STOP LAND SUBSIDENCE IN PEAT MEADOW AREAS

THE ‘GREEN HEART’ AREA AS AN EXAMPLE

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Council
for the Environment
and Infrastructure

About the Council for the Environment and Infrastructure

The Council for the Environment and Infrastructure (*Raad voor de leefomgeving en infrastructuur*, Rli) advises the Dutch government and Parliament on strategic issues concerning the sustainable development of the living and working environment. The Council is independent, and offers solicited and unsolicited advice on long-term issues of strategic importance to the Netherlands. Through its integrated approach and strategic advice, the Council strives to provide greater depth and breadth to the political and social debate, and to improve the quality of decision-making processes.

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SUMMARY

For decades, the land in rural peat meadow areas has been subsiding. The main cause is the systematic draining of the land to make it suitable for agricultural use. This dewatering results in the peat drying out and oxidising – or 'burning' – under the influence of oxygen, which causes subsidence. Then, the water authorities lower the water level even further, so that agriculture can continue.

In this advisory report, the Council for the Environment and Infrastructure (RIi) (hereafter: the Council) argues that continuing on this downward spiral is no longer acceptable, because:

a. drainage leads to reduced water quality, a deterioration in the quality of the natural environment and greater safety risks. Locally it also leads to salinisation and the uncontrolled upwelling of groundwater (hydraulic soil failure)
b. drained peat produces relatively high CO_2 emissions, while the Paris Climate Agreement and the Dutch Climate Act stipulate that CO_2 emissions must be drastically reduced over the next 30 years (for the Netherlands by 95% compared with 1990 levels)
c. if policy remains unchanged, the costs of water management in peat meadow areas will continue to rise.

In brief, continuing along the path of dewatering, resulting in continuous land subsidence and CO_2 emissions, is irresponsible in the long term, from the point of view of the economy, ecology and society. In view of our climate obligations, reducing land subsidence is actually unavoidable. Although land subsidence cannot be completely eliminated (a minor part of it is not caused by humans and is difficult to prevent), reducing it means that the adverse effects will manifest themselves over a period of centuries rather than decades, so that the damage and nuisance caused by land subsidence can be better absorbed. This is why the Council is advocating that the path of continually lowering water levels in peat meadow areas be abandoned.

The need for a transition: from lowering water levels to raising them

To counter land subsidence in peat meadow areas, the groundwater level needs to rise. This requires a different way of thinking, but such a turnaround cannot be achieved overnight. Particularly for farmers in peat meadow areas, a rise in the groundwater level can have far-reaching consequences, as it leads to 'rewetting' of their land. In many cases they will have to adapt their operations to the changed situation, for example through extensification, with fewer head of livestock per hectare and more land, and/or different crops. This is no small step. A number of tests have shown that farming on peat is possible – in an adjusted form – with a higher water level, and it is also necessary to preserve the culturally and historically valuable peat meadow landscape. However, the prerequisites have to be suitable for a profitable business, such as the availability of a market (e.g. for regional products) and structural compensation for nature conservation services, for example. In view of the major consequences that stopping subsidence will have for farmers, the Council thinks that the government should help this group – financially and in other ways – to make the transition.

Work is already being carried out here and there, on the basis of inter-administrative programmes and regional agreements, to bring about a transition in peat meadow areas. However, large-scale implementation of work to counter land subsidence is often still lacking. Those involved prefer to put off far-reaching decisions and pilot projects are not scaled up. At the local level, parties keep reinventing the wheel. The Council therefore urges the national government to intervene as quickly as possible, to achieve a substantial reduction in land subsidence in peat meadow areas.

Indicative target 70% less land subsidence in 2050; interim target 50% in 2030

Effective direction to slow land subsidence requires clear objectives. The Council advises the national government to draw up a *national policy framework* with a specific target for reducing land subsidence in rural peat meadow areas. The Council derives this target from the obligations contained in the Dutch Climate Act: the starting point is therefore a 95% CO_2 reduction in peat meadow areas. This means that a 70% reduction in land subsidence must be achieved by 2050. Because the possibilities for profitable agricultural activity with high water levels (20 cm below ground level) have not yet been established, this target of 70% should be laid down as an *indicative* target in regulations based on the Environment

and Planning Act. In 2030, it will be possible to assess whether this goal can be reached, in which case it can be laid down in legislation as a fixed goal. In applying this indicative target, room must also be left to allow for differences between localities. It is clear that in places where land subsidence is limited (e.g. because the peat layer is thin), a 70% reduction in subsidence would require a disproportionate effort. For this reason, the target of 70% applies until land subsidence of a maximum of 3 mm per year has been reached. The Council also advises laying down an interim target of 50% as a fixed standard for the short term. This will make it clear to all the stakeholders that they have to start preparing now. It is expected that reaching the interim target will fulfil the requirement under the National Climate Agreement of a one-megatonne per year reduction in CO_2 emissions in peat meadow areas by 2030.

According to the Council, in addition to the national goals, the policy framework must specify transition paths up to 2030 and 2050, so that farmers and water authorities have time to prepare and to make changes. The framework must also outline the perspective for land subsidence over the long term, after 2050. Furthermore, the national government will have to include in the policy framework the legend for zoning maps (to be drawn up by the provinces), which indicate priorities in the approach by the areas. Finally, the Council considers that, in order to monitor the achievement of the national target for land subsidence reduction, a minister or state secretary should be made responsible for land subsidence – a person who can take decisions if this does not happen at regional level.

Regional, area-based approach to implementation

The Council advises that regional *'implementation assemblies'* should be used in tackling land subsidence. These should concentrate on areas that are manageable for local parties (in the Green Heart, for example, the Krimpenerwaard or the Alblasserwaard). Where possible, the composition of the implementation assemblies should be aligned with existing cooperation initiatives. Provinces and water authorities will of course also be closely involved in implementation.

More clarity about costs and benefits, and financing the transition

The Council recommends that the costs and benefits of land subsidence be identified and documented in greater detail. These are currently insufficiently understood, especially from a quantitative perspective. In addition, the Council advises the national government to set up a financing system in which farmers can be paid, for example by companies, for the reductions in CO_2 emissions that they achieve beyond the current climate agreements for peat meadow areas. The Council also advises the government to make a conversion premium available to farmers and to provide an implementation budget for restructuring peat meadow areas. In 2030, it can be considered more closely whether the indicative target for 2050 requires adjustment and what instruments are needed for hitting that target.

Investing in a knowledge base, monitoring and information

Finally, a solid knowledge base on land subsidence is essential. The Council therefore advises the national government to continue investing in research

on land subsidence and to create a national information service. Besides that, a national monitoring network is needed to monitor the national target for reducing land subsidence. In addition, the Council thinks it is important for the national government to set up an information centre where farmers can obtain information and advice on adapting their business operations.

Acting quickly to limit damage and costs

The Council is aware that reducing land subsidence in peat meadow areas in the way that is advocated here can have a considerable impact. All the more because there are a number of other major tasks in the peat meadow areas that require attention, such as improving water quality and the quality of the natural environment, and reducing nitrogen emissions. Tackling subsidence provides an opportunity to combine solutions to various challenges. If action is taken quickly, it will lessen the economic damage to entrepreneurs in the area and reduce the costs to society. This will make it possible to limit the negative consequences of land subsidence.

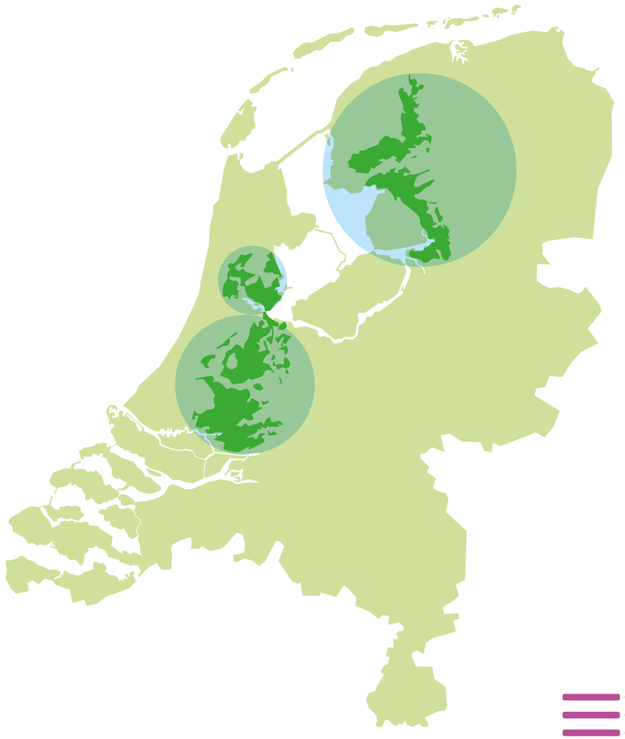
Figure 1: Summary of recommendations

Recommendation 1 – to the national government: Provide clear direction on reducing land subsidence, set a 70% reduction in land subsidence in rural peatlands by 2050 as an indicative target, with an interim target of 50% by 2030, as part of a national policy framework on land subsidence.	Lay down in legislation the indicative target of a 70% reduction in land subsidence by 2050 and the interim target of a 50% land subsidence reduction by 2030. Draw up a national policy framework for land subsidence that comprises: • transition paths to 2030 and 2050 • long-term perspectives • legend for zoning maps. Make a minister or state secretary responsible for the national target for land subsidence.
Recommendation 2 – to regional parties: Work together in an area-based fashion on implementing efforts to tackle land subsidence, but do so within the national policy framework.	Work with regional implementation assemblies. Provinces: establish implementation assemblies and adapt existing set of land policy instruments. Water authorities: use expertise and anticipate a changing role.
Recommendation 3 – to the national government: Identify costs and benefits, use CO_2 pricing, make a conversion premium available and fund restructuring of peat meadow areas.	Ensure maximum transparency regarding costs and benefits. Use CO_2 pricing, so that farmers are paid for CO_2 reduction beyond climate agreements. Make a conversion premium available to farmers. Make implementation budget available for restructuring, with co-financing.
Recommendation 4 – to the national government: Ensure a solid knowledge base for land subsidence; monitor subsidence using a monitoring network and facilitate the provision of information to farmers.	Continue investing in research on land subsidence and create a national information service. Develop a national monitoring network for land subsidence in order to monitor the achievement of targets. Facilitate information to farmers.

1 INTRODUCTION

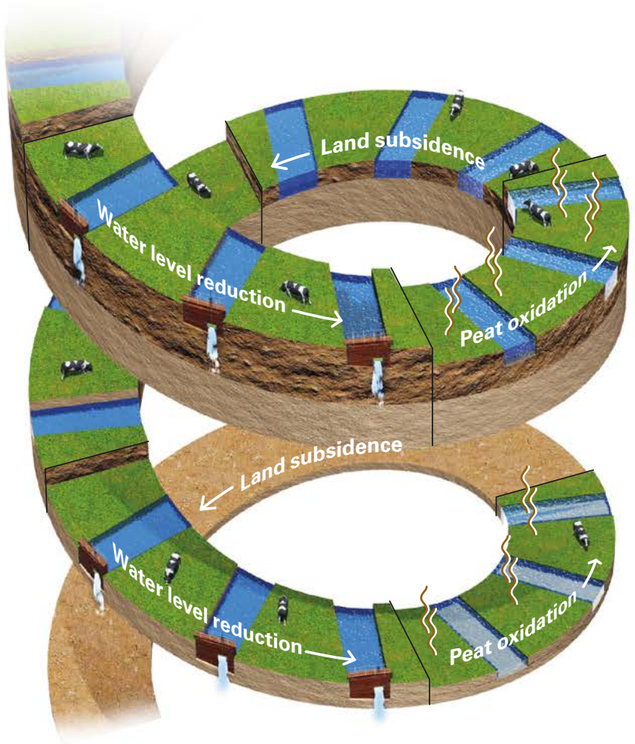
Land subsidence is occurring in many parts of the Netherlands. This is also the case in peat meadow areas, including in the Green Heart, an area of open countryside situated between Holland's four largest cities, which serves as an example in this advisory report (see Figure 2). Land subsidence in rural peatlands is principally caused by drainage, which is done to make agriculture possible in these areas. This dewatering results in the peat drying out (it is no longer saturated with water) and breaking down under the influence of oxygen (peat oxidation). This causes the land to subside (see Figure 3).

Figure 2: Clusters of peat meadow areas in the Netherlands



This process has been going on for centuries, but it has accelerated over the last 100 years due to improved pumping techniques that have been applied to meet the increasingly high requirements of agriculture. In the Green Heart, for example, the ground is currently subsiding by around one centimetre a year. If policy remains unchanged, this subsidence will continue (Deltares et al., 2018) and it will develop even faster if the climate warms further. This is because higher temperatures cause peat to break down more quickly (PBL, 2016; Royal HaskoningDHV, 2019a).

Figure 3: Process of water level reduction, peat oxidation and land subsidence



Land subsidence causes numerous problems. For example, damage results from subsidence of infrastructure and buildings; peat oxidation, which causes carbon emissions; and the drying out of nature conservation areas. These problems are also cumulative and build up over time, making them harder to manage. In ever more places, high costs have to be incurred in order to continue using the land for its current purposes.

Public authorities, research agencies and civil society organisations are well aware of the fact that land subsidence has adverse consequences. This has been a topic of discussion for at least 20 years. Many studies and advisory reports have been published on the subject. Perspectives have been developed for the future of peat meadow areas. Various pilots have been set up to study how land subsidence could be slowed (see Appendix C for an overview). In spite of all this, the practical implementation of tackling land subsidence has long been neglected. In the meantime, the land has continued to subside steadily.

Not all land subsidence in rural peatlands can be prevented, as some 10% of subsidence is autonomous. However, it is preventable to a very great extent.[1] Work is now being carried out in various places on a transition to counter land subsidence. For example, public authorities, water authorities

1 Land subsidence can result from autonomous, natural processes (such as geological settlement and tectonic plate movements) or from human activity (such as peat oxidation after dewatering). In rural peat meadow areas, the ground subsides by about 8 mm per year (Van den Akker et al., 2007). Only a limited part of this subsidence (less than 1 mm per year, or around 10%) is caused by unavoidable processes (Deltares, 2018). Around 0.3 mm of land subsidence is caused by geological settlement and some 0.7 mm by other natural processes (Kooi et al., 1998; Erkens et al., 2016; Deltares, 2018). Most subsidence (around 90%) in peat meadow areas is a consequence of preventable human action, specifically water level management. In urban areas, these proportions are different.

and other stakeholders are cooperating on the Regional Deal on Land Subsidence in the Green Heart [*Regiodeal Bodemdaling Groene Hart*]; on peat meadow projects in the Inter-Administrative Programme for a Living Countryside [*Interbestuurlijke Programma Vitaal Platteland*]; and on the development of regional peat meadow strategies. However, large-scale implementation of work to counter land subsidence is often still lacking. Those involved prefer to put off far-reaching decisions. Pilot projects are not scaled up and remain stuck in the experimental phase. At the local level, parties keep reinventing the wheel. Many interviewees for this advisory report agree with these observations and experience the situation as a general inability to take implementation one step further.

1.1 Continued drainage and land subsidence not an option

It has to be asked whether it is a bad thing that the land is subsiding in rural peat meadow areas. In the Netherlands, technology is so well-developed that feet can be kept dry in any area, even if it has sunk considerably, for example by means of higher and broader dykes, stronger pumps and a redevelopment of the surface water system. If there is no reason to counter land subsidence from a technical point of view, why not carry on in the same way?

The Council for the Environment and Infrastructure does not consider this to be an option. This has to do with the consequences for rural areas of further land subsidence. The steady process of land subsidence is causing increasing damage to the quality of the natural environment and water quality, salinisation, and the uncontrolled upwelling of groundwater (hydraulic soil failure) in the very low-lying polders. At the same time, the continued land subsidence brings a growing risk of flooding. In the coming years, the costs of water management will therefore continue to rise and the social costs for nature, water, safety, hydraulic soil failure and salinisation will increase.

Although these consequences are far-reaching, they in no way persuade everyone of the urgency of taking measures to reduce land subsidence. This is in itself understandable. After all, land subsidence is a gradual, almost stealthy process that has been going on for a long time. However, it is urgent due to the challenge of climate change. Substantially reducing CO_2 emissions, including the emissions created by peat oxidation in peat meadow areas, is an urgent task with specific targets for 2030 and 2050. Continuing along the path of dewatering, resulting in continuous land subsidence and CO_2 emissions, is unsustainable in view of the climate agreements, among other things. This is dealt with in greater detail in Section 1.2.

Box 1: CO_2 reduction targets in the Climate Act

The Dutch Climate Act stipulates that by 2030, greenhouse gas emissions in the Netherlands must be reduced by 49% compared with 1990, and by 2050 they must be reduced by 95% (Bulletin of Acts, Orders and Decrees [*Staatsblad*], 2019). How this is to be achieved is elaborated in the National Climate Agreement 2030, which includes a target for the reduction of CO_2 emissions in peat meadow areas by 1 megatonne per year by 2030. There is currently no detailed plan for the period from 2030 to 2050.

CO_2 emissions are not simply a problem; they can also help to break the deadlock and make progress. The Council anticipates that reducing CO_2 emissions will be worth money. Large polluting companies require CO_2 emission rights to compensate for their CO_2 emissions, and they will be prepared to pay increasing amounts for those rights. It is possible that the costs that farmers face as a consequence of rewetting could be partially covered by selling 'CO_2 emission rights' to companies, with a view to accelerating the reduction of carbon emissions from peat. This could help in dealing with the problem of land subsidence more quickly. Subsidy schemes could also speed up the process.

Conversely, tackling land subsidence effectively could possibly provide a solution to other urgent problems. Rural peat meadows, such as in the Green Heart region, are areas where a lot will have to happen in the near future. They face a number of major challenges. Apart from the national and international targets for reductions in CO_2 emissions, there are also targets for water quality (the Framework Directive on Water) and nitrogen reduction. Depending on the local situation, the issues of land for residential construction, energy generation or nature and leisure activities might require redevelopment. These challenges can be combined with countering land subsidence.

The Council is aware that the advisory report has a substantial impact. It involves a protracted transition for farmers and water authorities; it will be expensive (but it will also avoid costs); it requires a shift in thinking (from lowering water levels to raising them); there must be enough water available; and it will require extensive technical interventions and developments. For this reason, the Council urges that a strong reduction in land subsidence be achieved as soon as possible by means of a regional approach. By taking action now, it will be possible to anticipate necessary changes. This will lessen the economic damage to entrepreneurs in the area and reduce the costs for society. In this way, the negative consequences of land subsidence can be limited. If the national government wishes to achieve this, it will have to get to work with a sound vision, good policy and sufficient funding and instruments to implement plans. That is the core message of this advisory report. The details can be found in the rest of this report.

1.2 Why is continuing along the same lines not an option?

If there is no targeted approach to dealing with the continuing land subsidence in peat meadow areas, this will have undesirable effects.

Ecological damage and loss of nature conservation areas

Firstly, further land subsidence through continuous downward adjustment of water levels[2] will have adverse effects on biodiversity, soil quality and water quality. Biodiversity will decline due to the leaching of nutrients. This leaching causes eutrophication in both ground and surface water: water is enriched with nutrients, causing certain aquatic plants to grow excessively,

2 In this advisory report, the overarching term 'water level' is used for both the groundwater level and the surface water level. Of the two, the groundwater level is harder to influence than the surface level. This is because the groundwater level is the result of various factors, including precipitation, the height of the water in drainage channels and the extent of evaporation.

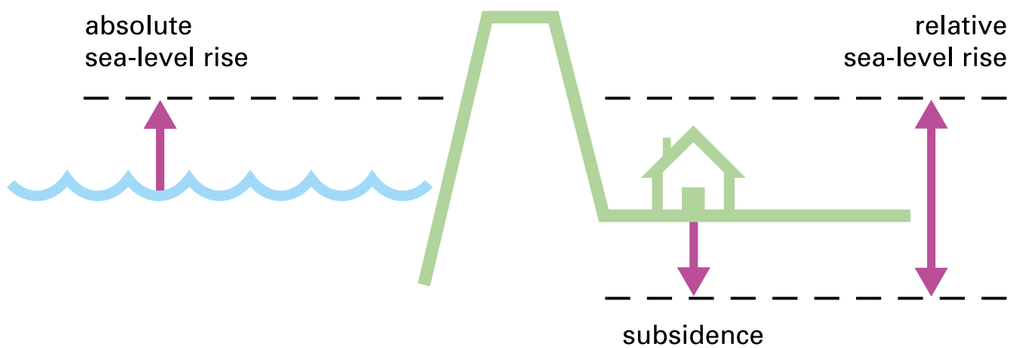
increased activity of specific micro-organisms and a drop in the oxygen level. Soil and water quality, which are currently already under pressure, decline further as a result (RIi advisory report 'De bodem bereikt?!' [*Soils for sustainability*], 2020). Soil quality also declines due to salinisation (increase in the salt content of ground and surface water) as a result of salt seepage.

In addition, it is becoming increasingly difficult to maintain nearby nature conservation areas. For example, nature conservation areas in the Green Heart, which make up around 10% of the surface area, are increasingly struggling to keep the water level high, due to water 'seeping' to the lower-lying surrounding area. At the same time, the nutrients that have leached out elsewhere end up in these nature conservation areas, disrupting the balance of nutrients. Increasingly large investments are needed in order to meet national and international targets for soil and water quality.

Deterioration in safety

Another effect that arises with further land subsidence in peat meadow areas concerns the likelihood of flooding. Due to the low-lying location of peatlands, the risk of flooding in the west of the Netherlands is rising. If land subsidence continues, large parts of an area such as the Green Heart will be five or six metres below sea level in 100-200 years' time (Deltares et al., 2018). This will have consequences for safety. The safety risk will be increased even further by the rise in sea level that is expected in the coming decades (see Figure 4). The Royal Netherlands Meteorological Institute (KNMI) forecasts a rise of 1.1 metres by 2100 compared with 1986-2005 (KNMI, 2019).

Figure 4: Sea level rise and land subsidence



Source: KNMI, 2019

Because increasing numbers of people and companies have established themselves in the Green Heart, the consequences of any flood would be greater, both in terms of victims and economic damage. There are technical means for ensuring safety, but they are costly. For instance, increasing the height of a dyke also involves widening it, which is often a major operation. In addition, many of the current quays and secondary defences are on soft soil and will need to be completely rebuilt from the ground up if they need to be raised.

Salinisation and hydraulic soil failure

If peatlands continue to be drained in the same way, hardly any peat will remain in the Green Heart, for example, in 100 to 200 years. The deepest parts of the Green Heart will then be low-lying polders grappling with

problems of salinisation and hydraulic soil failure (Deltares et al., 2018; see Box 2 for an explanation of hydraulic soil failure).

Box 2: What is hydraulic soil failure?

Hydraulic soil failure is the uncontrolled upwelling of groundwater from deeper levels. The phenomenon is caused by the reduced pressure (weight) of the soil, especially in the case of deep drainage. Peat layers become thinner as a result of this dewatering and the subsequent peat oxidation, making it more difficult for the soil to withstand the pressure of groundwater. Hydraulic soil failure can be seen in the landscape in meadows that feature pools ('boils'). It currently occurs in deep polders in the Province of Zuid-Holland and some polders around Mijdrecht in the Province of Utrecht. With the continued lowering of the water level and peat oxidation, there could be hydraulic soil failure in more places in future (Deltares et al., 2018; Deltares, 2019; Provincie Utrecht, 2018; Sweco & WEcR, 2017). It is virtually impossible to reverse the effects of hydraulic soil failure. It is difficult to seal boils at ground level. Once it has been created, there is a strong chance that a boil will continue to exist for a long time, possibly forever. Due to the constant flow of water, the boil will remain open (Deltares et al., 2018).

Polders where there is hydraulic soil failure can cause real headaches from a hydrological point of view. Surface water management is hampered by ditches that become silted up and the salinity of the water. Agricultural use of the soil is made difficult by salinity in ground and surface water and by the wet conditions of the soil as a result of rising water (seepage). In time, the land may become unusable locally because (a) the soil at ground level becomes unstable and the carrying capacity of the land deteriorates, and (b) many agricultural crops cannot withstand brackish water (Deltares et al., 2018; Deltares, 2019).

Peat as a source of CO_2 emissions

As already mentioned, drained peat is an important source of CO_2 emissions. The Dutch Climate Act stipulates that by 2030, greenhouse gas emissions must be reduced by 49% compared with 1990, and by 2050 they must be reduced by 95%. The National Climate Agreement details how the 2030 target is to be achieved. In the Agreement, the target is a reduction in CO_2 emissions from peat meadow areas of 1 megatonne per year by 2030.[3] This goal for CO_2 reduction is in practice also a goal for land subsidence. Keeping the peatlands wetter and lowering the water level less will reduce emissions of CO_2 and will also mean less land subsidence. The target for CO_2 reduction therefore also has consequences for rural land subsidence, although this link is not made in the National Climate Agreement. This is

3 For the same period, the Netherlands must also meet obligations under a 2018 European Regulation, the LULUCF 2021-2030. The abbreviations stands for *Land Use, Land Use Change and Forestry*. In the Regulation, it is agreed that every EU Member State will ensure that, over time, the LULUCF sector on its territory will not cause any net emissions according to the accounting rules ('no net-debits rule'). The Regulation gives rise to an additional policy task involving some 2.7 megatonnes of CO_2 equivalents. PBL Netherlands Environmental Assessment Agency anticipates that this can be achieved with the measures adopted in the National Climate Agreement (PBL, 2019). According to the Regulation, no net increase in emissions is permitted in this sector in relation to a reference level. If this does happen, compensation is possible, within the land use sector or with non-ETS sectors. For example, a drop in CO_2 storage by forests can be compensated for by reducing drainage in peat meadow areas, or vice versa (PBL, 2016; PBL, 2019). Member States may also buy and sell net storage from and to other Member States (Öko-Institut, 2019, p. 8).

wrong, however, as in order to fulfil the climate agreements and reach the targets contained in the Climate Act, it is essential to limit CO_2 emissions from peat meadow areas – and thus also limit land subsidence.

In theory, the Netherlands could opt to compensate elsewhere for CO_2 emissions from peat, within the agriculture and land-use sector or outside those sectors. According to the European rules, CO_2 emissions from peat can be compensated for by ensuring that more CO_2 is stored by forests (PBL, 2019). However, this would bring higher costs. Moreover, in that case, the ongoing CO_2 emissions from peat would make up a large share of the emissions still permitted in 2050. CO_2 emissions through peat oxidation currently total between around 4 and nearly 7 megatonnes per year (PBL, 2016; CBS & WUR, 2017; Lof et al., 2017). Total national CO_2 emissions must be cut to 11 megatonnes by 2050. If nothing changes, in 2050 the peat meadow areas will therefore account for nearly half or more of the total CO_2 emissions permitted for the Netherlands (see also Buro Sant en Co & Fabrications, 2019). This would significantly reduce the scope for residual emissions from other sectors. This makes it unavoidable that in peat meadow areas, too, a contribution will have to be made to the necessary task of reducing CO_2 emissions.

Financial consequences

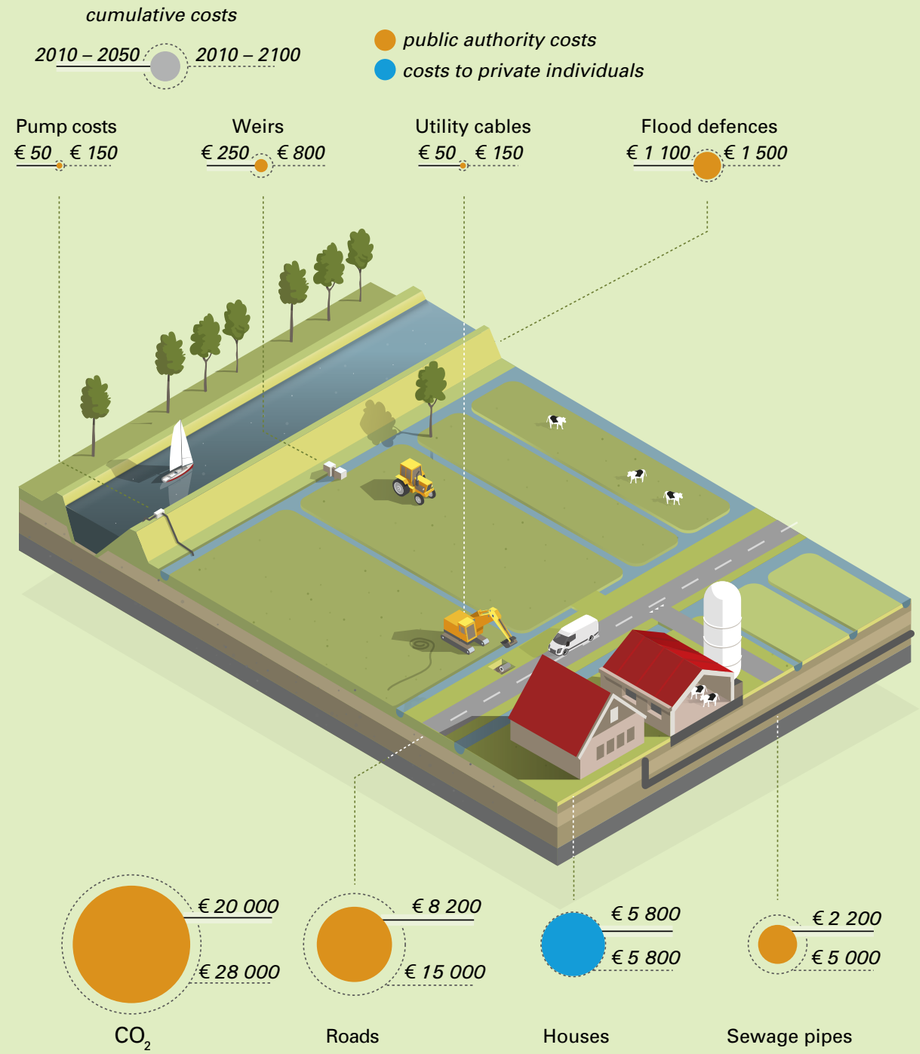
Countering the negative effects of land subsidence (ecological damage, damage to the environment, deterioration in safety, hydraulic soil failure/ salinisation, and CO_2 emissions) requires substantial investment. The level of investment is currently known in part. For example, the costs of CO_2 emissions from peat meadows based on the expected price development of CO_2 are estimated at more than €197 million per year (see Appendix B). The costs for water management in rural peat meadow areas are also increasing. This is because changes need to be made to the water system to ensure that agriculture will continue to be possible. PBL Netherlands Environmental Assessment Agency has made an estimate of a total of €200 million up to 2050 (PBL, 2016).[4] This is on the low side: it is only an initial overall estimate and not all the aspects have been included (see Box 3 and Chapter 2). Furthermore, all the elements of the costs are not yet known (e.g. the costs linked to the deterioration in the safety situation) or the costs are hard to quantify.

4 Land subsidence also causes damage to foundations, roads and pipelines in rural areas. The costs of these types of damage are estimated at 1 to 2 billion euros up to 2050. However, these costs cannot be wholly avoided through a higher water level, because the damage involved is partly caused by settling (PBL, 2016).

Box 3: Water management costs due to land subsidence

PBL Netherlands Environmental Assessment Agency made an initial estimate in 2016 of extra costs of water management as a consequence of land subsidence. In response to this study, two water authorities stated that the estimate of €200 million up to 2050 was too low and that the real financial consequences would be greater (Dutch Water Authorities, 2017). In order to enable a separation of functions, high-water trench systems were constructed in the past, which will no longer be sustainable and affordable in the future. Interviews for this advisory project also confirmed that estimates of water management costs have been low. These costs will rise, particularly in the long term, over 100 years. The complex water management system, with villages and ribbon development, will then push up costs. In addition, there will then be more 'problem polders'. PBL does not cover this longer period in the 2016 study, but in an earlier study it does provide a look ahead to the period 2050-2100 (see Figure 5). Based on expected land subsidence, the costs for flood defences, weirs and pumps will become structurally higher after 2050 (PBL, 2015).

Figure 5: Extra costs due to land subsidence in peat meadow area (per hectare)



Source: PBL, 2015, p. 47

In short, the further lowering of the water level that is needed to ensure that peat meadow areas continue to be suitable for agriculture results in higher costs for dealing with the consequences of land subsidence. Added to the adverse impacts mentioned earlier in this section, this brings the Council to the conclusion that continuing in the same way is not an option.

The Council notes furthermore that social discontent could develop over time, regarding the way in which the costs of land subsidence are distributed among residents. The water authorities in the Green Heart are currently incurring costs for the agricultural user, while the bill for most of these costs ends up outside the agricultural sector. This can reduce support among urban inhabitants for lowering the water level. As the costs of water management increase, greater account will need to be taken of the likelihood of such reactions.

1.3 Goal and questions to be addressed in this advisory report

The above clearly shows that countering land subsidence is an important task, including in an area such as the Green Heart peat meadows. However, as has already been noted, it is proving difficult to get the practical implementation off the ground. With this advisory report, the Council wishes to help break the deadlock.

The key questions in this advisory report are:
Which substantive and organisational choices have to be made in order to counter the negative effects of land subsidence in the rural peat meadow area, with the Green Heart as example? What is the relationship with other challenges in peat meadow areas and what opportunities do they offer? Who is responsible for making those choices and implementing them? And what role does the national government have to play?

1.4 Demarcation

The Green Heart as an example

As shown in Figure 2, the Netherlands has three clusters of peat meadow areas: the western peat meadow areas, the Noord-Holland peat meadow areas and the peat meadow areas in the provinces of Friesland and Overijssel. These clusters differ greatly. The differences include the thickness of the peat layer, the exploitation history, the level of drainage and the land parcelling pattern. There are also differences in the relationship with other undertakings in the area, such as residential construction, energy generation, nature conservation or leisure activities.

Land subsidence in peat meadow areas is discussed in this advisory report with the Green Heart as an example. The Council has chosen this area because the Green Heart faces various complex challenges. The location of the Green Heart in three provinces also makes the area more complex administratively than other peat meadow areas. However, many of the

findings and conclusions in the report can also be applied to peatlands outside the Green Heart. This is because all peatlands face the same types of problems, which only differ as to their urgency and relative importance. For example, the pressure of urbanisation probably plays a greater role in the Green Heart than in the peat meadow area of Friesland. Nevertheless, the location of the Green Heart in proximity to large cities appears to have a limited influence on countering land subsidence. The big cities make only a marginal administrative contribution to finding solutions.

Focus on rural area

Land subsidence is a problem that also arises in urban areas. However, this advisory report concentrates on rural peat meadow areas, with land subsidence caused by peat oxidation. This demarcation has been chosen because the issue of land subsidence is different in urban areas and rural areas. In an urban area, increasing the water level has a limited effect on land subsidence, because the subsidence there is caused mainly by pressure from above ('settling'). In consequence, the solution is also different in urban areas: damage from subsidence in buildings and infrastructure must be prevented as much as possible and where necessary, foundations and sewers must be repaired. The challenge is mainly to find a solution to the high costs. In rural areas, the policy choice to be made is less clear. This advisory report concentrates on the problem in these rural areas. The Council does include urban themes, insofar as they have consequences for rural areas. One example is the pressure of urbanisation on the Green Heart.

1.5 Structure of the advisory report

This report is structured as follows. Chapter 2 contains the Council's findings and conclusions. It discusses the implications of a strategy in which peat meadow areas are no longer drained, but are 'rewetted' instead. Various aspects of this possible policy choice are highlighted: the relationship with CO_2 emissions from peat; the possible consequences for local farmers; the importance of national direction and oversight; the conditions for proper implementation of the operation; the costs and benefits; and the knowledge that is needed for a sound approach and execution of the task relating to land subsidence. In Chapter 3, based on its findings and conclusions, the Council formulates a number of specific recommendations, some directed at the national government and some at the regional parties involved in countering land subsidence in peat meadow areas. Finally, the advisory report has three appendices, which explain and examine in more detail some topics covered in the advisory report.

2 FINDINGS

Based on interviews with professionals, expert meetings, studies and desk research, the Council for the Environment and Infrastructure has arrived at the following findings and conclusions.

2.1 From drainage to 'rewetting'

Contribution of rewetting to reduction in land subsidence and CO_2 emissions

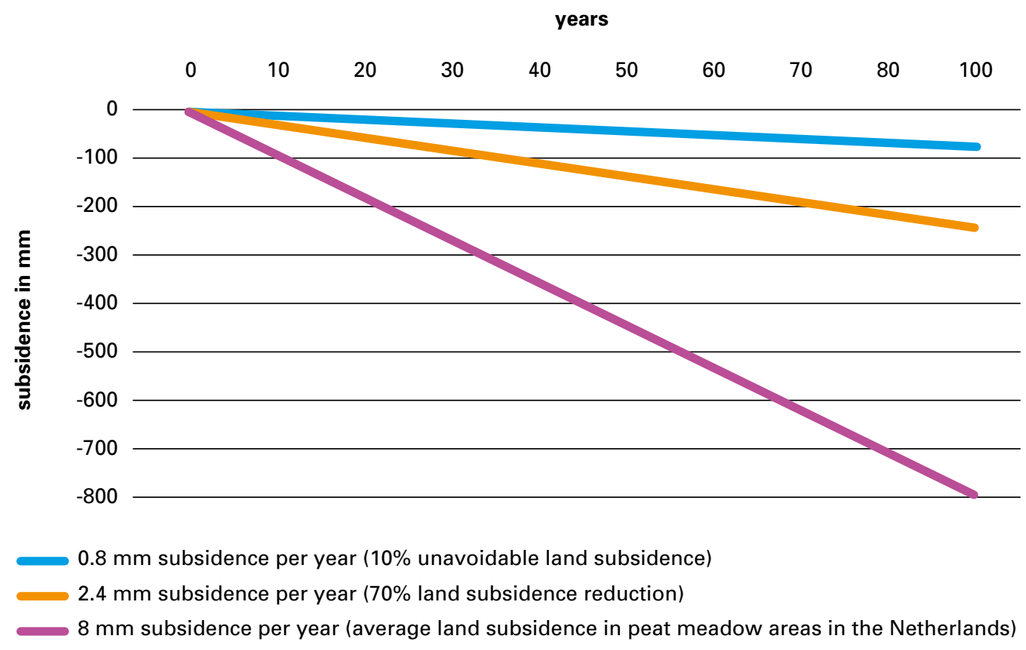
Land subsidence can be reduced through higher groundwater levels ('rewetting'). With rewetting, the peat soil no longer dries out and oxidises, which at the same time reduces CO_2 emissions. However, if water levels are substantially higher, emissions of two other greenhouse gases – methane and nitrous oxide – increase. A balance therefore has to be sought between reducing CO_2 emissions and causing methane and nitrous oxide emissions, so that an optimum reduction in CO_2 is achieved without methane and nitrous oxide cancelling out the benefits. British and recent German research shows that a groundwater level of around 20 cm below ground level probably provides an optimum balance, with minimal emissions of CO_2 as well as methane and nitrous oxide (Evans et al., 2016; Tiemeyer et al., 2020). These figures still have to be confirmed for the Netherlands, but it is likely that the picture will be similar.

With a groundwater level of some 20 cm below ground level, peat degradation will be greatly reduced, which will curb land subsidence. If there is minimal peat degradation, subsidence in rural areas will decline by 70% (see Box 4). Land subsidence will then continue, but at a much slower rate, so that the damage and other problems caused by subsidence will be considerably reduced (see Figure 6). With careful water management and optimum land use (among other things by reducing the load on the soil caused by vehicles and livestock), land subsidence in rural peat meadow areas could ultimately be cut by as much as 90%. That is the maximum that can be achieved. The remaining 10% is unavoidable land subsidence in rural peat meadow areas due to autonomous processes: geological settling and movements in the Earth's crust.

Box 4: Relationship between reducing land subsidence and reducing CO_2 emissions

If land subsidence in rural peat meadow areas decreases, CO_2 emissions also decline. The relationship between the two reduction processes is not exactly one-to-one, but it is not far off. If there are minimal CO_2 emissions due to peat degradation, this means around 70% less land subsidence. According to current data, over the long term, peat degradation resulting from drainage is responsible for around 70% of land subsidence in rural areas (Schothorst, 1977; Den Haan & Kruse, 2006; Erkens et al., 2016), so substantially limiting peat degradation can reduce land subsidence by approximately 70% in the longer term.

Figure 6: Cumulative land subsidence at different rates



Contribution to solving other problems

A groundwater level of around 20 cm below ground level not only slows land subsidence and greenhouse gas emissions, but also helps in solving other problems. For example, the risk of flooding in such an area will decrease due to the lasting relatively high position; ecological damage and the loss of nature conservation areas will be limited; and there will be a significantly decreased risk of hydraulic soil failure and salinisation. If the higher water level is accompanied by an extensification of agriculture, with fewer cows per hectare, it can also contribute to reducing the nitrogen

problem, although nitrogen emissions related to cows currently kept in stalls are higher than those for grazing cattle. The risk of water damage to grassland and crops during very rainy periods will increase somewhat.

Customisation and differentiation

Although a water level of around 20 cm below ground level is the optimal level from the point of view of reducing greenhouse gas emissions, this does not mean that such a level is necessary or achievable everywhere. There must be room for differentiation, depending on the subsoil (e.g. soil type, hydrology) and on the demands for space in an area (land use: nature, agriculture, building, etc.). That will require customised solutions. For the Green Heart, this could mean that a large part of the peat meadow area will consist of wet grasslands, alongside a smaller share for crops suited to wet conditions, natural areas, water, etc. In 2019, the Provincial Advisors on Spatial Quality [*Provinciaal Adviseurs Ruimtelijke Kwaliteit*] (PARK) of the three Green Heart provinces outlined a similar vision for the area: a varied landscape with the best possible combinations of soil, water and land use (Roncken et al., 2019). The Council believes that a certain degree of rewetting forms the core of the strategy for dealing with land subsidence.[5]

5 Besides rewetting, there are other strategies for dealing with land subsidence in peatlands. For example, one could choose to let the subsidence continue until all the peat soil has disappeared. From the point of view of safety, ecology and water quality, and the risks of hydraulic soil failure, the Council believes that this is an undesirable strategy. If the Green Heart were ultimately transformed into a residential area, with many new lakes, the above-mentioned negative factors would have an impact in the intervening years and would result in high costs to society. The other extreme is a strategy that is focused on reversing land subsidence. This strategy concentrates on allowing peat to develop again, with the help of an increase in the water level. Peat growth is only possible with a water level that is above ground level (a water level of plus 10 cm is often cited). However, higher water levels can cause emissions of methane and nitrous oxide to increase. There are ways of dealing with this, but it is not easy.

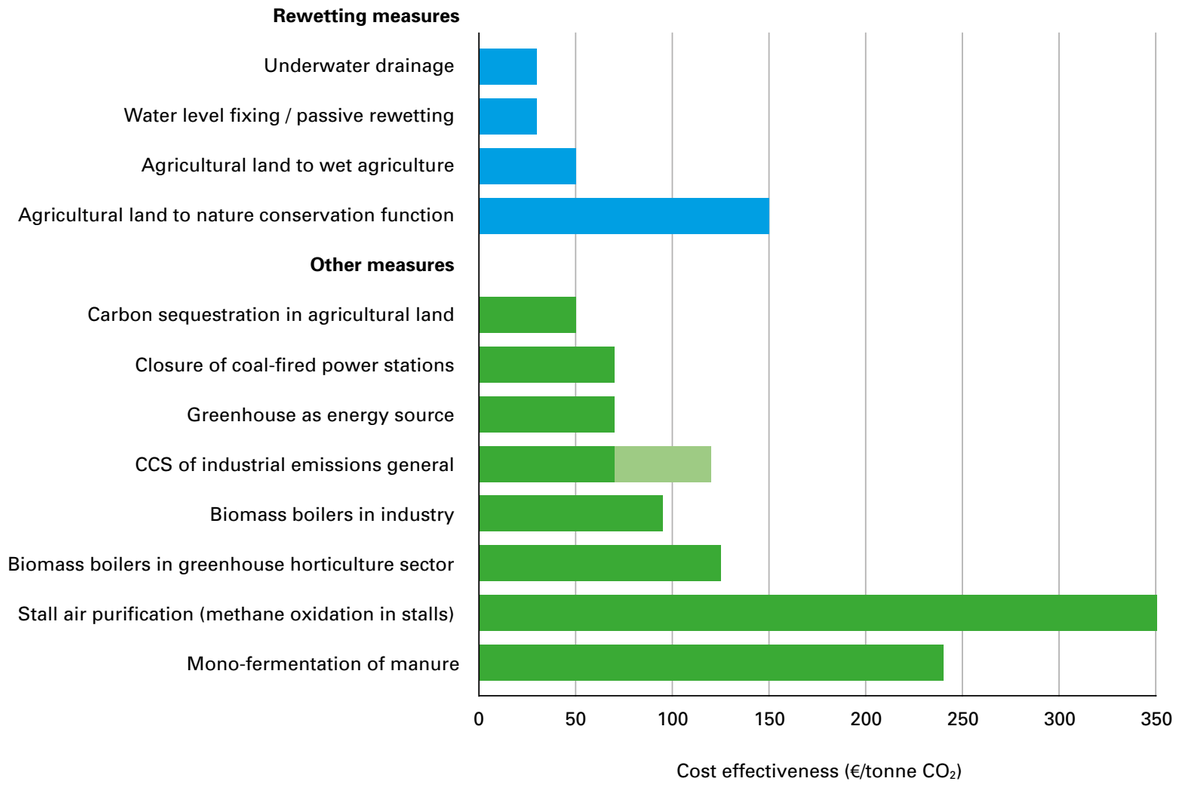
Cost-effectiveness

Opting for rewetting peat meadow areas as a strategy for reducing CO_2 emissions, among other things, can only be justified if cost-effectiveness is also considered. One must therefore answer the question of whether the same CO_2 reduction could not be achieved at a lower cost. Research shows that in general, rewetting measures are significantly cheaper than many other CO_2-reducing measures (Koelemeijer et al., 2018; see also House of Representatives [*Tweede Kamer*], 2019a). Figure 7 shows that measures for fixing the water level, underwater drainage and adapting agricultural land to wet agriculture cost less and are more effective (and are therefore more cost-effective) than measures such as the capture and underground storage of CO_2 (CCS)[6], biomass boilers in the greenhouse horticulture sector and mono-fermentation of manure.

It should be noted that rewetting of peat meadow areas cannot take place independently of the water authorities. This is because, in order to raise the water level, it is necessary for water authorities to review the existing water level decision in which the desired water level is laid down. An individual may then deviate from the water level decision under certain conditions. To this end, the individual has to apply to the relevant water authority for a permit for increased or decreased drainage in relation to the water level decision. Differences in the water level are therefore possible within one water level area, which is an area in which the water authority tries to maintain the same water level.

6 CCS stands for *Carbon Capture and Storage.*

Figure 7: Cost effectiveness of rewetting measures compared with some other measures



Source: Koelemeijer et al., 2018, p. 6-7

Break with tradition

Actively raising the water level to counter land subsidence is generally not yet the practice of water authorities, policymakers and farmers. Over the last centuries, the emphasis has been on further and better drainage.

This concentration on drainage became even stronger after World War II, with large-scale land consolidation among other things. This consolidation was needed in order to modernise agriculture and enable higher labour productivity and food production, and a higher income for farmers. The whole water system, agricultural system and government policy were organised accordingly. It is a huge step to abandon this focus on drainage and shift it to rewetting the soil to counter subsidence in peat meadow areas.

Conclusion:

A shift in thinking is necessary among water authorities, policymakers and farmers: from draining to rewetting peat meadow areas.

2.2 Farming on peat still possible, but changes needed

Possible consequences for operating profit

Increasing the water level can have consequences for agricultural businesses. Farmers are faced with the rewetting of their land, which can depress their operating profit. The consequences will not be the same for every farmer, but will depend on the soil type and other characteristics of the area concerned, and also on the water level of the land that is farmed. If that water level was originally fairly low, the damage caused by increasing the level will be more limited than if the water level was already relatively high. In the second case, the loss of income can be substantial (Daatselaar & Prins, 2020).

Box 5: Why does a higher water level bring extra costs for farmers?
When the water level is raised, dairy farmers on peat face higher costs if their business operations are unchanged. These costs mainly relate to the purchase of extra cattle feed, because the grass starts to grow later and the cows have to remain indoors for longer. In autumn and in wet weather, they also have to go indoors earlier. As the water level rises further, the costs also go up.

With unchanged operations, an increase in the water level from -1 metre to -80 cm does not cause extra costs; an increase from -80 cm to -60 cm costs farmers €87 per hectare; and a further step to -40 cm costs €312 per hectare, etc. (see Table 3 in Box 10). For an average-sized farm in the Green Heart with 50 hectares and an annual income of €50,000, the cost of €312 per hectare means a loss of income of more than a quarter (€15,000 per year). For dairy farmers who see their water level rise from -40 to -20 cm, the associated additional cost of €470 per hectare will nearly halve their income (Daatselaar & Prins, 2020).

Farming on peat on rewetted soil only feasible with adjustments
These figures call into question the possibility of farming on peat in the future if the water level is increased in order to counter land subsidence. It must, first of all, be emphasised that the alternative – peatlands without agricultural activities – is not a real option, according to the Council for the Environment and Infrastructure. Agriculture, and more specifically dairy farming, continues to be necessary for managing the human-made landscape. Transforming an area of land and managing it as a nature conservation area is simply too expensive, as can be seen in Figure 7 in the previous section (Koelemeijer et al., 2018). In addition, the peat meadow landscape that currently exists in the Netherlands, with its characteristic parcelling into grasslands, is highly valued internationally as a human-made landscape.

According to the Council, maintaining dairy farming on peatlands is not only desirable, but is also expected to be possible. Several ongoing pilots and experiments point in that direction (see Box 6). However, it will not be possible to continue farming on peat in the same way. Farmers will have to make changes to their operations if they want to farm profitably with a higher water level. One example is more extensive dairy farming with more land. After all, peat soils are still suitable for growing grass, even with a higher water level. However, farmers will need time to make the transition, because of ongoing investments in buildings and the development of alternative farming structures (extensification with more land, integration with nature, wetland crops, and energy generation). The pilots will have to indicate which business changes are the most profitable and in which situation. Over the longer term, it will have to be considered whether it is still profitable to farm with a water level of -20 cm with alternative business operations, or whether a different solution will need to be sought. In Chapter 3, the Council will argue that financial support for converting to alternative business practices is essential (see recommendation 3).

Box 6: Pilot 'Farming with high water', KTC Zegveld

On the high-water farm of KTC Zegveld (Knowledge Transfer Centre Zegveld), the groundwater level on a few plots has been raised to 20 cm below ground level, to see whether a profitable business model with dairy cattle is possible under such circumstances. What are the consequences for the soil, air and water? In addition to the water level, the pilot is looking at a variety of business factors, such as the livestock breed, the grazing system, nutrition and fertilising. Three breeds of cattle are being considered in order to establish which type of cow is most profitable with a high water level, and for one breed, the effect of the water level on technical and economic performance is studied.

Required changes to business operations

As has already been stated, a higher water level, resulting in marshier plots, requires changes to farming practices and investment in farming. Possibilities are:

- working with lighter machines and lighter-weight cattle
- bringing in cattle feed from outside to compensate for the lower grass yield
- extensification, with fewer cattle per hectare, possibly in combination with the purchase of more land
- switching to a new business model (e.g. wetland crops, circular model)
- and/or switching to complementary activities to earn additional income (leisure activities, healthcare provision, regional products, nature or energy).

The extent to which business operations need to be changed depends on factors such as the soil type, the water level prior to rewetting and the proximity of nature conservation areas. Differentiation is necessary and possible (see Section 3.1).

Box 7: Alternative business models on peat

In peat meadow areas, agricultural land consists mainly of grasslands. In the Green Heart, for example, the share is 75% of agricultural land (Buro Sant en Co & Fabrications, 2019). Various business models are possible with an increase in the water level, from adapted dairy farming to wetland crops, and/or income from solar farms, biomass production, nature and leisure.

In two studies for the Green Heart and Friesland (Buro Sant en Co & Fabrications, 2019; Countus, 2019), a number of alternative business models were calculated (land-based, nature-inclusive, circular, and 'green-blue' combining nature and grazing areas with bodies of water). These studies showed that there are various possible business models that are promising from a commercial point of view. However, subsidies are necessary for a profitable business model, as well as payment for services that benefit society, such as reducing land subsidence or cutting CO_2 emissions.

Prerequisites for new earnings models

Different earnings models are needed for a transition to new business models. The prerequisites for such earnings models will have to be present, such as a sales market and the availability of compensation payments. There is currently no structural sales market for alternative crops (paludiculture, such as cranberries or rushes), and a sales market will also have to be found for new regional products. In addition, studies for the Green Heart and Friesland show that 'new' business models, such as a circular or nature-inclusive business, can only be profitable if subsidies are provided and if there is remuneration for services to society, such as reducing land subsidence, CO_2 reduction or storage, water retention, improvements in water quality, and nature development (Buro Sant en Co & Fabrications, 2019; Countus, 2019). It is important for there to be more long-term certainty on these matters (see recommendation 3 in Chapter 3).

Conclusion:

It is possible to continue farming on peat with a higher water level, but changes to business operations are necessary in order to do so. There is uncertainty regarding the opportunities offered by new business models for generating revenue. New business models can be profitable, but to achieve this, subsidies and remuneration for new and existing services to society are needed.

2.3 Insufficient national direction for tackling land subsidence

The national government is currently not providing comprehensive direction for slowing land subsidence in peat meadow areas. The 'Werkgroep Brede Heroverweging' [Working Group for Broad-based Review] also recently drew attention to this: "There is currently no nationally coordinated approach to countering land subsidence." (2020, p. 9). This lack of a national approach is striking. After all, the Netherlands is one of the lowest-lying areas in the world and the sea level is rising. It is therefore disadvantageous for such a low-lying country to have to deal with land subsidence. Other countries do have a national or regional policy framework for land subsidence, such as Indonesia and areas of the United States and China, but the Netherlands does not (see Box 8).

Box 8: National approach to land subsidence in other countries

Indonesia

Indonesia has large peatland areas. Over recent decades, these have been reclaimed and drained on an increasingly large scale, which has damaged the peatlands and caused the soil to subside there. The drained – and therefore dryer – peat is also more flammable (Wösten, 2017). Extensive peat fires in 2015, which destroyed 875,000 hectares of land, prompted the government to take action. The reclamation of peatlands was forbidden and a national agency was established, specifically for maintaining and restoring the peatlands. This agency has developed a step-by-step plan to bring the fires, greenhouse gas emissions and land

subsidence in peatlands under control (UN Environment Programme, 2019).

United States
Due to dyke construction and land drainage, the marsh areas of the US state of Louisiana are drying out. This has resulted in land subsidence in the delta. To counter this process, in 2005 the state established by law the 'Coastal Protection and Restoration Authority' (CPRA). The CPRA's task is to draw up a 'masterplan' for the coast and to update it every six years. The plan is supposed to ensure coastal restoration and protection, including countering land subsidence, also looking ahead to the anticipated rise in sea level (CPRA, 2019).

China
Shanghai, the largest city in China, is located in the Yangtze delta. The region is facing serious land subsidence due to excessive groundwater extraction for household and industrial use. In 2012, in order to control land subsidence in the Yangtze delta, among other places, the Chinese government established a national programme for the prevention and management of land subsidence for 2011-2020. Within the programme, targets have been set for reducing the speed of land subsidence in critical areas, and networks are being created to monitor subsidence (Ye et al., 2016).

National direction currently only addresses aspects of the problem
Although the national government is not providing comprehensive direction for reducing land subsidence, there is government policy aimed at aspects of the problem. Ministers take action based on their own policy responsibilities (see letter to Parliament 'Rijksbrede aanpak Bodemdaling' [*Government-wide approach to land subsidence*], Tweede Kamer, 2019c).[7] An important element is government policy focused on CO_2 reduction, which also implicitly contains a target for land subsidence reduction (see Section 2.1).

The National Climate Agreement concluded by the Dutch public authorities, the business community and civil society organisations in 2019 shows that rewetting peat meadow areas is an important track that the Netherlands is following in order to achieve a reduction in CO_2 emissions. Elements include underwater drainage, an increase in the summer water level for the benefit of meadow birds, a transition to wetland crops and a switch to agricultural nature, including sphagnum moss growth (Tweede Kamer, 2019b). In the case of rewetting peat meadow areas, the relationship with other policy goals, including nature conservation goals, is also considered. However, according to the Council, this comprehensive view of the connection between tasks could and should be given greater emphasis, also with a view to the long term. This is because once land subsidence is brought under control, there will still be societal challenges that require

7 Contrary to common perception, land subsidence barely features in the national government's Delta Programme (2019). Land subsidence is only addressed indirectly in the section on spatial adaptation, which mentions local stress tests and the aim of a climate-proof soil and surface water system.

attention. The water supply, for example, also needs to be regulated in a structural manner, and flood protection, too, is a persistent cause of concern.

Importance of having a long-term perspective

It is important for interested parties to have a clear picture of the consequences of land subsidence and understand what the long-term targets for countering subsidence could mean for them. Parties in peat meadow areas often lack such a clear picture. For example, is it possible for farmers to continue running their dairy farms in peat meadow areas without any changes? Or will rewetting the area make this increasingly difficult and expensive over the years? The uncertainty on this subject makes it almost impossible for farmers to take investment decisions, even within one generation.

Other parties in peatland areas, such as water authorities, also have an interest in clarity regarding developments. In accordance with their legal duty, water authorities make water level decisions, in which they take the different activities in the area and the requirements of the water system into consideration. In this process, water authorities have some room for manoeuvre, but it is limited. They are subject to the spatial planning choices of provincial policy. This can mean that water authorities will continue to invest for years in infrastructure for lowering the water level, even though this could later turn out to be an unprofitable investment. A national policy framework could help local and regional authorities to legitimise the necessary – and sometimes difficult – decisions on how to tackle land subsidence. National targets for land subsidence and water management give local and regional authorities 'backing' for their own policy changes (De Putter, 2016).

Importance of connecting land subsidence reduction with other challenges

Solutions for dealing with land subsidence often coincide with solutions to other challenges, such as tasks relating to the climate and the natural environment. For example, the problem of nitrogen will in many cases be improved when the problem of land subsidence is being dealt with, and vice versa. Both tasks benefit from the extensification of agriculture. At the same time, the natural environment also benefits from land subsidence being countered through rewetting and extensification. Nature conservation areas are then less affected by groundwater flowing away to lower-lying polders. Biodiversity is also helped by wetter and more extensive agriculture with less fertiliser and a different mowing system. In turn, nature conservation subsidies, such as those for agricultural nature management, can help facilitate the reduction of land subsidence. Other areas where there are opportunities to combine approaches to challenges are energy transition, water quality and flood protection.

Because of the lack of a government policy framework for land subsidence, opportunities can be missed for such a cross-sector approach to tackling land subsidence, which can benefit shared interests. Although an integrated approach is not a goal in itself for the Council (it is not necessary for everything to be linked to everything else, as this can sometimes actually hamper implementation), an integrated perspective for land subsidence

does make it possible to identify these synergies (Rli, 2019a). Once synergies between challenges and solutions have been identified at national level, they can be elaborated into plans at regional and local level.

A transition takes time

It is not possible to reduce land subsidence in peat meadow areas from one day to the next. This is because processes in the soil and the water system move slowly, so that the effects of interventions can only be seen over the long term. This has to be taken into account in the solutions. Moreover, parties in the area need time to prepare and adapt. This applies to the farmers in the area, but equally to the water authorities, which have to adjust their policy and water level decisions. Working with 'transition paths' can be helpful for this purpose: a path that describes the changes in the short term and a path for changes over the long term.

Conclusion:

There is a need for a national policy framework for 'Land subsidence in peat meadow areas'. This policy framework must not only focus on reducing land subsidence, but must also be alert to its relationship with other challenges. The policy framework should also contain 'transition paths' that describe the changes over the short and long term. This provides parties with clarity about the direction of developments in peat meadow areas and gives backing to local and regional authorities in their policy decisions.

2.4 Implementation: top-down and bottom-up approach do not reinforce each other

Multitude of projects and pilots: competition for attention in policy and funding

In the Green Heart there are countless ongoing projects and pilots initiated by policy programmes and knowledge projects in the area of land subsidence. Many of the initiatives focus on subareas or sectoral issues. To give an impression of the 'multitude' of existing pilots and of their sector-based character, the map provided shows the projects and pilots of various government programmes, some of them involving different tiers of government, in the Green Heart (see Figure 8). Ongoing pilots of provinces or knowledge programmes are not included on the map.

The fact that many of the pilots focus on individual sectoral issues is connected with the current fragmentation of administrative responsibility for land subsidence across five departments.[8] The multitude of pilots and projects heightens complexity in the areas. The countless different pilots compete with each other for attention from policymakers and financial support.

8 These are: (1) the Ministry of Agriculture, Nature and Food Quality (LNV); (2) the Ministry of the Interior and Kingdom Relations (BZK); (3) the Ministry of Infrastructure and Water Management (IenW); (4) the Ministry of Education, Culture and Science (OCW); and (5) the Ministry of Economic Affairs and Climate Policy (EZK).

Figure 8: Government programmes for the Green Heart

Inter-administrative Programme (IBP) Living Countryside: Holland-Utrecht Peat Meadow Area

Focus on sustainable agriculture

1 Groot Wilnis Vinkeveen: future perspective in the polder.

2 Panorama Krimpenerwaard: area dialogue for approach to land subsidence, combined with energy transition and landscape management.

3 Kagerplassen: countering land subsidence with three strategies.

4 'De Tol Toekomstbestendig' (Kamerik): climate-adaptive pumping area.

5 Herbaceous grassland and new water management methods to counter land subsidence [*Groene Cirkel Kaas*].

6 Calculate social costs and benefits of measures aimed at biodiversity and land subsidence.

Regional Deal land subsidence in the Green Heart

Focus on land subsidence

7 Updating and extending Zegveld monitoring network.

8 Living lab farmers on high water, Zegveld.

9 Restveengebied (Residual peat area) Zuidplaspolder: transition from agriculture to nature conservation area.

10 Veen, voer en verder II Zegveld [*Peat, feed and further II Zegveld*]: field experiment wetland crops.

11 Peat Meadow Innovation Centre Zegveld.

12 Living lab Trots op de Krimpenerwaard [*Proud of the Krimpenerwaard*].

13 Dialogue on transition task for area susceptible to land subsidence.

14 Funding arrangement for rewetting peat.

15 Rush, certification for market opportunities.

16 Designing long-term perspective.

17 Peat farmers in movement: energy landscapes.

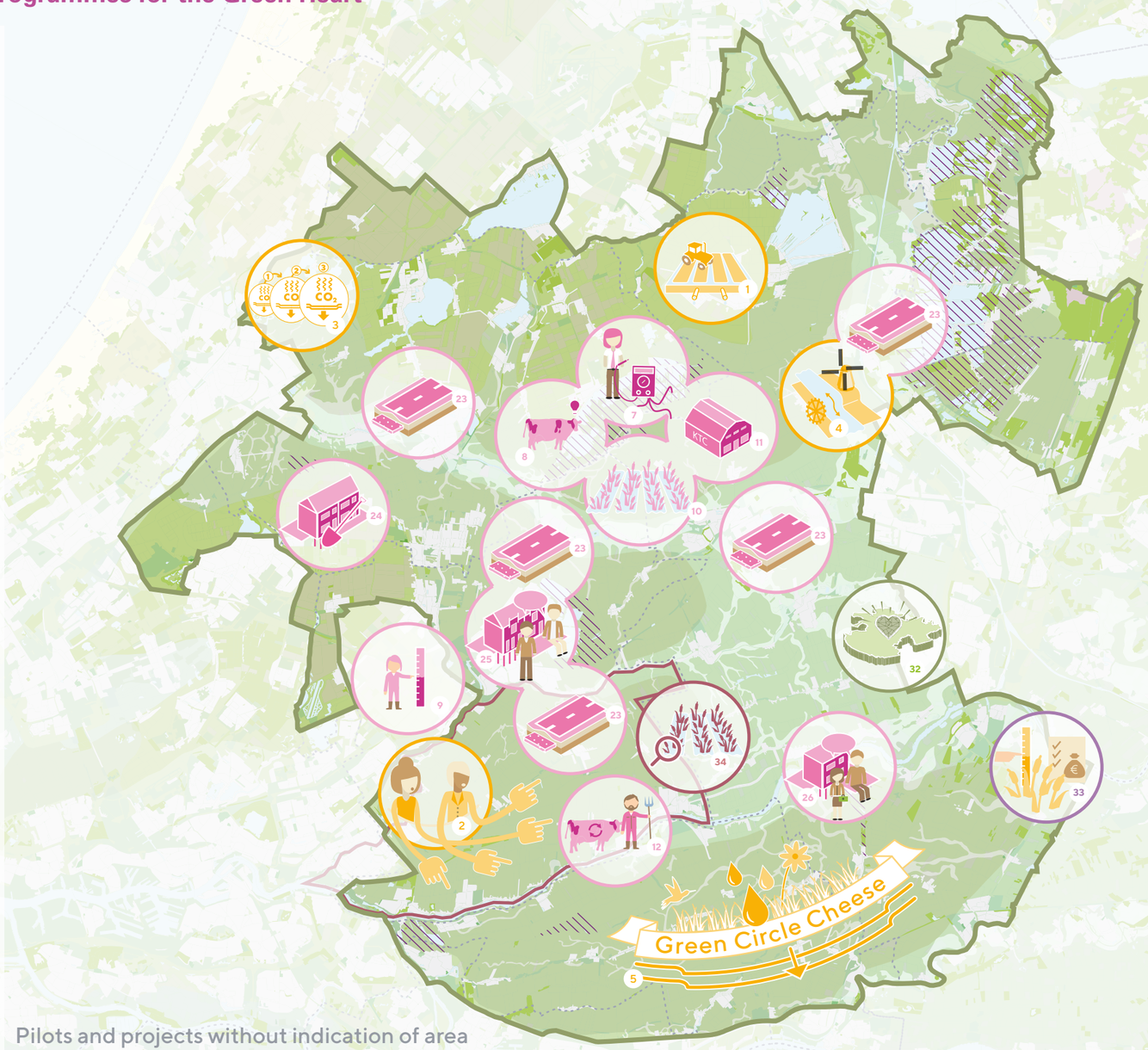
18 Various research projects for Nationaal Kennis-programma Bodemdaling [*National Knowledge Programme for Land Subsidence*].

19 Mapping land subsidence and looking into the soil.

20 Nationaal kennis- en belevingscentrum bodemdaling [*National knowledge and experience centre for land subsidence*].

21 Forecasting land subsidence and subsoil model Green Heart.

22 Mobile information centre on land subsidence.



Pilots and projects without indication of area

6

13-17

18-22

27-31

23 Expansion and monitoring of trial plots on soft soil.

24 Improvement of foundation problem Tuinstraat Hazerswoude-Dorp: approach.

25 Improvement of foundation problem 19th-century Gouda ring: communication.

26 Improvement of foundation problem of De Stichtse Rijnlanden Water Authority (HDSR): communication.

27 Combining life-cycle costs approach and land development in new building.

28 Floating construction 2.0.

29 Feasibility study mass stabilisation of infrastructure on soft soil.

30 Service life EPS (polystyrene) for infrastructure on soft soil.

31 Toolbox land subsidence historical towns.

OUR Landscape

Focus on landscape

32 Green Heart valuable landscape to be protected in design-NOVI.

Boundaries of Green Heart.

Climate Agreement

Focus on CO_2 emissions

33 Impetus for dealing with peat meadows; various pilots (raising water level, underwater drainage and different crops); rollout of measures (mix of measures); and development of earnings models.

Agricultural nature and other nature conservation measures related to Natura 2000 areas.

Regional Energy Strategy

Focus on energy

RES areas.

CRa (Board of Government Advisors) agriculture pilots

Focus: ruimte, ecologie & landbouw

34 Design-based research on agriculture that gives space for nature and landscape in the Krimpenerwaard.

Boundaries of Krimpenerwaard.

Landscape units

Water
River area (with peat layer)
Lowland peat area
Reclaimed land
Woodland
Urban area
Levee/alluvial ridge

N
0 2,5 5 km

Source GIS data: TOP10NL, Geoservices Prov. Zuid-Holland, Geodatabeheer Ministerie van LNV and Rijksdienst voor het Cultureel Erfgoed

Area-based tailored solutions essential

When implementing policy to counter land subsidence, tailored solutions that focus on specific areas are of great importance. This is because there are significant differences between peatlands, for example in their soil composition, water management and land use. It is not surprising that the Provincial Advisors for Spatial Quality have called for 'twenty shades of green' (Roncken et al., 2019). The rich range of soil profiles requires different individual measures and diverse forms of vegetation and land use. For example, when the water level is lowered, a thick peat layer goes down faster than soil consisting of a layer of clay on peat. Most knowledge about this is available in the areas themselves. In addition, area-based tailored solutions are important due to the various questions on spatial planning and land use in the area – questions about what one wants to achieve with regard to residential development, leisure activities, energy generation, and agriculture. The issue is therefore not just one of dependence on the soil type, but also the question of how the limited space in the area is to be used in the best possible way for society.

Link between bottom-up and top-down direction lacking

Although it is important, area-based work alone is insufficient for various reasons. In many cases, an area-based approach to tackling land subsidence lacks a supraregional administrative assessment. Choices in one area can have consequences and unwanted or unforeseen effects in another area. Take, for example, the dilemma posed by the decision to slow land subsidence in peatland, which can be damaging for nearby reclaimed land ('deep polders'). Raising the water level increases the pressure of the groundwater in these polders, with all the associated risks of hydraulic soil failure and boils (Deltares et al., 2018; Deltares, 2019). Or take the issue of the water supply in a dryer climate. Rewetting peat meadow areas can require a supply of fresh water from elsewhere to raise the water level. It must be ensured that this does not cause problems in the – possibly drier – area that is supplying the water. It therefore helps in solving geographical problems such as land subsidence if supraregional bodies also consider the matter from a spatial point of view. Top-down and bottom-up direction need to reinforce each other, but this is currently often not the case.

In addition, there is the question of whether far-reaching choices can be made at the local level. After all, a local community has strong bonds with the existing situation, the existing landscape and existing interests. Major differences in the perception of the problem and of the desired solution bring the risk that people will fail to agree locally and that progress will remain limited (Veerman, 2019). Where necessary, choices will have to be made at a higher decision-making level (province, national government). Local decision making about the future of an area can also be made more complicated if the area concerned is very large and not well-connected internally. In both situations, it is helpful if area-based tailored solutions are facilitated by clear frameworks at a higher administrative level of scale. The basic principle must be 'local where possible, supralocal where necessary'.

Lack of coherent implementation apparatus

Reducing land subsidence in peat meadow areas also requires properly functioning implementation capacity. In recent years, part of this capacity

for implementation has disappeared and another part has become fragmented among various different bodies. The Rural Areas Department (DLG) was dissolved in 2015 and its tasks were transferred to the provinces and the Netherlands Enterprise Agency (RVO). DLG staff left for other organisations, such as the provincial authorities and water authorities. The DLG dealt with purchasing land, restructuring it, and advising on its management and the transfer to organisations and farmers that manage areas of land. These tasks are now the responsibility of the provinces and the RVO, and have therefore become fragmented. A coherent implementation apparatus is a key condition for starting effective efforts to curb land subsidence in peat meadow areas.

Conclusion:

To achieve an effective reduction in land subsidence after the pilot phase, an area-based approach is necessary, with supplementary supraregional direction. It is additionally important for there to be a sound and coherent implementation apparatus.

2.5 Funding: costs and benefits of land subsidence and the price of CO_2

Cost flows: the elephant in the room

A major obstacle to implementing the approach to land subsidence is the matter of cost. It is known in general what the costs will be, but it is not known what they will look like in detail and what the costs will be, for example, of the complete redevelopment project involving rewetting a peat meadow area such as the Green Heart. In addition, little is known about the composition of the current cost flows and who pays for what. In 2016, research by the PBL provided a first indication of the expected costs of land subsidence (PBL, 2016). This revealed enormous sums: around €2 billion for damage to infrastructure and foundations in the rural area and as much as €21 billion for the urban area up to 2050. The PBL estimated the extra water management costs in rural areas of continuing land subsidence at €200 million up to 2050. This last amount is a relatively cautious estimate. Box 9 shows that the costs of raising the quays and flood defences could rise sharply up to 2050.

Many of the professionals with whom the Council has spoken have pointed out that the high (and still partially unknown) costs are an important reason for the deadlock in which efforts to tackle land subsidence have been for years. The high costs ensure that nobody wants to take the risk of tackling land subsidence. Particularly at the national government level, there is a fear of taking on the administrative responsibility. This hinders the actual implementation of reductions in land subsidence.

Box 9: Estimate of increase in water management costs with continuing land subsidence (2021-2050)

The committee that has compiled this advisory report did a ‘warm-up’ exercise to gain a clearer picture of water management costs in rural peatlands. Based on key figures for increasing the height of quays and the number of kilometres of secondary quays and flood defences in the rural

peatland area, it is possible to estimate the costs of raising the quays and flood defences in water authority areas in a situation of continuing land subsidence. There are thousands of kilometres of quays and secondary flood defences in the rural peat meadow area.[9] These quays and flood defences are raised by 30 cm at a time, so that with land subsidence of 1 cm per year, this will have to be done around once every 30 years. Assuming that all quays and flood defences are raised once, it is possible to calculate the costs of this work. If one assumes a cost of around €400,000 per kilometre to raise an unpaved quay by 30 cm, this gives a minimum total cost of €1 billion for the coming 30 years.[10] This is significantly higher than the 200 million estimated by the PBL for the period to 2050. This rough indicative result is grounds for follow-up research.

Components of the costs and benefits of land subsidence in rural peat meadow areas

As previously mentioned, the approximate costs of land subsidence are known to a certain extent, but the total picture of costs and benefits is still incomplete. However, the individual components of the costs and benefits can be identified. Tables 1 and 2 below give an overview of the key costs and benefits included in the various cost-benefit analyses for peat meadow areas, for two strategies: continuing in the same way (continuing current water level management) and slowing land subsidence (rewetting the soil). What is striking is that in the strategy of 'continuing in the same way', it is agriculture that mainly reaps the benefits. For 'slowing land subsidence', the result is the exact opposite.

Table 1: Costs and benefits of continuing in the same way[11]

Costs	Benefits
Damage to buildings and infrastructure - Foundation damage to homes - Settlement damage to roads, sewage pipes, cables and pipelines	Agriculture - Revenue livestock/crop - Land value
Water system - Construction (quays, dykes, weirs) - Management and maintenance	
Greenhouse gas emissions (CO_2, methane, nitrous oxide)	
Decline in biodiversity/natural values	
Decline in water quality	
Amenity value, cultural heritage & archaeology	

9 Starting from a rough estimate based on the total number of kilometres of regional flood defences in the Netherlands (Dutch Water Authorities et al., 2016) and the proportion of them that stand on peat or peaty soil. This is at least 2,500 kilometres (because there are comparatively more quays and flood defences on peat, this is expected to be the lower limit).

10 The figure of €400,000 per kilometre to be raised is used by Deltares in its own studies and comes from water authority practice. This figure is a lower limit: it largely concerns unpaved quays, without the use of sheet piling (which is sometimes necessary). A share of these costs comes under regular maintenance, but exactly what share still has to be determined.

11 This table is based on various studies of costs and benefits of land subsidence in the peat meadow areas, for example: the study 'Dalende bodems, stijgende kosten' (PBL, 2016); the SCBA 'Remming bodemdaling Friese veenweiden' (Witteveen+Bos, 2019); study 'Knikpunten watersysteem Restveengebied Zuidplaspolder' (RoyalHaskoningDHV, 2014); and the SCBA 'Reeuwijk West en Polder Middelburg en Tempelpolder' (Hoogheemraadschap van Rijnland, 2016).

Table 2: Costs and benefits of slowing land subsidence[12]

Costs	Benefits
Agriculture - Revenue loss livestock/crop - Land value - Costs of converting business operations and/or technical measures such as drainage	Damage avoided to buildings and infrastructure - Foundation damage to homes - Settlement damage to roads, sewage pipes, cables and pipelines[13]
	Water system costs avoided - Construction (quays, dykes, weirs) - Management and maintenance
	Costs of greenhouse gas emissions avoided
	Biodiversity/natural values
	Water quality
	Amenity value, cultural heritage & archaeology[14]

Banks cautious about offering necessary prefinancing

To date, banks have had very little involvement in the problem of land subsidence, barring rare exceptions. In practice, this is seen as a hindrance, as pre-investment is needed for many measures aimed at countering land subsidence. Banks are in no way always prepared to take on that prefinancing. This reluctance is based on the risk of capital destruction (due to an uncertain return on investment) and of a fall in land value (e.g. due to the switch to wetland crops). However, there are now pilots in which banks are involved, such as the Green Circle in the Green Heart. In this pilot, a bank gives farmers the opportunity to invest in equipment for precision pumping in each plot (pumps and drainage).

CO_2 emissions as problem *and* contribution to solution: CO_2 emissions will bring costs

As explained earlier in this report, peat oxidation is a source of CO_2 emissions. Targets for the reduction of CO_2 emissions were agreed in the National Climate Agreement. The agreements concern not only emissions from peat meadow areas, but also those from other sources (industry, traffic, etc.). As a result of these agreements, emissions of CO_2 have become a cost item, including a cost to society. Particularly for polluting industrial companies, there is a price tag attached to CO_2 emissions. The price they have to pay for their emissions is determined by the system for trading CO_2 emissions, or ETS system.[15] In 2019 the CO_2 price for industrial companies in the ETS system was around €22 per tonne of CO_2 equivalent. CO_2 rights are expected to be worth more in the future. Polluting companies that are unable to reduce their emissions enough or quickly enough will be prepared to pay increasing amounts for those emissions. The prognosis is that the price will rise to around €50 in 2030 (PBL, 2019). Others consider

12 Ibid.
13 However: see also footnote 4 in Chapter 1.
14 Amenity value, cultural history and archaeology are on the benefits side of the 'slowing land subsidence' strategy. This is in line with the way many cost-benefit studies of land subsidence deal with them. If the water level drops less, this has a positive effect on, among other things, the conservation of wooden and other archaeological objects in the soil and the preservation of farms that are historical monuments. It can lead to a different landscape, but it is not known whether it also leads to a different appreciation of the landscape.
15 ETS stands for: *emissions trading system.*

the possibility of a higher CO_2 price, such as Witteveen+Bos (2019) and the IPCC (2018).[16]

Research shows that, at a CO_2 price of €40 per tonne, it is already of interest to society to rewet agricultural land in a peat meadow area up to a water level of 40 cm below ground level (Daatselaar & Prins, 2020). The costs of avoided emissions of greenhouse gases are then approximately equal to their economic value (the revenue from CO_2 rights). And this does not take into account avoided costs resulting from, for example, damage to infrastructure (due to subsidence) or benefits from nature conservation. If these avoided costs and extra benefits were also considered, or if the CO_2 price were to rise to €58, further rewetting to -20 cm would become economically attractive (see Box 10).

Box 10: Economic tipping point for CO_2 reduction in the Green Heart

Wageningen Economic Research (WEcR) has found out for the RIi the effects on CO_2 emissions of rewetting in the Green Heart (Daatselaar & Prins, 2020). Every 20-cm step in rewetting saves around 8 tonnes of CO_2 emissions per hectare. The social costs that are avoided in this way increase with every 20-cm step in rewetting; see Table 3. With a rise in the water level from -1 m to -80 cm, the costs are negligible.

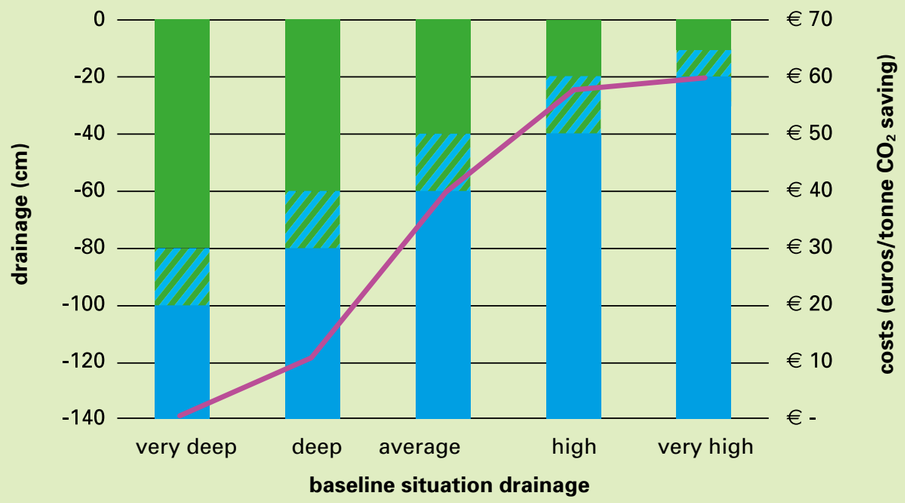
Thereafter, the costs increase. If, in a few years' time, the price of CO_2 emission rights has reached €40 per tonne, an interesting situation will arise. At a water level increase from -60 cm to -40 cm, CO_2 reduction in a large part of the Green Heart will then cost less than or around the same amount as it provides. If other avoided costs were also considered, or if the CO_2 price were to rise to €58, further rewetting to -20 cm would become economically attractive. A water level of -20 cm is the level at which greenhouse gas emissions are at a minimum, while the human-made landscape and dairy farming are preserved. A social cost-benefit analysis should also include the costs of change (investment costs).

Table 3: Effect on CO_2 emissions and estimated extra costs per tonne of CO_2 saving with a 20-cm reduction in drainage in the Green Heart with different baseline situations

	-100 → -80 cm	-80 → -60 cm	-60 → -40 cm	-40 → -20 cm	-30 → -10 cm
Share of surface water levels in the Green Heart	12%	10%	28%	43%	7%
Effect on CO_2 emissions (1,000 kg/ha)	-8,0	-8,0	-8,0	-8,1	-8,2
Cost effect (euro/ha)	€ 0	€ 87	€ 312	€ 470	€ 489
Cost effect (euro/tonne CO_2 saving)	€ 0	€ 11	€ 39	€ 58	€ 60

16 In its 2018 report (*'Global warming of 1.5 °C'*), IPCC already referred to the big differences in the expected value of CO_2 equivalents in different scenarios and according to different models. The report mentions amounts ranging from a few tens of euros to thousands of euros in 2030. Witteveen+Bos (2019) mentioned a price of €100 per tonne of CO_2 equivalents by 2120 as an average of a high and a low economic growth scenario, derived from Aalbers et al. (2016).

Figure 9: Costs per tonne of CO_2 saving with reduced drainage of 20 cm with different baseline situations



Costs and benefits may be in equilibrium from the point of view of society, but they are not yet balanced at the level of the actors. The benefits of rewetting peat meadow areas, in the form of avoided CO_2 emissions, come to the government, and by extension to the taxpayer. The reduction in CO_2 emissions achieved through rewetting contributes toward reaching the goals of the National Climate Agreement and the Climate Act. The costs of rewetting are for the account of the dairy farmer, who incurs higher costs for his business operations and sees his income decline.

A follow-up question is therefore who is going to pay the costs: the farmers themselves, the Ministry of Finance (i.e. the taxpayers) by means of a subsidy, or polluting companies in industry by means of a trading system? If farmers were paid for the reduction in CO_2 emissions achieved through the rewetting of farmland, CO_2 reduction would become a financial resource that could help in initiating change in the peat meadow areas.

According to the Council, it is obvious that not all of the reduction in CO_2 emissions should be paid for, but only that part of CO_2 reduction that is on top of the existing reduction obligations of the agricultural sector under the climate agreements. This is explained in greater detail in Chapter 3 of this advisory report. A second question is how the funding of additional CO_2 reduction can best be organised. This is also explained in Chapter 3.

Conclusion:

In order to implement an approach to land subsidence, it is essential to have an understanding of the costs and benefits of land subsidence and of who pays for what. Because CO_2 emissions cause costs to society and also come at a cost to polluting companies, CO_2 can contribute toward accelerating action against land subsidence.

2.6 Knowledge: shortage, fragmentation and excuse

Lack of knowledge

For a long time, countering land subsidence did not feature on the political agenda in the Netherlands. Attention was mainly directed at dewatering, that is to say adapting to land subsidence (adaptation). Countering land subsidence (mitigation) was much less in the spotlight. As a result, the Netherlands is at a relative disadvantage with respect to knowledge about land subsidence, both when compared with other topics (e.g. sea level rise and climate adaptation), and with other countries (e.g. China). The lack of knowledge mainly relates to the long-term effects of interventions that reduce land subsidence and the interactions between those effects (for an example, see Box 11). It is therefore important to acquire specific, relevant knowledge.

Box 11: Underwater drainage disputed

Underwater drainage is a technical measure to curb land subsidence. In underwater drainage, a system of pipes is installed below ground level. In wetter periods, underwater drainage leads to better dewatering of the land. In drier periods, water is infiltrated into the plot via the drains to prevent the groundwater level from becoming too low. As a result, the peat dries out less, CO_2 emissions are reduced and agricultural production is maintained. Constructing underwater drainage requires investment. On the other hand, the expected yields are higher due to longer grazing and less drought damage or wetting damage.

Science is still not clear about the effectiveness and the long-term effects of the 'underwater drainage' measure. Underwater drainage can be a relatively good measure to enable farming to continue in spite of a higher water level. However, this intervention only postpones developments and is not a definitive solution to the problem. Underwater drainage does limit peat degradation (and therefore CO_2 emissions), but it does not completely stop land subsidence. After a few decades, the drainage pipes will once again be lying close to the surface water level and will lose their purpose. These systems therefore have a limited service life. Moreover, it is not yet clear how effective underwater drainage is with different peat depths, soil types and surface water levels, nor is it known by exactly how much CO_2 emissions are reduced (see, for example, Grootjans et al., 2019; Smolders et al., 2019; Van den Akker et al., 2018; Middel & Noordhoff, 2020). The PBL also recognises the existence of gaps in knowledge about the effectiveness of underwater drainage (Hekkenberg & Koelemeijer, 2018).

Knowledge fragmentation

In the Netherlands, most of the time knowledge about subsidence is being developed in separate knowledge programmes, such as the knowledge projects of the Regional Deal on land subsidence in the Green Heart, the research of the Dutch National Research Agenda Living on Soft Soil (LOS), Diep NL (about soil movement in Groningen), and knowledge projects at the Peat Meadow Innovation Centre (VIC). This fragmentation brings the risk of people reinventing the wheel over and over again because

of the multitude of local studies and pilots. Moreover, these are usually short knowledge programmes of around three to five years, whereas there is a need for an easily accessible, structural knowledge base. There is already a National Knowledge Programme for Land Subsidence, but it currently functions primarily as a network programme and does not itself develop the necessary knowledge. A structural knowledge base is also relevant in relation to what the post-2030 strategy should be, as the Climate Agreement does not go much further than that year. The start of the National Research Programme for Greenhouse Gases in Peatlands [*Nationaal Onderzoeksprogramma Broeikasgassen Veenweiden*] (NOBV) in 2019 was a good step towards a more structural knowledge base. This national research programme, financed with climate funding, studies and monitors the effectiveness of various measures against peat degradation at five measuring points in peat meadow areas in the Netherlands.

Need for knowledge as an excuse

Because the consequences of reducing land subsidence are not fully understood, it is difficult to make good policy choices. The response to this is often to avoid taking far-reaching decisions on the best approach by taking refuge in planning yet more research. It is important for the way knowledge is dealt with to change over time and also for knowledge already acquired to be more frequently applied and used.

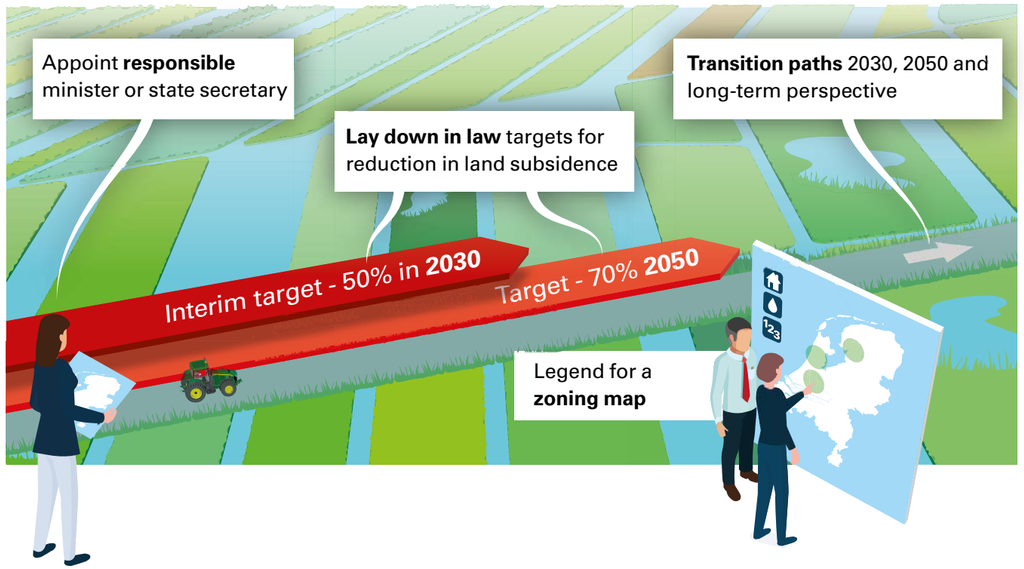
Conclusion:

There is a need for more knowledge and for a structural and less fragmented knowledge base. The way knowledge is dealt with is currently not optimal. The reflex reaction of 'taking refuge' in the planning of extra research should give way to applying and using knowledge.

3 RECOMMENDATIONS

Based on the findings and conclusions of the previous chapter, the Council for the Environment and Infrastructure has formulated four specific recommendations. Three of these are directed at the national government and one at the regional parties involved in tackling land subsidence. The recommendations relate successively to a national policy framework, implementation, funding, and knowledge.

3.1 Specific direction for reducing land subsidence based on national policy framework



Recommendation 1 – to the national government:
Provide clear direction on reducing land subsidence and set an indicative target of 70% reduction in land subsidence in rural peatlands by 2050, with an interim target of 50% by 2030, as part of a national policy framework on land subsidence.

The Council believes that a national target for reducing land subsidence is essential for all rural peat meadow areas, in order to provide clarity for all the parties involved in land subsidence in peat meadow areas. Such a target gives direction and ensures that stakeholders know where they stand. Farmers can use this to select the investments to make in their business operations and, if necessary, switch to a different business model in time. Water authorities can work towards the new situation and adjust their policy and investments accordingly. The same applies to provinces and municipalities.

70% reduction in land subsidence by 2050, 50% subsidence reduction by 2030

The Council advises the Dutch government to set a national goal for reducing land subsidence in peat meadow areas: an indicative target of 70% by 2050 and a mandatory interim target of 50% by 2030. These targets should be laid down in regulations based on the Environment and Planning Act.

In determining the level of ambition of the national goal for reducing land subsidence in rural peat meadow areas, the Council seeks alignment with the goals of the Dutch Climate Act. The Climate Act stipulates that in 2050, greenhouse gas emissions must be 95% lower than in 1990. As explained in Chapter 2, cutting CO_2 emissions is inextricably linked to reducing land subsidence. A 95% cut in CO_2 by 2050 is more or less equal to a reduction of around 70% in land subsidence in rural peat meadow areas. In that situation, there is hardly any peat degradation anymore and therefore virtually no CO_2 emissions. The target of a 50% reduction in land subsidence by 2030 is in line with targets for land subsidence reduction that some water authorities and provinces in the Green Heart are already

working with.[17] It is expected that this will allow the Netherlands to meet the requirement in the National Climate Agreement of a one-megatonne reduction in CO_2 emissions in peatlands by 2030.

According to current understanding, a 70% reduction in land subsidence in peatlands by 2050 is achievable at a groundwater level of around 20 cm below ground level. However, there is still some uncertainty as to the possibility of profitable agricultural business operations at such a water level (see also Section 2.2). For this reason, the Council advocates an indicative target to be aimed for in 2050.[18] This gives time for further research in the coming years to determine whether profitable farming is possible at a water level of -20 cm, and whether structural additional resources, such as subsidies, are needed. Over the next few years, the development of dairy farming more generally will also become clearer. Using this new information, it will then be possible in 2030 to lay down by law the definitive target for the reduction in land subsidence by 2050.

If rewetting were complemented with optimum water level management and optimum land use (among other things through a decreased load on the soil from livestock and vehicles), it would even be possible to reduce land subsidence by 90%. In this situation, emissions of greenhouse gases (CO_2, methane and nitrous oxide) would be as low as possible (see Box 4 in Chapter 2). However, 90% is a tough challenge, which can only be achieved with a great effort. On their own initiative, ambitious regions can drive up their land subsidence reduction to 80 or 90% through optimum land use and water level management.

The demanding goal of a reduction in land subsidence of at least 70% by 2050 means that the transition has to be completed within one generation of farmers. The Council notes that this is a significant challenge. The use of an interim target for 2030 clearly shows that parties have to start adapting now and that the shift in thinking has to be made now. In this context, the expectation that the CO_2 price will rise over the coming years (see Section 2.5) is beneficial. It will make solutions for countering land subsidence increasingly affordable.

The Council wishes to underline once again that the level of 70% for a reduction in land subsidence by 2050 is directly derived from the agreements in the Paris Climate Agreement and the goal of the Dutch Climate Act. In the Council's opinion, it is important to be explicit in making this link – something that is still not done often enough. This clear message highlights the scope and severity of the challenge of land subsidence.

Attention to local differences: land subsidence of a maximum 3 mm per year

To take account of local differences, because the land is not subsiding as quickly everywhere, the Council advocates an addition to the national

17 The target of a 50% reduction in land subsidence by 2030 corresponds to the target for a reduction in land subsidence of the Hoogheemraadschap De Stichtse Rijnlanden water authority (HDSR, 2019) and the Province of Utrecht (Provincie Utrecht, 2019).

18 The reference year or period in relation to which the target for land subsidence reduction applies still has to be considered. There are a number of options for this. For example, one could choose a reduction in land subsidence in relation to the current rate or in relation to the rate of subsidence in the 2005-2009 period. The latter is the reference period in the European LULUCF regulation for CO_2 emissions in peatlands.

target. In places where there is little land subsidence (e.g. due to a thin layer of peat or a relatively high groundwater level), a 70% reduction in land subsidence would require a disproportionate effort and investment. In other words, a water level of -20 cm is not achievable or not necessary everywhere. For this reason, the Council advocates adding a phrase to the national target which does reflect local variation: a 70% reduction *until land subsidence of a maximum of 3 mm per year has been achieved*. The target is therefore not – or no longer – applicable once an area subsides by less than 3 mm per year. Such an area will then have met the national target for land subsidence. However, this does not preclude peat degradation and greenhouse gas emissions needing to be reduced further in the long term under the Climate Act. The Council sees land subsidence of 3 mm per year as 'acceptable land subsidence' in rural peat meadow areas. This represents 30 cm in 100 years. This is a manageable amount, meaning that flood defences only need to be reinforced by 30 cm once every 100 years, and that land subsidence is substantially less than the current average of around 8 mm per year, or 80 cm per 100 years. The Council sees a target for land subsidence of less than 1 mm per year as fairly unrealistic in any case. This can be classified as unavoidable land subsidence.[19] Moreover, land subsidence of less than 1 mm per year is not measurable with the current state of the art.

19 If average land subsidence in a rural peat meadow area is 8 mm per year, around 1 mm of that is unavoidable land subsidence. See also Chapter 1, Section 1.1.

National policy framework for land subsidence

According to the Council, the national target for reducing land subsidence should be part of a national policy framework for land subsidence that outlines the government's perspective on subsidence. Such a policy framework belongs to the updating of the National Strategy on Spatial Planning and the Environment. The government framework needs to give direction, not on the question of whether rewetting of peat has to take place, but on the best way of facilitating it: in what way, how inclusively (the extent to which costs are passed on), and in connection with which other challenges (integrated approach). Because of its integrated perspective, this national policy framework encompasses more than the Veenplan (Peat Plan), which focuses primarily on reducing CO_2 emissions. In addition, the Veenplan, which will be sent to the House of Representatives before summer 2020, is expected to have a short-term horizon of two years, while the national policy framework for land subsidence presents a longer-term outlook.[20] In that respect, the Veenplan and the national policy framework for land subsidence complement each other. According to the Council, in addition to a quantitative target for land subsidence, the policy framework should contain the following elements:

a) Transition paths to 2030 and 2050

Earlier in the advisory report, it was concluded that time is needed to effect a transition. Change processes in the soil, water systems and – to a lesser extent – infrastructure are slow and the solution has to take that

20 As far as is known at the time of writing.

into account. Parties in the area, such as farmers and water authorities, need to be given time to prepare and adapt. Therefore, the targets for land subsidence have to be achieved step by step.

There need to be two transition paths: one for 2030 and one for 2050. Each of the two periods – from now to 2030 and from 2030 to 2050 – focuses on a different type of measures. Up to 2030, no-regret measures will be taken that can be achieved within the current agricultural business structure, i.e. today's dairy farm in its current location, which is faced with rewetting. Examples are measures such as nature contracts for pool and marshy areas (areas where there is standing water in lower-lying parts; important for meadow birds); tapping a higher-value market segment of milk and cheese, as is also done when switching to organic farming; giving permission for solar farms; and partially converting from agricultural use to nature conservation, leisure activities or residential development where these are possible without land subsidence problems. For public authorities, no-regret measures in this period are, for example, financial incentives from the POP funds or provincial funds for nature conservation.[21] In the period to 2050, work will have to be done on fundamental changes to agricultural business structures and water systems. These measures are more far-reaching and more difficult to reverse. Examples are establishing new spatial zoning plans; enshrining rewetting in water level decisions; moving and ending businesses or making fundamental shifts to other crops. Stakeholders must start preparing for these changes in the period to 2030, because otherwise the 2050 target will no longer be achievable.

b) A look beyond 2050: long-term perspective

The national policy framework must include a look ahead to the period after 2050, when the rewetted peat meadow area has been achieved. What water management investments are needed to maintain the rewetting? What does it mean for peat meadow areas if the Netherlands faces drought more frequently as a result of the warmer climate?

Over this long period, a link can also be made with other major delta challenges, such as sea level rise and salinisation. A long-term perspective is also important to prevent peat meadow areas from having to undergo a transition several times. The changes up to 2050 will be far-reaching and themselves require a considerable effort from politicians and residents.

c) Draw up zoning maps

Because the soil in peat meadow areas is not the same everywhere, the approach to land subsidence requires customised work. In that context, the Council advocates the creation of zoning maps (by the provinces). Three things need to be shown on these maps:

1. the desired land uses over the longer term (in addition to farming, zones for construction, nature, water storage, pool and marshy areas, etc.)

21 The POP funds come from the EU's Rural Development Programme [*Plattelandsontwikkelingsprogramma*] (POP-3).

2. target levels over the longer term (pool and marshy areas for nature conservation, -20 cm for sustainable agriculture, unchanged drainage of reclaimed land)
3. prioritising.

The third point involves dividing the areas into three types: (i) areas where it is urgent to slow land subsidence (e.g. because there is a thick peat layer or because of nearby nature conservation areas); (ii) experimental areas where there is a little more time for reducing land subsidence; and (iii) areas that can carry on as before and where little or no extra effort is needed to counter land subsidence. This prioritisation determines the order in which work will be done.

Drawing up zoning maps requires spatial planning decisions, for which the provinces are responsible. They have considerable knowledge of the area. They know the territory well, as do the water authorities and other parties. For this reason, the Council proposes that the national government should only provide the legend to the maps. The provinces will subsequently develop the zoning maps for their territories, involving the parties that will also work on implementing the approach to land subsidence (the 'implementation assemblies', see Section 3.2), such as water authorities, municipalities, residents and users. After this, the provinces will adopt the zoning maps.

Finally: make a minister or state secretary responsible for the national target for land subsidence

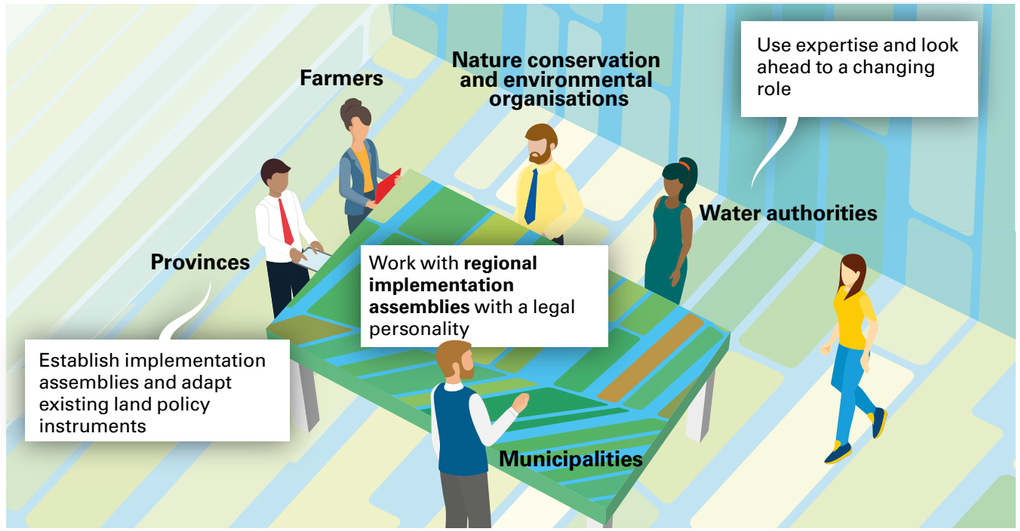
To ensure that the nationally approved target for limiting land subsidence is achieved, the Council believes it is necessary for a minister or state secretary to be given responsibility for land subsidence. This person will not only have a management role, but on the basis of the Environment and Planning Act, they will also be able to give instructions [*aanwijzing*] to provinces if an approach to reducing land subsidence is lacking at regional level.

In the first instance, the responsible minister or state secretary should encourage regional parties in the areas as much as possible to start work quickly. This is an attractive proposition, because the regional parties could then determine themselves how they want to achieve the target for reducing land subsidence. If parties fail to put together an implementation assembly within two years, the minister or state secretary can direct the province to set one up (see also Section 3.2 below). This will prevent delays caused by regional bottlenecks and differences of opinion in relation to the desired solution or who will pay. In addition, the responsible minister or state secretary will ensure the necessary coherence and balance between challenges (integrated approach), the necessary knowledge building, and preventing unwanted or unforeseen effects.

In view of the establishment of the policy framework for land subsidence in the National Strategy on Spatial Planning and the Environment (NOVI) and the desired connection with other tasks (see Section 2.3), it makes sense that responsibility for the reduction in land subsidence should be entrusted

to the member of the government in charge of environmental policy. This is currently the Minister of the Interior and Kingdom Relations. Sector-specific issues can be allocated to the relevant ministers (agriculture, nature and water). The Minister of Agriculture, Nature and Food Quality has a key role regarding this portfolio due to her responsibility for the agriculture sector.

3.2 Area-based work on implementation (within national policy framework)



Recommendation 2 – to regional parties:

Work together in an area-based fashion on implementing efforts to tackle land subsidence, but do so within the national policy framework.

When working on reducing land subsidence, the bottom-up and top-down approaches need to complement and strengthen each other. This is why *regional implementation assemblies* are required in addition to the national policy framework in order to achieve proper direction and implementation. Furthermore, important partners have to be involved in implementation. Examples are municipalities, land managers, nature conservation organisations, and land users (in many cases farmers). The role of provinces and water authorities will be explained in more detail.

Work with regional implementation assemblies

If the national government has established clear frameworks and targets, and the province has translated these into provincial decisions (e.g. provincial zoning maps, for which the regional parties have been consulted; see Section 3.1), it is best if implementation is carried out in and by the areas themselves. For the Green Heart, for example, the size of the area as a whole is not suitable and it would be better to organise implementation in a number of subareas (eight to nine), in line with existing cooperation initiatives or regional divisions. With their knowledge of the area, the subareas are best placed to deal with the complexity of the local problem and ensure that the right parties bring their local knowledge and expertise to the implementation assemblies. This allows customised work to be delivered for and within an area (Roncken et al., 2019). Working 'from the bottom up' in this way is also more likely to create support, because stakeholder groups are involved from the outset and can put forward solutions themselves. The parties that participate in the implementation assemblies may differ from one area to another.

Examples are water authorities, municipalities, provinces, nature conservation and environmental organisations, and, for example, the Land- en Tuinbouworganisatie Nederland LTO [*Netherlands Agricultural and Horticultural Association*].

The Council proposes aligning as much as possible with existing cooperative partnerships for the regional implementation assemblies. In the Green Heart, for example, there are already cooperative partnerships in the Krimpenerwaard, Alblasserwaard-Vijfheerenlanden, the area around Alphen/Gouda/Woerden, the municipality De Ronde Venen, the Kagerplassen, the Amstelscheg, and the Gooi and Vechtstreek. Administrative boundaries should not be allowed to hinder the organisation of the regional implementation assemblies: after all, the peat meadow area does not stop at the edge of the Green Heart or at the border of a specific municipality.

It is important that the regional implementation assemblies ensure cohesion with the approach to other challenges. This distinguishes the implementation assemblies from the national 'veenweideregietafel', or peat meadow management partnership, which coordinates the efforts of all peatland provinces to reduce CO_2 emissions in line with the Climate Agreement.

The regional implementation assemblies are not starting their work from scratch. To begin with, there is the zoning map, showing land use, target levels and priorities. It is obvious that areas with substantial land subsidence (a thick peat layer, a relatively low water level) will be given priority, in line with the zoning map. To be able to carry out implementation properly, the implementation assemblies additionally need to have a legal personality. They also have to have a sufficient budget for implementation (see recommendation 3 below). And finally, implementation capacity is important. Such capacity is available in the region, but currently it is often organised separately for each sector. In this context, it is important for the implementation activities of municipalities, water authorities, and farming and nature conservation collectives to be coordinated with each other in connection with the implementation assemblies. Where necessary, the implementation assemblies can act as commissioning parties for implementation.

Provinces: establish implementation assemblies and apply existing land policy instruments

The provinces are involved in the approach to land subsidence due to their responsibility for landscape and spatial planning. The transition in the peat meadow area goes to the heart of a province's spatial planning policy, which is why the choices to be made and the management of this process from the point of view of democratic legitimacy belong at the provincial level. Provinces also play a crucial role in implementing the approach to land subsidence, in view of the fact that the tasks of the former Rural Areas Department have partly been assigned to the provinces. It is up to the provinces to set up the implementation assemblies (with legal personality) and to make sure that these get to work within two years. To this end, the provinces ensure that the implementation assemblies have sufficient

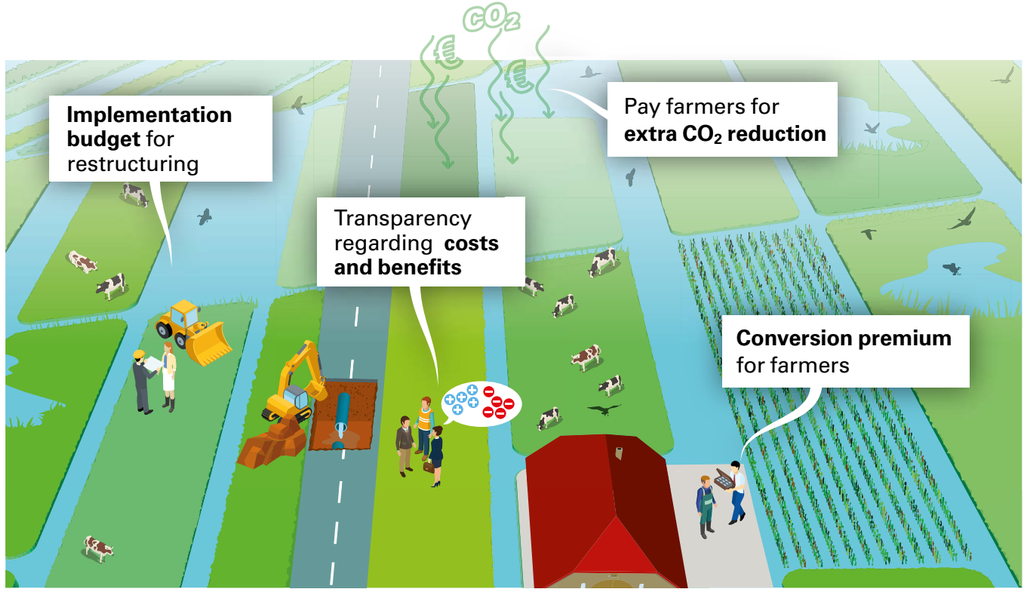
authority, budget and implementation capacity. The provinces receive government funding and then distribute it among the implementation assemblies in each province. The basis for this is co-financing: the national government invests and regional and local parties contribute. Each province does this for its own implementation partnership(s). In the western Netherlands, the Green Heart Administrative Platform (previously the Green Heart Steering Committee), has an important function above the implementation assemblies, relating to exchanging information and monitoring. The Administrative Platform can be the central point for monitoring whether all regional initiatives are good for the whole of the Green Heart.

Provinces must actively use their existing set of land policy instruments to support land subsidence policy. This will allow provinces to facilitate farmers in making the necessary changes to land use. After all, rewetting land means that farmers may face a decline in their earning capacity per hectare. To compensate for that loss, farmers need more land or a different business model. This can enable them to keep their family income steady with a lower yield per hectare. Provinces can facilitate the changing land use with the existing set of land policy instruments of the decentralised Land Development Act. They can either purchase land to exchange, in order to move farms to other locations, or buy land and then make it available again for farm expansion. The land can temporarily be held in a provincial land bank. The Council is aware that the active purchasing of land by a public authority brings financial risks. It is nevertheless unavoidable in order to achieve the target for reducing land subsidence.

Water authorities: use expertise and anticipate a changing role

Currently, water authorities are usually already administrative partners and financial backers of projects related to land subsidence. They are therefore more than just executors. The water authorities are conducting a variety of interesting experiments in the area of water level increases, aimed at reducing land subsidence. The water authorities generally have outstanding expertise with respect to the workings of the water systems. This is essential for good land subsidence policy. This expertise is still underused and must be brought more prominently into the cooperation with provinces and other parties. Moreover, water authorities also have sufficient powers for dealing with land subsidence. However, they are facing new challenges. For example, they will have to address land subsidence more explicitly in their water level decisions. In many cases, this will mean fixing or raising the water level. In addition, there is increasing emphasis on ensuring a sufficient water supply, which is crucial for rewetting large areas of peatland. For example, water has to be kept in the Green Heart (greater water retention capacity), but also brought in from outside the Green Heart (Roncken et al., 2019). Finally, with a higher water level, it will be necessary over the long term to consider the arrangement of water level areas – areas in which the water authority tries to maintain the same water level: does it meet the new requirements for the water system?

3.3 Organise transparent financing based on CO_2 pricing, among other things



Recommendation 3 – to the national government:
Identify costs and benefits, use CO_2 pricing, make a conversion premium available and fund restructuring of peat meadow areas.

In order to obtain support among the stakeholders, it is important to be *transparent* about the costs and benefits of land subsidence. However, more needs to be done. The Council thinks it is a good idea to offer farmers *compensation* if, by rewetting their land, they achieve a reduction in CO_2 emissions in excess of the climate agreements. In addition, the national government should make a *conversion premium* available to farmers who, following rewetting, want to continue their business with a different business model. An implementation budget will also have to be made available for restructuring peat meadow areas where the water level has been increased.

Ensure maximum transparency regarding costs and benefits

It is important to address the elephant in the room and to be as transparent towards all stakeholders about the costs and benefits of tackling land subsidence (see also Tables 1 and 2 in Section 2.5). The experience of other countries shows that land subsidence is always associated with high costs: if nothing is done, costs rise due to damage (for an estimate, see Deltares & Delta Alliance, 2019). There is a lack of knowledge and understanding on this point. The costs will have to be identified at various levels of scale. At national level, a realistic estimate will have to be made of the costs of tackling land subsidence, set off against the costs of unchanged policy. Costs must be defined much more specifically at regional level, in particular to inform the regional implementation assemblies.

Use CO_2 pricing, so that farmers are paid for CO_2 reduction beyond climate agreements

In the approach to land subsidence, farmers on peat are an important – but also often cautious – party. This is not surprising, as they are directly affected by the consequences of a higher water level. The previously mentioned research by WEcR shows that raising water levels in the peat meadow area in the Green Heart has adverse consequences for the vast majority of dairy farmers (see Chapter 2, Section 2.2) (Daatselaar & Prins,

2020). Their caution is therefore completely understandable. As argued in Chapter 2, CO_2 pricing can contribute to change here. The national government should ensure that the money produced by CO_2 reduction ends up with the parties that are disadvantaged by water level increases – the farmers – whether or not through farmers' collectives. This gives farmers more certainty and can encourage them to take the plunge. If farmers receive money for reducing CO_2 emissions on their land, it is income they can use to cover the costs of buying additional feed or to start on the extensification of their business. In this way, a price for CO_2 represents a contribution towards an alternative earnings model for the farmer. Furthermore, paying the farmer compensation for reduced CO_2 emissions is in accordance with the standpoint in the National Climate Agreement, which states: "A financing system in which the farmers are paid for storing CO_2 is essential and must be developed" (Tweede Kamer, 2019b, p. 137).

In this advisory report, the Council assumes that farmers will only be compensated for limiting CO_2 emissions if there is a cut in CO_2 beyond the reduction that the farmers are already obliged to make in line with the national climate agreements made for peatlands up to 2030 and the agreements yet to be made for the subsequent period to 2050. This means that farmers have no right to compensation for a reduction in CO_2 if the farmer has to comply with a new water level decision involving rewetting in order to achieve the targets of the National Climate Agreement. The agriculture sector has already signed up to this mandatory part of CO_2 reduction in the National Climate Agreement. A farmer is entitled to compensation if he or she goes to extra efforts to reduce CO_2 emissions on his or her own land through additional rewetting. Such compensation can be paid individually or through a farmers' collective. The farmer or the collective will first have to apply to the water authority for a permit for extra rewetting (see Section 2.1). For this reason, it seems most obvious to work with farmers' collectives.

Farms on peatland need compensation for extra CO_2 reduction, because rewetting causes them extra costs, specifically for buying additional feed for their livestock (because livestock cannot graze outdoors for as long on wet ground). Compensation for CO_2 reduction can be an extra source of income, on top of other additional income from leisure activities, for example (see Chapter 2, Section 2.5). But in that case, the compensation must significantly exceed the level of the costs incurred. A calculation based on the data from the previously mentioned WEcR study (Daatselaar & Prins, 2020) shows that a CO_2 price of €40 is not enough to compensate for the costs. In this situation, it is not likely that farmers will go ahead with extra rewetting of their land. For this purpose, the price has to be higher. If the CO_2 price rises further, it does become financially attractive for farmers to carry out extra rewetting. The estimate of the Climate and Energy Report [*Klimaat- en Energieverkenning*] (KEV) (PBL, 2019) already assumes a CO_2 price of €47 per tonne of CO_2 in 2030, which means that this higher price is already expected in a fairly short time.

The existing subsidies for measures focused on nature conservation, landscape, cultural history, leisure activities or water management – known as green and blue services – will continue to be needed. This can give

farmers certainty that these services will also be rewarded in the long term and that their business model is viable. Green and blue services are funded from the budgets of the European agricultural policy (Common Agricultural Policy). The national government must ensure that this funding is guaranteed over the long term and is earmarked.

It will have to be decided in greater detail whether the compensation for extra CO_2 reduction is to be only a temporary additional source of income for farmers or whether it will still apply after 2050. If the rewetting measures mean that there is almost no peat degradation by 2050, there will by then only be minimal scope for additional reductions in CO_2. In any case, in the transition phase up to 2050, compensation to farmers for reducing CO_2 emissions will act as an incentive. By 2050, current investments in buildings will probably have been written off and alternative business structures (e.g. wetland crops, energy production) will have been set up. The Council proposes that in 2030, when the target for 2050 is set, it should be decided at the same time whether either remuneration or compensation for income loss is still necessary for CO_2 emissions reduction after 2050.

The national government must ensure that the extra reduction of CO_2 emissions in peatlands is incorporated into a funding system. Work still needs to be done to determine how best to design such a system. There are several options:

- Inclusion in a *trading system*. A polluting company then pays for the extra CO_2 reduction that farmers achieve.
- Inclusion in a *voluntary system*. It could then be individuals or civil-society organisations that reward farmers for the extra CO_2 reduction. 'Valuta voor Veen' (Money for Peat) in Friesland is an example of such a voluntary system.
- Inclusion in a *subsidy scheme*. In that case, the taxpayer will foot the bill for the extra CO_2 reduction by farmers.

The third option of setting up a subsidy scheme is not uncommon. In other policy areas such as sustainable energy, for example, a subsidy scheme has been introduced in order to accelerate the reduction of CO_2 emissions. The national government could also consider this option for land subsidence.

Make a conversion premium available to farmers

The Council thinks that the national government must make additional money available to enable farmers to adapt their operations to the wetter conditions that are required. Such a 'conversion premium' is specifically aimed at farmers who have to extensify (fewer head of livestock per hectare, working with lighter-weight livestock, different feed) or switch to a dairy business that is nature-inclusive or circular. In some areas, a completely different business model is needed, with wetland crops being the most obvious choice. This depends on the zoning maps drawn up by the province (see recommendation 1).

The conversion premium can be designed in a similar way to the existing premium for converting to organic farming. Under this scheme, farmers can receive a conversion premium for a maximum of two years for the

transition from a conventional to an organic business, to cover the period when the family income has not yet returned to previous levels. Something similar could also be applied to the conversion to a business model suitable for rewetting the land. An example could be a conversion premium that farmers are entitled to if, for example, they go from a water level of -60 cm to one of -20 cm.

To fund the conversion premium, budgets can be used from the second pillar of the European Union's Common Agricultural Policy (CAP). The money from this pillar is intended for innovation, but it currently goes mainly to technological innovations such as air washers and high-tech robots. The provinces should ensure that the money is earmarked for the transition of farms in peatland areas. Furthermore, the Minister of Agriculture, Nature and Food Quality can adjust the eco-schemes in the first pillar of the coming CAP, by including in the requirements for these eco-schemes critical performance indicators relating to land subsidence (see RIi advisory report 'Europees landbouwbeleid, inzetten op kringlooplandbouw' (2019b) [*European Agricultural Policy: Working Towards Circular Agriculture*] for an explanation of critical performance indicators).

Make implementation budget available for restructuring, with co-financing

Investment is necessary for the one-off restructuring of peat meadow areas, when these are adapted to rewetting. An implementation budget is needed for this (see also recommendation 2). This budget can be used for changing the structure of the agricultural spatial structure, the water system[22] and infrastructure, including roads. In order to respond to the new situation and the planned zoning, the agriculture sector needs land for exchanging plots and relocating farms. A land bank can be used for this purpose, for example. Funding the restructuring is an investment that can be recouped over the long term, because various costs are avoided that would otherwise have to be incurred in the future.

In some cases, *compensation* is needed for farmers in peat meadow areas who have to deal with a decline in the value of their land as a consequence of restructuring and a higher water level. There does not necessarily have to be a drop in value. If after conversion to a different business model, the income capacity per hectare stays the same (and more rather than fewer hectares are needed per business), the land value will not decline. But if restructuring does lead to a lower operating value, the ground will lose in value. If restructuring plans are known far enough in advance, compensation is not necessary. Agricultural entrepreneurs can then take the plans into account long enough in advance and have their buildings and the like written off by then. In the case of restructuring at fairly short notice, it can be assumed that compensation will be needed.

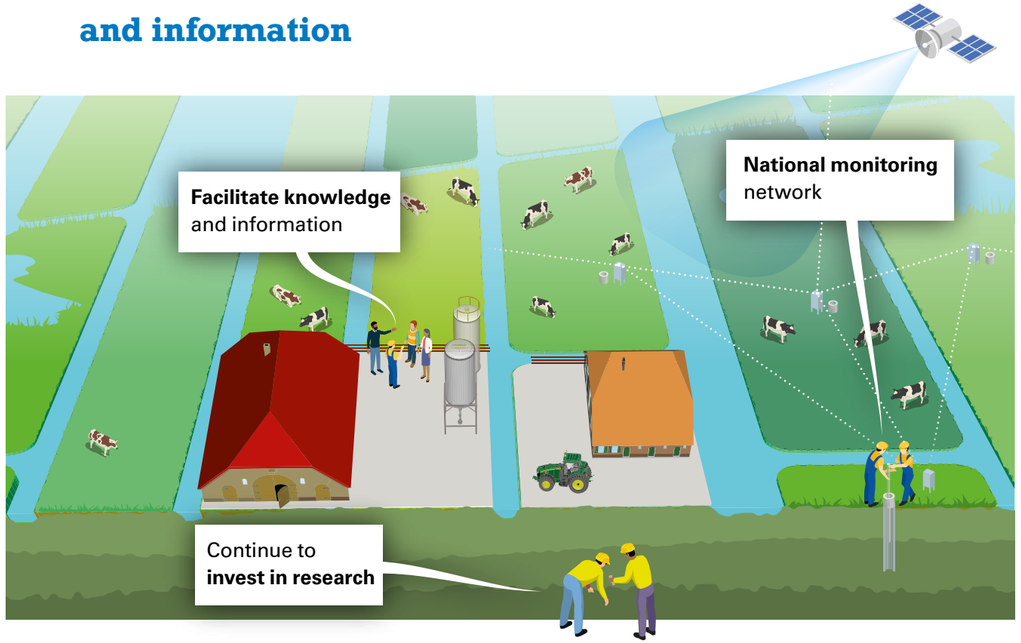
In the event of a change in water level management, it will have to be considered whether there are grounds to set up a scheme for compensation for losses resulting from administrative acts for landowners and land

22 Additional investment in the water system is necessary because not only does the water level need to be adjusted, but space also has to be created for water retention.

users. The need for such a scheme depends on the scale of the damage; the possibility of taking measures to prevent or reduce damage; the period within which the increase in the water level will be implemented; and the question of whether individual owners are disproportionately disadvantaged.

An alternative solution that some provinces are currently exploring as part of sustainable soil management, is for the province or a land management organisation to purchase the land, accept the decline in value as a loss, and sell or lease the land back with the legal constraint that it must be exploited with the desired new business structure.

3.4 Provide a knowledge base, monitoring and information



Recommendation 4 – to the national government:
Ensure a solid knowledge base for land subsidence; monitor subsidence using a monitoring network and facilitate the provision of information to farmers.

Continue investing in research on subsidence and create a national information service

A good knowledge base is essential for countering land subsidence effectively in peat meadow areas. Many aspects require further research on understanding land subsidence; updating forecasting models for land subsidence; estimating damage relating to land subsidence; governance in relation to implementing measures; determining the effects of measures against land subsidence; and monitoring and evaluating measures.

The national government bears system responsibility for knowledge development in the area of land subsidence. The government can meet its responsibility by investing in a ‘National Information Service for Land Subsidence’, which will make data and information on land subsidence available to public authorities, the business community and citizens. Based on the available knowledge, regional governments can make well-founded decisions about reducing land subsidence. Engineering firms and consultancies can make use of the available knowledge when advising regional governments, agricultural and other businesses, and individuals, so that a shared level of knowledge is created. This knowledge base can also prevent delays in decision-making due to a lack of knowledge, or prevent a lack of knowledge being used as an excuse for failing to make

decisions. Information from local pilots and projects can be collected together in the new knowledge structure. Valuable experience is currently already being gained in these pilots and projects. The overview thus acquired can also reveal gaps in knowledge and show where there is overlap between pilots and projects.

Develop a national monitoring network for land subsidence in order to monitor the achievement of targets

If a target is set at national level for reducing land subsidence, it is important to have accurate data on the degree of subsidence. By how many millimetres is the land currently subsiding in peatland? And what is needed exactly in order to achieve a reduction in land subsidence of 50% by 2030 and 70% by 2050? A national monitoring system can show whether the targets are being met.

A monitoring system for CO_2 emissions is already being developed, with five measuring points in peat meadow areas in the Netherlands: Friesland, Noord-Holland, Zuid-Holland, Utrecht, and Overijssel. The monitoring system has been set up in such a way that in future it will also monitor land subsidence. According to the Council, this system should be expanded into a national system for measuring land subsidence as well as greenhouse gas emissions in peat meadow areas. It must be a system that can remain operational for a number of decades. It will create the required insight into the current extent of land subsidence in the Netherlands and the contribution that peat degradation makes to it. Apart from monitoring the achievement of the national targets, the system can also be used for reports on meeting obligations at European level for limiting CO_2 emissions from soils (laid down in the European LULUCF regulation)[23] and for fulfilling the national obligations for reducing CO_2 (laid down in the National Climate Agreement and the Dutch Climate Act).

Facilitate information to farmers

Farmers on peat who are thinking about their future have a number of options. They can move their business, farm less intensively (possibly with compensation for loss of income), switch to other crops or voluntarily end the business. If farmers on peat face such major choices about the future of their business and are considering adapting their business operations, it is important for them to be offered proper support. To this end, the Council believes an information centre should be established that can help farmers convert their operations. Initiatives of this type already exist, such as the support that farmers can obtain in the search for appropriate ways of farming on peat successfully and in a climate-smart manner. The Ministry of Agriculture, Nature and Food Quality helps to fund the programme 'Klimaatslim boeren op veen' [*Climate-smart farming on peat*], which began in 2019.

23 LULUCF stands for: *Land use, land-use change and forestry.*

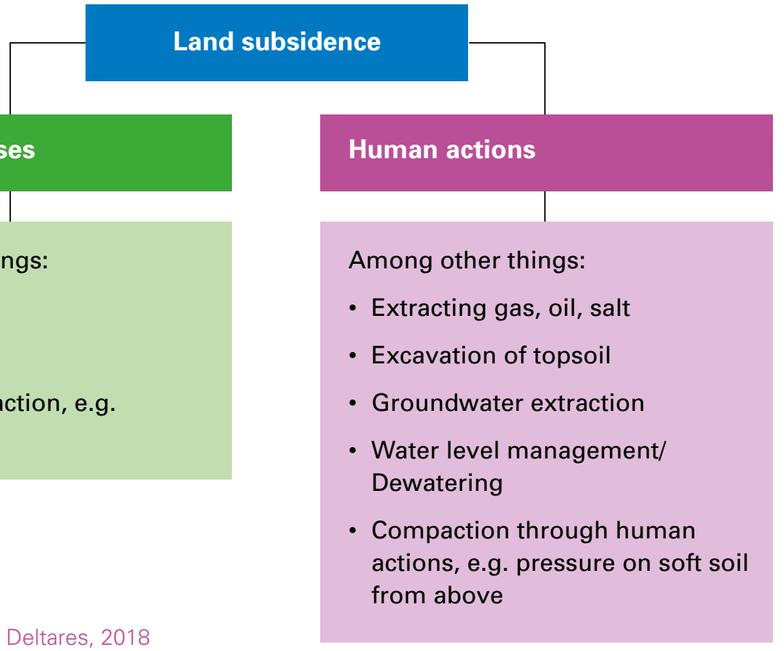
BACKGROUND APPENDICES

A. LAND SUBSIDENCE: CAUSES AND KEY TERMS

Causes of land subsidence

Land subsidence has various causes (see Figure 10). It can be due to natural processes such as ‘tectonics’ (movements or deformations of the Earth’s crust), or to human actions such as water level management or dewatering.

Figure 10: Causes of land subsidence



Source: Stowa, 2020; Deltares, 2018

Key terms for land subsidence

Compaction
Compaction is an umbrella term for increasing the density of the subsoil. This increase in density has various causes, such as shrinkage due to drying out or settling due to construction. In practice, there is no precise definition of the term compaction – what comes under the term and what does not.

Isostasy
Isostasy is the equilibrium between the layers of rock of the Earth's crust and the somewhat liquid underlying mantle. Isostasy causes the Netherlands to tilt slightly in a north-westerly direction. This makes the ground rise in the east and south of the Netherlands, while it sinks in the west and north.

Compression
This refers to the compression of the subsoil under the influence of its own weight. Compression occurs if the groundwater level in peat is lowered, so that upward pressure decreases. The consequence of this is that the pressure of the topsoil (its own weight) increases and the subsoil is compressed.

Shrinkage
Shrinkage occurs if drying causes the solid parts of the soil to be pressed together. The opposite of shrinkage is swelling. This is the sponge effect of peat: shrinkage and swelling is a natural process, which can make a good 10-centimetre difference in soil height in a year.

Tectonics
All the movements and deformations of the Earth's tectonic plates, which are caused by forces that the plates exert on each other. This leads to fractures and folds of rock layers, and is accompanied by the lifting and lowering of the Earth's surface (Stowa, 2020).

Settling
Settling is the compression of the soil profile as a result of external loading (from above) by, for example, buildings or raising the soil level.

Peat oxidation
Peat oxidation occurs above the groundwater level, where the oxygen that enters the peat digests ('burns') the organic matter. Lowering the groundwater level therefore 'dries' the peat. The peat reacts with oxygen and is broken down. This is peat oxidation, which releases greenhouse gases, specifically CO_2 (Royal HaskoningDHV, 2019b).

B. COSTS OF CO_2 EMISSIONS OF PEAT MEADOWS BASED ON ETS PRICE

According to PBL (2016), 4.2 megatonnes of CO_2 per year are currently being emitted by the peat meadow areas of the Netherlands. It was agreed in the National Climate Agreement of 2019 that by 2030, these emissions will have been reduced by around a quarter – by 1 megatonne per year. If this target is reached, the peat meadow areas will therefore still emit around 3.2 megatonnes of CO_2 per year from 2030 onwards.

Below is a calculation of the costs of CO_2 emissions from peat meadow areas over the coming decades that can be avoided by tackling land subsidence. The costs are calculated on the basis of three CO_2 prices (see Table 4):

1. the current ETS price
2. the minimum ETS price for 2030 as agreed in the National Climate Agreement
3. the expected ETS price for CO_2 in 2030.

Costs of CO_2 emissions from peat at current ETS price of CO_2 (without tackling land subsidence)

If the Netherlands does not deal with land subsidence in peat meadow areas and therefore also fails to reduce CO_2 emissions from peat meadow areas, emissions will cost a total of €92 million per year at the current CO_2 price of approximately €22 per tonne of CO_2.

Assuming that the land subsidence continues for at least 100 years (see Chapter 1, Section 1.3), Dutch society will be faced with a substantial bill (100 years x €92 million per year = €9.2 billion). These costs can be avoided by taking action against land subsidence in peat meadow areas; see Table 4.

Costs of CO_2 emissions from peat at expected ETS price in 2030 (without tackling land subsidence)

The CO_2 price is expected to rise over the coming years to €47 per tonne of CO_2 in 2030 (PBL, 2019).[24] In that case, the continuing land subsidence in peat meadow areas will cost Dutch society not €92 million, but €197 million per year.

Assuming that land subsidence in peat meadow areas continues for another 100 years without measures, with unchanged policy the total costs of the CO_2 emissions will result in a much bigger bill for Dutch society (100 years x €197 million = €19.7 billion). These costs can be avoided by taking action against land subsidence in peat meadow areas; see Table 4.

24 Calculations of the expected CO_2 price for the period after 2030 are lacking.

Table 4: Avoidable costs of CO_2 emissions from peat

		Costs of CO_2 emissions from peat meadows if emissions total 4.2 megatonnes* per year	Costs of CO_2 emissions from peat meadows if emissions total 3.2 megatonnes per year (from 2030, if 2030 target of Climate Agreement is achieved)
Current ETS price of CO_2 (€22)*		€92 million	€70 million
ETS price in 2030	Agreed minimum price of CO_2 in 2030 (€31.9)**	€134 million	€102 million
	Expected ETS price of CO_2 in 2030 (€47)*	€197 million	€150 million

* Source: PBL, 2019

** Source: Tweede Kamer, 2019d

C. OVERVIEW OF SOME IMPORTANT PROGRAMMES, PUBLICATIONS AND INITIATIVES RELATING TO LAND SUBSIDENCE AND PEAT MEADOWS IN THE NETHERLANDS

Name	Year	Initiator(s) / author(s)	Theme / goal
Establishing Soft Soil Platform [*Platform Slappe Bodem*]	2007	17 municipalities and water authorities	Focused on integrated approach to problem of land subsidence
Peat Meadow Innovation Centre Zegveld [*Veenweiden Innovatie Centrum*]	2010	Commissioning parties: three provinces, six water authorities	Knowledge and innovation centre for western peat meadows, focused on sustainable agriculture in peat meadow areas by means of pilots
Friesian Peat Meadow Vision [*Friese Veenweidevisie*]	2015	Province of Friesland and Friesian water authority	Call for slowing land subsidence in Friesian peat meadow area by limiting drainage
Peat meadows in the Dutch Delta metropolis	2016	Delta Metropolis Association [*Vereniging Deltametropool*]	One of the few studies from the perspective of the metropolis
National Knowledge Programme for Land Subsidence [*Nationaal Kennisprogramma Bodemdaling*]	2016	Initiative of STOWA; Province of Zuid-Holland; Soft Soil Platform; Rijkswaterstaat; and knowledge institutions	Focused on knowledge about countering land subsidence, with the themes: developing knowledge of innovative techniques, farming, data, governance
Green Heart Perspective 2040 [*Perspectief Groene Hart 2040*]	2017	Green Heart Steering Committee [*Stuurgroep Groene Hart*] (provinces, water authorities and municipalities)	Vision on future of the Green Heart, with the themes: strengthening landscape and identity, slowing land subsidence, energy transition, sustainable economy
Peat Innovation Programme [*Innovatie-programma Veen*]	2017	Agricultural nature management association Water, Land & Dykes [*Agrarische natuurvereniging Water, Land & Dijken*] and nature conservation organisation Landscape Noord-Holland [*Landschap Noord-Holland*]	Focused on experiments for countering land subsidence through profitable agriculture; with test sites; funded by province, water authority and 'Low Holland' area committee [gebiedscommissie Laag-Holland]
Places of Hope, workshop on the future of peat meadows in Friesland	2018	Curator Maarten Hajer, workshop leader Jandirk Hoekstra	Focused on developing future prospects for Friesian peat meadow area, in cooperation with architects and landscape architects, experts and local professionals; funded by, among others, province, water authority and national government
Vision on Land Subsidence [*Visie Bodemdaling*]	2018	Province of Utrecht	Building block for Provincial Strategy on Spatial Planning and the Environment [Provinciale Omgevingsvisie], aimed at slowing land subsidence in 2030 and 2050
Vision on land subsidence in western Netherlands [*Visie bodemdaling West-Nederland*]	2018	Netherlands Agricultural and Horticultural Association [*Land- en Tuinbouworganisatie, LTO*] North	Aimed at slowing land subsidence by at least 50% by 2050

Name	Year	Initiator(s) / author(s)	Theme / goal
Inter-administrative Programme Living Countryside [*Interbestuurlijk Programma Vitaal Platteland*]	2018	National government, provinces, municipalities, water authorities and civil society organisations (varying by area)	Inter-administrative programme for, among others, Holland-Utrecht Peat Meadow Area, Friesian Peat Meadow, Amsterdam Wetlands; focused on working on economically vigorous, liveable and eco-friendly countryside through area-based approach in promising areas
Regional Deal Land Subsidence in the Green Heart [*Regio Deal Bodemdaling Groene Hart*]	2019	Ministry of Agriculture, Nature and Food Quality & subarea Green Heart	Focused on collaborating on an approach to dealing with land subsidence: public authorities, knowledge institutions, agriculture sector, residents and business community
Programme Climate-smart farming on peat	2019	Water Authority HDSR & agricultural collectives	Focused on slowing land subsidence, increasing biodiversity and studying relationship between CO_2 emissions and land subsidence; with subsidy from Ministry of Agriculture, Nature and Food Quality and under the direction of the provinces
Initiative policy document 'Veen red je niet alleen' (You cannot save peat on your own)	2019	House of Representatives, GroenLinks and D66 parties	Call for national government vision on peatlands
Draft National Strategy on Spatial Planning and the Environment	2019	Ministry of the Interior and Kingdom Relations	In this document, the Green Heart is called an 'important landscape to be protected'
National Climate Agreement	2019	Dutch Cabinet	Aimed at reducing CO_2 emissions in peat meadow areas, among others
Advisory report on new approach to peat meadows of the Green Heart	2019	Three Provincial Advisors on Spatial Quality (PARK)	Call for recognition of diversity of Green Heart and for work tailored to type of peat: soil type decisive for water level & function
Design-based research on Green Heart for PARKs	2019	Buro Sant en Co & Fabrications	Background study to PARKs advisory report: soil and water as basis for land use, biodiversity and landscape quality in the Green Heart
Three design studies for regional details for PARKs	2019	Vista & Circular Landscapes Flux Landscape Bureau Peter de Ruyter	Regional design studies for Ronde Hoep, block polders Kamerik & Kockengen and Alblasserwaard
Advisory report on Land Subsidence in Noord-Holland	2019	C.P. Veerman	Plea for prioritising in government policy the reduction of land subsidence in peat meadow areas, with approach for each area
Peat strategy 'Stean for it fean'	2019	Peter de Ruyter commissioned by nature conservation organisation It Fryske Gea	7-step plan for the future of Friesian peat meadow area
A New Deal between farmer and society: Krimpenerwaard pilot	2020	Board of Government Advisors [*College van Rijksadviseurs*] CRa	Future prospects for landscape-inclusive agriculture harnessing the power of design
Provincial peat meadow visions	2020	Provinces	Input for National Peat Plan of the Ministry of Agriculture, Nature and Food Quality; to be drawn up in 2020
National Peat Plan	Not yet known	Ministry of Agriculture, Nature and Food Quality together with the provinces	Outcome of vote in House of Representatives; plan yet to be drawn up for reduction of CO_2 in peat meadow areas

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APPENDICES

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2020

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2019

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