammonia which are not included in the EU ETS.

In Chapter 5 scenarios are discussed in which we assume the inclusion of the agricultural sector in the EU ETS.

3.4 Future legislation

In this section the future possible policy to reduce greenhouse gas emission is discussed. How can farmers be stimulated to reduce emissions and at the same time keep a profitable business.

Green Deal

The Green Deal is a new program of the European Commission that is implemented in 2019 to battle climate change and be the first climate neutral continent in 2050. It is an Action Plan to use natural resources more sustainable and thereby to switch to a circular economy and to restore biodiversity and reduce pollution. The Dutch vice-president of the European Commission Frans Timmermans is responsible for the Green Deal (Europese Commissie, 2019).

To become climate neutral the Green Deal proposes measures to reduce the emission of greenhouse gasses in sectors like transport, energy, agriculture and infrastructure. These measures require an estimated investment of €1 trillion. This money needs to come from governments and private investors. About €500 billion comes from the different funds from the EU (Cohesion fund and European fund for Regional Development). Member states finance €100 billion, €100 billion comes from the new “Transition fund” and due to the Emission Trading System of the European Union expect to raise another €300 billion (Schutrups, 2020 & Europa-Nu, 2021).

As part of the Green Deal the EU has presented in May 2020 a strategy which contributes to a sustainable future for Europa:

<u>Biodiversity strategy</u>: this strategy needs to battle the loss of biodiversity in Europe. With this strategy damaged ecosystems are restored, protected areas better protected, less pollution stimulated and agriculture made more sustainable. To accomplish this the European Commission has the goal to assign in 2030 30% off the land and the sea as a nature area (Europa-Nu, 2021).

To achieve the goals of the Green Deal the European Commission comes in June 2021 with proposals for a revision of European legislation. To reach a climate neutral Europe in 2050 the European Commission wants to implement:

- A directive for the new EU ETS;
- Regulations for land-use, land-use change and forestry;
- Directive renewable energy and energy efficiency;
- CO_2 norms for cars (Europa-Nu, 2021).

Future CAP

The CAP is currently in a transition phase between the old and new CAP. In these two years (2021-2022) the old CAP (2014-2020) is still in place. As mentioned in the previous section the new CAP for 2023-2027 is not exactly clear yet, but the broad outlines of policy and regulations are clear:

- All the member states need to make a National Strategic Plan. In this plan the members states need to describe how they are going to implement the European legislation and which measures they are going to take to reduce greenhouse gas emissions from agriculture.
- The new CAP will have higher ambitions with respect to nature, climate and the environment. Farmers who are reducing greenhouse gas emissions need to get higher rewards, in this way farmers need to be stimulated to take these costly measures to reduce greenhouse gas emission (Toekomst GLB, 2021).

The Netherlands

The changes in the CAP and the new EU Green Deal the legislation with regard to emission will also affect the Netherlands. This will mean stricter regulation with respect to emissions and strict policies to support nature and biodiversity.

In the Climate plan ('Klimaatplan') the Dutch government outlines the main points of the Dutch climate policy for the coming 10 years. The Climate plan is the elaboration of the Climate agreement.
To reduce the emission of CO_2 and other greenhouse gasses (calculated in CO_2 equivalents) in agriculture the national government has assigned main areas where reduction needs to be realised:

- Reduction of emissions in the dairy sector. Manure causes the emission of methane, ammonia and N_2O. In the climate agreement the sector has made agreements to reduce these emissions by optimizing feed and by improving the handling and storage of manure. For example mono manure fermentation to reduce the emission of greenhouse gasses. Farmers also need to take measure in the stables, for example low emission stable systems to reduce the emission of ammonia. The government facilities the reduction of these emissions by means of subsidies for investment in emission reducing techniques There is also an arrangement for pig farmers who want to stop farming, hereby the number of pigs and emission will reduce (Warme sanering varkenshouderij).
- CO_2 reduction by smart land-use Due to oxidation of the peat soil there is emission of CO_2. Several finished and ongoing pilots and studies have shown how these emissions can be reduced. In the climate agreement the agricultural sector has made

agreements about sustainable land-use and the expansion and restoration of natural areas.

- Food waste and consumption. Food waste and consumption contribute indirectly to the emission of CO_2. To reduce emission the agricultural and food sector have made agreements to top food waste (Rijksoverheid, 2020b).

Climate policy effects many policy domains, this means that to make successful policy all these domains need to work together. The execution of policy is not only a task for national government there is also a task for regional governments, for example provinces being responsible for spatial planning (Rijksoverheid, 2020b).

Stricter regulations from the EU means more effort of the Netherlands to reach the emission reduction goals. To reach these goals an effort is needed from all the sectors. In some sectors is emission reduction easier than others. For example emission reduction in transport seems easier than in housing (Hekkenberg et al., 2020).

A possibility for the Netherlands is to look at agriculture and land-use as one sector. In this way the fixed CO_2 in the soil, for example peat soils, could be a compensation of the other greenhouse gas emission in the agricultural sectors. The situation in the Netherlands differs from the European average because of high emissions from agriculture and also net emission from land-use. How European legislation will deal with this and how the Netherlands makes his own policy inside the European framework can be decisive for the emission reduction in the agricultural and land-use sector (Hekkenberg et al., 2020).

Furthermore measures which reduce emission need to be cost-effective and suitable for individual farmers. To accomplish this the government needs to actively stimulate farmers to take measures, for example with subsidies. Only in this way are farmers willing to take these costly measures and will they reduce emissions.

Chapter 4: Price formation in the agricultural land market

The purpose of this chapter is to discuss price formation of agricultural land in the Netherlands. Section 4.1 provides some background information. The functioning of the agricultural land market will be discussed in section 4.2 and 4.3. In section 4.4 the value of agricultural land will be discussed. Section 4.5 discusses which effects land measures such as drainage have on the land price.

4.1 Background

Agriculture uses 54% of all the available land in the Netherlands (CBS, 2016). Therefore, agriculture is the most important submarket. Besides, agriculture supplies land to the other submarkets (Segeren et al., 2005). This supply goes via a change in the land-use assigned by the zoning policies. Not only supply and demand determine the price of land, a number of other factors like the quality of land and the future land-use function of land determine the land price.

4.2 Supply and demand

In this section supply and demand on the agricultural land market will be discussed. On a market supply and demand reach each other to determine the price and quantity of the good, in this case land. But how works this on the agricultural land market? To be able to explain the demand function the shadow price of land will be first discussed.

In economics we presume that producers want to maximize their profits. To determine if they can make more profit they look at the shadow price of a fixed production factor. In this case land. The amount of land for a firm is fixed in the short term. The shadow price of land shows the extra profit which can be made if the farmer buys one extra piece of land. The shadow price also shows the maximum amount the farmer is willing to pay.

The shadow price depends on variables which determine profit, for example: input and output prices, quantity of fixed inputs.

Equation (1) shows the profit formula. This is the summation of the value of all the revenues (price x quantity) minus the summation of the costs or value of the variable inputs (price x quantity).

$$(1)\ \pi = \max_{x,y}\{\sum py - \sum wx; T(y, x, La, C, L)\}$$

In case of only one output Y technology is represented by a production function:

$$(2)\ Y = f\ (x, La, C, T, L)$$

Where: π is profit, p is a vector of the prices of the outputs y, y is a vector of the outputs, w is vector of prices for the variable inputs x, x are the variable inputs, La is labour, C is capital, T is technology, L is land.

With Hotelling's lemma (Drabik & Peerlings, 2019) we can get from the profit function to the shadow price of land:

$$(3)\ P_L = \frac{\delta\pi}{\delta L} = P_L(p, w, La, C, T, L)$$

Where: P_L: shadow price of land

Land is not a homogeneous production factor; the quality of land differs between regions. Different land qualities lead to different shadow prices. The higher the quality of land the higher the shadow price, if the quality of the land is very poor the shadow price is low.
If land has a shadow price of zero than using one unit more land would not lead to more profit, in this case a farmer will not use more land even if the price is zero (Peerlings, 2017).

Figure 4.1: Change in the shadow price of land.

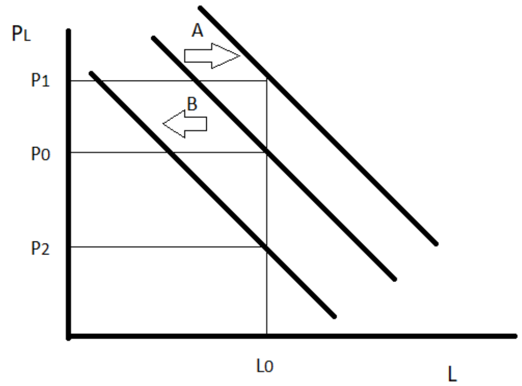


Figure 4.1 shows the shift in the shadow price function if one of the explanatory variables in the shadow price equation changes (p, w, La, C, T, L), the shadow price function can shift to the left or the right.
If the shadow price function moves to the right (A) the shadow price of land increases (P0 to P1 keeping the amount of land fixed at Lo). This increase can be caused by a number of reasons:

- Increase in the output price (p). An output can for example be grain. If the price of grain increases a farmer wants to produce more grain, therefore he needs more land which leads to an increase in the shadow price of land.
- Increase in the price of a variable input which is a substitute for land. If for example the price of fertilizer increases farmers will buy less fertilizer, this leads to lower production. To compensate for the lower production farmers buy more land to maintain the level of production which increases the shadow price of land.
- Decrease in the price of a variable input which is a complement of land. Seed is a complement of land. If the price of seed decreases it is attractive to seed more land which leads to an increase in the shadow price of land.

If the shadow price function moves to the left (B) the shadow price of land decreases (P0 to P2). This decrease can be caused by a number of reasons:

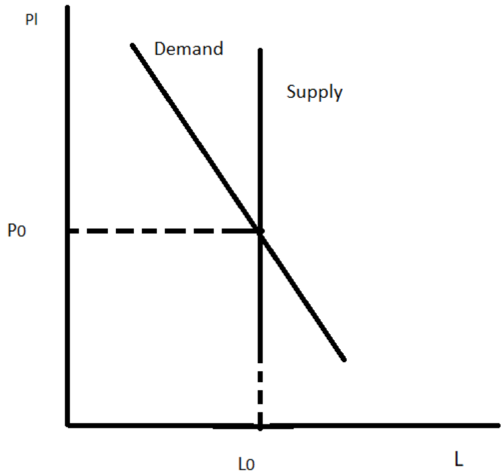
- Decrease in the output price (p). If we take the same output: grain. If the price of grain decreases it is less attractive to produce grain, this means that less is land needed which leads to an decrease in the shadow price of land.

- Decrease in the price of a variable input which is a substitute for land. If for example the price of fertilizer decreases than farmers buy more fertilizer, this will lead to higher production which means that less land is needed. This decreases the shadow price of land.
- Increase in the price of a variable input which is a complement of land. Seed is a complement of land. If the price of seed increases it is less attractive to seed more land which leads to an decrease in the shadow price of land.
- If due to new techniques crops grow better less land is needed. This will lead to a decrease in the shadow price of land.

If we sum up the shadow functions of land of all farmers we get the aggregate shadow price function. In the long-term land is no longer fixed which means that a shadow price equation of land becomes the individual demand function. This means that the aggregate shadow price function becomes the aggregate demand function of land.

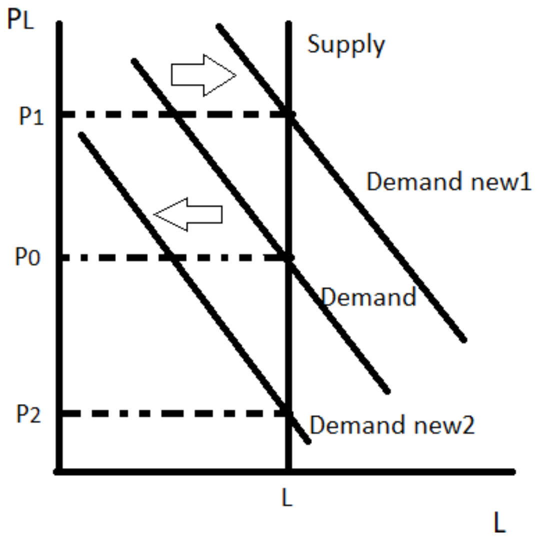
The supply of land in the Netherlands is price inelastic, this means that supply does not respond easily to changes in the price. This is a result of the fact that without land farmers cannot produce or when they produce with less land profits go down. However, it is possible that individual farmers supply land after exit because of e.g. retirement, divorce or death. This means that the supply of land is rather fixed and the price elasticity of supply close to 0. For the long run this means that land supply is almost completely inelastic which means that the total amount of land is constant (Peerlings, 2017).
The downward sloping demand function and the aggregate supply can be seen in Figure 4.2.

Figure 4.2: Supply and demand on the agricultural land market.



Because the demand function is directly related to the shadow price, a change in the shadow price is directly reflected in the demand function of land.
This can be seen in Figure 4.3.

Figure 4.3: Change in demand with constant supply.



Due to the fact that supply on the land market is almost perfect inelastic, a change in the demand function has only influence on the land price. There is no effect in the amount of land supplied.

There are however scenarios in which the supply of land also changes, for example if due to spatial planning agricultural land gets a new function. This will be further discussed in section 4.3.

4.3 Other factors

Institutions and regulations play and important role in the agricultural land market. Especially the government plays an important role in the agricultural land market by means of spatial planning. There are also other factors which influence the land market, these factors make that the land market does not work exactly as theory predicts. These other factors will also be discussed in this section.

Spatial planning

One of the institutional environments is spatial planning. The government determines the land-use which effects the shadow price of land. Zoning is used to e.g. protect the agricultural use of land. Other uses of land have a higher shadow price of land, for example housing. If there would be no spatial planning the land would always go to the function with the highest shadow price. The spatial planning prevents this, and therefore, preserves the landscape.

If due to spatial planning the function of agricultural land changes there will be also a shift in the demand and supply functions, and therefore, price of agricultural land.

Figure 4.4: Effect on the agricultural land market if the function of land changes.

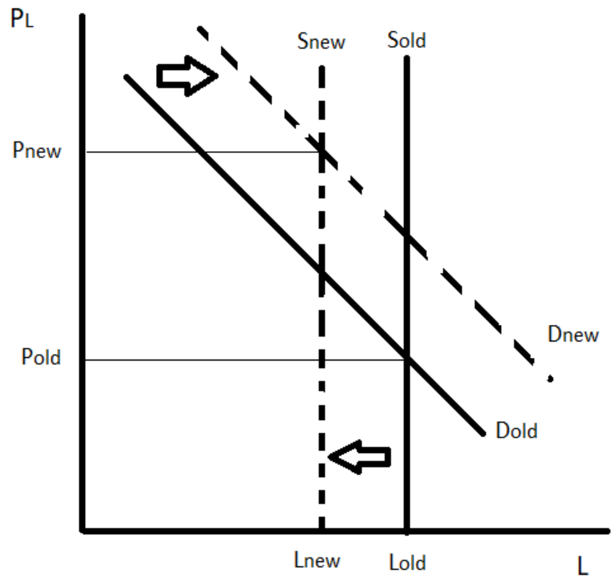


Figure 4.4 shows that due to a change in the function of land the demand and supply function change. If agricultural land gets a new function this means that the total amount of agricultural land decreases, this means that the supply function of land shifts to the left. The demand function moves also, but the demand function moves to the right. If a farmer sells or is forced to sell his land to the government because new houses will be build he gets a much higher price than when he sells his land to another farmer. The land price for housing is higher than the land price for agriculture. Farmers who have to sell their land to the government and want to continue farming they go back on the land market to buy agricultural land. Due to the sell-out they have more financial means than other farmers which means they can pay a much higher price. This leads to a shift of the demand function to the right.

Farmers do not always act as profit maximisers

As discussed in section 4.2 we assume that farmers want to maximize profits. This is not always the case, for example if farmers have imperfect information about the land they want to buy or sell.

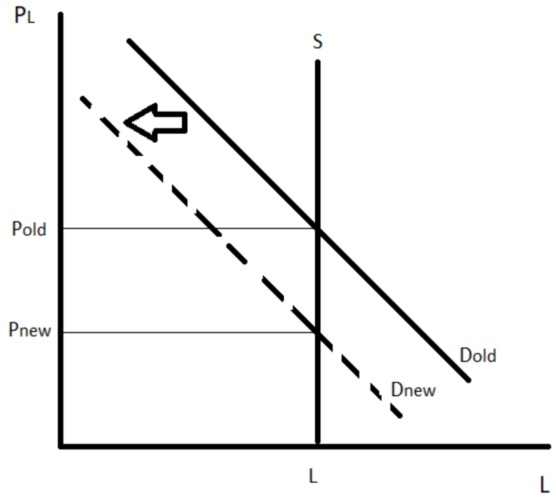
Another reason is that neighbours land is only once for sale. As said before land is scarce and farmers will only buy land that is close to their farm due to high transport cost. This means that when neighbour's land is for sale this is a once in a lifetime opportunity to buy land. Even if this is financially and economic not optimal farmers sometimes choose to buy because it is a chance they cannot let pass.

Bird management

In the peat soils area there are a lot of meadow birds. However, the populations of these meadow birds are decreasing due to intensive agriculture. Bird protection organisations try to protect the birds with the help of farmers. If we assume that farmers maximize profit they will never participate in projects which protect the environment because these projects cost money. However, if farmers choose to participate in such projects, because they also find the landscape and the environment important, it will reduce the shadow price of their land.

Bird management is for example that farmers mow later, not in May but in June. Another measure can be a higher water level in the ditches. These two measures reduce the productivity of land, because less grass will grow due to the high-water level and farmers can mow less due to an extended date on which the grass is allowed to be mowed. The shadow price of land will reduce due to these measures. A lower shadow price leads to a shift of the demand function as can be seen in Figure 4.5. This shift of the demand function with no shift in the supply function leads to a lower land price.

Figure 4.5: Effect bird management on demand function.



4.4 Agricultural value of land

The value of land is determined by the function of the land and the possible change in function. If a farmer wants to expand his farm he needs to invest, i.e. buy more land. How much a farmer is willing to pay depends on the Net Present Value. With the NPV the farmer can calculate if an investment if profitable over time.

When we calculate the shadow price of land we do not consider time. This means that when calculating the shadow price of land we can consider the shadow price of land as the maximum amount of money a farmer is willing to pay if he uses the unit of land one period. There is always an alternative for buying land, these incomes are lost if a farmer invests in land. There is also a time preference for money, we rather have money now than over 10 years. This is the same with saving, we want to be compensated for the fact that we give up consumption now, meaning that money loses value over time.

This means that the discount rate is determined by two factors:

1. The return r a farmer would get is he invests in something else, for example if he puts the money on the bank. In this case he would receive interest.
2. Time preference: People prefer money now over receiving money in 10 years. How much is determined by the time preference rate r, r can be interpreted as the relevant discount rate. If the capital market works perfectly, the time preference rate r is the same as the interest rate someone gets if he puts the money on the bank.

The individual discount rate is difficult to determine because of differences in time preference. That is why in practice the real interest rate is used for the discount rate. The real interest rate is the nominal interest corrected for inflation.

To determine the maximum price a farmer is willing to pay for land we have to determine the present value of the future shadow prices. This present value is the same as the present value of a stream of future incomes.
It is only attractive to buy an extra piece of land if the NPV is positive.

$$(4)\ NPV = -I_{t=0} + \sum_{t=1}^{T} \frac{P_L^t}{(1+r)^t}$$

- NPV: Net Present value
- I: investment, the cost of buying the extra piece of land. t=0 because it happens at a certain point and does not depend on time.
- P_L^t: shadow price of land in a certain year t. This starts from t=1 because from that year on you get income of the land (output of grain).
- r: discount rate (interest).

As can be seen in Equation 4 the NPV consists of an initial investment (I) plus the summation of all the shadow prices of land over a period of time. In this case we are talking about the future shadow prices of land, as these are unknown we talk about the expected future shadow prices of land (EP_L^t)
The longer the time the land can be used (i.e. T) the higher the NPV will be. In case land is used well (i.e. no depreciation) it keeps its value and therefore $T \rightarrow \infty$.

The NPV of land is not equal to the land price, it shows only the maximum amount of money a farmer would be willing to pay for that piece of land.

The NPV is an useful tool to analyse factors that influence the value of land. All the factors which influence the shadow price of land have influence on the value of land plus it includes time preference. However, the NPV can also be used to see if an investment in for example land quality or to reduce the emission of CO_2 is profitable or not. This will be explained in section 4.5.

4.5 Measures on the land which effect land price

Investments to improve the quality of the land or restrictions on the use of land have impact the shadow price of land. To calculate the economic effect of these investments and restrictions on the value of land the NPV formula can be used again. A lower NPV implies a lower land value.

$$(1)\ NPV = -I_{t=0} + \sum_{t=1}^{T} \frac{P_L^t}{(1+r)^t}$$

With the NPV it is also possible to calculate if an investment is profitable or not. Not the investment of the purchase of new land but for example an investment to improve the quality of land or an investment to reduce the emission of CO_2 from peat soils.

Measures which reduce emissions have impact on the quality of the land. These measures will lead to a decrease in the quality of the land. This means that an investment in such a measure will never result in a positive NPV. The farmer has investment costs (I) and due to a lower quality the shadow price of land will also decrease (P_L^t).

This means that to persuade farmers to make such an investment the government needs to step in and financial reward farmers who want to make investments to reduce CO_2 emission.

Several measures can be taken to reduce the emission of CO_2 from peat soils:

Underwater drainage
With underwater drainage tubes in the land deeper than the ditch level are installed. In the summer the evaporation of ground water is bigger than the infiltration from the ditches. This means that the ground water level can drop below the ditch level. Oxygen can penetrate the peat soil which leads to oxidation. The underwater drains make sure that the ground water level cannot drop this much. Higher ground water level results in lower oxidation. In times with much rain these drainages remove the water from the soil to the ditches, like normal drainage (Kwakernaak et al., 2010).

High water level in ditches
High water level in the ditches ensures that the peat stays wet and by that, the settlement of the peat soil is prevented. When the settlement of the peat soil is prevented the emission of CO_2 is also prevented because there is no oxidation (Kwakernaak et al., 2010).
Increasing the water level has also negative effects on the land. If the land is more wet it is less accessible for machines and the crops will grow less due to too much water. This means that the measure to increase the water level reduces the shadow price of land.

Land-use change
To reduce the CO_2 emissions from peat soils it is also a solution to change the function of the agricultural land. Towards another agricultural function and towards a non-agricultural function. As a possible other agricultural function of the peat soil is wet farming, producing crops and plants which are suited for high water levels. Possible plants are for example thatch and orchids. A non-agricultural function of the peat soil is nature with extensive agriculture in combination with tourism (Van den Born et al., 2016).

The 3 measures to reduce CO_2 emissions in peat soils will be further discussed in Chapter 5.

Chapter 5: Effect of measures to reduce CO_2 emissions on the land price

The aim of this chapter is to discuss the effect on the land price of measures which reduce CO_2 emissions in the Veenweidegebied. Section 5.1 provides some background information. In section 5.2 the measures are explained in terms of cost-effectiveness and applicability. Section 5.3 shows the agricultural land price in the Netherlands. In section 5.4 the effect of the measures explained in section 5.2 on the land price is discussed.

5.1 Background

The "Veenweide gebied" is a Dutch landscape type of grassland on low lying peat soil. This type of landscape can be found in the lower parts of Holland, Utrecht, Friesland and Overijssel. In these areas the land is lowering due to settlement and the oxidation of the peat. This gives emission of CO_2. This CO_2 emission is 2.5% of the total CO_2 emission in the Netherlands. To stop these emissions of CO_2 and lowering of the soil an increase in the water level is needed (Hendriks, 2020). This impacts the quality of the soil and thereby effects the value of the land.

5.2 Measures to reduce emissions from peat soils

In this section the measures which reduce emissions are discussed. Information about the costs, effectiveness and applicability are provided. The three measures explained are: underwater drainage, high water level in ditches and land-use change.

Underwater drainage

In the summer the evaporation of ground water is bigger than the infiltration from the ditches. This means that the ground water level can drop below the ditch level. Oxygen can penetrate the peat soil which leads to oxidation. A measure to deal with the settlement of the soil and the oxidation of the peat is underwater drainage. With underwater drainage tubes in the land deeper than the ditch level are installed. The underwater drains make sure that the ground water level cannot drop this much. Higher ground water level results in lower oxidation. In times with much rain the drainage removes the water from the soil to the ditches, like normal drainage (Kwakernaak et al., 2010).

According to Stowa (2020) the average the investment costs of underwater drainage are somewhere between €1,700 and €2,500 per ha. These are the construction costs. Underwater drainage has according to Stowa an expected lifespan of 30 years. According to Van den Akker et al. (2013) the investment costs for underwater drainage are €1,800 per ha with a life span of 20 years. The annual costs including maintenance costs are €117 per ha over 20 years.
A possible benefit for farmers having underwater drainage is more grass revenue per ha. In wet periods the underwater drains make sure the land is dry which benefits the growth of crops like grass. In the most positive scenario the growth of more grass will lead to a benefit of €171 per ha per year. This implies that an investment in underwater drainage has a positive balance of approximately €54 per ha per year (Van den Akker et al., 2013).

Van den Akker et al. (2013) state that this benefit of extra grass is unrealistic and can only be met in optimal conditions, it is therefore more realistic that this extra grass revenue for farmers is approximately €85 per ha per year. This implies that an investment in underwater drainage gives a negative balance of somewhere around €30 per ha per year (van den Akker et al., 2013). Subsidies by the government help to make the investment of underwater drainage profitable.

In the two areas where Van den Akker et al. (2013) did their research the annual CO_2 emission reduced with respectively 6.8-13.5 ton per ha in the Krimpenerwaard and 11.3-18.1 ton per ha respectively at the Demmerikskade (Van den Akker et al., 2013). This is a 50% reduction of the emission of CO_2. According to Stowa (2020) underwater drainage reduces the CO_2 emission by 9-11 ton per year per ha.
The effectiveness of underwater drainage is still under debate, there are also researches where no reduction of emission is not found (IMCG, 2018). Despite this the Dutch government and research institutes like the WUR believe underwater drainage is helpful to stop the settlement of the soil and the reduction of CO_2 emission (H2Owaternetwerk, 2018).

Water level fixation
A high-water level means that the water level in the ditches is fixed for the whole year. After the water level fixation the ground level will lower for some time which means that the grassland will become more and more wet. After some time the land settlement stops.
High water level in the ditches ensures that the peat stays wet and by that, the settlement of the peat soil is prevented. When the settlement of the peat soil is prevented the emission of CO_2 is also prevented because there is no oxidation (Kwakernaak et al., 2010).
The effect of high-water level on the settlement on the soil increases in time which means that the reduction of CO_2 emission from peat soils will increase even further according to Van den Born et al. (2016). The increase of the water level reduces the emission of CO_2 by 17.6 ton per ha per year if the peat soils has still an agricultural function (GDNK, 2018).

In theory water level fixation is a technical measure which is applicable everywhere, it does not require a lot of changes in the current water management (Van den Born et al., 2016).

Increasing the water level to a fixed level has also negative effects on the quality of the land. The land becomes more and more wet which means that the land is less accessible for machines and the crop productivity decreases. The land becomes less suitable for intensive agriculture which means that farmers needs to switch to a more extensive form of agriculture (Van den Born et al., 2016). Lower crop productivity and farming more extensively reduces the income for the farmer. The lower crop productivity ensures higher costs for the farmer, the farmer needs to make more costs because he has to buy feed which he cannot produce on his own land anymore. The average loss of income for the farmer due to water level fixation and the thereby loss in grass yield is €168 per ha.

To compensate for these costs a farmer can choose to sell his products in a higher market segment, a niche market, for example organic (Van den Born et al., 2016). Another measure to compensate for the loss of income is subsidies. With subsidies the government can stimulate farmers to raise their water level.

Land-use change
The previous two measures have impact on the way of farming but are meant to keep the land-use the same. There are also measures in which the land-use changes, this can be change of the function of land within the agricultural sector or a change towards a non-agricultural land function.

Agricultural function
A land-use change inside the agricultural sector is wet farming (i.e. paludiculture). Wet farming provides interesting possibilities on low lying peat soils which will be unfit for dairy farming in the future (Mettrop et al., 2020). The water level is adjusted to the conditions in which the cultivated plants can grow. These wet conditions of agriculture stop the settlement of the soil and thereby the emission of CO_2. There are several crops which are suited for paludiculture, for example: thatch, cattail and cranberries and orchids (Van den Born et al., 2016).

This land-use change from grassland to wet farming reduces the emission of CO_2 by 20 ton per ha per year. This depends on the original water level, the new water level and the soil type (Westerhof, 2018). According to Mettrop & Oosterveld (2019) the average reduction of CO_2 emission with paludiculture is 17 ton per ha per year. GDNK (2018) state: the reduction of CO_2 emission due to wet farming is approximately 28.1 ton per ha per year.

The products which can be produced in these wet conditions are special and are not commonly cultivated in the Netherlands. The markets for these products are food, feed, flower, energy and construction. The choice to cultivate which crop where is based on the location and the purpose of the crop. Wet farming can primarily be used for the storage of biomass, but for example cattail can be used as isolation material (Mettrop & Oosterveld, 2019). The markets for these products are very thin, that is why there needs to be cooperation between farmers and other local entrepreneurs. With this cooperation there is support for regional development which can make these markets successful (Mettrop et al., 2020). Because wet farming is still in an early stage this means that there is not much to say about market potential and economic benefits for the farmer (Van den Born et al., 2016).

Non-agricultural function
A non-agricultural function of land means a land-use change from agriculture towards nature. This means that the function of the peat soil in the Veenweidegebied is no longer primarily agriculture but nature.
In peat soil areas where the parcels are small and with a lot of seepage the circumstances to adapt measures like underwater drainage and water level fixation are very difficult. High costs for the farmer because of low grass yield and high costs in the water management make farming difficult. In some cases it can therefore be profitable to make a transition towards nature (Van den Born et al., 2016).

Nature areas in cultural landscapes like Veenweidegebieden can become very popular for tourists, in this way these areas maintain their economic value. The agricultural function of these lands will not completely disappear because these lands are very well suited for extensive agriculture like grazing of cattle. With the switch from agriculture to nature the peat soils can help to increase the biodiversity and limit climate change (Van den Born et al., 2016).

If 10% of all the peat soils make a transition towards a non-agricultural function like nature the emission of CO_2 reduces with 0.4 million tons per year in 2050 (Van den Born et al., 2016). The CO_2 emission reduction with nature peat soils is 33.1 ton per ha per year. With nature the CO_2 can be captured in peat, swamps or vegetation, also the emission which happens during mowing is prevented because it is now an nature area. This is why the reduction of CO_2 is quite high (GDNK, 2018).

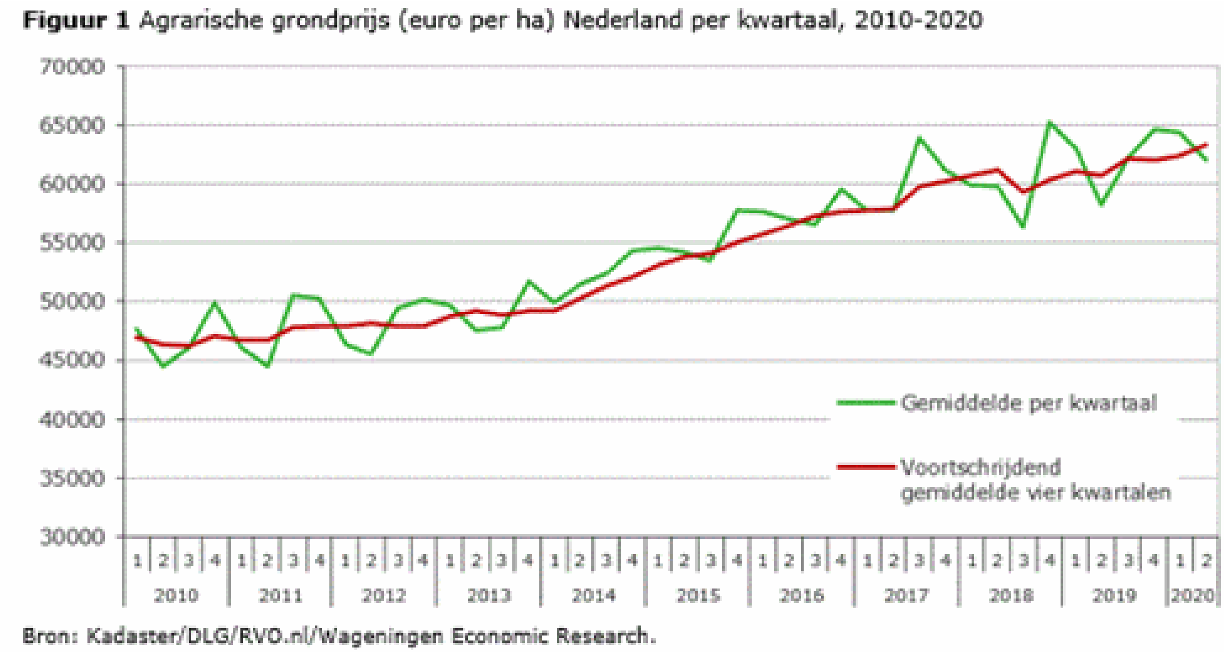
To prevent the emission of CO_2 in these nature areas a high-water level is needed to stop the settlement of the soil and thereby reducing the emission of CO_2. In this way these wet areas become a mix of wetlands, reed beds and dry lands. These conditions are very suitable for meadow birds. Because these lands are now nature areas the influence of the intensive agriculture is gone which means the meadow birds are protected from agricultural machines (Verhoeven et al., 2010).

5.3 Agricultural land price

To be able to determine the effect of measures to reduce emissions on the land price I first need to know the land price. This section presents the current land prices in different regions in the Netherlands but also discusses the development of the land price in recent years.

Figure 5.1 shows the development of the agricultural land price in the Netherlands from 2010 to 2020. The average agricultural land price has increased in this period from €47,000 per ha to €64,000 per ha in the second quarter of 2020.

Figure 5.1: Development of the agricultural land price in the Netherlands, 2010-2020.



Source: ASR Real estate, 2020.

There are a number of reasons for this increase of €17,000 per ha in the last 10 years:

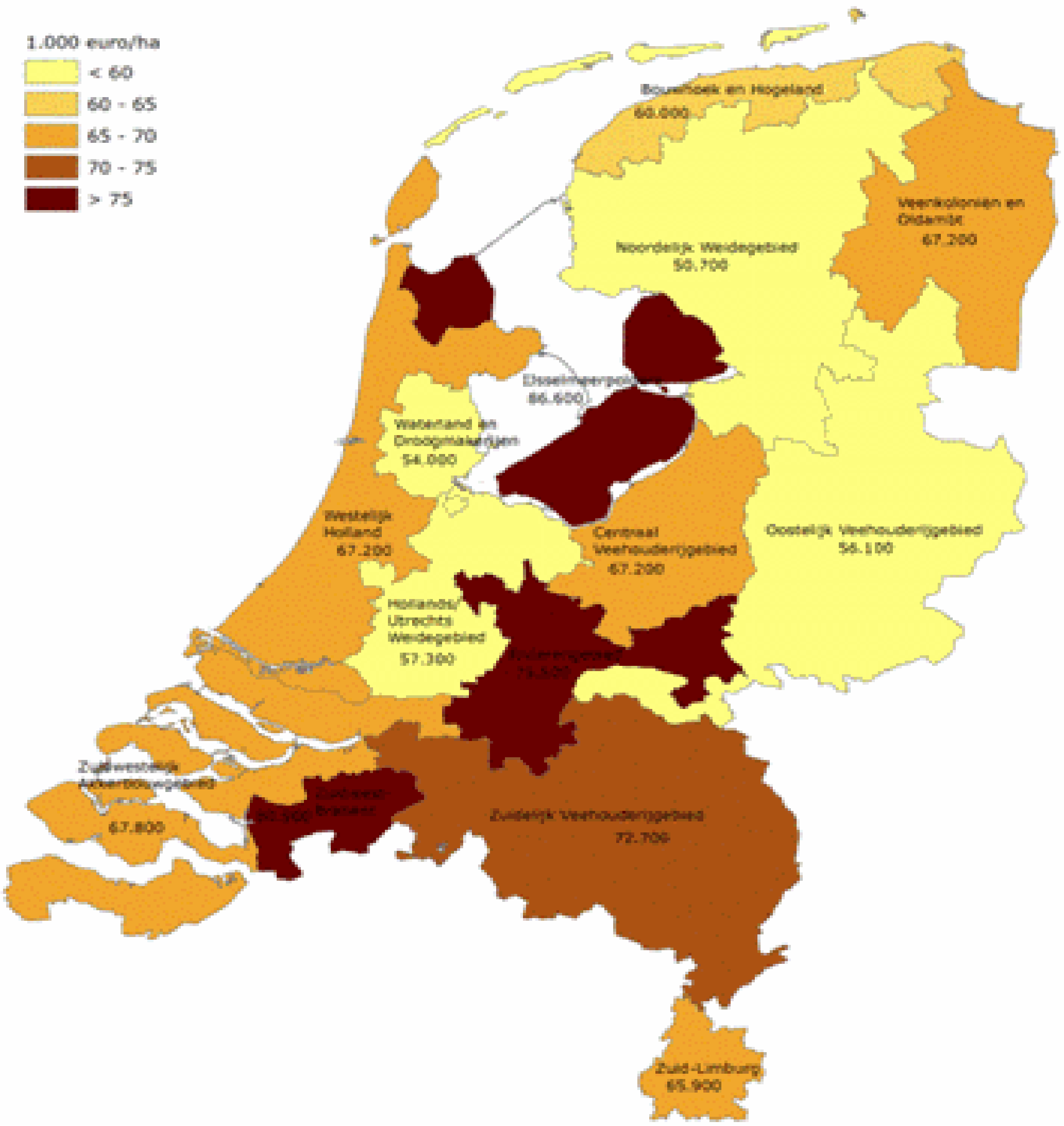
- First, as shown in Chapter 2 the amount of agricultural land in the Netherlands is decreasing. Agricultural lands get a new function, like housing, industry, infrastructure and nature. A change in the function of land, e.g. from agriculture to housing leads to a higher land price as agricultural land becomes scarcer. Moreover, demand increases when selling farms enter the land market. This also pushes prices up. If the supply of houses wants to meet its demand many extra houses need to be build. A growing population also asks for more infrastructure and recreation areas.
- Second, if the Netherlands wants to reach their energy goals more solar panels are needed. This includes solar panels on agricultural land. This is already happening and will increase in the future. For farmers, solar panels are attractive given the payments they get which vary between €3,500 and €6,000 per ha per year Doorn (2018). This development is mostly happening in the North of the Netherlands because in this region the land prices are lower than in the rest of the Netherlands which makes it more attractive to land developers and farmers (Doorn, 2018).
- The third reason which leads to a higher land price is the construction of more nature. In the climate agreement of 2016 it is agreed that the Netherlands gets more nature. This means that there is less land available for agriculture and less supply of agricultural land leads to an increase in the agricultural land price (Doorn, 2018).

Agricultural land prices in the Netherlands are not everywhere the same (see Figure 5.2). Land prices differ from €50,700 per ha in the “Noordelijk Weidegebied” to €86,600 per ha in the IJsselmeerpolders. The difference in these prices is caused by the quality of the land, differences in crops grown and the pressure on the land market from non-agricultural functions.

The peat soils in the Netherlands are located in Friesland, Noord-Holland and Utrecht. In Figure 5.2 these regions are called the Noordelijk Weidegebied and Holland/Utrecht’s Weidegebied. Agricultural land prices are €50,700 per ha for the Noordelijk Weidegebied and €57,300 per ha in the Holland/Utrecht’s Weidegebied (ASR Real estate, 2020). This means that there is a difference of almost €7,000 per ha between these regions, regions which have the same soil type, peat soil. The difference can be explained by the pressure on the land market from non-agricultural functions, like housing. The need to build new houses is higher in Utrecht and Noord-Holland than in the North of the Netherlands which leads to a higher land price in this region.

Figure 5.2: Regional agricultural land prices in the Netherlands.

Kaart 1 Agrarische grondprijs (euro per ha) naar 14 groepen landbouwgebieden, tweede kwartaal 2020 *



Source: ASR Real estate, 2020.

5.4 Effect of the measures on the land price

In this section the effect of the measures discussed in 5.2 on the land price are explained. This is done with the help of the NPV formula, which is already provided in 4.4.

$$NPV \ = -I_{t=0} + \sum_{t=1}^{T} \frac{P_L^t}{(1+r)^t}$$

Where:

- NPV: Net Present value
- I: investment, the cost of installing the measure. t=0 because it happens at a certain point and does not depend on time.
- P_L^t: shadow price of land in a certain year t. This starts from t=1 because from that year on you get income of the land (grass).
- r: discount rate.
- T: total time period.

All the calculations in this section are made per ha. Calculations of the NPV can be seen in Annex II.

With respect to the effect of the investment on the land price, the NPV is subtracted from or added to the agricultural land price.

The measures explained in this chapter reduce the emission of CO_2 from peat soils. Farmers are not rewarded for this reduction because agriculture is not included in the Environmental Trading System (ETS) of the EU. Here, permits which allow companies to emit CO_2 are traded. If agriculture would be included farmers can sell CO_2 permits when they invest in a measure which reduces the emission of CO_2. The price of a CO_2 permit is currently €30 per ton (Ember-Climate, 2021). In scenarios 3, 4, 6, 8 and 10 we assume that agriculture is included in the EU ETS.

Underwater drainage

In scenario 1 the P_L is different compared to scenario 2. This is caused by the difference in the value of extra grass yield, the extra grass yield is debatable and therefore Van den Akker et al. (2013) give two different scenarios of extra grass yield. A lower more realistic one (scenario 1: realistic) and a higher more positive one (scenario 2: positive).

<u>Scenario 1: realistic scenario</u>

The investment costs for underwater drainage are €1800, with a life span of 20 years. According to Van den Akker et al. (2013) the extra grass yield has a value of €85 and the yearly maintenance costs are €117. This gives a P_L of -32. The discount rate is set equal to 3%. This is the average interest rate for a loan. This gives and NPV of -€2.276.

The negative NPV for this investment in the quality of land decreases the land price with €2.276. In the Noordelijk Weidegebied the agricultural land price is €50.700 per ha. With this investment the land price becomes 50.700-2.276 = €48.424 per ha. The agricultural land price is €57.300 per ha in the Holland/Utrecht's Weidegebied. With this investment in underwater drainage the agricultural land price becomes 57.300-2.276 = €55.024 per ha.

Scenario 2: positive scenario
The investment costs for underwater drainage are €1800, with a life span of 20 years. According to Van den Akker et al. (2013) the extra grass yield has a value of €171 and the yearly maintenance costs are €117. This gives a P_L of 54. The discount rate is set equal to 3%. This gives an NPV of -€996.

Even with a positive P_L the NPV of an investment in underwater drainage is negative. This negative NPV implies a lower land price.
This means that in scenario 2 the land price in the Noordelijk Weidegebied becomes €49.704 (50.700-996) per ha and in Holland/Utrecht's Weidegebied €56.304 (57.300-996) per ha.

Scenario 3
Same situation as in scenario 1 but now with a reward for reducing the CO_2 emission. Underwater drainage reduces approximately 10-ton CO_2 per year per ha, this means a benefit of 30*10 = €300 for the farmer. With this extra benefit the P_L becomes €268 (-32+300). This means the NPV becomes €2.187.

In scenario 3 the land price becomes in the Noordelijk Weidegebied €52.887 (50.700+2.187) per ha and in Holland/Utrecht's Weidegebied €59.487 (57.300+2.1876) per ha.

Scenario 4
Same situation as in scenario 2 but now with a reward for reducing the CO_2 emission. Underwater drainage reduces approximately 10-ton CO_2 per ha, this means a benefit of 30*10 = €300 for the farmer. With this extra benefit the P_L is €354 (54+300). In scenario 4 the NPV is €3.466.

The NPV of underwater drainage is positive, this leads to an increase in the agricultural land price. In the Noordelijk Weidegebied the land price becomes €54.166 (50.700+3.466) per ha and in Holland/Utrecht's Weidegebied €60.766 (57.300+3.466) per ha.

High water level

Scenario 5
Increasing the water level in the ditches does not require any changes or adjustments in water management leading to zero investment costs. According to Van den Born et al. (2016) the negative economic effects due to less grass yield is an annual €168 per ha. Duration is 20 years, discount rate equal to 3%. The NPV becomes -€2.500.

Increasing the water level has impact on the land price: in the Noordelijk Weidegebied the land price becomes €48.200 (50.700-2.500) per ha and in Holland/Utrecht's Weidegebied €54.300 (57.300-2.500) per ha.

Scenario 6
According to GDNK (2018) the reduction of CO_2 emission due to high water level is 17.6 ton per ha per year. If agriculture is included in the EU ETS farmers can be rewarded for reducing CO_2 emission. With the current price of €30 for a CO_2 permit (Ember-Climate, 2021), the

financial benefit for a farmer equals 30*17.6 = €528. With this financial benefit the P_L becomes €360 (-168+528). In scenario 6 the NPV is €5.355.

With the reward farmers get for reducing the emission of CO_2 the NPV becomes positive. A positive NPV increases the agricultural land price. In the Noordelijk Weidegebied the land price becomes €56.055 (50.700+5.355) per ha and in Holland/Utrecht's Weidegebied €62.655 (57.300+5.355) per ha.

Land-use change

Agricultural use
Scenario 7
With wet farming (e.g. paludiculture) farmers lose the grass yield of a particular piece of land, according to Blanken et al. (2020) this is €2000 per ha per year. With the paludiculture the revenue is approximately €250 per ha per year for cattail (Van Duursen & Nieuwenhuijs, 2016). This means the P_L is -€1.650 (-2000+350). The initial investment costs for wet farming are small, €50. The duration of a wet farming project is 10 years (GDNK, 2018). To be able to compare with the other measure we also take for land-use change a duration of 20 years. This gives an NPV of -€24.598.

As can be seen in the negative NPV an investment in paludiculture is not profitable. This negative NPV lowers the agricultural land price. In the Noordelijk Weidegebied the land price becomes €26.102 (50.700-24.598) per ha and in Holland/Utrecht's Weidegebied €32.702 (57.300-24.598) per ha.

Scenario 8
Suppose agriculture is included in the ETS. If we compare different studies, the average CO_2 reduction of wet farming is 22-ton CO_2 per year. This leads with the current carbon permit price of €30 to a benefit of €660 (22*30) for the farmer annually. This means that the P_L becomes €-990 (-1.650+660). In scenario 8 the NPV is -€14.779.

The negative NPV decreases the agricultural land price. In the Noordelijk Weidegebied the land price becomes €35.901 (50.700-14.779) per ha and in Holland/Utrecht's Weidegebied €42.501 (57.300-14.779) per ha.

Non-agricultural use
Scenario 9
If the peat soils lose their agricultural function and become nature areas, the farmer loses almost his total grass revenue of €2000 per ha per year. In a nature area very extensive agriculture is still possible with an grass revenue of approximately €150 per ha per year. P_L becomes €-1.850 (-2000+150). The initial investment is small, €50 and the duration is 20 years. This gives a NPV of -€-27.573.

As can be seen the NPV of changing towards nature area is negative. A negative NPV lowers the land price. In the Noordelijk Weidegebied the land price becomes €23.127 (50.700-27.573) per ha and in Holland/Utrecht's Weidegebied €29.727 (57.300-27.573) per ha.

Scenario 10

In this scenario agriculture is included in the EU ETS. Farmers can earn money with selling their CO_2 which they no longer need due to reduction of CO_2. With nature 33-ton CO_2 per ha per year can be reduced. The current price for a CO_2 permit is €30. This leads to a benefit of 30*33 = €990. The P_L becomes -€860 (-1850+990). In scenario 10 the NPV is -€12.845.

With the EU ETS the change towards nature is still not profitable, NPV is still negative. A negative NPV decreases the land price. In the Noordelijk Weidegebied the land price becomes €37.855 (50.700-12.845) per ha and in Holland/Utrecht's Weidegebied €44.455 (57.300-12.845) per ha.

Table 5.1: Overview all measures and scenarios.

Measure	**Investment costs in €**	**P_L in €**	**Discount rate**	**Time**	**CO_2 reduction per a per year in ton**	**NPV in €**
Underwater drainage Scenario 1	1800	-32	0.03	20 year	10	-2.276
Underwater drainage Scenario 2	1800	54	0.03	20 year	10	-996
Underwater drainage (EU ETS) Scenario 3	1800	268	0.03	20 year	10	2.187
Underwater drainage (EU ETS) Scenario 4	1800	354	0.03	20 year	10	3.466
High water level Scenario 5	0	-168	0.03	20 year	17	-2.499
High water level (EU ETS) Scenario 6	0	360	0.03	20 year	17	5.355
Land-use change (paludiculture) Scenario 7	50	-1750	0.03	20 year	22	-24.598
Land-use change (paludiculture) (EU ETS) Scenario 8	50	-990	0.03	20 year	22	-14.799
Land-use change (nature) Scenario 9	50	-1850	0.03	20 year	33	-27.573
Land-use change (nature) (EU ETS) Scenario 10	50	-860	0.03	20 year	33	-12.845

Table 5.1 gives an overview of the outcomes of all the different measures and scenarios. There are large differences in P_L and thereby the NPV. If agriculture is not included in the EU ETS an investment in underwater drainage is for the farmer the best choice (scenario 1 and 2). The NPV is negative but higher compared to the other measures.

If agriculture is included in the EU ETS the most profitable investment is to increase the water level. Due to the reduction in CO_2 the farmer can sell CO_2 permits which generates revenue (scenario 6).

All the investments in land-use change have negative a NPV, this has impact on the agricultural land price. With an investment in paludiculture or nature the value of land decreases due to the negative NPV.
For the investment in underwater drainage and high-water level the inclusion of agriculture in the EU ETS determines if the land price increases or decreases. If agriculture is not included there is a negative NPV leading to a price decrease but inclusion gives a positive NPV which leads to an increase in the agricultural land price.

Chapter 6: Conclusion and Discussion

6.1 Conclusion

The answers to the research questions are given in this section.

The function of land is in the Netherlands determined by spatial planning. Due to spatial planning land gets a function, for example housing, industry, transport, nature or agriculture. These functions have changed in the recent years. The total amount of agricultural land has been decreasing in the recent years. Agricultural land has been changed to housing and industrial areas.

To reduce greenhouse emissions from the agricultural sector European and national legislation is in place. With the CAP, EU ETS and the EU Green Deal the European Union wants to reduce emissions from the agricultural sector. The national government has also policy in place like the new Climate agreement with the target to reduce 55% of CO_2 emissions in 2030 and legislation about the maximum allowed emission of greenhouse gasses.
In the peat soil areas measures need to be taken to reduce the emission of CO_2. This to stop the settlement of the soil and to comply to European and national policy to reduce greenhouse gasses.

The shadow price of land shows the extra profit which can be made if the farmer buys one extra piece of land. The shadow price also shows the maximum amount the farmer is willing to pay. In the long-term the shadow price equation of land becomes the individual demand function. Due to various reasons the shadow price equation can shift to the left or right which means a decrease or increase of the shadow price of land.

The value of land is determined by the function of the land and the possible change in function. Overall there is an increasing demand for agricultural land which increases the agricultural land price, as did happen in the last 10 years.

In this thesis 3 measures were discussed which reduce the emission of CO_2 from peat soils underwater drainage, high water level and land-use change.
As shown in Table 5.1 (overview all measures and scenarios) the measures to reduce CO_2 emission in peat soils have effect on the shadow price of land. The NPV of such investment influence the agricultural value of the land and thereby the agricultural land price.

Based on the results of Table 5.1 a few conclusions can be made. An investment in a measure which reduces the emission of CO_2 is not profitable so only possible with financial rewards or compensation of costs. An alternative is the inclusion of agriculture in the EU ETS. This would make the NPV of underwater drainage and increasing the water level positive which implies a financial benefit for the farmer. Inclusion of agriculture in the EU ETS leads to more pressure on the land market and thereby increases the price of agricultural land.

The highest reduction of CO_2 is realised with a land-use change. However, this has large implications for financial situation of the farmer. Due to the negative NPV the agricultural land price decreases in that scenario.

The location of the peat soils has influence on the agricultural land price. If the peat soil (Holland/Utrecht's Weidegebied) is close to urban areas the pressure of the other land functions is high which increases the agricultural land price. This pressure of other land functions is less in peat soils located in more rural areas as the Noordelijk Weidegebied which means a lower agricultural land price. This is confirmed in a study done by Cotteleer et al. (2007).

This means that in peat soil areas not only the pressure of other land functions determine the agricultural land price. The measures to reduce CO_2 emission have an influence too. If an investment, with or without financial reward, becomes profitable the agricultural land price will increase. If an emission reducing measure is not profitable the land price will decrease.

6.2 Discussion

The goal of this thesis was to get insight in the agricultural land market in the Netherlands, with a specific focus on the peat soil area. The land market is a complex market with many actors involved and with complex legislation. As discussed environmental legislation is more important than ever and will even increase in the future. This environmental policy and regulation has therefore an impact on the land and the land market. But how this influence looks like is uncertain, depending on the choice politics makes with respect to for example climate change.

Currently new policy is developed on a national and European level. The exact execution of the Dutch Climate Agreement and the new CAP and the Green Deal on an European level is still unclear. Targets are set but the exact policy and regulations are uncertain, therefore also the effect of these policies on the land price and market. That is why in this thesis these policies are discussed. Due to the uncertainty the effect of these policies and measures on the price formation in the agricultural land market is unclear. It is not clear how the measures which will be taken to reach the emission reduction targets will look like and what their effect will be on the agricultural land market and price. It is frustrating for farmers that politicians present their plans but do not indicate exactly how these plans should be realised given that these plans have strong implications for them. It makes it impossible to address policy accurate and give information about the effect of certain policies. So, clearly more research is needed.

The Veenweidegebied faces also challenges with emission of greenhouse gasses and soil settlement, new policies indicate how to deal with these problems but are still vague and ambiguous. This makes it impossible to say something useful and accurate about these policies and the influence these policies have on the price formation of agricultural land in the Veenweidegebied. That is why further research needs to be done to address the influence of future environmental policy on land and thereby on the land market.

In this thesis the link was made between the agricultural land market and measures which reduce greenhouse gas emissions. A lot of studies have discussed and investigated the agricultural land market. Moreover, many studies discuss policy and measures to reduce greenhouse gas emission. However, studying the link between measures to reduce emissions in the peat soil area and the price formation on the agricultural land market is new. This thesis shows that climate measures not only influence the emission of a certain greenhouse gas. It also influence land in terms of accessibility, quality and price. These factors influence the price formation on the agricultural land market, which are important for individual farmers, for their farm management.

In this thesis I used mainly existing scientific policy and research reports written by national and international research institutions. I did not collect any data myself.

A caveat of this thesis is that the analysis is based on literature and some basic economic theory but no statistical/econometric analysis is done. I worked out the 10 scenarios with the different measures but more could have been done to consider uncertainty, for example by using a Monte Carlo analysis. It is recommended to perform such an analysis in the future.

Another caveat of this thesis is that the data, for example about the CO_2 reduction of the measures, it is based on preliminary research. The emission reduction in peat soil is still in a very early stage and a lot is unclear yet. If further research is done, outcomes of the NPV of the investments could change which leads to different effects for investments and the agricultural land price.

As policy recommendation I suggest including the whole agricultural sector in the EU ETS. In this way farmers are financially rewarded if they take the expensive measures to reduce CO_2 emissions. Due to lower CO_2 emission they can sell some of their permits on the carbon market which leads to financial benefit for the farmer. More research is in that case also needed on the emission of the other greenhouse gasses (methane and ammonia) and due to the investments. Moreover, the effect on farm structure and income is needed to see if inclusion of agriculture in the EU ETS a way is to stimulate farmers to reduce CO_2 emissions from peat soils.

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Appendices

Annex I

Table I.1: Land-use change in the Netherlands

		2006	2008	2010	2012	2015	Percentages 2015
Totale oppervlakte	**ha**	4154307	4154307	4154307	4154302	4154303	
Verkeersterrein							
Totaal verkeersterrein	**ha**	115955	117149	117602	116123	115563	2,78%
Spoorterrein	**ha**	8510	8585	8630	8882	8885	
Wegverkeersterrein	**ha**	104994	105115	106607	104941	104402	
Vliegveld	**ha**	2451	2449	2365	300	2276	
Bebouwd terrein							
Totaal bebouwd terrein	**ha**	337927	344874	350161	355986	361526	8,70%
Woonterrein	**ha**	227810	230103	231375	233575	235839	
Bedrijventerrein	**ha**	75547	78558	81358	84081	86336	
Semi-bebouwd terrein							
Totaal semi-bebouwd terrein	**ha**	52849	513914	51202	51002	49318	1,19%
Recreatieterrein							
Totaal recreatieterrein	**ha**	96311	97659	98834	102561	105418	2,54%
Agrarisch terrein							
Totaal agrarisch terrein	**ha**	2285799	2275827	2264376	2252233	2236317	53,83%
Terrein voor glastuinbouw	**ha**	16241	16791	16622	15868	15511	
Overig agrarisch terrein	**ha**	2269558	2259037	2247754	2236365	220806	
Bos en open natuurlijk terrein							
Totaal bos en open natuurlijk terrein	**ha**	484024	485002	486528	490088	498956	12,01%
Bos	**ha**	344700	344792	345380	344043	341270	
Open droog natuurlijk terrein	**ha**	84991	85530	87758	90016	95055	
Open nat natuurlijk terrein	**ha**	54332	54681	53390	56029	62631	
Binnenwater							
Totaal binnenwater	**ha**	362628	363529	366121	367982	371941	8,95%
Buitenwater							
Totaal buitenwater	**ha**	418815	418874	419483	418325	415264	10,00%

Source: CBS, 2018.

Annex II

<u>Scenario 1:</u>
I: 1800
P_L: -32
r: 3%
T: 20

$$\mathrm{NPV} = -1800_{t=0} + \sum_{t=20}^{T} \frac{-32}{(1.03)^{20}} = -€2.276$$

<u>Scenario 2:</u>
I: 1800
P_L: 54
r: 3%
T: 20

$$\mathrm{NPV} = -1800_{t=0} + \sum_{t=20}^{T} \frac{54}{(1.03)^{20}} = -€996$$

<u>Scenario 3:</u>
I: 1800
P_L: 268
r: 3%
T: 20

$$\mathrm{NPV} = -1800_{t=0} + \sum_{t=20}^{T} \frac{268}{(1.03)^{20}} = €2.187$$

<u>Scenario 4:</u>
I: 1800
P_L: 354
r: 3%
T: 20

$$\mathrm{NPV} = -1800_{t=0} + \sum_{t=20}^{T} \frac{354}{(1.03)^{20}} = €3.466$$

Scenario 5:
I: 0
P_L: -168
r: 3%
T: 20

$$\text{NPV} = -0_{t=0} + \sum_{t=20}^{T} \frac{-168}{(1.03)^{20}} = -€2.499$$

Scenario 6:
I: 0
P_L: 360
r: 3%
T: 20

$$\text{NPV} = -0_{t=0} + \sum_{t=20}^{T} \frac{360}{(1.03)^{20}} = €5.355$$

Scenario 7:
I: 50
P_L: -1750
r: 3%
T: 20

$$\text{NPV} = -50_{t=0} + \sum_{t=20}^{T} \frac{-1650}{(1.03)^{20}} = -€24.598$$

Scenario 8:
I: 50
P_L: -990
r: 3%
T: 20

$$\text{NPV} = -50_{t=0} + \sum_{t=20}^{T} \frac{-990}{(1.03)^{20}} = -€14.779$$

Scenario 9:

- I: 0
- P_L: -1850
- r: 3%
- T: 20

$$\text{NPV} = -50_{t=0} + \sum_{t=20}^{T} \frac{-1850}{(1.03)^{20}} = -€27.573$$

Scenario 10:

- I: 50
- P_L: -860
- r: 3%
- T: 20

$$\text{NPV} = -50_{t=0} + \sum_{t=20}^{T} \frac{-860}{(1.03)^{20}} = -€12.845$$