Adaptation Pathways

Development of adaptation pathways for the rural area of municipality Weert

SWECO

Climate Resilient Development Pathways: Municipality Weert

Decision points:

1 = Climater change has a big impact on feasibility of vulnerable agricultural and natura areas

2 = Policy implementation (KRW, PAS, energy transition, climate adaptaion/mitigation)

3 = Climater change has a big impact on feasibility of agriculture

4 = Climater change has a big impact on feasibility of agriculture

5 = Climater change has a big impact on nature and its ecosystems and habitats

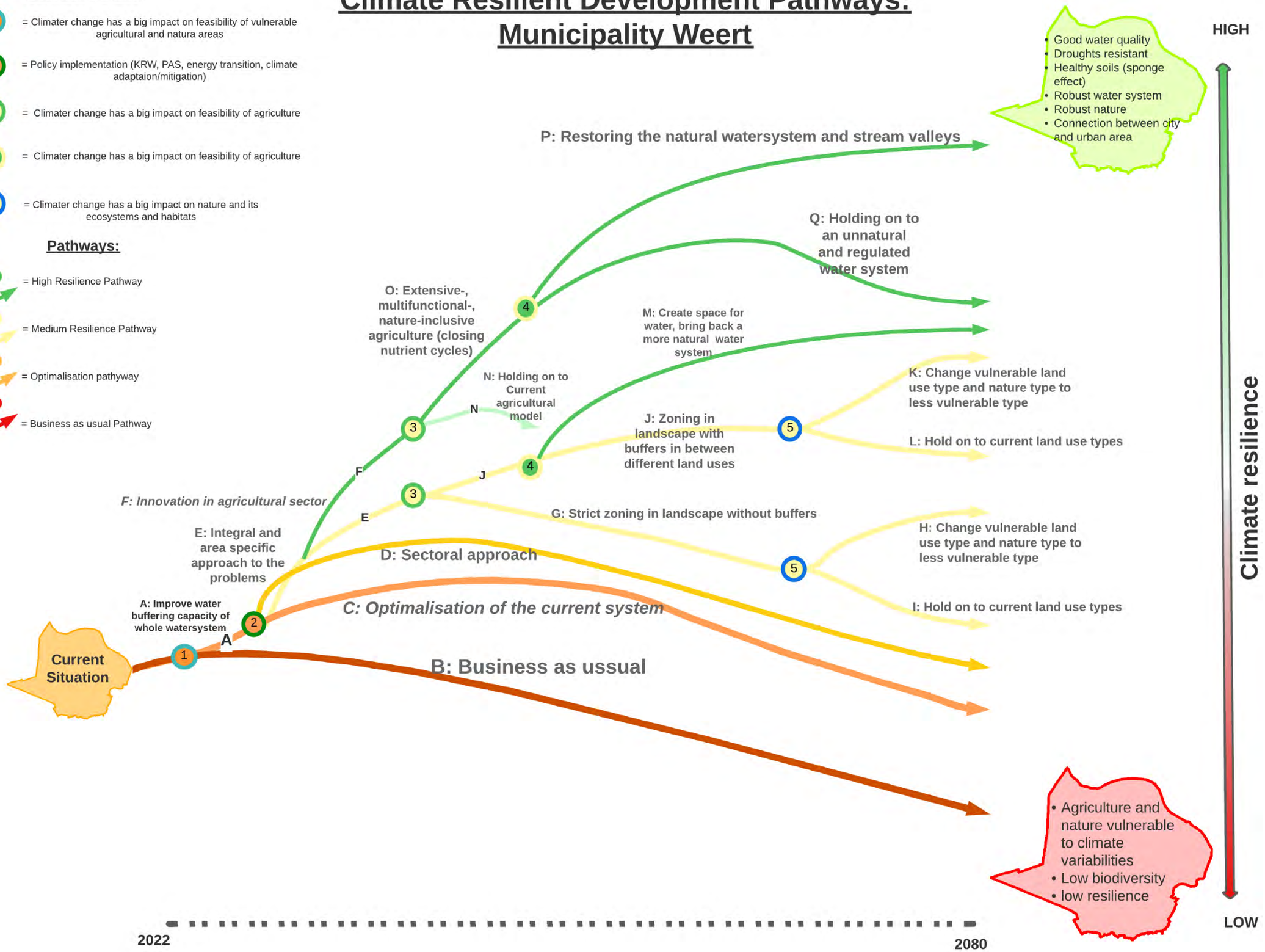
Pathways:

= High Resilience Pathway

= Medium Resilience Pathway

= Optimalisation pathyway

= Business as usual Pathway



Appendix 2 - Elaboration in 3 subareas

Introduction

This appendix contains the three subareas of Weert as a cross-section of the rural area. This appendix contains background information of these three subareas.

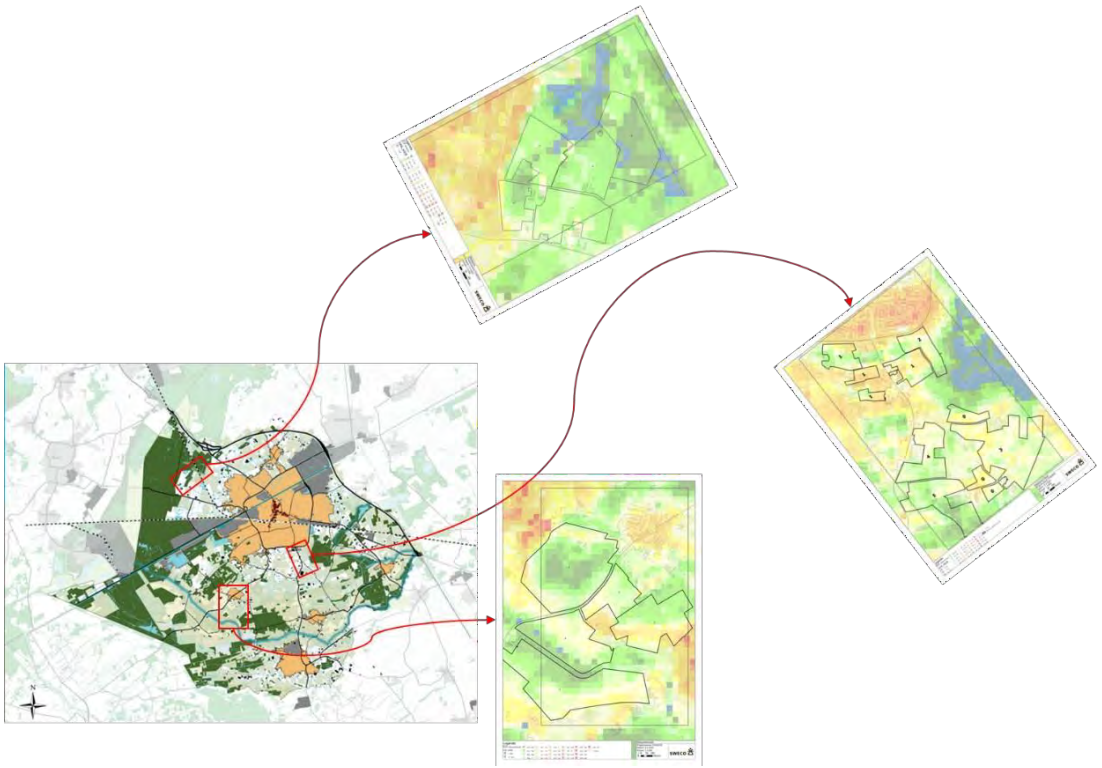
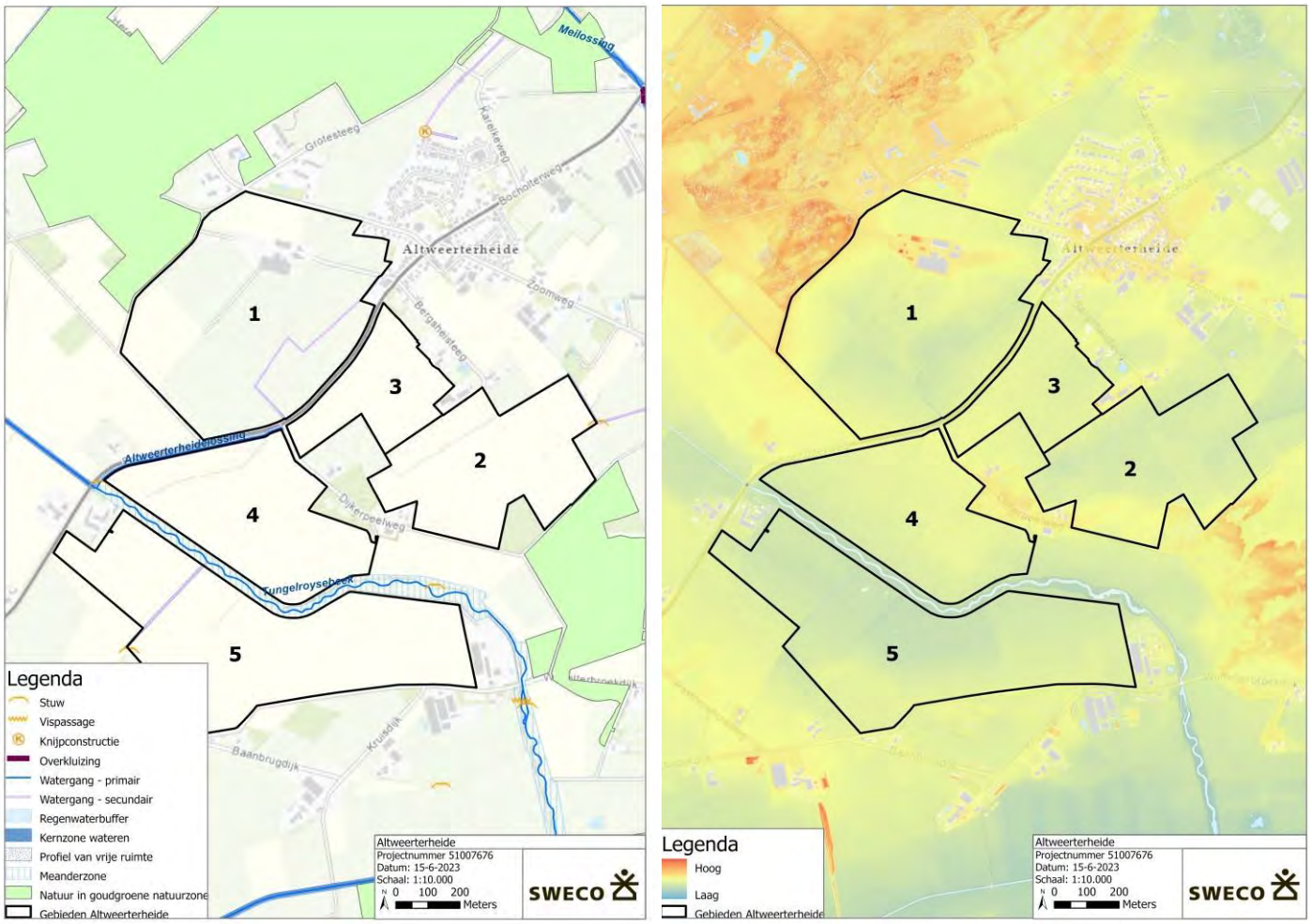


Figure A1: Location of the three subareas

Subarea 1 Altweerterheide and Tungelroyse brook

This subarea is characterised by core areas of agricultural use, also in the future and zoning along the stream that is more oriented towards natural landscaping. The core Altweerterheide on the north side is located at the intersection of the connection between the forest areas Altweerterheide on the northwest side and Tungelerwallen to the southeast and the axis from the stream valley via Bocholterweg to Weert. Land use is now predominantly as arable farming with a small section of grassland along the forest area on the northwest side.



Figures A2 and A3 situation and elevation (AHN4)

The area is characterised by the following types of plots with the numbering as shown in Figure A2:

1. Grassland, with wet spot
2. Arable, with wet spot
3. Arable, with dry spot
4. Arable farming, near Tungelroyse brook
5. Grassland, near Tungelroyse brook

The Altweerterheide core is relatively young, as at the beginning of the last century there was only a single dwelling and farm. Figure 4 shows the picture that was present around 1940 - 1945, with von Frijtag Drabbé[3] mapping all of the Netherlands into dry and wet areas in a shade of red to blue. When the first country-wide groundwater depth map of the Netherlands was produced in the early 1950s, this map was used, which was important for determining the potential for agricultural production. The nuances between red and blue show transitions from wet to dry conditions.

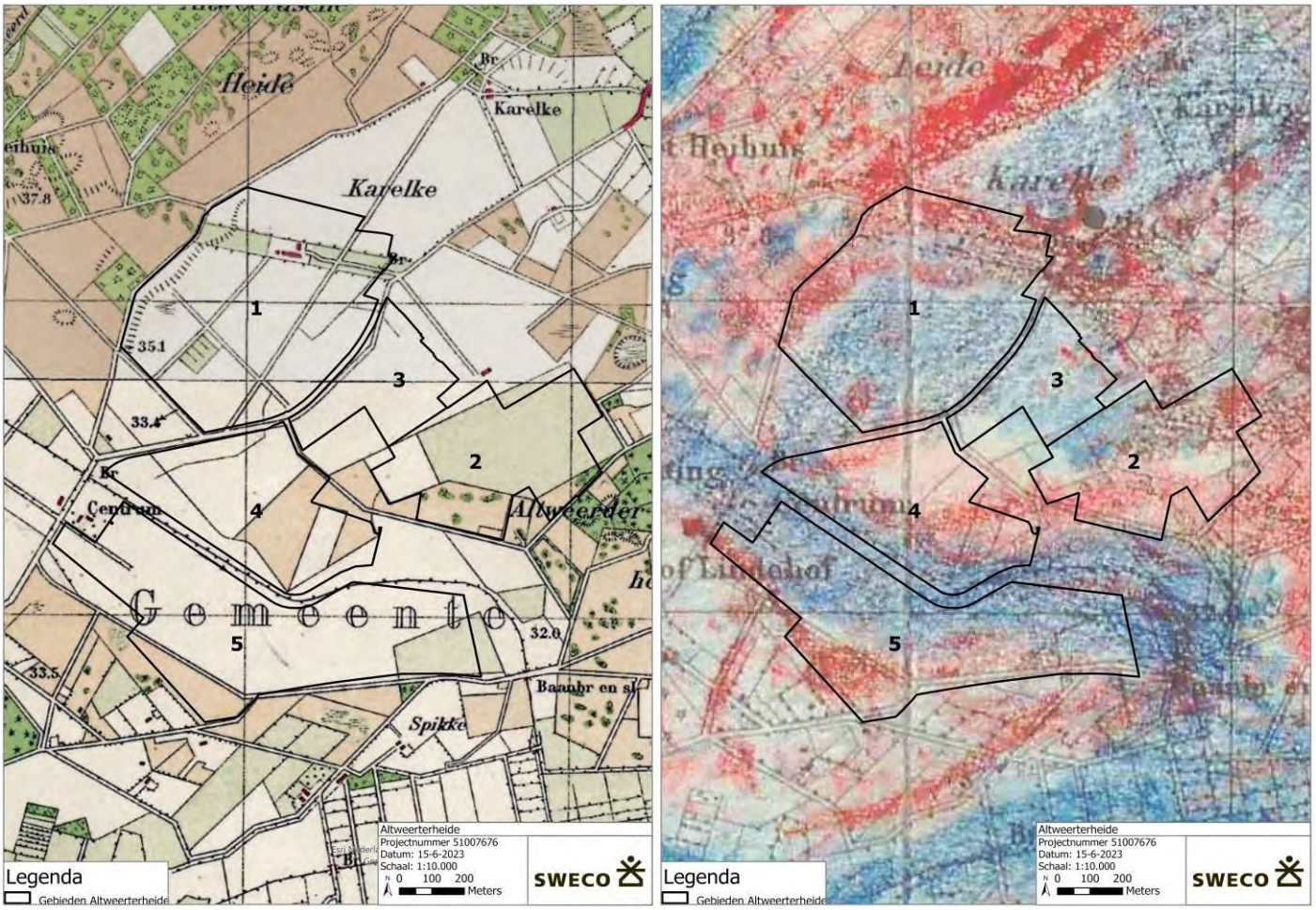


Figure A4 and A5 Historical map and von Frijtag Drabbé's map that formed the basis for the groundwater depth map from the 1950s

3

Water management

The Tungelroyse brook is characterised by remodelling since the 1990s of last century as a stream that meanders in a 10-20 m zone and has a two phase profile, with one bank having a gentle slope (about 1:3 - 1:5) and the other bank having a steeper slope of about 1:1.5. The level in the stream varies based on a threshold with a lower limit of +29.61 m NAP in a range ranging from +29.8 to +30.2 m NAP (range of about 0.4 m). The ground level along the stream is higher than +31.3 m NAP which means there is a drainage of more than 1.1 m here. The bottom of the stream is at about NAP 29.50 m.

The impacts have been calculated and analysed at the scale of Limburg as part of the Limburg Water Management Study (LIWA). The results of this study give an indication of the changes that occur. For translation at plot level, this gives an indication.

Land use and climate change impacts

Agricultural land use is predominantly arable with only along Altweerterheide a section of grassland. This is mainly motivated by the wetter conditions in this plot.

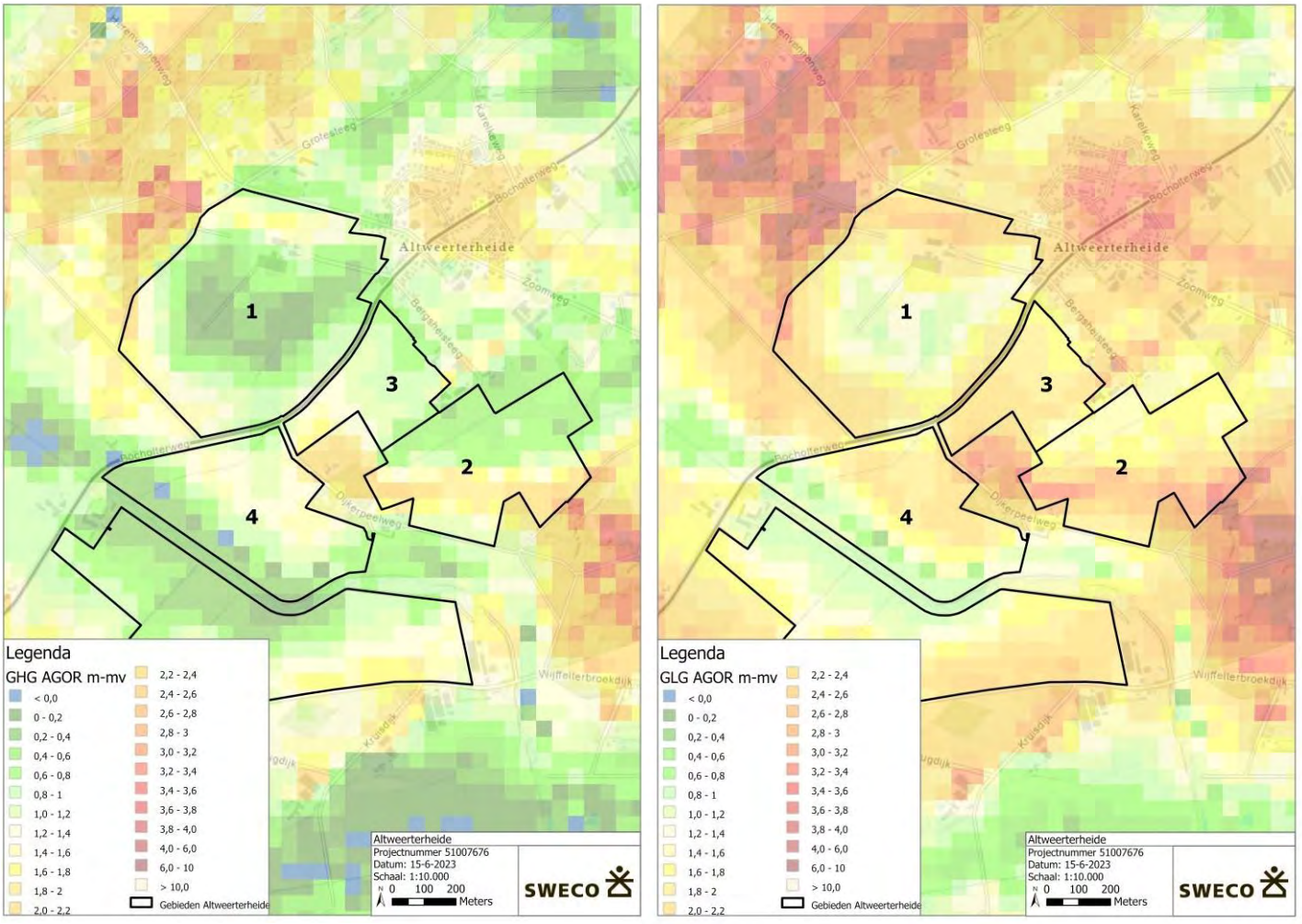


Figure A6 and A7 GHG and GLG

The Mean Highest Groundwater Level (GHG) in plot 1 is at about 0.2 - 0.4 m below ground level (coloured green). This also occurs in a zone along the stream. This zone along the stream has always had much wetter conditions, as evidenced by historical maps in Figure A5: on these, the area is marked as wet.

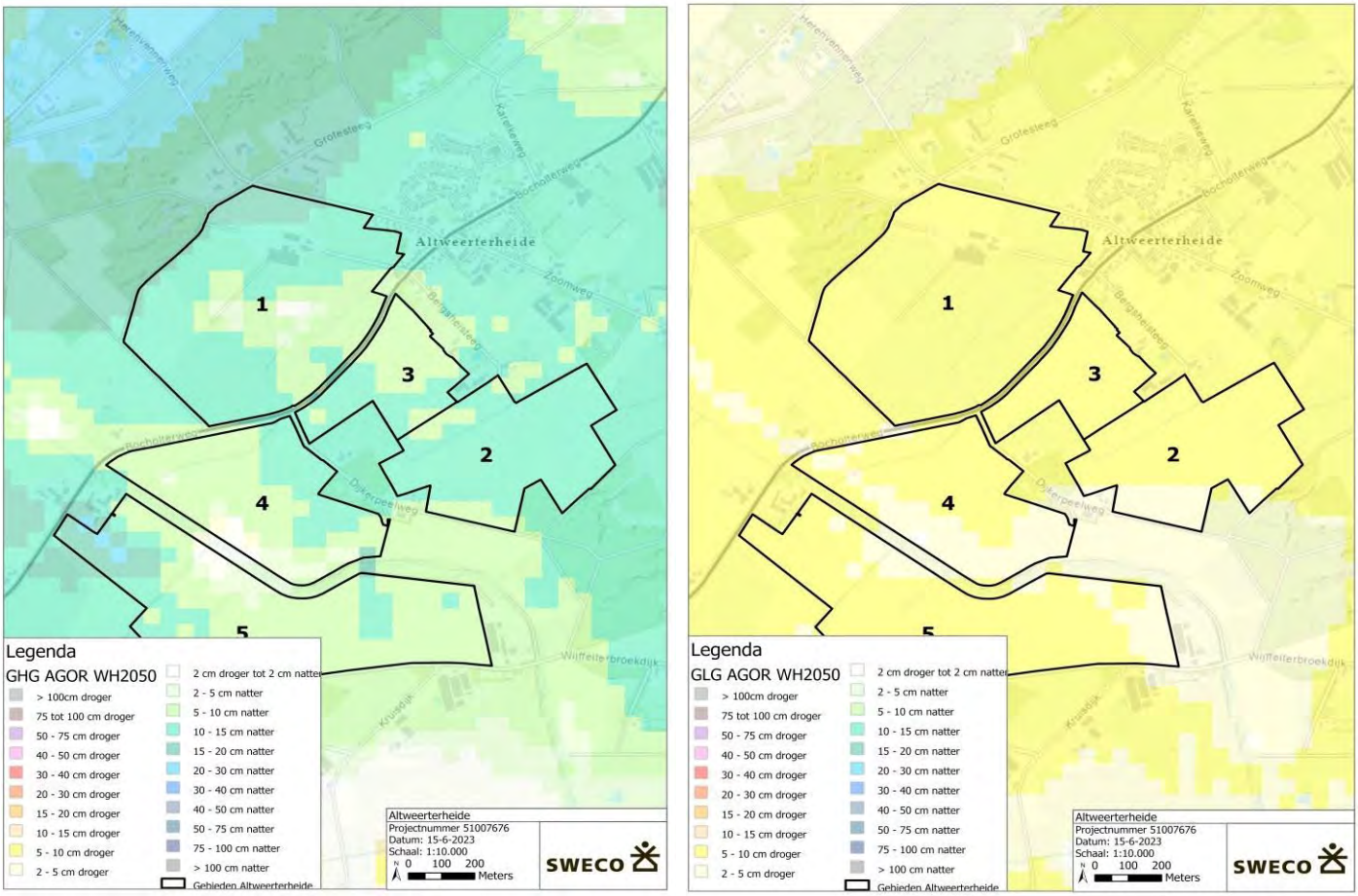


Figure A6 and A7 difference in groundwater levels in 2050 GHG and GLG compared to current situation, droger=dryer & natter=wetter

Effects of climate change

As shown in Figure A6, the GHG changes in 2050 (green-blue areas in Figure A6) and the GLG will continue to drop about 0.10 over much of the area (yellow areas in Figure A7). This mainly means that the extremes increase.

Impact on agricultural yields

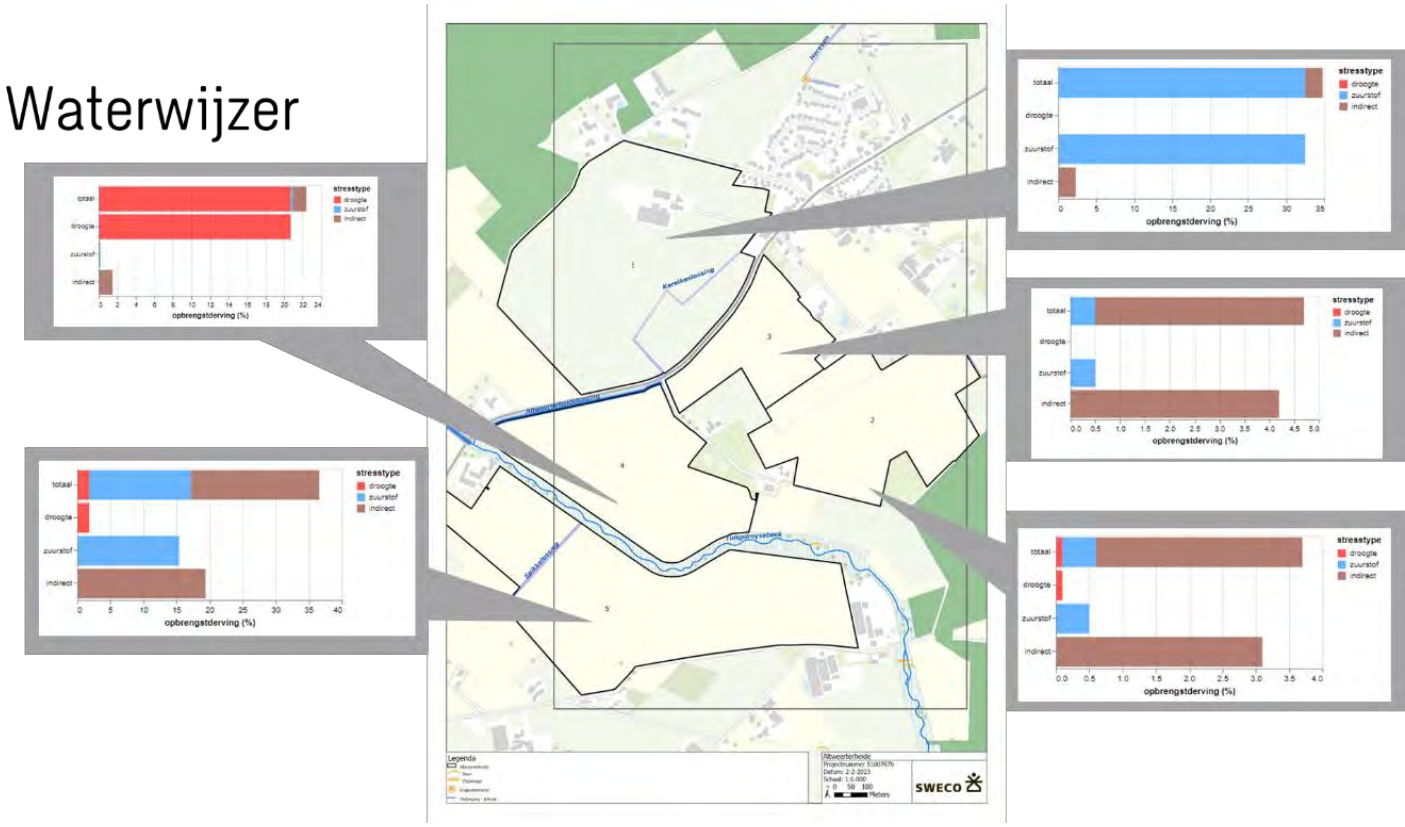


Figure A8 Outcomes “Waterwijzer” showing the yield loss, in **red** caused by drought, in **blue** caused by oxygen deficit, in **brown** by indirect causes

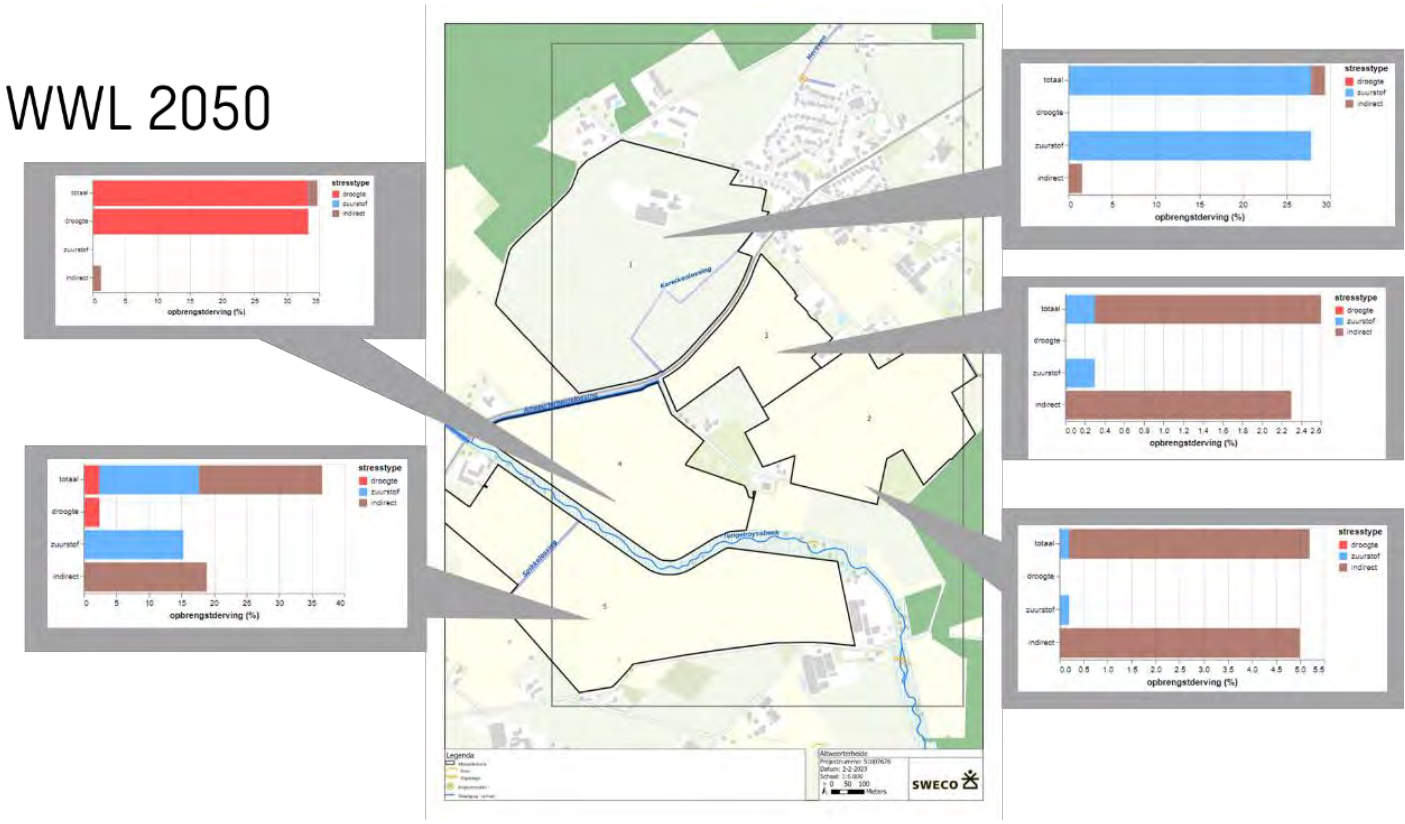


Figure A9 Outcomes “Waterwijzer” 2050, in red caused by drought, in blue caused by oxygen deficit, in brown by indirect causes

Figure A9 shows the results of the Waterwijzer for current crops in 2050. The Waterwijzer gives an indication of the relative crop damage caused by water shortage (red, drought), wet damage (blue, displacement of oxygen in the soil by water causes suffocating roots) and indirect damage (e.g. due to shifting seasons, trampling losses and mowing moments). As the GHG will continue to drop in the future, drought-related damage increases. This happens especially on plots where the groundwater level is already dropping far. On the relatively wet plots not much will change.

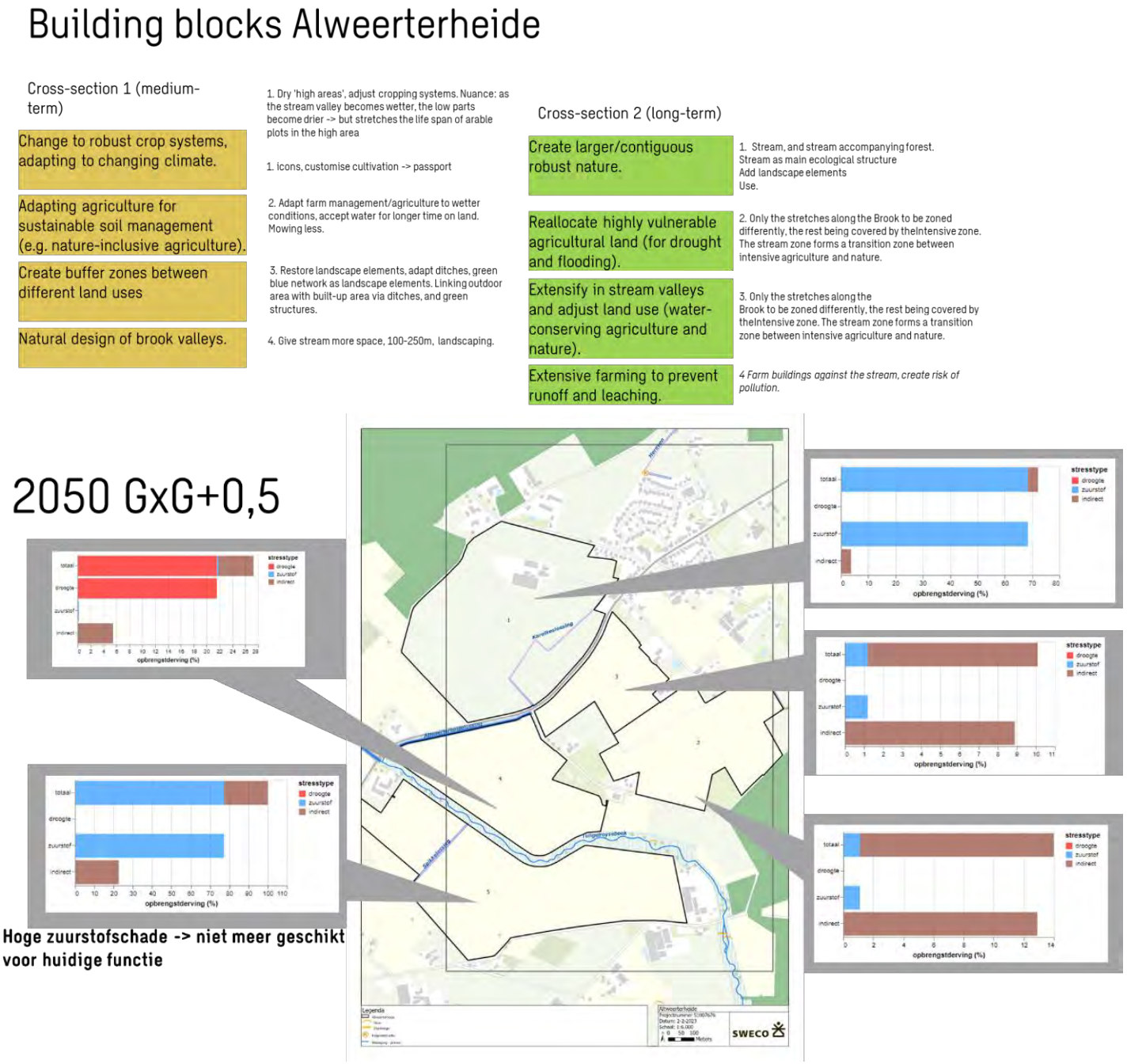


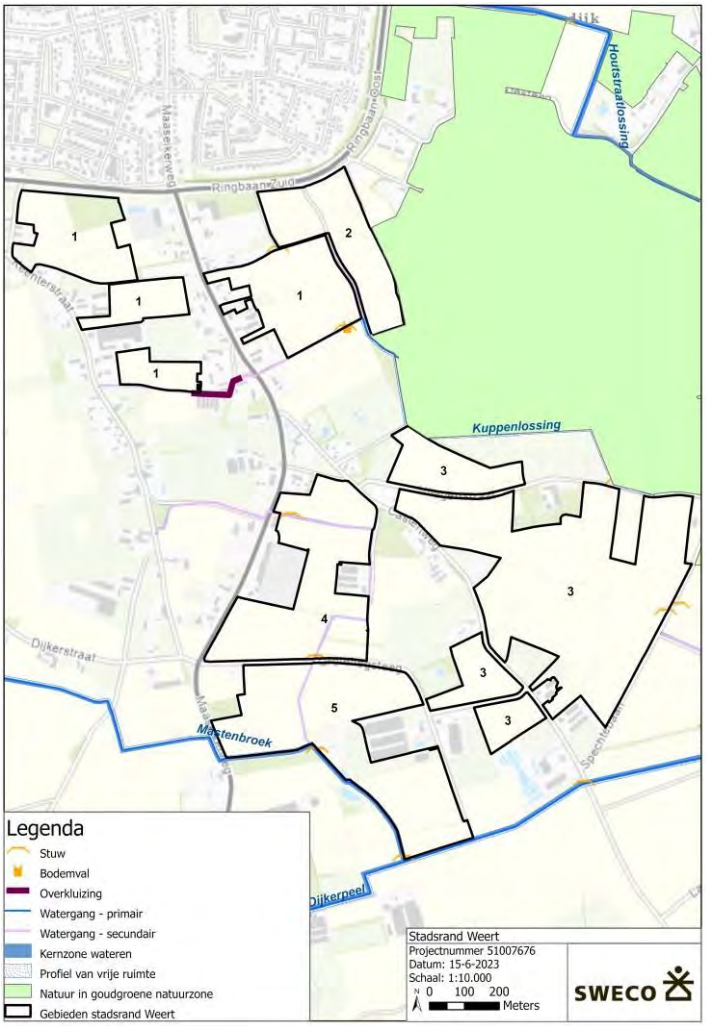
Figure A10: Outcomes water indicator “Waterwijzer”, situation with elevated groundwater levels, in red caused by drought, in blue caused by oxygen deficit, in brown by indirect causes

Figure A10 shows the results of the Waterwijzer for current crops in 2050 when groundwater levels are raised 0.5 meters. The Waterwijzer gives an indication of the relative crop damage caused by a water shortage (red, drought), wet damage (blue, displacement of soil oxygen by water causes suffocating roots) and indirect damage (including through shifting seasons, trampling losses and mowing times). As groundwater levels rise, crop losses from drought damage decrease, but crop losses from wet damage increase.

Subarea 2 City rural areas Weert

This subarea is characterised by development along infrastructure to the south of Weert's city rural areas. The following 5 types of areas have been distinguished here:

1. Arable farming, high dry soils
2. Arable, high ground, deep water table
3. Arable farming, high dry soils
4. Orchards
5. Grassland, low grounds



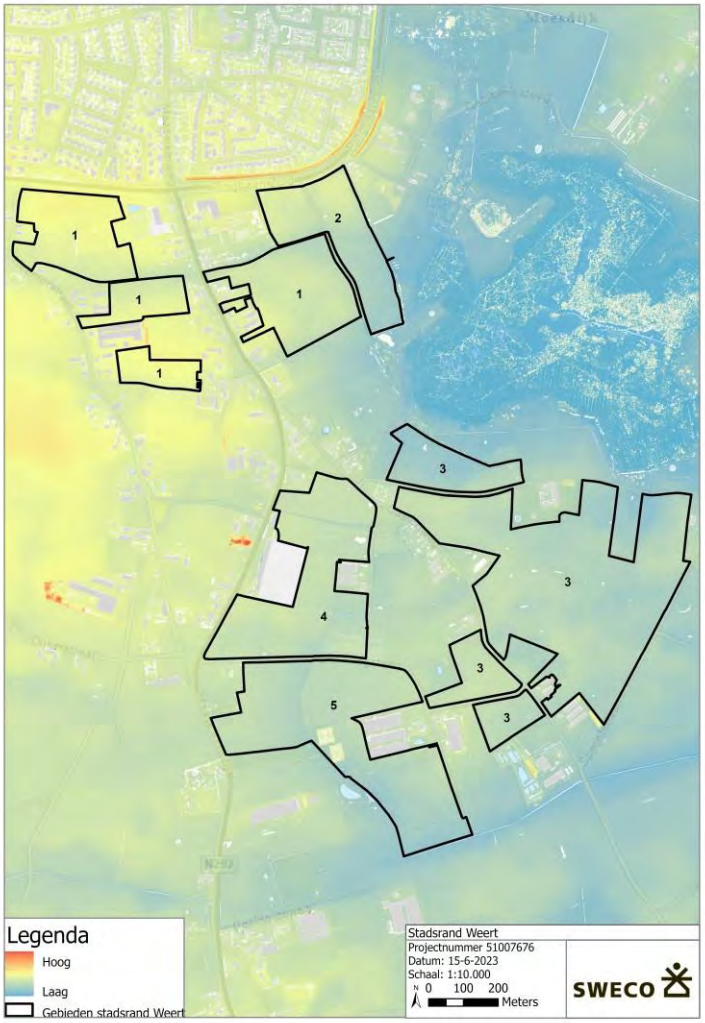


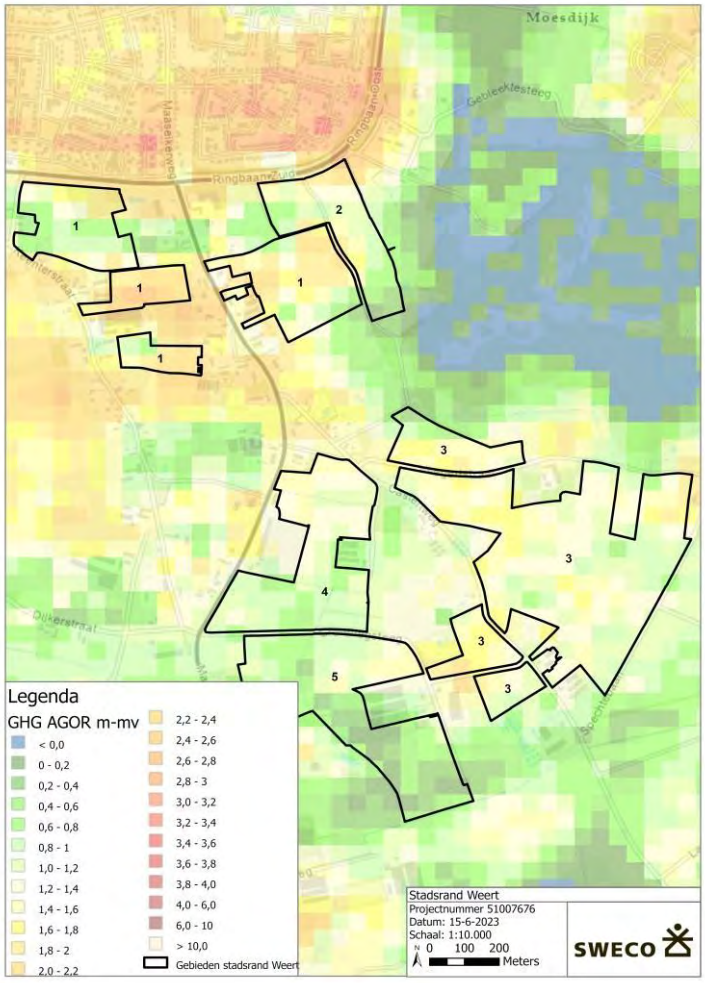
Figure A11 Current situation and Figure A12 Elevation gradient

Figure A12 shows that the natural areas in Figure A11 are lower than the agricultural plots. Between the agricultural plots in the north and south there are relatively large differences in elevation.

Figure A13 Historic land use and Figure A14 wet/dry conditions 1940-1945 von Frijtag Drabbé

Historical maps show that the area where nature now is located was previously a wet (figure A14) marsh (figure A13). Historical irregular block parcels of land on the higher arable plots are still reflected in the current plot division.

Water management



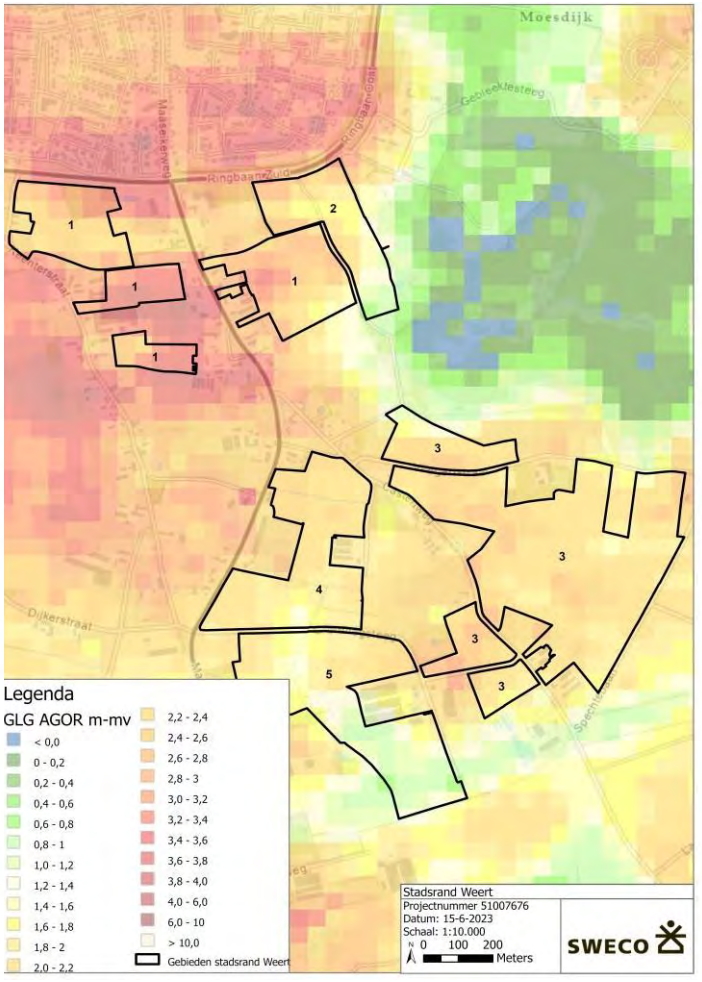


Figure A15 GHG and Figure A16 GLG in the current situation

The Mean Highest Groundwater Level (GHG) is >2 meters below ground level in plot 1. The agricultural areas to the south have shallower groundwater levels. Figures A15 and A16 also clearly show that in wetlands to the east, groundwater levels are much less deep below ground level than in the rest of the area.

Effects of climate change

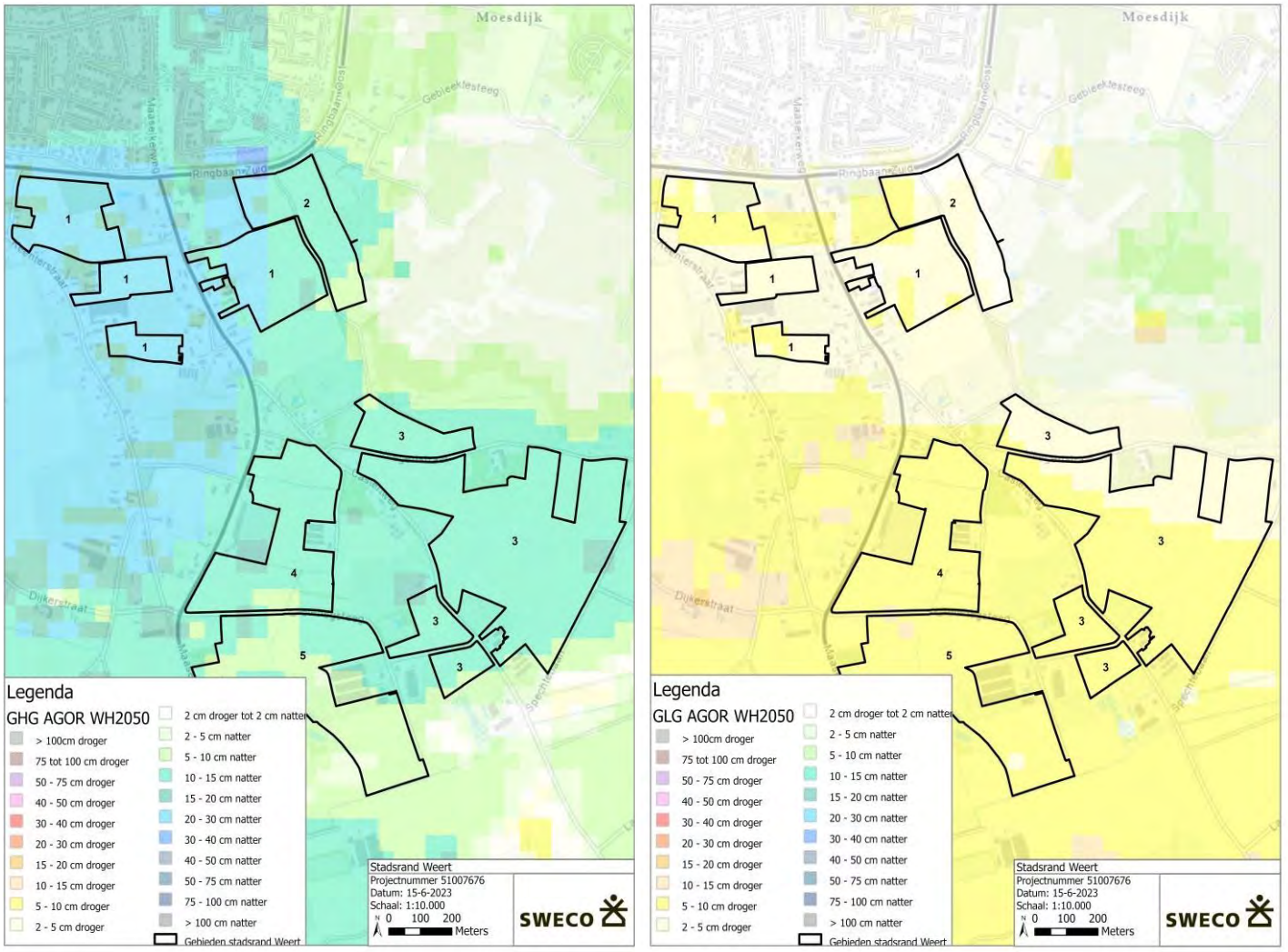


Figure A17 difference GHG 2050 and figure A28 difference 2050 for the GLG compared to the current situation

The GHG will rise slightly in the future (green in figure A17), while the GLG will continue to drop (yellow in figure A28). This means that extremes will increase.

Figure A19 Water indicator “Waterwijzer”, agriculture current situation, in red caused by drought, in blue caused by oxygen deficit, in brown by indirect causes

Figure A20 Water guide agriculture 2050, in red caused by drought, in blue caused by oxygen deficit, in brown by indirect causes

Figure A20 shows the results of the Waterwijzer for current crops in 2050. The Waterwijzer gives an indication of the relative crop damage caused by water shortage (red, drought), wet damage (blue, displacement of oxygen in the soil by water causes suffocating roots) and indirect damage (e.g. due to shifting seasons, trampling losses and mowing moments). As the GHG will continue to drop in the future, drought-related damage increases. This occurs particularly on plots where the groundwater level is already dropping far. On the relatively wet plots, this may cause a slight decrease in wet damage.

Building blocks urban periphery

Cross-section 1 (medium-term)

Change to robust crop systems, adapting to changing climate.	1. Dry parts cultivation systems adapt to future situation, using groundwater passport in intensive parts.
Adapting agriculture for sustainable soil management (e.g. nature-inclusive agriculture).	2. Especially applicable to the parts with land-based agriculture. 3. Zoning around nature reserve, zone of extensive agriculture around nature reserve, more gradual transition.
Create buffer zones between different land uses	• Walkout areas from the city 'circle'first example, new cycle bridge for better connection. • Historic structure, as green-blue veining. • Buffer plans water around city on map
Natural design of brook valleys.	4. n.v.t.

Cross-section 2 (long-term)

Create larger/contiguous robust nature.	1. Run-off from the city creates structure to the natural areas and villages around it. - Use of historic landscape structures to use as ecological structures.
Reallocate highly vulnerable agricultural land (for drought and flooding).	2. Dry farmland adjacent to urban fringe, to be reallocated for buffer.
Extensify in stream valleys and adjust land use (water-conserving agriculture and nature).	3. n.v.t.
Extensive farming to prevent runoff and leaching.	*4. Intensive (partly) non-land farming in south-east, waters or on tungelroyse brook. Risk of pollution. Extensify in these areas.*

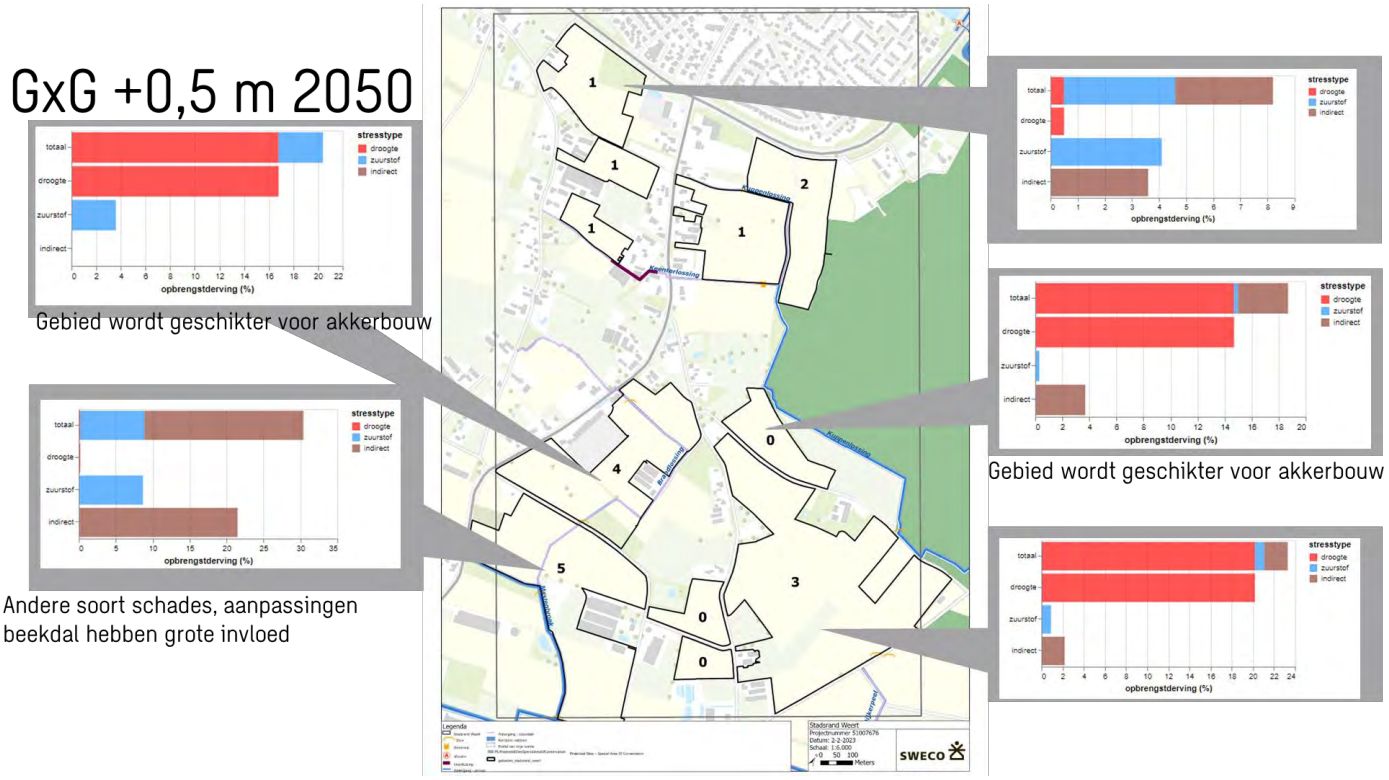
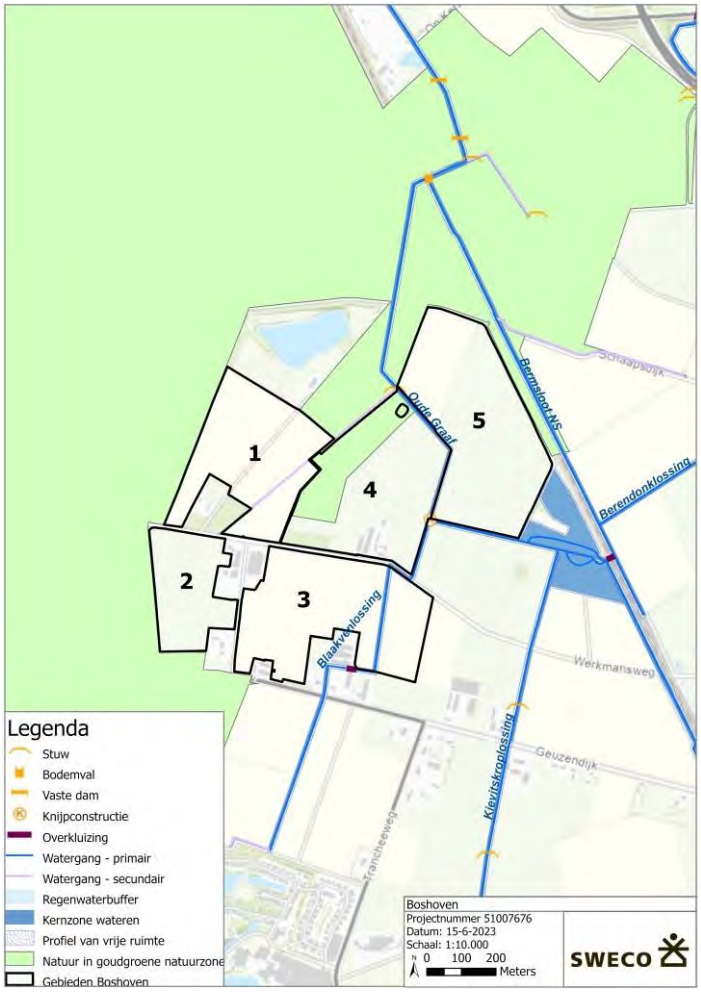


Figure A21 Water indicator “Waterwijzer”, agriculture elevated groundwater levels, in red caused by drought, in blue caused by oxygen deficit, in brown by indirect causes

Figure A21 shows the results of the Waterwijzer for current crops in 2050 when groundwater levels are raised 0.5 meters. The Waterwijzer gives an indication of the relative crop damage caused by a drought, wet damage (blue, displacement of soil oxygen by water) and indirect damage (including through shifting seasons, trampling losses and mowing times). With higher groundwater levels, crop losses due to drought damage can be reduced. This increases the likelihood of crop loss due to wet damage for some plots.

Subarea 3 Boshoven

This subarea is located along the eastern flank of N2000 area Weerter- and Budelerbergen & Ringselven and in the upper reaches of the Oude Graaf. This area is now subject to agricultural use, partly by intensive livestock farming.



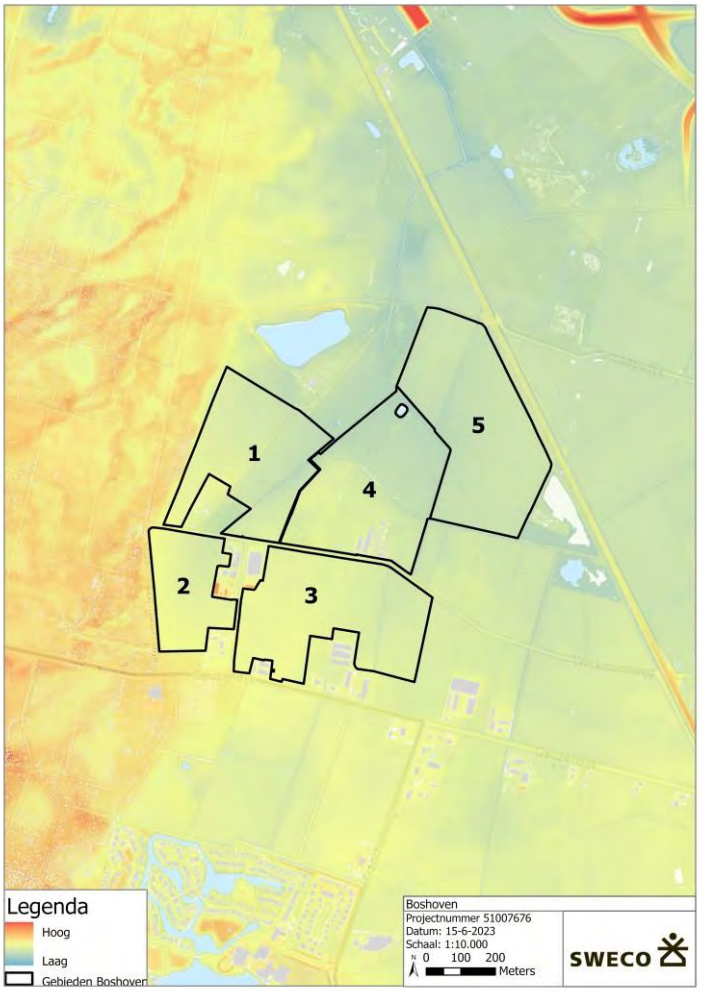


Figure A22 current situation and figure A23 elevation

In the current situation, the following types of plots can be distinguished:

1. Arable, high soil, shallow water table
2. Arable, high ground, deep water table
3. Grassland, high ground
4. Grassland, low soil, shallow water table
5. Grassland, high ground, much desiccation

There is a height difference between the higher (Figure A23, orange-yellow) Natura2000 area Weerter- en Budelerbergen & Ringselven and the lower (green-blue) agricultural plots.

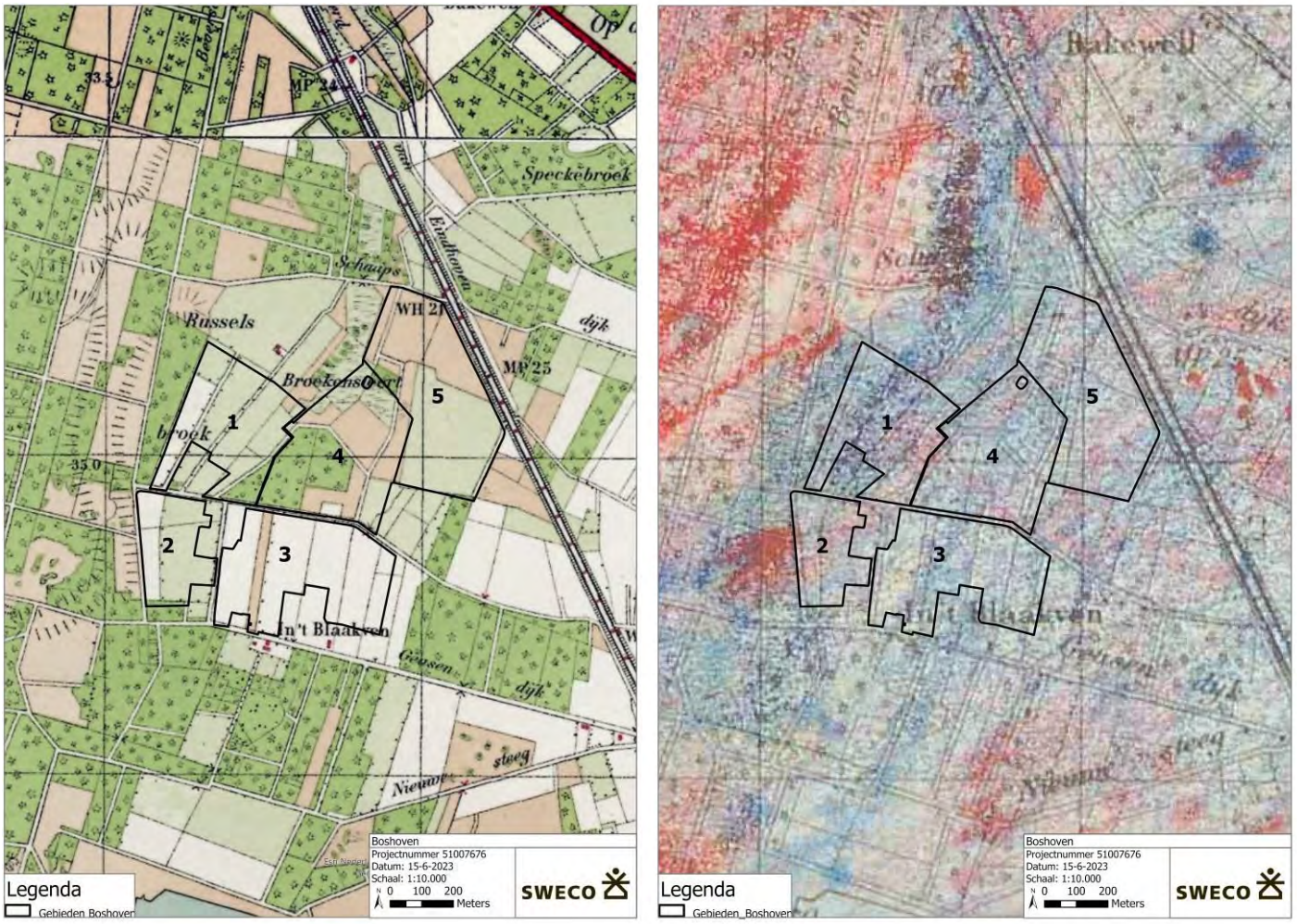


Figure A23 Historic land use and Figure A24 wet/dry conditions 1940-1945 from Frijtag Drabbé

Historical maps of the area show that no stream or other watercourses used to run in the area. Instead, wet parts are inscribed (Figure A23) and toponyms like 'Broek' indicate wet places. Frijtag Drabbé's map of dry and wet conditions also shows a large blue stain near the agricultural plots (Figure A24). This indicates that historically wet conditions are common here, while in on the higher moors dry conditions apply.

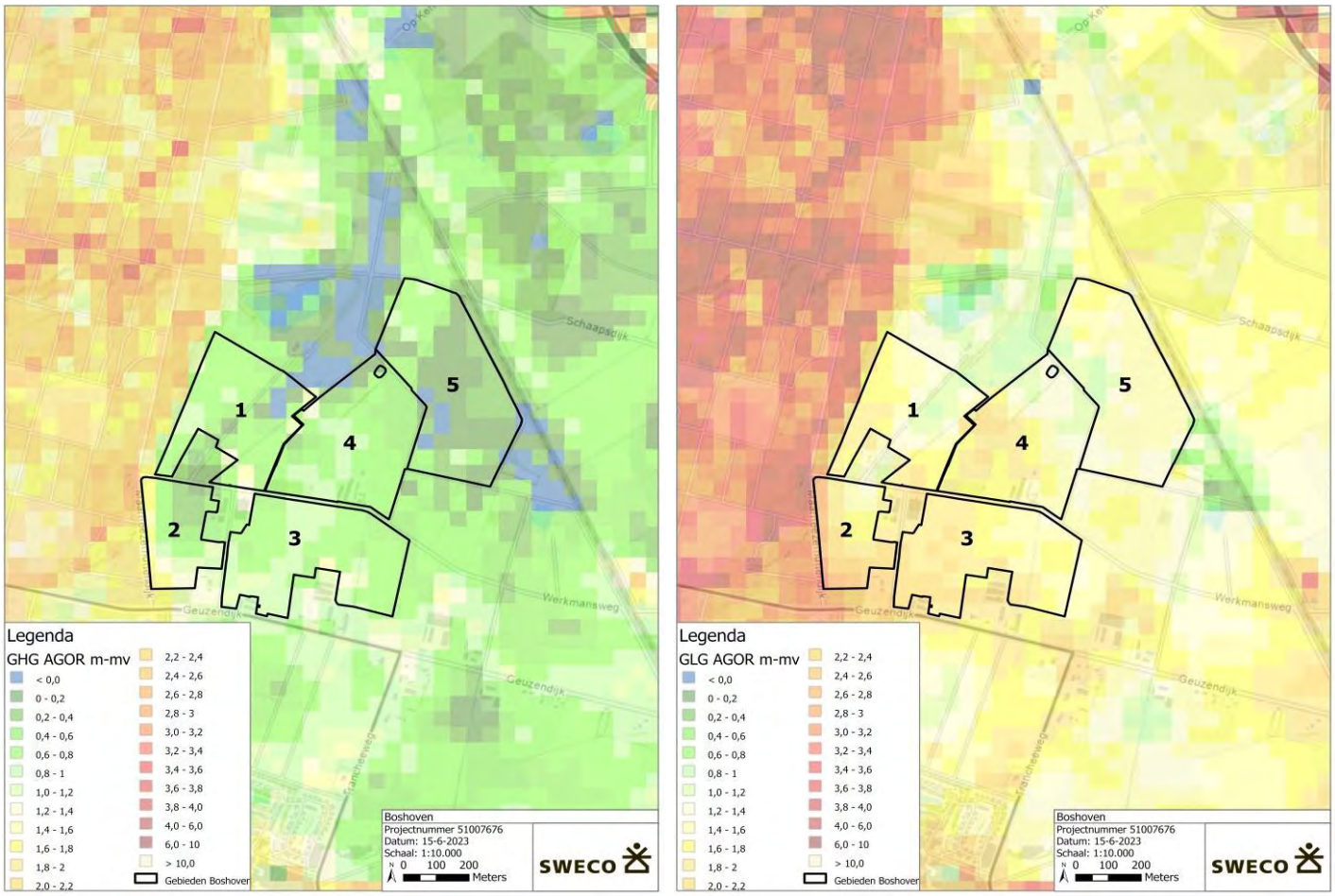
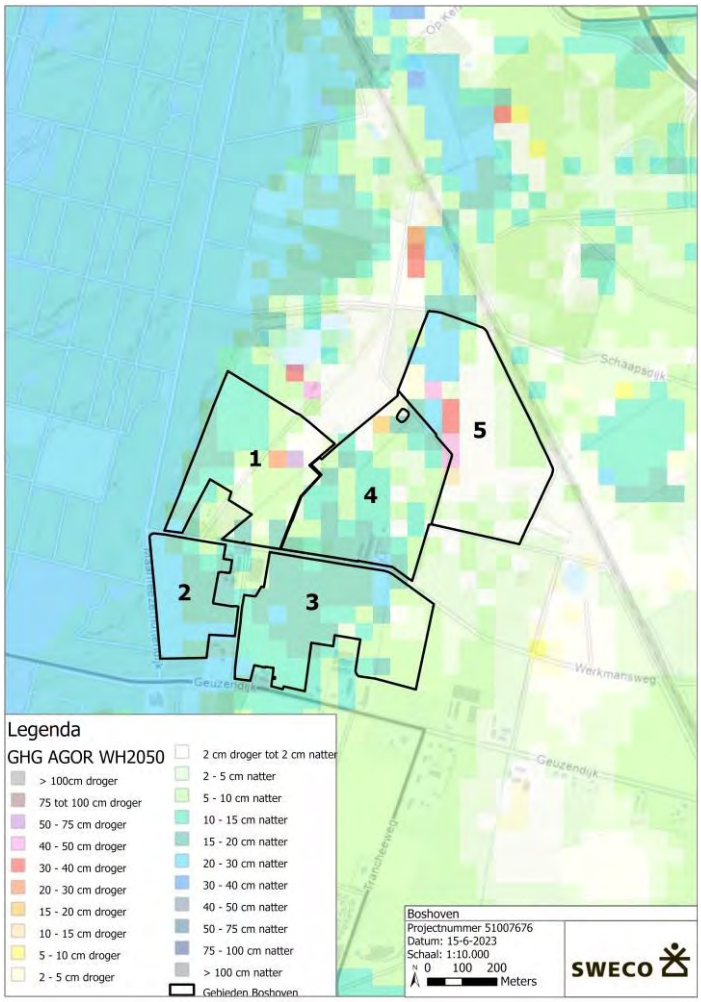


Figure A25 GHG and Figure A26 GLG in the current situation

The Mean Highest Groundwater Level (GHG) is >1 meter below ground level in plot 1. The agricultural areas have shallow groundwater levels. At Area 5, groundwater may rise to ground level (blue areas in Figure A25). Even with the GLG in Figure A26, these areas remain green, meaning that groundwater here does not sink very far either.

Effects of climate change



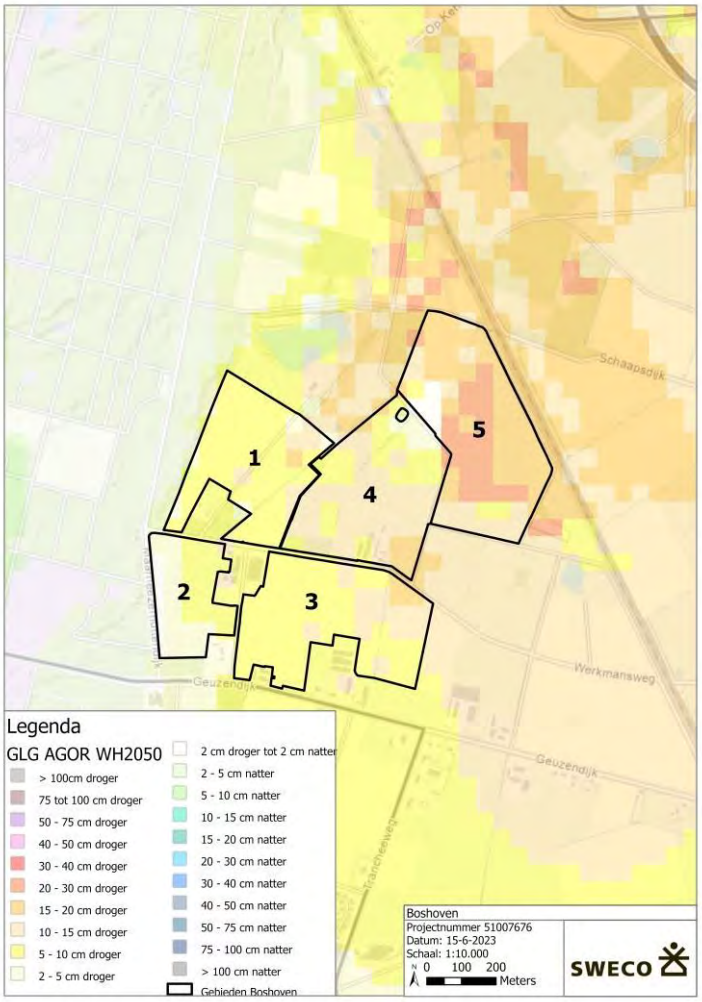


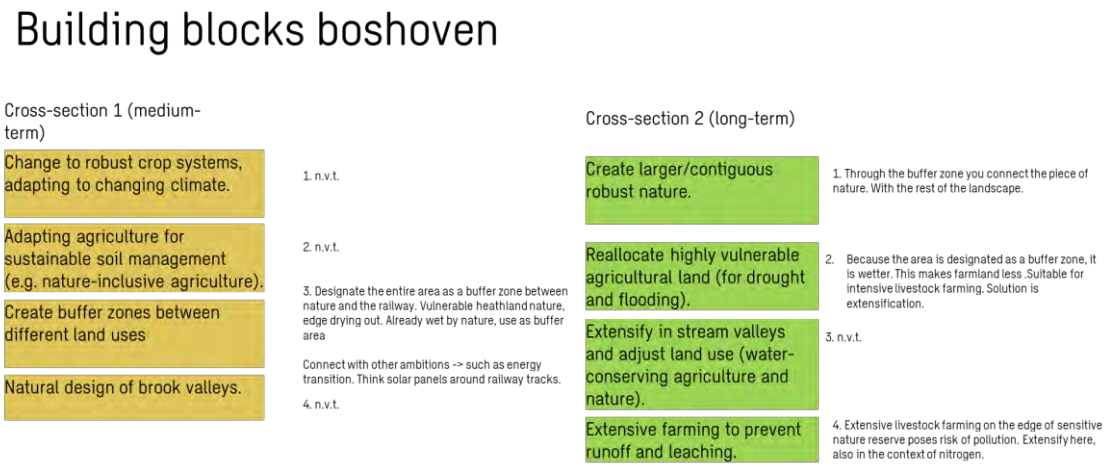
Figure A27 Change GHG in 2050 and Figure A28 change GLG in 2050 compared to the current situation

As shown in Figures A27 and A28, the GHG changes in 2050 due to an increase in the areas that are already wet. On the other hand, the GLG will drop further. This means that extremes increase.

Figure A29 Water Guide Agriculture current situation, in red caused by drought, in blue caused by oxygen deficit, in brown by indirect causes

Figure A30 Water guide agriculture in 2050, in red caused by drought, in blue caused by oxygen deficit, in brown by indirect causes

Figure A30 shows the results of the Waterwijzer for current crops in 2050. The Waterwijzer gives an indication of the relative crop damage caused by water shortage (red, drought), wet damage (blue, displacement of oxygen in the soil by water causes suffocating roots) and indirect damage (including from shifting seasons, trampling losses and mowing times). Due to the high groundwater levels in this area, crop losses due to wet damage are especially common. On arable plots (plots 1 and 2), this leads to more damage than on grassland plots.



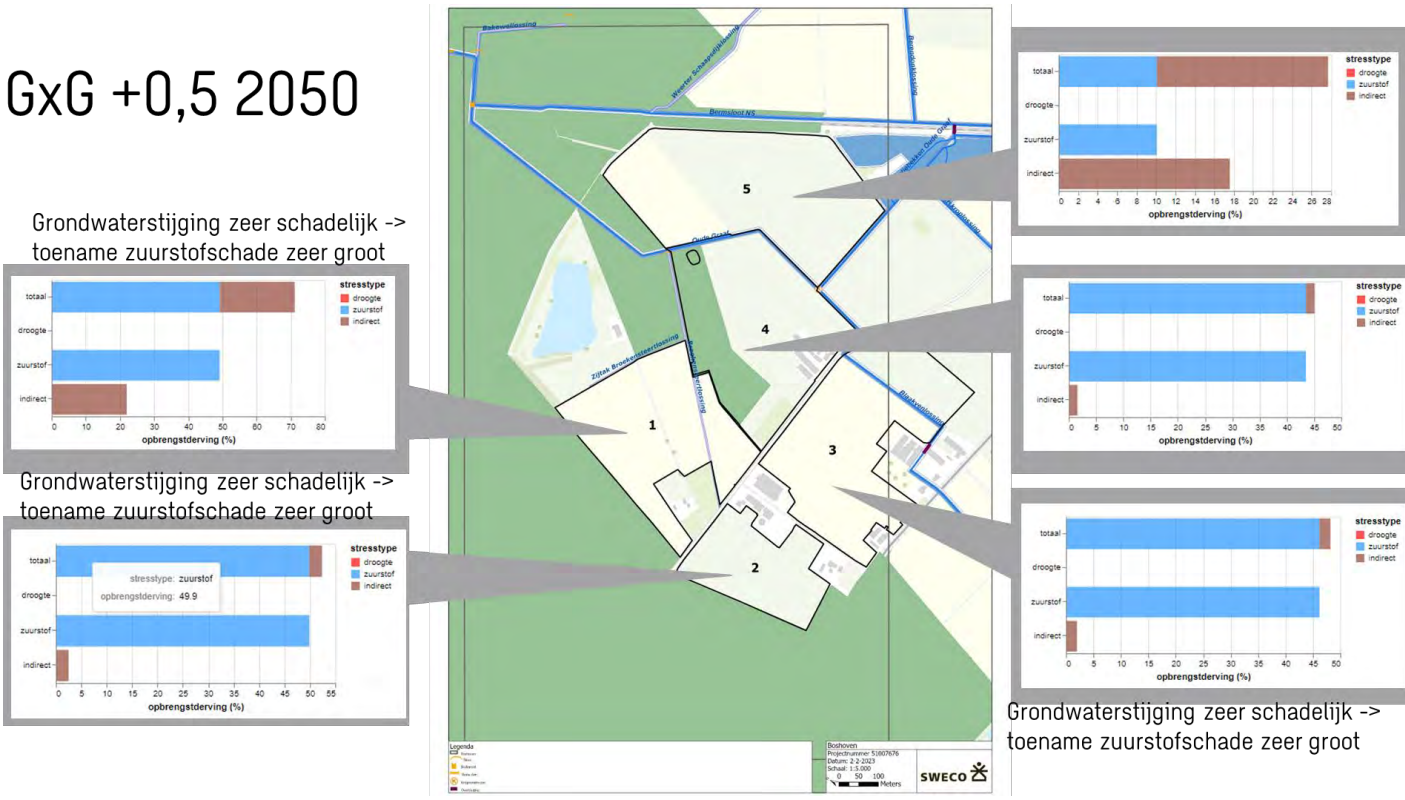


Figure A31 Water indicator “Waterwijzer”, agriculture situation with elevated groundwater levels, in red caused by drought, in blue caused by oxygen deficit,
in brown by indirect causes

If groundwater levels are raised, arable crops in this area will suffer even more crop loss due to wet damage. With a crop loss of almost 50%, crop loss due to soil oxygen deficiency is high. The area will become much wetter, which means that all forms of agriculture will no longer suit these conditions equally well.