SCENARIOS FOR THE OUDLANDPOLDER

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COASTAL
Collaborative Land-Sea Integration Platform

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CONTEXTUAL ELEMENTS INFLUENCING SCENARIO BUILDING

The **Oudlandpolder** contains about 17.000 ha of land reclaimed from the sea. The landscape emerged from centuries of battles against high tides, ultimately won by farmers who developed sophisticated systems of dikes and (little) channels to safeguard their pastures from the salty water. From the 10th century on until today, water management practices have therefore had a pivotal role in the development of this region.

As a result of changing climate patterns and an intensification of agricultural and other water consuming practices, the Oudlandpolder suffered from severe droughts during the last hot summers. The delicate balance between fresh water supply and demand, which had been built up during centuries, appears to be difficult to maintain under the current challenging circumstances. As a result, the polder threatens to become more and more saline, flooding risks increase, and some essential sectors, such as agriculture and nature, are confronted with severe water shortages. **A thorough reorganization of the water system in the area is** therefore **unavoidable**.

As a result, a **framework agreement was signed in 2018 by all governmental bodies responsible for water management in the Oudlandpolder**, that is the Flemish minister of environment, nature and agriculture, the Province of West-Flanders, all municipalities having (part of) their territory in the Oudlandpolder, the Flemish environmental department, the Flemish agricultural department, the Flemish maritime department, the Flemish agency for nature and forests, the Flanders heritage agency, the Flemish environmental agency, the Flemish land agency, the polder's dike warden, and representatives of nature and agricultural organizations.
The objectives of this framework agreement can be summarized as follows:

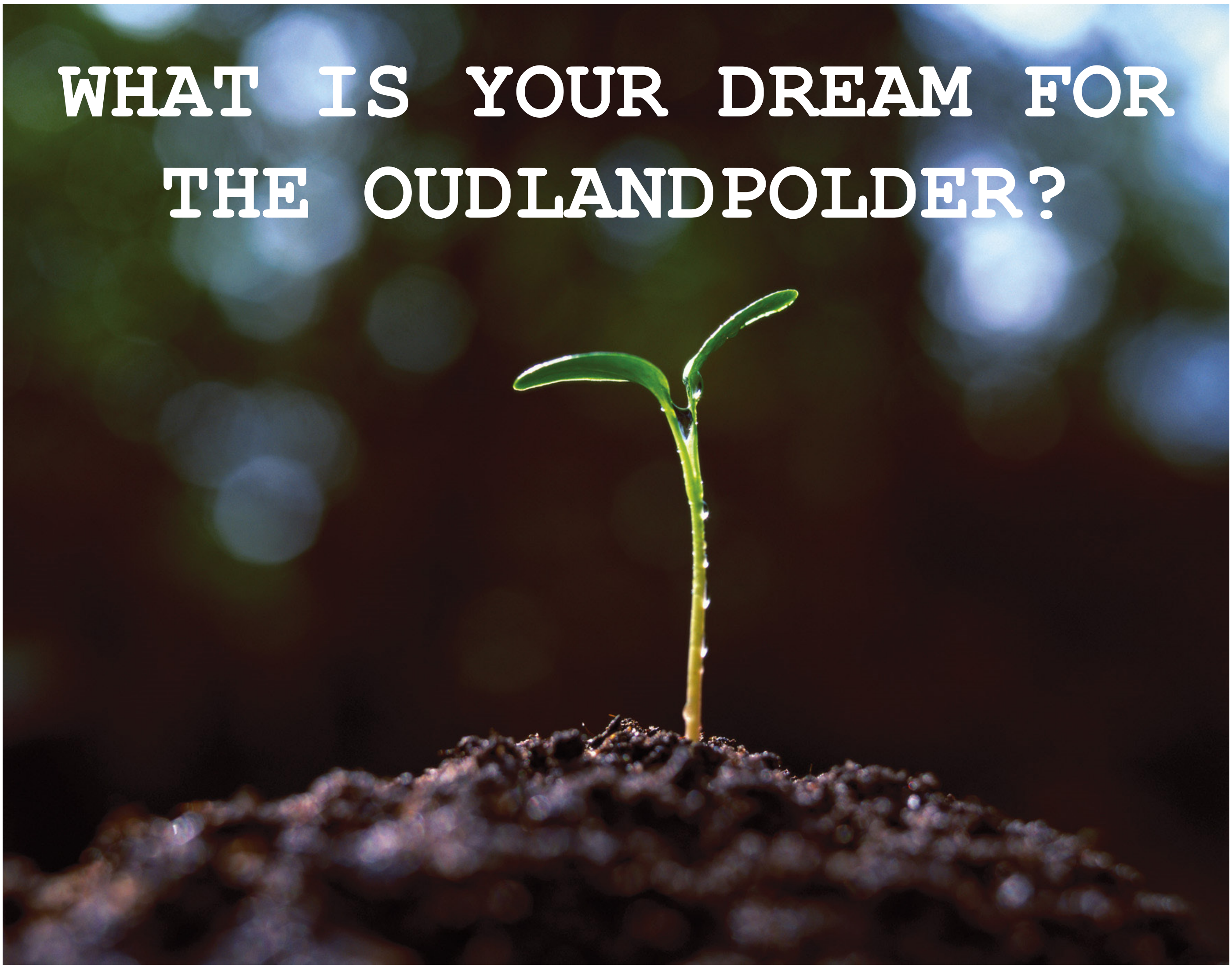
- The implementation of a climate adaptive water management system in the Oudlandpolder.
- The development of dedicated spatial plans marking out essential agricultural and natural structures in the Oudlandpolder.
- The organization and establishment of spatial preconditions allowing for the development of sustainable farming practices in the Oudlandpolder.
- The realization of polder related nature conservation targets in the Oudlandpolder.

This **framework agreement will be implemented by means of** several interlinked spatial planning processes, studies and operational projects assembled by the responsible authorities in **the land development project Oudlandpolder**, coordinated by the Flemish land agency (VLM) – one of the COASTAL partners. This project was **officially launched on December 18, 2020 by the Flemish government**. It involves a diversity of actions throughout the Oudlandpolder supporting the transition towards climate resilient water management, robust ecosystems, sustainable agriculture, vibrant polder villages and sustainable mobility. For this land development project a budget has been allocated of, in total, about 53 million EUR. It is supervised by an official planning guidance group established by the Flemish government.

The **scenarios** that are presented in this report, are developed in collaboration with the VLM and several thematic experts, among which also representatives of the Oudlandpolder planning guidance group. They consist of **narratives and figures explaining the uncertain evolution of several factors external to the Oudlandpolder** system we modelled, such as changes in land use, population growth or (technological) developments in urban water management systems, hence factors going beyond the control of the people involved in the Oudlandpolder's development at a local and regional scale. Notwithstanding this, these external evolutions may impact the development of the Oudlandpolder.

That is why we tried to come to a clear understanding of their true nature, and linked them to the Oudlandpolder's SD model. The latter implies that we scaled down these external uncertainties to the level of the modelled system and defined input variables where these external uncertainties connect with the processes giving rise to the Oudlandpolder's internal functioning.

Complementary to our modelling work, we initially started with a broader scenario development exercise that also covers themes going beyond the scope of the SD model. This way, we had access to a set of scenarios visualizing the future of the Oudlandpolder, both in narratives and pictures, that we could use to feed the ongoing stakeholder process discussing the future development of the region. These narratives were made accessible to interested parties through the publication repository of the Flemish government (cfr. this link). (An English version of this publication is available through COASTAL's knowledge exchange platform via this link.) In practice this means that the scenarios were used to feed the co-creation process supporting a broad group of stakeholders in the Oudlandpolder to develop shared 'guidelines' for the future development of their region. At the same time, the scenarios also functioned as a reference point to assess the impact and consequences of the shared development principles the stakeholders came up with. (Both these shared principles and the assessments can be found in the publication 'Signposts for a sustainable Oudlandpolder', which is also openly accessible via the online repositories just mentioned.)



EXPERT INVOLVEMENT DURING THE SCENARIO BUILDING PROCESS

PROJECT PARTNERS

Throughout the scenario development process several organisations were consulted to review the scenarios, and hence to correct and/or supplement them with additional information when needed. Representatives of the following COASTAL partner organizations gave input to the scenarios:

Organisation	Type of organisation	Expertise	Number of participants	M	V	X
Flemish Land Agency (VLM): coordinator of the Oudlandpolder land development project	Executive Agency of the Flemish government	rural development, land development	3	2	1	
VITO	Independent Flemish research organization	sustainable water management, spatial planning, societal transitions	2	1	1	

OTHER EXPERTS

In order to cover all needed expertise, also representatives of other organizations were consulted. Their details are summarized here:

Organisation	Type of organisation	Expertise	Number of participants	M	V	X
Departement Omgeving	Public administration	Spatial planning	2	1	1	
Agency for Nature and Forestry (ANB)	Public administration	Nature conservation and development	1	1		
Research Institute for Nature and Forestry (INBO)	Research Institute	Nature conservation and development	1	1		
Research Institute for Agriculture, Fisheries and Food (ILVO)	Research Institute	Agriculture, Aquaculture, Fisheries and Food systems	1	1		
University of Ghent	Research Institute	Agricultural Innovations	1	1		
Province of West-Flanders	Public administration	Agriculture	2	2		
Inagro	Research Institute	Agriculture	2	1	1	

RATIONALE EXPERT SELECTION

A draft version of the scenarios was created by the core team leading the Oudlandpolder case in COASTAL, that is VITO in collaboration with the VLM. In a next step, this draft version was reviewed and complemented with additional information by external experts. The latter were chosen in the first place based on their expertise. However, they also helped to increase the legitimacy of the scenarios.

APPROACH

The scenarios were developed over the course of a year (March 2020 – March 2021) by means of desk research, email conversations, one-on-one meetings and telephone calls, as well as discussions taking place in larger settings. The overview below gives a summary of the main meetings that took place in this course of events.

In addition to these meetings, part of the scenarios were also discussed during other events organized in the context of the COASTAL project, for instance in relation to the work that had to be done for WP3 (policy and business roadmaps) or WP4 (model development). The majority of the work, however, has been done by desk research due to the (severe) restrictions caused by the Corona pandemic and is reflected in numerous email exchanges.

1	Meeting with	VLM
	When?	March 3, 2020
	Main goal	Taking the first decisions concerning the direction to go with the Oudlandpolder case.
2	Meeting with	VLM
	When?	June 23, 2020
	Main goal	Discussing the main lines in the narratives of the scenarios in order to be able the progress with the calculations done by the Spatial Model Flanders.
3	Meeting with	INBO
	When?	November 12, 2020
	Main goal	Discussing the potential of wetland restoration in the Oudlandpolder.
4	Meeting with	VLM & Departement Omgeving
	When?	November 17, 2020
	Main goal	Discussing categories of land use in the Oudlandpolder.
5	Meeting with	ILVO
	When?	November 20, 2020
	Main goal	Discussing the potential of saline agriculture in the Oudlandpolder.
6	Meeting with	VLM, Departement Omgeving & ANB
	When?	December 7, 2020
	Main goal	Workshop to discuss the guiding elements in the land use scenarios for the Oudlandpolder.
7	Meeting with	VLM
	When?	February 4, 2021
	Main goal	Discussing elements that should be changed in the agricultural parts of the scenarios based on the review of the agricultural expert of the VLM.
8	Meeting with	VLM
	When?	February 5, 2021
	Main goal	Discussing elements that should be changed in the nature parts of the scenarios based on the review of the nature expert of the VLM.
9	Meeting with	University of Ghent
	When?	February 23, 2021
	Main goal	Discussing elements that should be changed in the agricultural parts of the scenarios based on the review of the agricultural expert of the University of Ghent.

10	Meeting with	Province of West-Flanders
	When?	February 24, 2021
	Main goal	Discussing elements that should be changed in the agricultural parts of the scenarios based on a review of the agricultural experts of the Province of West-Flanders (part 1).
11	Meeting with	ANB
	When?	March 3, 2021
	Main goal	Discussing elements that should be changed in the nature parts of the scenarios based on the review of the expert of the Agency for Nature and Forestry.
12	Meeting with	Province of West-Flanders
	When?	March 10, 2021
	Main goal	Discussing elements that should be changed in the agricultural parts of the scenarios based on a review of the agricultural experts of the Province of West-Flanders and INAGRO (part 2).

THE SCENARIOS IN RELATION TO THE OUDLANDPOLDER MODEL

As the scenarios for the Oudlandpolder deal with uncertainties *external* to the modelled system, they cannot be understood correctly without knowing the exact delineation of this system. What is 'in'? And what is 'out'? What is part of the modelled system? And what is not? This section therefore gives a brief introduction to the system dynamics model developed for the Oudlandpolder. Next, an overview is given of the uncertainties in the system's environment that were taken as a starting point to develop the scenarios.

WHAT DID WE MODEL?

In the context of COASTAL, we choose to focus in our SD model on a selection of land planning and management challenges that will most probably have an impact on the Oudlandpolder's water management system. The model therefore combines insights on the functioning and dynamics of the polder's water system with an agricultural component and spatial planning processes. The latter is done with the help of the Spatial Model for Flanders and allows to include spatial projections concerning the expansion of nature area and a decrease of agricultural lands, as well as urbanisation dynamics.

The spatial challenges that can be answered with the Oudlandpolder SD model, can be summarized by means of the following questions:

- Suppose that the agricultural businesses in the Oudlandpolder gradually adopt less water-intensive crop schemes, and hence choose to plant crops demanding less water during dry summer months, will the region then retain enough rainwater under all climate scenarios with the current polder canal system to cover water demand from both nature and agriculture?
- Suppose that the water system in the Oudlandpolder becomes decoupled from the canal Brugge-Oostende, which currently feeds the polder with considerable amounts of fresh water, how much buffering capacity should then be developed to retain enough rainwater in the region to meet the water demand from nature and agriculture?
- Suppose that, due to sea level rise, gravitional discharge of the Oudlandpolder is not possible anymore, what size of polder drainage pools and pumping capacity will then be needed?

More detailed information about the SD model's structure, its variables and associated quantitative information is reported about in the COASTAL deliverable D14 and deliverable D16. Both publications are accessible via the COASTAL website.

WHAT KIND OF EXTERNAL UNCERTAINTIES WERE TAKEN INTO ACCOUNT?

As has been explained in the introductory part of this report, the Shared Socio-economic Pathways, complemented with the Representative Concentration Pathways (RCPs), were used as a common starting point to develop the model-specific scenarios. In the table below, an overview is given of the parameters from this generic framework identified as being system external uncertainties that may affect the behaviour of the model described above. The second column displays the input variables where the scenarios connect with the modelled system. The third column lists the parameters from the generic scenario framework that were taken into consideration to explain the future evolution of these model-specific input variables.

N°	Model input variable	System-external uncertainties affecting this model input variable
1	Area agriculture	Population growth; urbanization level; land use
2	Area nature	Population growth; urbanization level; policy orientation; land use
3	Waste water treatment plant (WWTP) effluent available for polder	Population growth; urbanization type; policy orientation; technology transfer; resource use
4	Sea level rise	Climate change
5	Precipitation	Climate change
6	Reference evapotranspiration	Climate change

DETAILED DESCRIPTION OF THE SCENARIOS

In total, we developed 4 scenarios for the Oudlandpolder. Each of them is rooted in the combination of a SSP with a climate scenario corresponding with a certain RCP. We choose to work with SSP-RCP combinations that are frequently used in publications of the Intergovernmental Panel on Climate Change (IPCC) and other climate-related studies. This way, inter-study comparisons and meta-analyses will be easier to perform. We named our scenarios as follows, and linked them to the following SSPs and RCPs:

» **Sustainability**: SSP1 + RCP2.6
» **Not choosing is losing**: SSP2 + RCP4.5
» **Structural inequality**: SSP4 + RCP6.0
» **Technological optimism**: SSP5 + RCP8.5

In the remaining part of this section, the future evolution of each of the model input variables listed in the table above is described qualitatively. The quantitative data corresponding with these descriptions can be accessed via this link to the online data repository. To develop these region-specific scenario descriptions the following steps were taken:

- **Step 1** – All spatially explicit data were calculated making use of the Spatial Model for Flanders. This model was fed with land use projections coupled to different land use dynamics that were outlined during previous spatial planning studies for the Flemish government. In addition to this, the stakeholder process described above resulted in context-specific information that allowed to finetune these model projections to the characteristic dynamics of the Oudlandpolder.
- **Step 2** – To calculate the climate related data needed to feed the model, the Norwegian Earth System Model (NorESM1-M) was used (Bentsen, 2013[1]; Iversen, 2013[2]).
- **Step 3** – Population growth estimates were downloaded for each of the SSPs from the SSP Database developed by the International Institute for Applied Systems Analysis (IIASA). These figures were downscaled to the Oudlandpolder by means of the Spatial Model for Flanders.
- **Step 4** – The expected evolution in the amount of waste water treatment plant (WWTP) effluent under each of the SSPs was calculated based on a model developed by VITO water experts. This model assesses the consumption of tap water, grey water and rainwater in function of an increase in water use practices contributing to water use efficiency and the closure of water cycles. It allows to calculate the fraction ultimately ending up in a WWTP of the tap -, grey - and rainwater that was initially used.

[1] **Bentsen**, M., Bethke, I., Debernard, J. B., Iversen, T., Kirkevåg, A., Seland, Ø., Drange, H., Roelandt, C., Seierstad, I. A., Hoose, C., and Kristjánsson, J. E.: The Norwegian Earth System Model, NorESM1-M – Part 1: Description and basic evaluation of the physical climate, Geosci. Model Dev., 6, 687–720, https://doi.org/10.5194/gmd-6-687-2013, 2013.
[2] **Iversen**, T., Bentsen, M., Bethke, I., Debernard, J. B., Kirkevåg, A., Seland, Ø., Drange, H., Kristjansson, J. E., Medhaug, I., Sand, M., and Seierstad, I. A.: The Norwegian Earth System Model, NorESM1-M – Part 2: Climate response and scenario projections, Geosci. Model Dev., 6, 389–415, https://doi.org/10.5194/gmd-6-389-2013, 2013.

1&2. AREA AGRICULTURE & AREA NATURE

SUSTAINABILITY

This scenario includes the anti-urban sprawl land use scenario for Flanders. 'Anti-urban sprawl' not only tries to reduce the extra land take in Flanders to 0 ha by 2035, but also to make extra space over time for nature, agriculture and forestry. This results in a relatively large densification of villages, towns and cities. What the impact would be on the area of land dedicated to agriculture of the implementation of this kind of land use strategy in 2050, can be seen on this map of the Oudlandpolder.

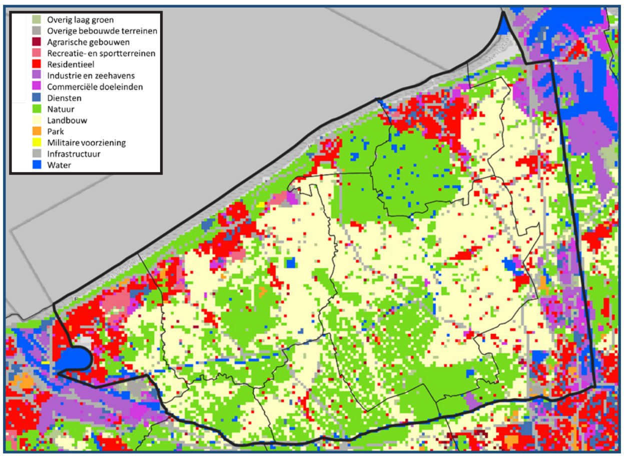


Figure 1. Land use in the OudlandPolder in 2050 according to the Spatial Model Flanders under the land use scenario 'anti urban sprawl'.

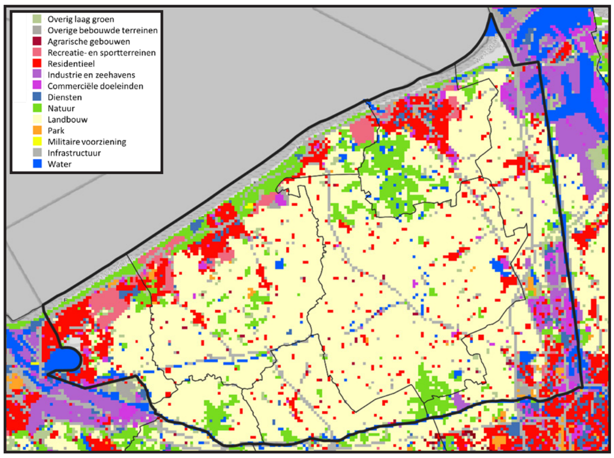


Figure 2. For comparison: Space use in the Oudlandpolder in 2013.

NOT CHOOSING IS LOSING

This scenario includes the 'business as usual' land use scenario. In this scenario, land use will increase in proportion to population growth. Relatively speaking, more housing, commercial premises, restaurants, etc. are added in the centres of villages and cities than in the outlying area. Compared to growth as usual (the land use scenario applied in the next scenario), the densities in village and city centres are therefore higher in this scenario.

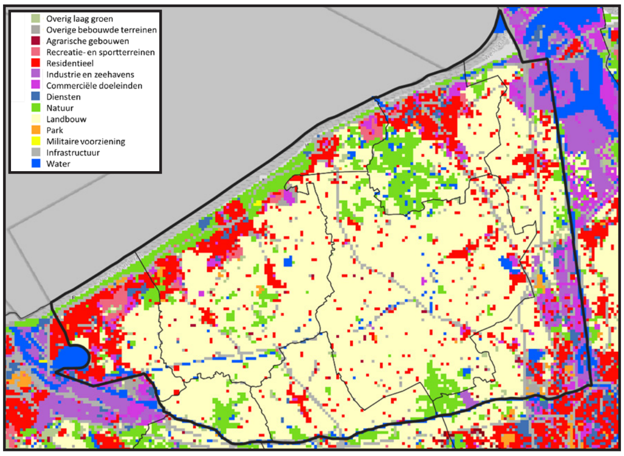


Figure 3. Land use in the OudlandPolder in 2050 according to the Spatial Model Flanders under the land use scenario 'business as usual'.

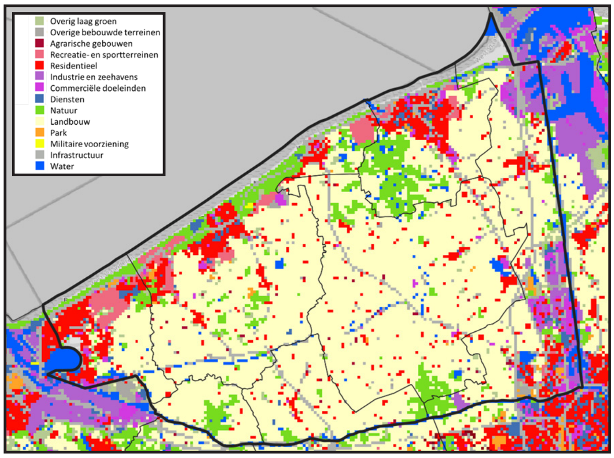


Figure 4. For comparison: Space use in the Oudlandpolder in 2013.

STRUCTURAL INEQUALITY

In this scenario, open space continues to be occupied at the current rate in Flanders. This means that every day about 6 ha of open space disappear. In this scenario you can therefore see a strong increase in the area of residential land.

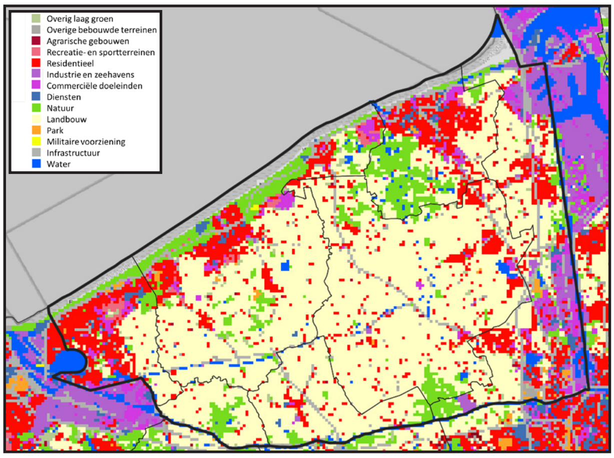


Figure 5. Land use in the OudlandPolder in 2050 according to the Spatial Model Flanders under the land use scenario 'anti urban sprawl'.

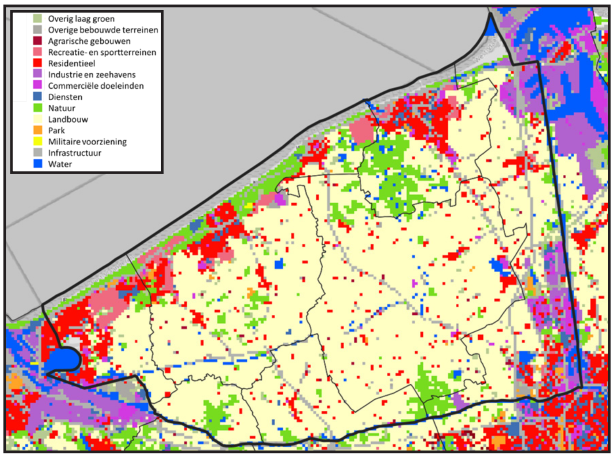


Figure 6. For comparison: Space use in the Oudlandpolder in 2013.

TECHNOLOGICAL OPTIMISM

This spatial scenario assumes strong densification based on the strategic spatial vision for Flanders (approved on July 13, 2018). The main objective of this vision is to reduce the growth in land take to 0 ha per day by 2040. This leads to the densification of city and town centres and well-located locations, namely locations with a high 'node value' and a high level of amenities.

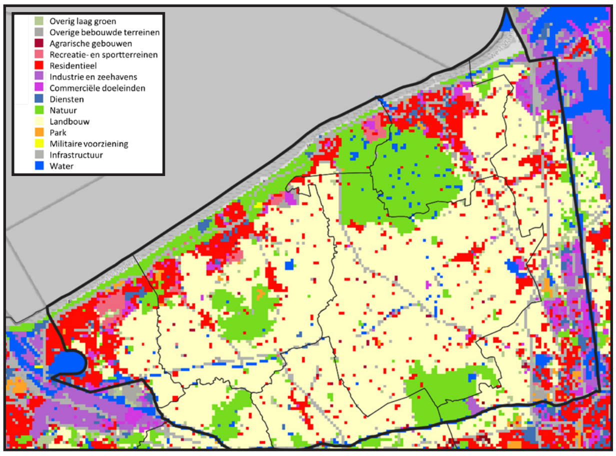


Figure 7. Land use in the OudlandPolder in 2050 according to the Spatial Model Flanders under the land use scenario 'strategic spatial vision Flanders'.

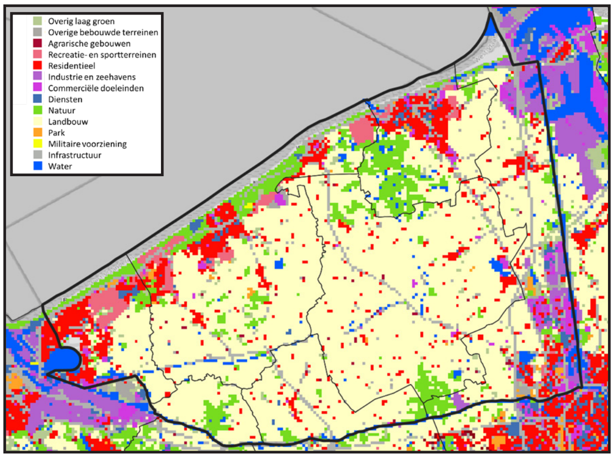


Figure 8. For comparison: Space use in the Oudlandpolder in 2013.

3. WASTE WATER TREATMENT PLANT EFFLUENT AVAILABLE FOR POLDER

Currently, the Oudlandpolder's water system is fed on a daily basis with about 70.000 m^3 of waste water treatment (WWTP) plant effluent. Due to a diversity of factors, among which technological developments leading to a more efficient use of (rain)water and attempts to close water loops, this amount of water is expected to decrease in the future. In order to be able to make an adequate estimation of this decrease, we quantitatively modelled the amount of waste water produced by four types of households:

1. households only using tap water - no implementation of additional water efficiency measures
2. households in which rainwater amounts to 33% of their water use - no implementation of additional water efficiency measures
3. households in which rainwater amounts to 32% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower
4. households optimally closing water loops resulting in grey water use amounting to 14% of their water use - rainwater representig 50% of their water use - no implementation of additional water efficiency measures
5. households optimally closing water loops resulting in grey water use amounting to 9% of their water use - rainwater representing 50% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower

The scenarios below show different proportions of these types of households.

SUSTAINABILITY

The proportions of the different types of households in this scenario are as follows in 2050:

1. (0%) households only using tap water - no implementation of additional water efficiency measures
2. (0%) households in which rainwater amounts to 33% of their water use - no implementation of additional water efficiency measures
3. (40%) households in which rainwater amounts to 32% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower
4. (0%) households optimally closing water loops resulting in grey water use amounting to 14% of their water use - rainwater representig 50% of their water use - no implementation of additional water efficiency measures
5. (60%) households optimally closing water loops resulting in grey water use amounting to 9% of their water use - rainwater representing 50% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower

In total, these changes in water consumption and management lead to an overall reduction of the amount of waste water of 41% compared to today. Furthermore, this scenario also incorporates a population growth based on the SSP1 growth projections for Belgium available in the IIASA database.

NOT CHOOSING IS LOSING

The proportions of the different types of households in this scenario are as follows in 2050:

1. (39%) households only using tap water - no implementation of additional water efficiency measures
2. (0%) households in which rainwater amounts to 33% of their water use - no implementation

of additional water efficiency measures

3. (50%) households in which rainwater amounts to 32% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower
4. (0%) households optimally closing water loops resulting in grey water use amounting to 14% of their water use - rainwater representig 50% of their water use - no implementation of additional water efficiency measures
5. (11%) households optimally closing water loops resulting in grey water use amounting to 9% of their water use - rainwater representing 50% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower

In total, these changes in water consumption and management lead to an overall reduction of the amount of waste water of 5% compared to today. Furthermore, this scenario also incorporates a population growth based on the SSP2 growth projections for Belgium available in the IIASA database.

STRUCTURAL INEQUALITY

In this scenario waste water processing becomes privatized. As a result of a growing demand for process water in industrial environments, the WWTP effluent is further processed and upgraded and eventually sold as process water. There is no WWTP effluent flowing into the polder anymore.

TECHNOLOGICAL OPTIMISM

The proportions of the different types of households in this scenario are as follows in 2050:

1. (0%) households only using tap water - no implementation of additional water efficiency measures
2. (20%) households in which rainwater amounts to 33% of their water use - no implementation of additional water efficiency measures
3. (0%) households in which rainwater amounts to 32% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower
4. (80%) households optimally closing water loops resulting in grey water use amounting to 14% of their water use - rainwater representig 50% of their water use - no implementation of additional water efficiency measures
5. (0%) households optimally closing water loops resulting in grey water use amounting to 9% of their water use - rainwater representing 50% of their water use - implementation of additional water efficiency measures as a result of which overall water consumption is lower

In total, these changes in water consumption and management lead to an overall reduction of the amount of waste water of 34% compared to today. Furthermore, this scenario also incorporates a population growth based on the SSP5 growth projections for Belgium available in the IIASA database.

4. SEA LEVEL RISE

The scenarios covering sea level rise projections are based on data provided for by the Intergovernmental Panel on Climate Change Working Group I in Chapter 9 'Ocean, cryosphere and sea level change' of Assessment Report 6. More precisely in Chapter 9.6.3.3 'Sea-level projections to 2150 based on SSP scenarios.' The graph below shows the different sea level rise trajectories that were taken into account in the modelling work for the Oudlandpolder.

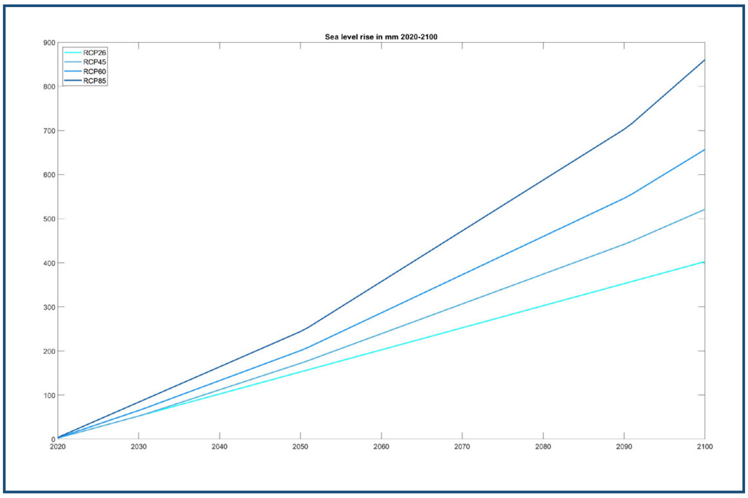


Figure 9. IPCC Working Group I sea level rise trajectories taken into account in the Oudlandpolder model.

5. PRECIPITATION

The average precipitation rate in the Oudlandpolder is currently estimated at 1045 mm/year. Due to climate change, however, precipitation patterns are expected to change. In general, model projections indicate that summer months will become dryer and winter months more wet. The more severe the climate scenario is, the more pronounced this phenomenon is expected to be. The graph below gives an indication of the expected evolution for the Oudlandpolder.

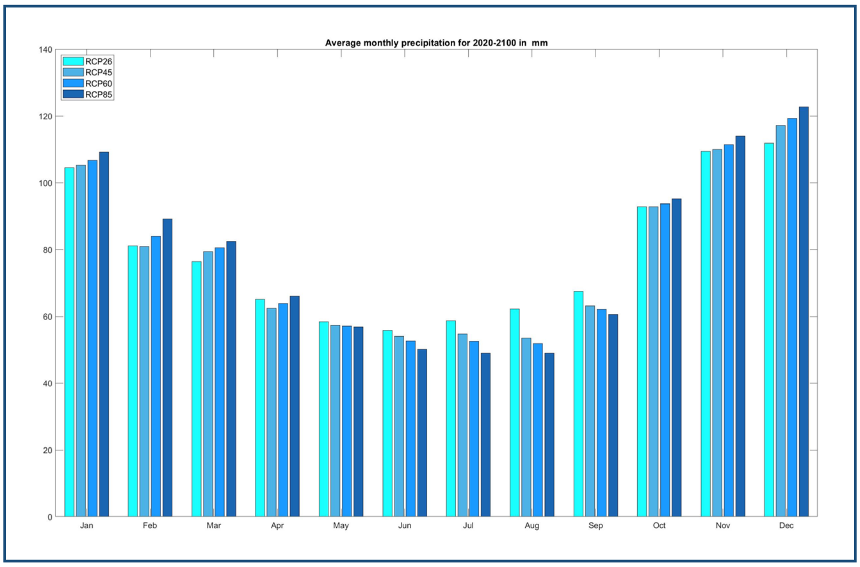


Figure 10. Average expected monthly precipitation over the period 2020-2100.

6. REFERENCE EVAPOTRANSPIRATION

Water demand in the Oudlandpolder is calculated for both nature and agriculture based on the potential evapotranspiration. This is the sum of (1) the evaporation of all water in and on soils and plants, and (2) the transpiration of water by plants. Evapotranspiration equals the total volume of rainwater ultimately going back to the atmosphere.

The potential evapotranspiration stands for the evapotranspiration happening when plants have access to enough water. In situations of water shortage the actual evapotranspiration will therefore be lower than the potential evapotranspiration. To calculate the potential evapotranspiration we followed the methodology proposed by the FAO (accessible via this link).

The figure belows shows the evolution of the potential evapotranspiration under several climate scenarios throughout the 21th century.

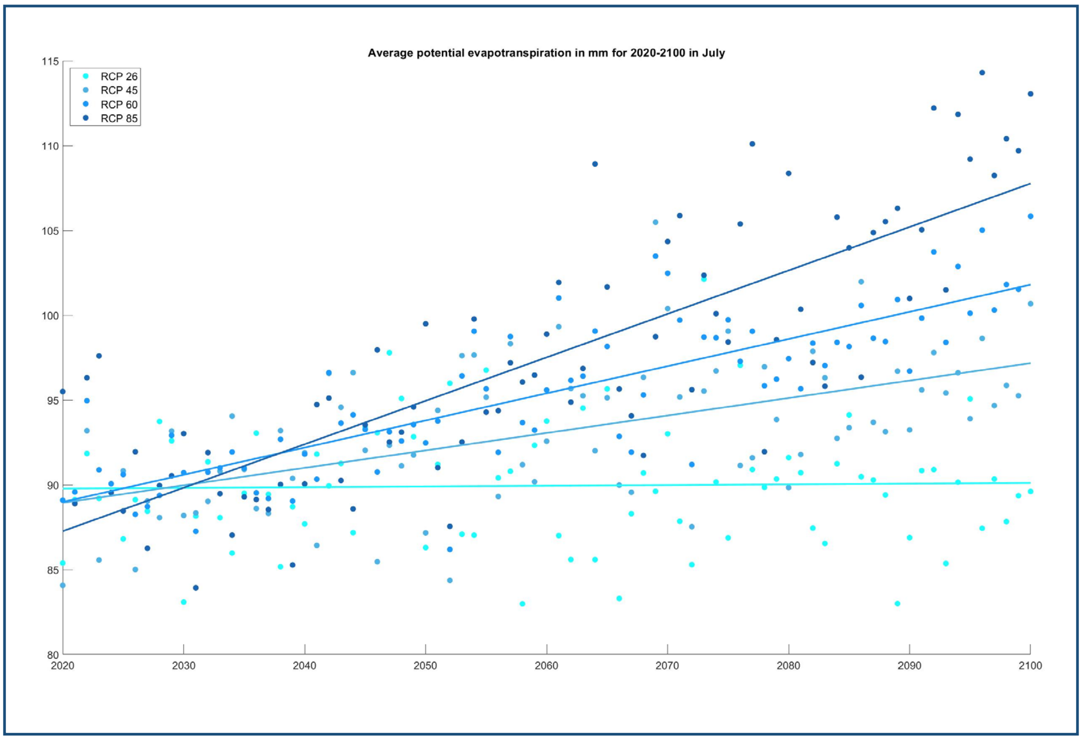


Figure 11. Evolution of the total potential evapotranspiration in the Oudlandpolder during the 21th century under different climate scenarios.

COMPARISON OF THE DYNAMIC PATTERNS OF KEY PERFORMANCE INDICATORS

Notwithstanding the vast amount of work that has been invested in the Oudlandpolder SD model during the COASTAL project, we unfortunately did not reach the point at which this tool can generate reliable output. Based on the latest test runs we had to conclude that the dynamic relation between surface and ground water levels in the polder should be further optimized. However, in the final stages of the COASTAL project we lack time and resources to complete this task. As a result, it's not possible, at the moment of writing, to present reliable results on the dynamic patterns of key performance indicators that can support decision making in function of the spatial development of the Oudlandpolder.