Effects of water level strategies in dutch peatlands: a scenario study for the polder Zegveld

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Summary

Peatlands in the Netherlands are threatened by subsidence of the soil surface, less favourable conditions for farming and rising costs for water management. This study looks at the future of the peatlands in the western part of the Netherlands, to support policy making. In a scenario study for the polder Zegveld, different water level strategies and climate scenario have been simulated, using the SIMGRO regional hydrological model. The analysis focuses especially on water management strategies to reduce subsidence and to create a system which is simple and robust. The use of subsurface drains is a good measure to reach this situation.

Key index words: climate change, hydrological modelling, pasture, subsidence**,** subsurface drains

Introduction

The Netherlands was originally a marshy delta with extensive peatlands formed by the rivers Rhine and Meuse. A rise in sea level, coupled with subsidence of the cultivated peatlands, means that more than half the country is now below sea level. Throughout this low lying part, the Dutch polders, the water table is shallow and a dense network of engineered watercourses is needed to drain the land. Water levels in the polders are lowered regular to maintain suitable conditions for agriculture. As a result of the lower ground level the expenditure for water management increases while a unique open and historical landscape is threatened. To preserve the meadows, drainage of the area is essential, but excessive drainage leads to subsidence of the peat, higher pumping costs, an increase in salinity and too dry conditions for nature areas. The deep polders (reclaimed lakes) and the groundwater extractions causes in large part of the peatlands a downward seepage, in summer this gives lower water levels and groundwater levels. Therefore water supply is needed to avoid too low groundwater levels (dry conditions). These lower levels would otherwise result again in an increase in subsidence. Furthermore the farming is under pressure because of agricultural reforms and increasing urbanization. Water quality is another bottleneck, especially with the implementation of the Water Framework Directive (WFD). With all these threatening factors, it was realized that a study was needed, focussing on the future of the peatlands in the western part of the Netherlands to support policy making.

This paper describes a study for the polder Zegveld, where different water level strategies and climate scenarios have been simulated, using the SIMGRO model. The aim of the study is to find feasible solutions: a more sustainable situation in the peat lands, so that it remains economically feasible for agriculture. Reduce the subsidence to a minimum, so that the water management of the peatlands become not too expensive and less complicated (too many areas with all different drainage levels). Further analysis of the model results are in terms of the effects on water quality and the conditions for agriculture and nature potentials. It is anticipated that the climate in the near future will be warmer and wetter. The set of climate change scenarios, based on moderately warmer or warmer conditions for the Netherlands were considered. For two extreme scenarios the consequences for the peatlands have been evaluated.

Study area and schematisation

The study area Zegveld is located in the western part of the Netherlands, within the so-called green hart of the Netherlands, a typical landscape with vast peatlands and polders (see Fig. 1). The study area covers 45 km^2 and is situated north of the river Oude Rijn (some 1000 years ago a major branch of the River Rhine). The ground surface in the study area slopes from about sea level along the Oude Rijn to about 2.5 m-MSL in the north-western part. This difference in elevation means that a number of polders cover the area, all with different (target) drainage levels. The modelling area consists of peat soils and along the Oude Rijn the peat soil is covered by a clay layer, as much as 1 m thick. Land use is predominantly pasture and is used mainly for dairy farming (Jansen *et al.*, 2007).

Some thousand years ago the elevation of the peatland was around 1 m above sea level and thus higher than the river Oude Rijn. A major loss of the peatland was caused by the use of it as fuel. This resulted in the forming of numerous lakes. From the 16th century onwards these lakes were reclaimed and nowadays these are the deep polders having a ground level of around 4-5 m-MSL. The reclamation of the peatland for agriculture started from around the 12th century, causing the peatland to subside

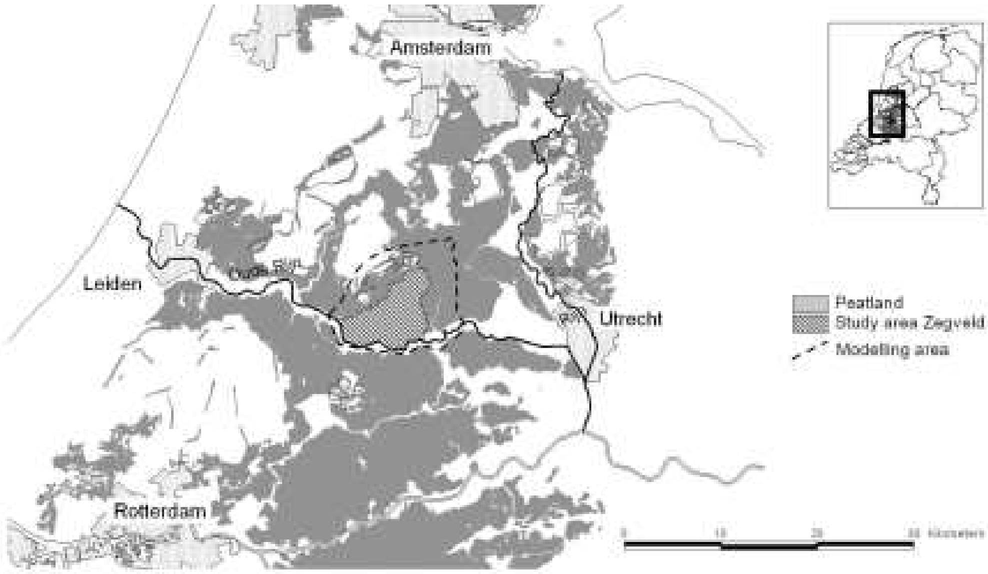

Figure 1. Map showing the peatlands in the western part of the Netherlands and the study area Zegveld.

slowly. Until the beginning of the 20th century the subsidence was around 2 meters. The last 100 years a further one meter lowering took place of which the major part occurred during the last 50 years. The water level management in this period focussed mainly on maximizing agricultural production and therefore wet conditions had to be avoided, needing lower groundwater and surface water levels. In general the water (drainage) levels in the peatlands were around 0.55 m-ss in summer and 0.65 m-ss in winter. Furthermore farmers who experienced still too wet conditions created their own pumped drainage area (small sub-polder) to create drier conditions. The result was an even more complex water system with numerous areas all with different drainage levels. Understanding the hydrology in such complex systems provides a proper basis for decision making on feasible measures.

In many practical applications, models are used as predictive tools, to evaluate various water management measures, policies or scenarios. The SIMGRO (SIMulation of GROundwater and surface water levels) groundwater model we applied, is distributed and physically-based (Van Walsum *et al.*, 2004 or Querner, 1997). The model simulates regional saturated groundwater flow, unsaturated flow, actual evapotranspiration, sprinkler irrigation, stream flow, groundwater and surface water levels as a response to rainfall, reference evapotranspiration, and groundwater abstraction. To model regional groundwater flow, as in SIMGRO, the system has to be schematised geographically, both horizontally and vertically. The horizontal schematisation allows input of different land uses and soils, in order to model spatial differences in evapotranspiration and moisture content in the unsaturated zone. For the saturated zone various subsurface layers are considered. For this study the model was adapted to give an estimate of the peat subsidence. From field measurements over the last 30 years, Akker *et al.* (2008), provided a relationship between the lowest groundwater level in summer and the subsidence.

Scenario analysis and the results

Based on the present situation two possible/feasible water management scenario's have been considered, creating wetter conditions in order to minimize the subsidence, but still dry enough that most of the study area can be used for agriculture. The scenarios are:

1. For the study area maintain the same drainage areas, but the surface water levels are raised to 0.3 m-ss in summer and 0.4 m-ss in winter, a raise in water levels of around 0.25 m as compared with the present situation. In this scenario also the small scale (farmer) pumped drainage areas have been disregarded.
2. In this scenario subsurface drainage is included. The subsurface drains are installed below the surface water level and they should reduce the dynamics of the groundwater table fluctuations. In wet periods water drains quickly and it lowers the high groundwater levels, during dry periods (in summer) the drains are used to supply water and the groundwater level does not lower too much. The low groundwater level in summer results in aeration of the peat soil, followed by oxidation of peat and the soil surface is lowered. Raising the groundwater level in summer will reduce the subsidence.

For the modelling area as shown in Fig. 1, the analyses have been carried out. The scenarios where considered for the entire study area. For the present situation and the two scenarios a calculation period of 45 years has been taken, being the meteorological conditions of the years 1950 to 1995. During the entire period the drainage levels were not adjusted, but each 15 years the subsidence of the previous period is estimated and the ground level is accordingly adjusted. In this way the ground level is lowered and the area gets slowly wetter conditions.

Higher surface water levels (scenario 1)

In scenario 1 the summer water levels have been raised from around 0.55 m-ss in the reference (present) situation to 0.3

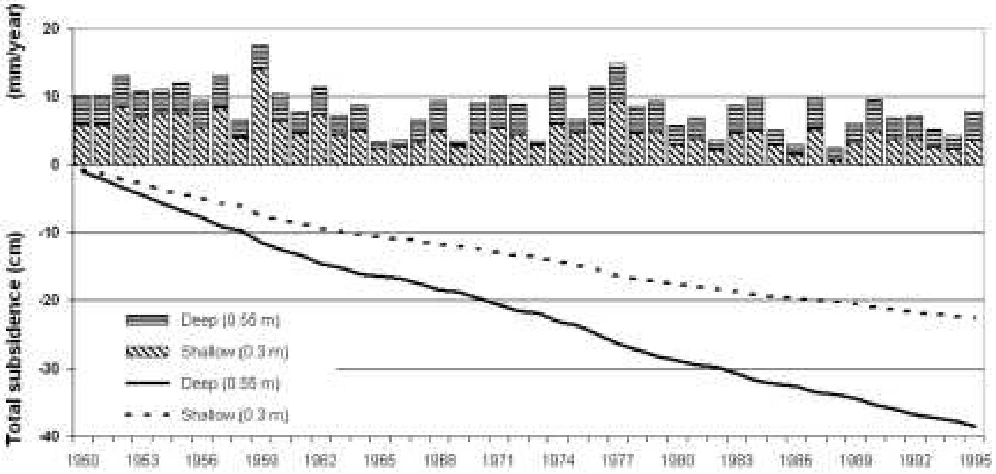

Figure 2. Calculated subsidence of the soil surface for the period 1950 – 1995 for surface water levels of 0.55 m (reference situation) and 0.3 m-ss (scenario 1).

m-ss. In Fig. 2 the subsidence for a location with peat is shown. As can be seen from this figure, the subsidence rate is more pronounced in the very dry summers, like the years 1959 and 1976. Over the 45 years of calculation in the present situation the subsidence will be around 0.38 m. If the surface water level is raised to 0.3 m-ss, then the subsidence reduces to 0.22 m. In the calculations the drainage levels have not been lowered to follow the subsidence, thus the rate of subsidence decreases slowly. If the drainage levels would have been lowered the same amount as the subsidence, then the lowering of the ground level would be much more. This lowering was estimated in the order of 0.50 m for the deep drainage level and 0.31 m for the shallow situation (Jansen *et al.*, 2007).

Because of nearby deep polders and groundwater extractions, there is downward seepage and surface water and groundwater levels tend to be lower in summer. In scenario 1 the higher water levels results in more water to maintain these levels therefore the water supply is 10 to 15% higher as compared to the present situation.

In this scenario the areas with (too) wet conditions for agriculture will be favourable for nature. In the remaining area it is still economically feasible for agriculture.

Subsurface drains (scenario 2)

The subsurface drains act as drainage in wet periods and during dry periods they infiltrate surface water into the ground. In figure 3 the groundwater levels for a location without subsurface drains (scenario 1) is compared with the levels when drains have been installed (scenario 2). In winter time the groundwater level is about 0.05 m lower and in summer around 0.2 m higher. The groundwater fluctuation levels out and particular in summer the higher groundwater level results in a reduction of subsidence of as much as 50%. As a consequence of the subsurface drains, which stimulate the subsurface infiltration, the water supply in summer is increased by about 30%.

Climate change

The Dutch Royal Meteorological Institute predicted a set of climate change scenarios, using the data and methods given in the 4th IPCC report (Van den Hurk *et al.* 2006). The average temperature will rise one or two degrees, the so-called moderate or warmer scenario (scenario G or W). Furthermore it is expected that the air circulation could change and results in much dryer summers. The increase in temperature results also in an increased oxidation of the peat

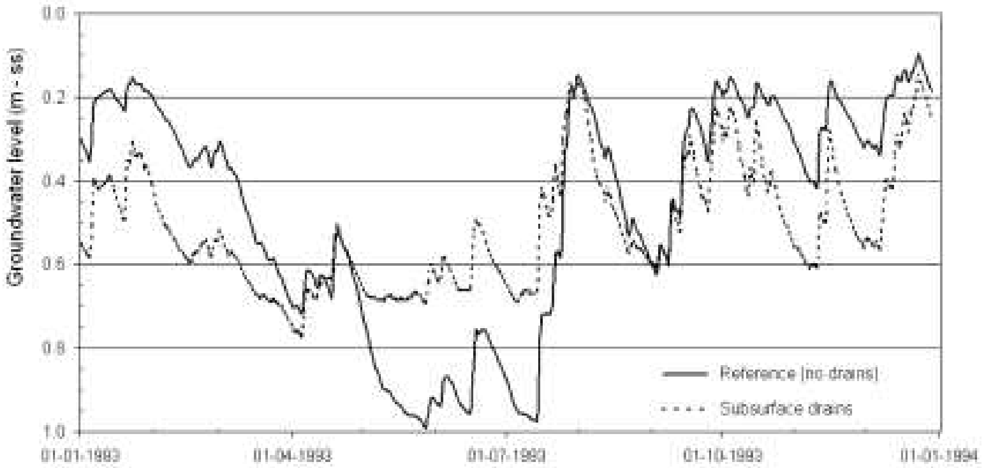

Figure 3. Change in ground water levels in time when subsurface drainage is installed.

and hence higher subsidence rates (Tate, 1987). For the peatlands the changes in summer are crucial. For the moderate scenario (G), the rainfall in summer increases 3% and the annual potential evapotranspiration increases 3%. For a temperature rise of two degrees, including the change in air circulation, the scenario W+, the average rainfall in summer will decrease by 19%. The annual potential evapotranspiration will increase by 15%. Based on these predicted changes historical meteorological data on a daily base was transformed into a new series applicable for the period around 2050.

For scenario G, the changes are not so much and therefore the increase in subsidence is in the order of 15%, which is caused by the lower groundwater levels in summer and by the increase in temperature and hence oxidation of the peat soil. For the scenario W+ the groundwater levels in summer are about 0.15 m lower, because of the decrease in precipitation and increase in evapotranspiration. Even though groundwater levels are lower in this scanario, the increase in water supply is around 43% and the subsidence is increased by 68%. The amount of water supply in this scenario may be not available, because also other regions will need more water.

Conclusions

In order to preserve the peat lands in the western part of the Netherlands, as much as possible, the water management should be adapted and should focus on methods to keep the water level in summer as high as possible. To minimize the subsidence, requires maintaining shallow groundwater levels. The agriculture will face wetter conditions. The use of subsurface drains prooves to be a good measure to improve the conditions for farming and to raise the often deep groundwater levels in summer. A sustainable situation without subsidence is not possible, allways some will take place and the soil surface in the peatlands will lower slowly. The anticipated climate change can have a great inpact on the peatlands. The subsidence rate will increase and more water supply is needed to maintain the target water levels.

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