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Horizon 2020 Societal challenge 5: Climate action, environment, resource efficiency and raw materials

BINGO

Bringing INnovation to onGOing water management – a better future under climate change

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Note: This version of D3.2 includes changes implemented in order to address the comments from the review of the second reporting period.

Changes with respect to the DoA

No changes

Dissemination and uptake

This deliverable will be used as input for T3.4 of BINGO. The scenarios contained in this report can also be used in WP5 in the development of adaptation strategies.

Short Summary of results (<250 words)

This document reports the future land and water use scenarios at the six BINGO research sites. The scenarios consist of qualitative developments, for each of two future scenarios Economy First and Sustainability Eventually, developed within SCENES at the research sites. These qualitative developments are then translated into quantitative land use and water use tables. Prior to the results, the scope and methodology are explained and justified in the respective chapters. The results from this deliverable will be used to analyze the effect of land and water use on the hydrology of the research sites, compared to the effects of extreme weather events.

Evidence of accomplishment

Report

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1. SCOPE

1.1 Introduction

The main topic for WP3 is assessing the effects of climate change on the hydrological cycle in the six BINGO research sites. However, anthropogenic activities also have a potentially large impact on the hydrological cycle and are expected to change in the coming decade. According to some studies, the impact of land use and water use can even be larger than the impact of climate change[1]. Therefore, T3.3 of WP3 sets out to assess the changes in land use and water use at the six research sites: Cyprus (Pedieos Catchment) Portugal, Bergen, Badalona, Wuppertal and Veluwe.

Land use and water use changes don't happen in a vacuum. They are caused both by climate change and socio-economic and political conditions. For example, the choice of which crop to grow depends both on climatic conditions (such as temperature and precipitation) and on economic conditions (such as price levels and export opportunities).

Both changes in climate conditions and changes in socio-economic and political conditions are subject to prospective uncertainty. This is among other things caused by complexity of the phenomena and unpredictability of human behavior. It makes predictions very unreliable and requires to take multiple future outcomes into account. In WP3, we therefore take a scenario approach to the future of land use and water use at the research sites.

This task (T3.3) does not only aim to analyze future land and water use, it also provides the research sites with methodologies to assess uncertain futures. By using scenarios developed in the SCENES project, we aim to build on prior knowledge and apply this knowledge to the level of the research sites.

1.2 Outline of the report

After the introductory chapter 1, chapter 2 describes the methodology for Task 3.3, including the stepwise approach developed for the research sites.

Chapter 3 shows the results for each research sites and a description of how these results were achieved. For all sites, land use and water use tables are reported. Some sites have modified the stepwise approach to better fit their local situation, which is reflected in the different output formats (land/water use categories, assumptions regarding land/water use, etc), while still providing the necessary data for comparison and further analysis.

Chapter 4 provides a summary of the main results and an outlook on how the results of task 3.3 will be used further in the project. Chapter 5 provides the SCENES storylines.

[1] See for instance: Sala, Osvaldo E., et al. "*Global biodiversity scenarios for the year 2100.*" science 287.5459 (2000): 1770-1774; Beguería, Santiago, et al. *"Assessing the effect of climate oscillations and land-use changes on streamflow in the Central Spanish Pyrenees."* AMBIO: A Journal of the Human Environment 32.4 (2003): 283-286; Piao, Shilong, et al. *"Changes in climate and land use have a larger direct impact than rising CO2 on global river runoff trends."* Proceedings of the National Academy of Sciences 104.39 (2007): 15242-15247.

2. METHODOLOGY

2.1 Scenario approach

Many scholars have argued that scenario planning is a good tool to handle uncertainty[2] and its application in water management projects is widespread[3]. Scenarios are storylines, build from a combination of driving forces. They are often qualitative, but quantitative measures can be added to make the scenarios useful for modelling purposes[4].

A large number of scenario studies have been developed at the global and European level, with elaborate storylines, such as IPCC/SRES; GEO3-6; World Water Vision; EEA European Water Outlook and SCENES (FP6). The scenarios developed in SCENES are particularly useful for the purpose of BINGO as:

- They have a specific focus on water;
- They are downscaled to the sub-European (regional) level;
- They are accompanied by country-level data on land use and water use.

2.2 Combining a top-down and bottom-up approach

One of the aims of BINGO is to provide comparable and generalizable findings across the six research sites. At the same time, the research sites present different issues and circumstances and existing knowledge, approaches and practices. In our approach we try to do justice to both in combining the use of top-down scenarios, with nationally and locally available knowledge.

The SCENES scenarios are very well fitted for that purpose. The storylines have been developed at the European scale and have been scaled down to the regional level in multiple workshops with regional stakeholders[5]. Also, national level data on land use and water use have been developed for each of the scenarios, facilitating the adaptation of the scenarios to the level of the research sites.

The SCENES project developed four scenarios that are adapted from the GEO-4 global scenarios. The scenarios are based on driving forces from different categories: demographic, economic, socio-cultural, technological, ecological and political. The driving forces consist of developments with a high impact on ecosystems, but also with high uncertainty in future outcomes. Possible outcomes of these driving forces have been grouped in four scenarios:

- Economy First (renamed after Markets First in GEO4)
- Policy First
- Security First
- Sustainability Eventually (renamed after Sustainability in GEO4)

As shows in the GEO4 and SCENES studies, the scenarios differ in their projected impact on ecological systems. The Economy First scenario represents an emphasis on economic growth, globalisation and shows high ecological impact such as increased agriculture and water use, while the Sustainability Eventually

[2] See for instance Schoemaker, P. (1991) *When and how to use scenario planning: A heuristic approach with illustration,* Journal of Forecasting 10 (6) pp 549–564; van der Heijden, K. (1996), *Scenarios: the Art of Strategic Conversation*, Wiley, Chichester;
[3] van Vliet, M. & Kok, K. Mitig Adapt Strateg Glob Change (2015) 20: 43. doi:10.1007/s11027-013-9479-6
[4] Kamari, J., et al. *Envisioning the future of water in Europe-the SCENES project.* E-water (2008): 1-28.
[5] Kok, Kasper, et al. *Combining participative backcasting and exploratory scenario development: experiences from the SCENES project,* Technological Forecasting and Social Change 78.5 (2011): 835-851.

scenario is characterized by slower (but more equally distributed) growth, stronger regulation, local and regional emphasis and less ecological impact. The other two scenarios show intermediate values.

Because they represent the most diverging range of values, we have selected the Economy First and Sustainability Eventually storylines as a starting point for the analysis of future land and water use in BINGO.

2.3 Questionnaires

The top-down approach aims at scaling down and quantifying the two qualitative storylines from SCENES. The first step consists of translating the regional level SCENES scenarios into developments at the level of the research site using the PESTLE categorization. This step is not a prerequisite for filling in the land use and water use tables, but may be helpful in developing a logical link between the scenarios and the data. Table 1 shows the blank PESTLE table for the research sites.

Table 1: Empty PESTLE table

DIMENSION	RELEVANT TRENDS	EFFECT ON LAND USE	EFFECT ON WATER USE
POLITICAL *Changes in government, policy or power relations that are relevant to land use and water use*			
ECONOMIC *Economic changes that affect land and water use*			
SOCIOLOGICAL *Changes in culture, social relations and values*			
TECHNOLOGICAL *Development and implementation of new technologies*			
LEGAL *Changes in legislation and the legal structure*			
ENVIRONMENTAL *Changes in the environment and attitudes toward environmental issues*			

The second step is to derive from these trends quantitative values for land use and water use and reporting these in land use and water use tables (see Table 2 and Table 3). As a time horizon 2030 was chosen (5 years beyond the 'official' BINGO horizon), with 5 year time steps. If available, values for previous time periods could be submitted as reference values.

This top-down approach was presented to the research sites to provide them with a point of departure for developing the land use and water use tables. Research sites were free to integrate this approach with their local predictions/scenarios and to alter the land use and water use categories to their local situation. They were asked in that case, to link the local available knowledge to the SCENES scenarios.

Finally, the research sites were asked to produce land use maps (based on GIS) for each of the scenarios, in case a spatial distribution is required for the modelling of water resources.

Because the results of this deliverable are used in the hydrological models that are applied locally, the research sites had the liberty of adjusting the method and the land/water use classes to fit their local situation, as long as a connection to the SCENES scenarios was made.

For most case this has resulted in a focus on just a subset of land use classes (mainly for flood cases) or an addition of classes to better reflect the specifics of the land use at the research sites. The Wupper case and the Tagus case did not produce a spatial distribution of land use (in the form of land use maps) because they are not applied in further modelling (Tagus) or because the necessary data was not available (Wupper). This latter case is explained in the respective section of the report.

Table 2: Empty Land use table

PLEASE PROVIDE EXPECTED CHANGES IN LAND USE FOR DIFFERENT SCENARIOS, E.G. IN PERCENT OR KM².												
RESEARCH SITE												
scenario	year	urban + settlement	crops	irrigated area	grassland	forest	set aside	others (open water)	woody savannah	natural	WetIceSnow	Total
	2000											
	2005											
	2010											
	2015											
Economy First	2020											
Sustainability Eventually	2020											
Economy First	2025											
Sustainability Eventually	2025											
Economy First	2030											
Sustainability Eventually	2030											

Table 3: Empty water use table

PLEASE PROVIDE EXPECTED CHANGES IN WATER USE FOR DIFFERENT SUB-SECTORS AND SCENARIOS						
RESEARCH SITE						
scenario	year	domestic	industrial	livestock	irrigation	energy
	2000					
	2005					
	2010					
	2015					
Economy First	2020					
Sustainability Eventually	2020					
Economy First	2025					
Sustainability Eventually	2025					
Economy First	2030					
Sustainability Eventually	2030					

3. RESULTS FOR THE RESEARCH SITES

3.1 Cyprus

3.1.1 Land use

The Pedieos catchment represents a case for flooding evaluation, so only land use and not water use is considered in this case. Also, only those land use categories that are relevant for run-off are analysed.

For this Cyprus case, data from the CORINE Land Cover (CLC) were used as the point of departure for extrapolating future values. Table 4 and Table 5 show the translation from the CLC categories to the SCENES categories. The total area of each group was calculated for each Community/Municipality (Community/Municipality boundary level) within Pedieos catchment using GIS.

The built-up areas of rural communities of Pedieos catchments are represented by the CLC Category "Discontinuous urban fabric" and this category was assigned to the SCENE category named "urban + settlement", thus the built up areas (including rural roads) have been considered to the analysis. Furthermore, the CLC categories «Roads and rail networks and associated land» and «Continuous urban fabric» include the whole road network, and this categories was assigned to the SCENE category named "urban + settlement" as well (see Table 4 and 5).

Table 4: CLC Categories

NO.	CLC CATEGORIES
1	Continuous Urban Fabric
2	Discontinuous urban fabric
3	Industrial or commercial units
4	Roads and rail networks and associated land
5	Mineral extraction sites
6	Green urban areas
7	Sport and leisure facilities
8	Non-irrigated arable land
9	Permanently irrigated land
10	Fruit trees and berry plantations
11	Olive groves
12	Annual crops associated with permanent crops
13	Complex cultivation pattern
14	Land principally occupied by agriculture, with si*
15	Coniferous forest
16	Natural grassland
17	Sclerophylous vegetation
18	Transitional woodland/shrub
19	Sparsely vegetated areas
20	Construction sites
21	Water bodies

Table 5: Corresponding SCENES categories

SCENES CATEGORIES	CLC NO.
urban + settlement	1, 2, 3, 4,6,7,20
crops	8, 11, 14
irrigated area	9, 10,12,13
grassland	16
forest	15
set aside	
others (open water)	5, 21
woody savannah	
natural	17,18, 19
WetIceSnow	

Sustainable Eventually Scenario

Based on the population projection for the 2020, 2025 and 2030 for each Community/Municipality, derived from the population trends based on the available census data, the area of the “urban + settlement” category was increased accordingly. The Residential Town Planning Zones (RTPZs) areas of 2015 for each village within the Pedieos catchment area were used as a threshold for the “urban + settlement” increase. Furthermore, these RTPZs were used to find out which land use categories are affected (replaced) from the “urban + settlement” increase and therefore the added area to the “urban + settlement” was subtracted from those affected categories.

Economy First Scenario

It was assumed that by the year 2030 the Residential Town Planning Zones will be fully developed, so the area of the “urban + settlement” would be increased from 2012 to 2030 proportionally until the area of the “urban and settlement category” will be equal to the Residential Town Planning Zones areas (see Table 6).

For the land use change of the ‘’forest’’ category, 14.5 ha/y (based on the Management plan of Macheras Forest of the Department of Forests) was assumed as burnt areas for both scenarios.

Base on the above, the Land use table was filled as shown on Table 8. It shows for both scenarios an increase in the urban + settlement category, with a proportional decrease in the other categories, based on where the urban expansion takes place. The data for the CLC 2000 were omitted, because based on the results, were considered in certain cases as not reasonable.

Figure 1 shows the land use map for 2012, Figure 2 and Figure 3 show the land use maps for 2030 for the different scenarios.

It is strongly believed that these two scenarios are quite rational, because the future expansion of the built up area (“urban and settlement category”) has been confined within the Residential Town Planning Zones. These zones, for the communities of Pedieos, which could be considered in effect as suburban areas of

Nicosia, are quite large compared to the existing built up areas. Therefore, they are not anticipated to increase further in the next ten to fifteen years.

Table 6: Economy First PESTLE

ECONOMY FIRST		
DIMENSION	**RELEVANT TRENDS**	**EFFECT ON LAND USE**
POLITICAL	Residential Town Planning Zones will be fully developed	Proportional increase to the “urban and settlement” area
ECONOMIC	Higher economic growth	Faster expansion of urban area
SOCIOLOGICAL	Population grows according to local projections for 2020, 2025 and 2030	“Urban + settlement” area increases to the maximum RTPZs area
TECHNOLOGICAL	N/A	N/A
LEGAL	N/A	N/A
ENVIRONMENTAL	N/A	N/A

Table 7: Sustainability Eventually PESTLE

SUSTAINABILITY EVENTUALLY		
DIMENSION	**RELEVANT TRENDS**	**EFFECT ON LAND USE**
POLITICAL	Residential Town Planning Zones will not be fully developed	Proportional increase to the “urban and settlement” area
ECONOMIC	Slower economic growth	Slower expansion of urban area
SOCIOLOGICAL	Population grows according to local projections for 2020, 2025 and 2030	“Urban + settlement” area increases according to population growth
TECHNOLOGICAL	N/A	N/A
LEGAL	N/A	N/A
ENVIRONMENTAL	N/A	N/A

Table 8: Future land use Pedieos Catchment in km²

SCENARIO	YEAR	URBAN + SETTLEMENT	CROPS	IRRIGATED AREA	GRASSLAND	FOREST	OTHERS	NATURAL
	2000							
	2006*	27,27	20,06	21,26	3,26	27,68	0,55	22,02
	2010							
	2012*	28,03	19,47	21,29	3,13	27,27	0,83	22,02
Economy First	2020	35,19	16,56	17,04	4,29	26,11	0,83	22,02
Sustainability Eventually	2020	30,64	18,48	19,66	4,29	26,11	0,83	22,02
Economy First	2025	38,69	15,46	14,63	5,01	25,38	0,83	22,02
Sustainability Eventually	2025	31,99	18,28	18,52	5,01	25,38	0,83	22,02
Economy First	2030	42,04	14,14	12,61	5,74	24,66	0,83	22,02
Sustainability Eventually	2030	33,06	18,10	17,63	5,74	24,66	0,83	22,02
* data based on CLC								

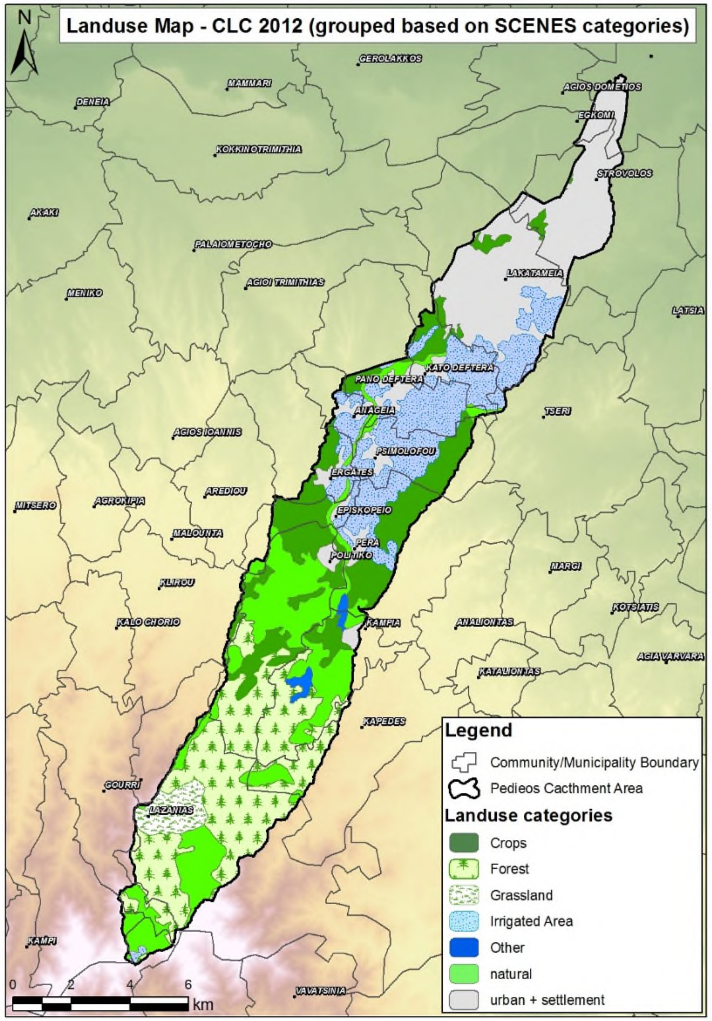

Figure 1: Land use map Pedieos Catchment 2012

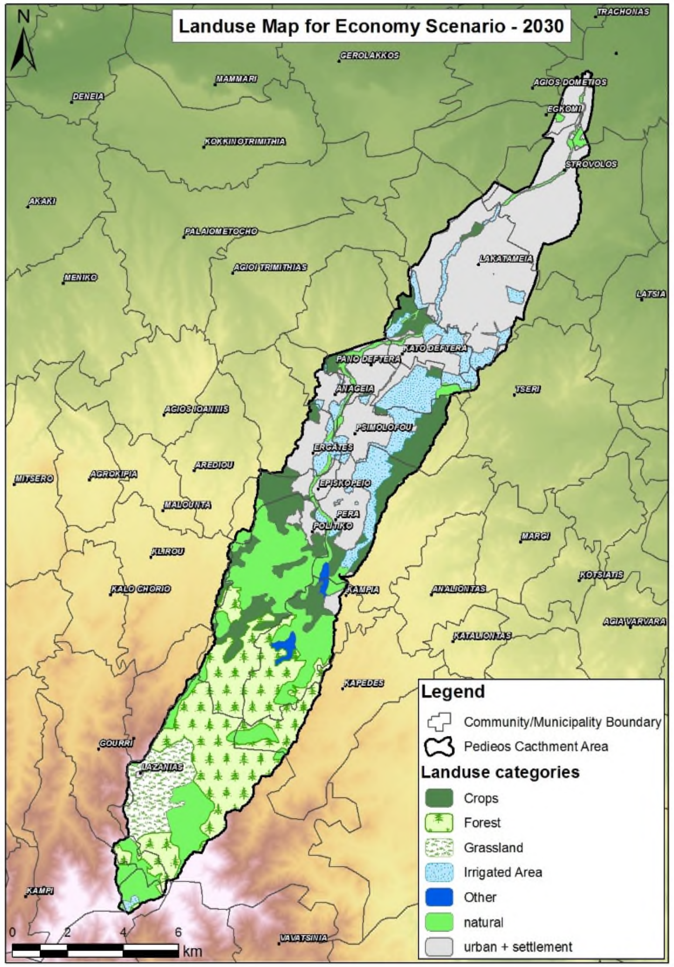

Figure 2: Land Use Map Economy First

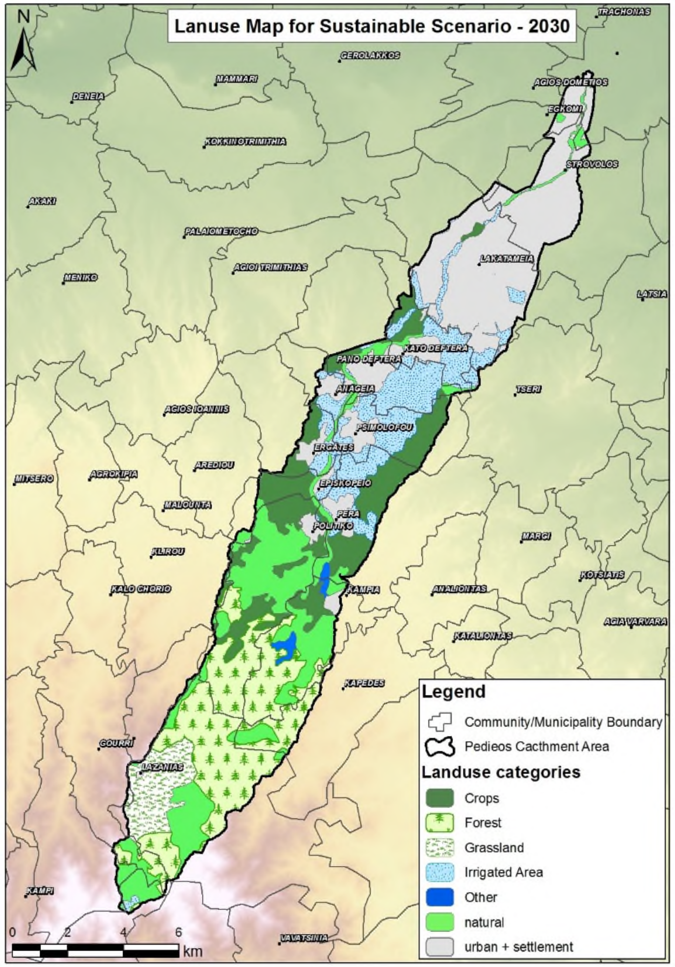

Figure 3: Land Use Map Sustainability Eventually

3.2 Bergen

3.2.1 Land use

3.2.1.1 Land use scenarios for the catchments comprising the water supply in Bergen

The catchments that comprise the water supply in Bergen are small and located in rural areas. They are strictly regulated and we haven't found any grounds to believe that these regulations will be "loosened up" no matter the scenario. Therefore, no change in these catchment is assumed and land use scenarios are only developed for the Damsgaard area where urban floods and stormwater are being analysed.

3.2.1.2 Norwegian Official Report (NOU) on stormwater

In Norway, an official report on stormwater management was recently published. The NOU outlines some legal issues regarding open (or "blue-green") stormwater solutions. In general, there is a positive perception of open, blue-green stormwater solutions but they are seldom applied because the legal responsibility of such solutions is not clarified. In the "sustainability first" scenarios we assume that political effort is put into solving this issue such that more installations of such kind are applied, thus more green areas / less paved surfaces in urban areas. In the "Economy first" scenario we assume the opposite, such that the report is left as it is, and nothing is actually done to improve this[6].

3.2.1.3 Population growth

The population in Norway is projected to grow and a detailed description of these projections is found at https://www.ssb.no/en/befolkning/statistikker/folkfram. The growth is expected to be high in regional centers such as Bergen. We assume population growth (with according pressure on water supply and land use in urban areas) for both the "Economy first" and the "Sustainability eventually" scenario. However, the population projections also have different scenarios where the levels of fertility, life expectancy, internal migration, and immigration are varying. In light of the SCENES scenarios, we find the latter component, immigration, most relative. In the "Economy first" scenario a storyline of economic growth and increasing disparities in income is outlined. Herein, we assume these disparities to induce immigration to Norway and have thus chosen the scenario of high population growth. In the "Sustainability eventually" scenarios we assume this effect to be lower and have chosen the moderate population growth projection.

[6] Source: (https://www.regjeringen.no/no/dokumenter/nou-2015-16/id2465332/?q=nou%202015:16.)

Table 9: Population development Bergen

POPULATION	MODERATE (SUSTAINABILITY EVENTUALLY)	HIGH (ECONOMY FIRST)
2015	275000	275000
2016	277263	279202,16
2017	279526	283404,32
2018	281789	287606,48
2019	284051	291808,64
2020	286314	296010,8
2021	288577	300212,96
2022	290840	304415,12
2023	293103	308617,28
2024	295366	312819,44
2025	297628	317021,6
2026	299891	321223,76
2027	302154	325425,92
2028	304417	329628,08
2029	306680	333830,24
2030	308943	338032,4
2031	311205	342234,56
2032	313468	346436,72
2033	315731	350638,88
2034	317994	354841,04
2035	320257	359043,2
2036	322520	363245,36
2037	324782	367447,52
2038	327045	371649,68
2039	329308	375851,84
2040	331571	380054

3.2.1.4 Summary Economy First

High population growth is assumed for this scenario. This puts strain on urban areas such as Damsgaard. Due to liberalization and less focus on environmental issues, policies and regulations becomes less strict such that natural/forest area is “sacrificed” to make room for new settlers. By 2030, the borders to the city mountains have been pushed back such that 10% of the forested area now is built-up environment.

Table 10: Economy First PESTLE Damsgaard

DAMSGAARD (STUDY SITE FOR STORMWATER MANAGEMENT) ECONOMY FIRST		
DIMENSION	RELEVANT TRENDS	EFFECT ON LAND USE
POLITICAL	1) Liberalization 2) International climate policies slows down – double CO2 emissions	1) decreased regulation of natural areas that are close to the city center 2) Warmer climate → longer growth season → investments in agriculture
ECONOMIC	High economic growth	N/A
SOCIOLOGICAL	High population growth (due to economic growth)	Higher strain on urban areas – decreased regulation of natural areas that are close to the city center (moving of borders to allow for new settlement)
TECHNOLOGICAL	N/A	N/A
LEGAL	N/A	N/A
ENVIRONMENTAL	N/A	N/A

3.2.1.5 Sustainability eventually

There is still population growth (but now moderate) and an increased strain on the Damsgaard area. Because environmental consciousness is high, and “green” politics influence policy- and decision-makers, the borders to the city mountains are left untouched. However, industry from the Damsgaard area is moved out of the city to make room for more households. Regulations and requirements to greenspace / utilization of the lots are stricter when the lots are used for housing and some greenspace in these areas is “gained”. Also, the Norwegian official report mentioned above leads to more incentives for creating blue-green storm water solutions. This also leads to a gain of greenspace within the built-up area. However, the changes are much smaller than in the “Economy first” scenario because the forest / city mountains are left untouched.

Table 11: Sustainability Eventually PESTLE Damsgaard

DAMSGAARD (STUDY SITE FOR STORMWATER MANAGEMENT) “SUSTAINABILITY EVENTUALLY”		
DIMENSION	**RELEVANT TRENDS**	**EFFECT ON LAND USE**
POLITICAL	“Green” and local initiatives leading	Protection of natural areas (e.g. recreational areas around city mountains) → no decrease in forested area
ECONOMIC	Medium growth	N/A
SOCIOLOGICAL	(Still) population growth and higher strain on cities, but the environmental consciousness is also high.	Moving industry out of strained areas to make room for urban housing. More “green” space when lots are regulated for housing than industry (in line with existing regulations)
TECHNOLOGICAL	N/A	N/A
LEGAL	N/A	N/A
ENVIRONMENTAL	N/A	N/A

3.2.1.6 Land use tables

Table 12 shows the baseline values for the Damsgaard case. As noted, only the categories in red, built-up and forest/natural are expected to change significantly. Table 13 shows the resulting land use tables for the two main land use categories in percentage changes.

Table 14 shows the same changes, but in square kilometers. As can be seen, the scenarios differ mainly in the extent to which forest/natural is replaced by built-up area. Figure 4 and Figure 5 show the future land use maps for the two scenarios.

Economy first:
The city center of Bergen is located by the fjord, surrounded by mountains, and is colloquially known as 'The city between the seven mountains'. Due to the closeness between the city center and mountainous areas, the mountains are highly valued and frequently visited by the inhabitants of Bergen. The mountainsides also inherits attractive building sites as they provide the best views possible and, again, because of their closeness to the city center. The interests of outdoor recreation and development of attractive building sites are conflicting. Today, the urban development bordering to the mountainous area is prevented due to well-established and respected city borders that do not allow development at the expense of mountainous areas.

In the Economy first scenario the opposite is assumed, such that natural/forested area is 'sacrificed' for urban development and to make room for new settlers. By 2030, the borders to the City Mountains in the Damsgård area of Bergen has been pushed back such that 10% of the forested area is now built-up environment. The changes are presented in the land use map for the Economy first scenario in Figure 4. The area selection for new development is based on topographic slope (<20%) and proximity to the current road network.

Sustainability eventually:
In the sustainability eventually scenario it is assumed that the city borders are kept as is and that 'blue-green' politics are dominating, i.e. in line with aforementioned Norwegian Official Report (NOU). One strategy that has been emphasized in this report is the opening of closed/piped rivers and creeks preferable with green 'corridors' along the banksides, in order to achieve a more flexible water routing. In the Damsgård area, there exist two piped rivers that could be eligible for being opened. In the Sustainability eventually scenario, opening of these two rivers is assumed (Figure 5).

Table 12: Baseline values Damsgaard

BASELINE VALUES FOR DAMSGÅRD		
	%	km^2
Total area	100	8,3
Built-up	48,3	4,0089
Forest/natural	44,5	3,6935
Farm	1	0,083
Open land	4,8	0,3984
Marsh	0,4	0,0332
Fresh water	1	0,083

Table 13: Land use changes in %

SCENARIO	YEAR	BUILT-UP	FOREST/NATURAL
Economy First	2020	2	-2
Sustainability Eventually	2020	0	0
Economy First	2025	6	-6
Sustainability Eventually	2025	-1	1
Economy First	2030	10	-10
Sustainability Eventually	2030	-2	2

Table 14: Land use changes in km^2

SCENARIO	YEAR	BUILT-UP	FOREST/NATURAL	TOTAL
Economy First	2020	4,1	3,6	8,3
Sustainability Eventually	2020	4,0	3,7	8,3
Economy First	2025	4,2	3,5	8,3
Sustainability Eventually	2025	4,0	3,7	8,3
Economy First	2030	4,4	3,3	8,3
Sustainability Eventually	2030	3,9	3,8	8,3

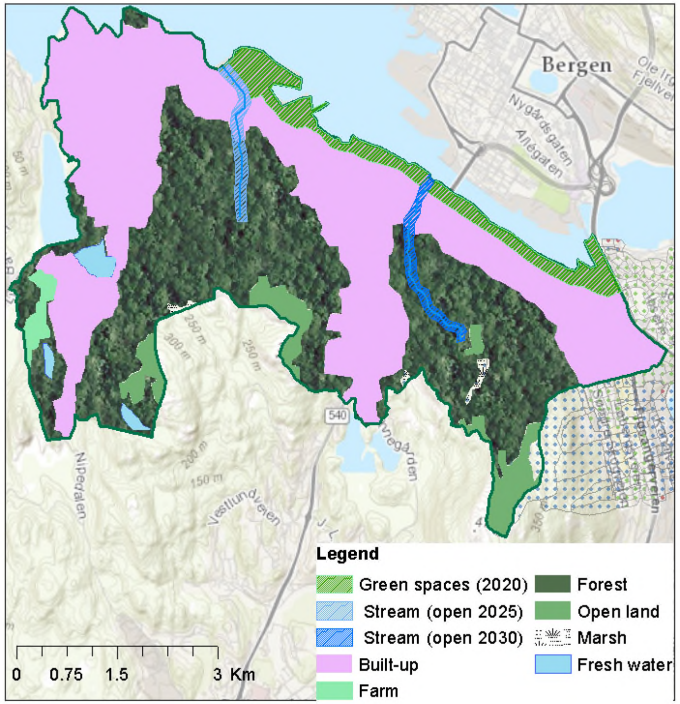

Figure 5: Land Use Map Sustainability Eventually

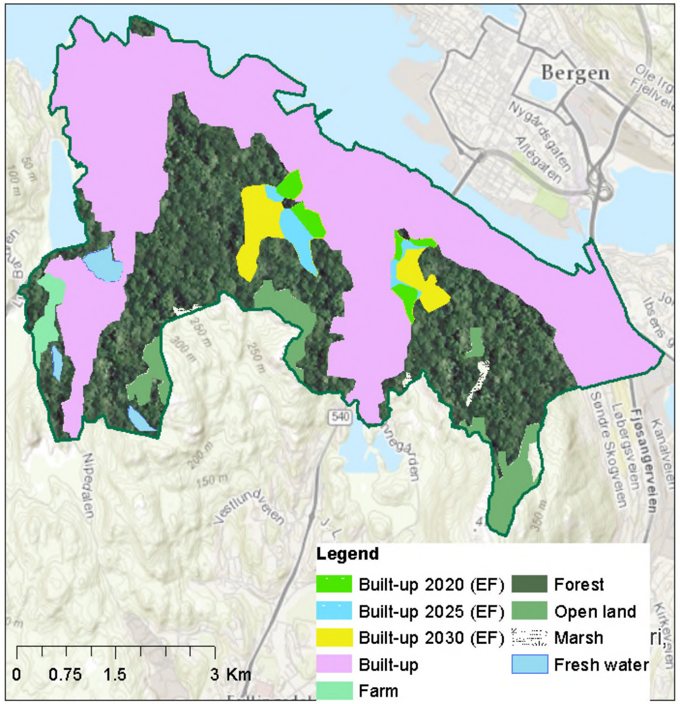

Figure 4: Land Use Map Economy First

3.2.2 Water use

3.2.2.1 Municipal Master plan for water supply

Table 15 shows the 2014 baseline numbers for the Bergen case. In the city's master plan for water supply (plans for 2015-2024), one objective is to reduce leakages such that leakages comprise <20% of the total consumption by 2024 (Table 16). In the "Sustainability First" scenario we assume this to be successful, while the leakage reduction is assumed slower in the "Economy first" scenario. Another objective is to reduce total water production from 34.5 Mm^3/y (2014) to 33 Mm^3/y (2024). The same assumptions are made for this case.

Table 15: Baseline values from the municipal Master plan for water supply

BASELINE VALUES 2014				
Total production	100	%	34,5	Mm^3/y
Domestic use	45	%	15,525	Mm^3/y
Industrial use (+other 3%)	24	%	8,28	Mm^3/y
Leakages	31	%	10,695	Mm^3/y
People supplied	275000	p		
Specific domestic consumption	56,45	$m^3/p/y$		

Table 16: Production goals

GOALS				
Total production 2024	100	%	33	Mm3/y
Leakages 2024	20	%	6,6	Mm3/y

3.2.2.2 Summary Economy First

High population growth in addition to higher water consumption per person gives an increased domestic water consumption. Due to economic and population growth more jobs are created and the industrial water consumption also increases. Leakages in the distribution network are reduced, but the goal of 20% leakage of total consumption is not reached. Also, due to the high population growth, the municipality is not able to reduce total consumption to 33 Mm3/y by 2024 as desired.

Table 17: Economy First PESTLE Bergen

WATER USE FOR BERGEN IN ECONOMY FIRST		
DIMENSION	**RELEVANT TRENDS**	**EFFECT ON WATER USE**
POLITICAL	Privatized water supply	Less investments in water infrastructure – less leakage reduction than planned
ECONOMIC	Growth in Norway – larger disparities in income and unemployment – high immigration to Norway	Increased domestic water consumption (due to more people) and more industrial water use due to more jobs
SOCIOLOGICAL	More single-person households	Increased water consumption per person (specific consumption)
TECHNOLOGICAL	Declining emphasis on environmental values - less focus on water saving technology	Less leakage reduction than planned
LEGAL	N/A	N/A
ENVIRONMENTAL	N/A	N/A

3.2.2.3 Summary Sustainability Eventually

Water consumption per person holds the same level, but due to moderate population growth the total domestic water consumption increases. The municipality is successful in reducing leakages to 20% and total production to 33 Mm3/y by 2024, but total production increases again by 2030 due to population growth.

Table 18: Sustainability Eventually PESTLE Bergen

WATER USE FOR BERGEN IN SUSTAINABLITY EVENTUALLY		
DIMENSION	RELEVANT TRENDS	EFFECT ON WATER USE
POLITICAL	"Green" and local initiatives leading → ensures a follow up on goals set by the municipality (numbers in excel sheet)	- Leakages reduced to <20% of total production by 2024 - Total water production reduced to 33Mm3/y by 2024
ECONOMIC	Economic recession – moderate population growth	Increase in domestic water consumption (but the effect is lower than for the "Economy first" scenario.)
SOCIOLOGICAL	N/A	N/A
TECHNOLOGICAL	N/A	N/A
LEGAL	N/A	N/A
ENVIRONMENTAL	N/A	N/A

3.2.2.4 Water Use tables

Table 19 shows the water use in the two scenarios for the different categories. The assumptions from the Municipal master plan for water supply have been intra- and extrapolated to generate values for the full time period. As can be seen, both scenarios show an increase in water consumption, stronger in Economy First, but all of the increase in Sustainability Eventually is off set by the reduction of leakages.

Table 19: Future water use Bergen

SCENARIO	YEAR	DOMESTIC	INDUSTRIAL	LEAKAGES	TOTAL	SPECIFIC WATER CONSUMPTION (M^3/P/Y)	CHANGE	LEAKAGE PERCENTAGE
	2015	15,5	8,28	10,7	34,5	56,45		31,00
Economy First	2020	16,7	10,0	10,0	36,7	56,57	+ 2%	27,00
Sustainability Eventually	2020	16,2	9,0	8,7	33,8	56,45	+ 0%	25,58
Economy First	2025	18,0	11,0	10,2	39,1	56,62	+3%	26,00
Sustainability Eventually	2025	16,8	9,6	6,6	33,0	56,45	+ 0%	20,00
Economy First	2030	19,2	12,0	10,4	41,5	56,68	+ 4%	25,00
Sustainability Eventually	2030	17,4	10,0	6,9	34,5	56,45	+ 0%	20,00

3.3 Badalona

3.3.1 Land use

Table 20 and Table 21 show the relevant local developments related to land use and water use in the Badalona case, based on a workshop with stakeholders. It must be noted that since the study area is practically consolidated, the land use scenarios differ primarily on both the extent to which the Sustainable Urban Drainage Systems (SUDS) are implemented and on the extent to which forest management is realized to increase infiltration capacity (to reduce stormwater runoff load to the combined sewer system) and to reduce soil erosion that is the cause of an increased sediment load to the combined sewer network of Badalona. Table 22 shows the land use changes hypotheses: the conversion of the non-urbanized permeable areas into either semi-permeable (due to the Economy first scenario that assumes sparse urbanization of the non-urbanized pervious areas) or more permeable (due to the Sustainability eventually scenario that assumes more infiltration capacity due to improved forest management) land.

Error! Reference source not found. and **Error! Reference source not found.** show the different land cover and building type changes based on the different scenarios.

Error! Reference source not found. shows that in the Economy First scenario the non-urbanized permeable area becomes semi-permeable (due to sparse urbanization of the natural pervious areas). In Sustainability Eventually scenario the non-urbanized permeable area remains permeable (however with higher infiltration capacity) and 6% of the urbanized area is turned into permeable (i.e. by retrofitting SUDS, such as green roofs, permeable pavements, etc.). The exact location of the SUDS retrofitting areas is not shown in the map, the municipality is currently working on identifying suitable areas. For instance, a criteria to select potential green roof retrofitting areas can be based on structure bearing capacity (only structures that can bear the additional green roof weight can be suitable) of the existing buildings.

Error! Reference source not found. shows small changes (close to the harbor of Badalona) in ground floor future scenarios due to the construction of new residential areas. It is noted that the ‘economically first’ and the ‘sustainability eventually’ scenarios are equal. Moreover, basements are assumed not to change.

Table 20: Economy First PESTLE Badalona

ECONOMY FIRST			
DIMENSION	RELEVANT TRENDS	EFFECT ON LAND USE	EFFECT ON WATER USE
POLITICAL	No commitment regarding an environmentally friendly industry. No policies for ground water levels protections.	This scenario will consider the decrease of infiltration capacity of the pervious areas located in the upstream part of the city catchments of Badalona.	No declining in the consumptions of clean water. Decrease of ground water as a resource
ECONOMIC	No changes regarding industry will take place, the scenario will reflect a reduction regarding employment and GVA. Decrease of the tourism earnings.	Increase in terms of flood damage and CSOs problems.	No declining in the consumptions of clean water. Decrease of ground water as a resource
SOCIOLOGICAL	Rising unemployment, no awareness in terms of the cleaning of the sewer network and natural areas.	Decrease of the amenity of the city spaces.	No declining in the consumptions of clean water. Decrease of ground water as a resource
TECHNOLOGICAL	No developments in terms of technologies will take place into the sewer network.	Increase of the problems within the sewer network, turning into more flood events and CSOs.	Increase of pollution in ground water and bathing waters.
LEGAL	No changes or more permissive laws for industry. Decline in the return of water into the aquifer.	Loss of natural area and water bodies for touristic uses.	No declining in the consumptions of clean water. Decrease of ground water as a resource
ENVIRONMENTAL	Increase of CSOs onto the water sea bodies and deforestation of the natural areas.	Increase of problems within the sewer network, turning into more flood events and CSOs. Loss of permeability in natural areas.	A decrease of the precipitation events and consequently reduction of ground water resources.

Table 21: Sustainability PESTLE Badalona

SUSTAINABILITY EVENTUALLY			
DIMENSION	RELEVANT TRENDS	EFFECT ON LAND USE	EFFECT ON WATER USE
POLITICAL	It is committed to a more sustainable and environmentally friendly industry New policies in order to increase ground water use.	This scenario will consider a decrease of infiltration capacity of the non-urbanized pervious areas located in the upstream part of the city catchments of Badalona. Decrease of infiltration capacity is associated with sparse urbanization of these natural pervious areas.	Reduction of clean water consumption Increase of ground water as a resource
ECONOMIC	The transformation into a more environmentally friendly industry turn into an increase on employment and GVA.	Decrease in terms of flood damage and CSOs problems.	Reduction of clean water consumption Increase of ground water as a resource
SOCIOLOGICAL	High awareness regarding the cleaning of the sewer network in order to reduce the hydraulic and environmental impacts of high intensity rainfalls.	Increase of the amenity of the city spaces.	Reduction of clean water consumption Increase of ground water as a resource
TECHNOLOGICAL	All the adaptation measures included in the last Drainage Master Plan will be executed.	Implementation of SUDS in the urbanized area of Badalona	Reduction of pollution in ground water and bathing waters.
LEGAL	More protection policies for natural areas Increase of the return of water into the aquifer.	New regulations for the promotion of SUDS through taxes reduction.	Reduction of clean water consumption Increase of ground water as a resource
ENVIRONMENTAL	A big effort in order to maintain a good quality level of the beaches and the upstream natural area of the basins.	Increase of the water quality in the bathing waters. Increase of the biodiversity and green areas through the implementation of NBS in natural and urban areas.	Reduction of clean water consumption Increase of ground water as a resource

Table 22: Land use change hypotheses

HYPOTHESES		
SUSTAINABILITY EVENTUALLY		
% of SUDS implemented:		6,00%
	1st period	2,00%
	2nd period	2,00%
	3rd period	2,00%
Non urbanized area --> Permeable area		
ECONOMY FIRST		
Non urbanized area --> Semipermeable area		
No changes in terms of vulnerability		

Table 23 shows the resulting changes in land use for the Badalona area. In line with the hypothesis and the PESTLE tables, the primary difference is in the permeability of the current non-urbanized permeable areas. In the Economy First scenario the non-urbanized permeable area is added to the semi-permeable area. In the Sustainability Eventually scenario, the non-urbanized area is added to the permeable area. Also, the Sustainability Eventually scenario part of the roof surface is transformed into permeable area.

Table 23: Future land use Badalona in m^2

SCENARIO	YEAR	NO URBANIZED AREA	PERMEABLE AREA	SEMI-PERMEABLE AREA	IMPERVIOUS AREA	ROOFS	STREETS AND ROADS	TOTAL
	2015	9223570	755408	782602	6423970	780060	4144715	22110325
Economy First	2020	0	755408	10006172	6423970	780060	4144715	22110325
Sustainability Eventually	2020	0	9994579	782602	6423970	764459	4144715	22110325
Economy First	2025	0	755408	10006172	6423970	780060	4144715	22110325
Sustainability Eventually	2025	0	10009868	782602	6423970	749170	4144715	22110325
Economy First	2030	0	755408	10006172	6423970	780060	4144715	22110325
Sustainability Eventually	2030	0	10024852	782602	6423970	734186	4144715	22110325

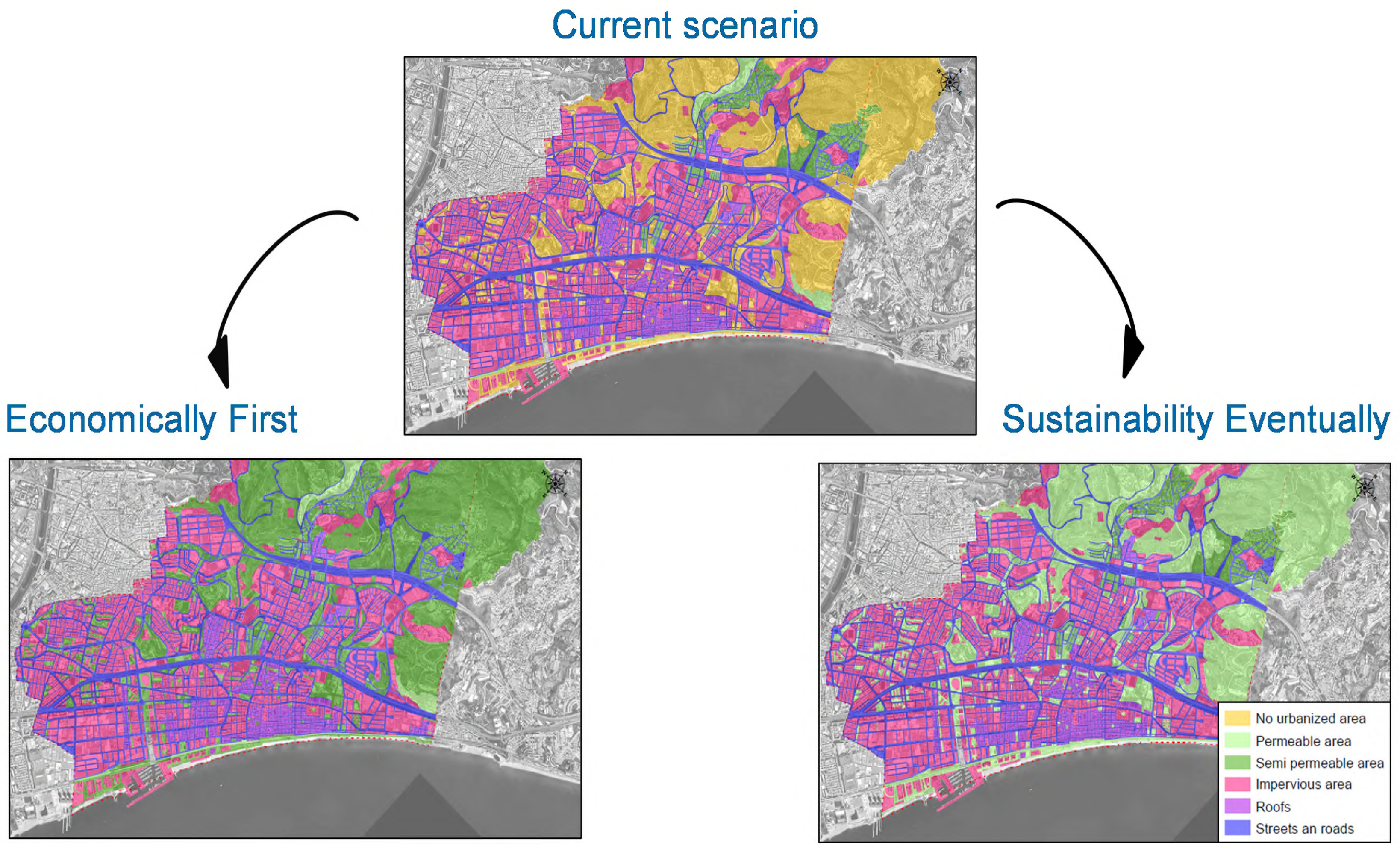

Figure 6: Land use maps for Badalona, baseline and two scenarios

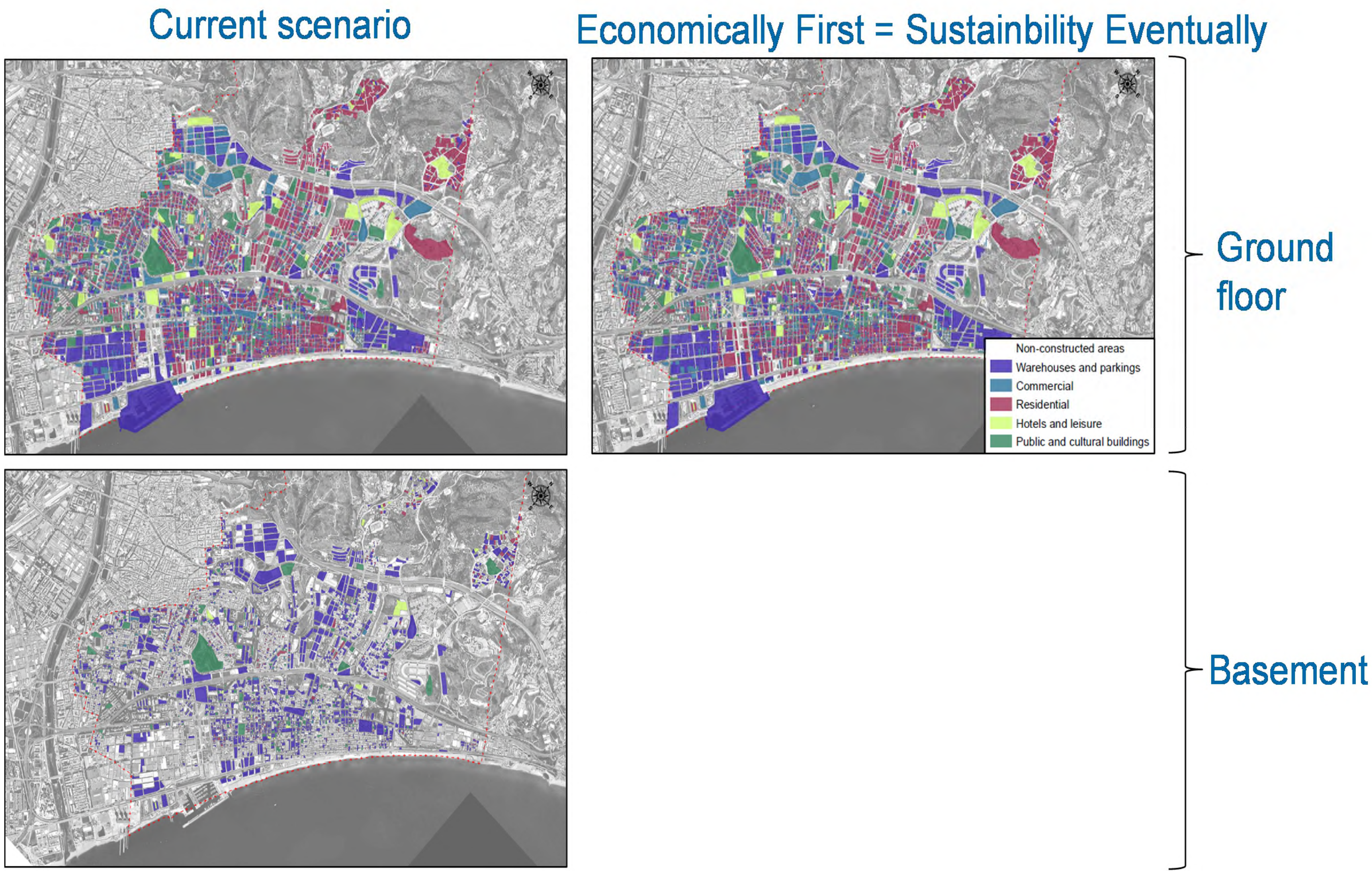

Figure 7: Building types and different levels

3.3.2 Water use

Table 24 shows the hypothized change in water use, based in the developments in the PESTLE-tables. The Sustainability Eventually scenario shows a steady decline in all three sectors under consideration. In the Economy First scenario, no change from current levels is expected. The resulting changes for water use in the different sectors are shown in

Table 25

Table 24: Future water use hypotheses

HYPOTHESES			
SUSTAINABILITY EVENTUALLY	DOMESTIC	INDUSTRIAL	IRRIGATION
2005	-6%	-4%	-6%
2010	-9%	-21%	-19%
2015	-4%	-13%	+16%
Average	**-6%**	**-13%**	**-3%**
ECONOMY FIRST	NO VARIATION		

Table 25: Future water use Badalona in m^3

SCENARIO	YEAR	DOMESTIC	INDUSTRIAL	IRRIGATION
	2000	9151747	1998131	587237
	2005	8587389	1914240	549105
	2010	7855250	1510038	442334
	2015	7574893	1315457	511187
Economy First	2020	7574893	1315457	511187
Sustainability Eventually	2020	7113798	1147956	493513
Economy First	2025	7574893	1315457	511187
Sustainability Eventually	2025	6680770	1001784	476450
Economy First	2030	7574893	1315457	511187
Sustainability Eventually	2030	6274101	874224	459978

3.4 Wuppertal

3.4.1 Introduction

For the determination of land and water use scenarios and their inclusion in hydrological modelling of the Wupper River Basin, it was necessary to determine: a) the available information in the study area and b) how this information is entered to the hydrological models.

a) Available information in the study area:

After consulting different sources (which are all cited in this chapter), it was ascertained that there are no maps for future land cover – either for the Wupper catchment area or the administrative units that lie within. In fact, it was found out that for the Wupper research site, the available information regarding land and water use is limited to the administrative units only, that is, this data is not *basin-based*. Moreover, there is no available information for future land use changes whatsoever; likewise, data regarding future water use, i.e., future water demand is non-existent. The only existing future trends are population growth.

Future information was generated based on past trends for each administrative unit, as described below. The methodology implemented is portrayed in section *Methodology for the establishment of future land use scenarios* and *Methodology for the establishment of future water use scenarios*). In order to establish future land and water use scenarios for the Wupper catchment area, the implementation of a procedure involving the regionalization of the available information per administrative unit using GIS tools was necessary, based on their surface within the Wupper catchment (i.e., weight-by-area).

In this manner, future increasing / decreasing factors for each land use unit (based on the increment / decrement in km²) and water use category (based on the increment / decrement in Mm³/year) were determined for the whole Wupper catchment area in combination with SCENES storylines.

Since it was firstly required to compile all existing information of districts and municipalities, a detailed description of the political organization was considered relevant.

b) How this information is entered to the hydrological models:

As land use data for the next decade was generated based on past trends, future spatial distribution could not be established. However, we were able to overcome this drawback on account of the properties of our hydrological models, namely, NASIM and TALSIM. For both models, sub-basin delineation must be carried out previously using GIS tools, based on topography and river network. In addition, with current, available land use and soil type, different hydrological response units (HRUs) are determined per sub-basin. This data is then exported to the hydrological models.

Once exported, the available information per sub-basin on the computational domains of NASIM and TALSIM is the extent (i.e., the area) of each HRU, without considering each HRU geometry. Since the geometry of each HRU is neglected by the models, we were able to increase / decrease each land use unit of each HRU within the hydrological models with the determined factors accordingly.

Administrative sub-divisions of the federal Republic of Germany

The administrative units/subdivisions in Germany are described in Table 26 and Figure 8.

Table 26: German administrative units (top-down)

German term	English translation
Bundesrepublik Deutschland	Federal Republic of Germany
Bundesland	Federal state
Stadtstaat	State city
Regierungsbezirk (Reg.-Bez)	Governmental district
(Land-)Kreis	County / District
Kreisfreie Stadt / Stadtkreis	District-free city / Urban district
Gemeinde / Kommune	Municipality / Community

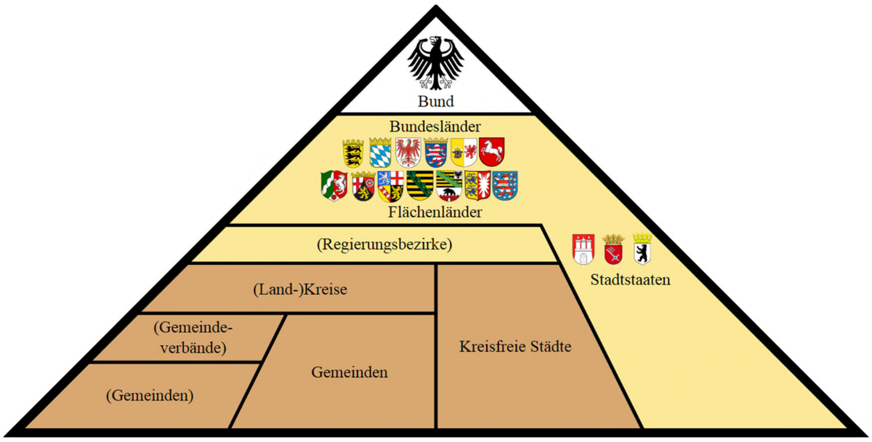

Figure 8: German administrative units (Source: Wikipedia)

Administrative sub-divisions within the Wupper research site

The Wupper River Basin has an area of ca. 813 km² and a population of approximately 950,000 inhabitants. It lies in the federal state of North-Rhine Westphalia (NRW), Germany, comprising the administrative units presented in Table 27 and Table 28 and Figure 9. Table 27 and Table 28 also show the municipalities' and districts' total area, the municipalities' and districts' area within the Wupper River Basin, and a factor indicating the area percentage of each municipality and district inside the Wupper catchment.

All available information regarding current land use, water use, and population growth is only generated for the administrative units.

Table 27: Administrative units and area percentage of each municipality within the Wupper River Basin

MUNICIPALITY (GEMEINDE)	DISTRICT (KREIS)	GOV. DISTRICT (REG.-BEZ)	MUNICIPALITY TOTAL AREA [KM²]	MUNICIPALITY - AREA INSIDE THE WUPPER BASIN [KM²]	FACTOR [%]
Burscheid	Rheinisch-Bergischer Kreis	Cologne	27,30	27,30	100,0
Hückeswagen	Oberbergischer Kreis	Cologne	50,50	50,50	100,0
Remscheid	Kreisfreie Stadt	Düsseldorf	74,51	74,51	100,0
Wermelskirchen	Rheinisch-Bergischer Kreis	Cologne	74,75	74,75	100,0
Odenthal	Rheinisch-Bergischer Kreis	Cologne	39,84	38,66	97,0
Leichlingen	Rheinisch-Bergischer Kreis	Cologne	37,29	36,03	96,6
Schwelm	Ennepe-Ruhr Kreis	Arnsberg	20,49	18,90	92,3
Wuppertal	Kreisfreie Stadt	Düsseldorf	168,38	136,48	81,1
Leverkusen	Kreisfreie Stadt	Cologne	78,82	62,76	79,6
Radevormwald	Oberbergischer Kreis	Cologne	53,83	40,81	75,8
Wipperfürth	Oberbergischer Kreis	Cologne	118,32	78,87	66,7
Solingen	Kreisfreie Stadt	Düsseldorf	89,42	54,24	60,7
Kierspe	Märkischer Kreis	Arnsberg	71,87	35,09	48,8
Marienheide	Oberbergischer Kreis	Cologne	54,93	19,83	36,1
Halver	Märkischer Kreis	Arnsberg	77,18	17,86	23,1
Kürten	Rheinisch-Bergischer Kreis	Cologne	67,30	12,48	18,5
Ennepetal	Ennepe-Ruhr Kreis	Arnsberg	57,72	9,08	15,7
Bergisch Gladbach	Rheinisch-Bergischer Kreis	Cologne	83,07	11,66	14,0
Langenfeld	Mettmann	Düsseldorf	41,05	1,71	4,2
Cologne	Kreisfreie Stadt	Cologne	404,95	10,65	2,6
Sprockhövel	Ennepe-Ruhr Kreis	Arnsberg	47,93	0,83	1,7
Gevelsberg	Ennepe-Ruhr Kreis	Arnsberg	26,31	0,03	0,1

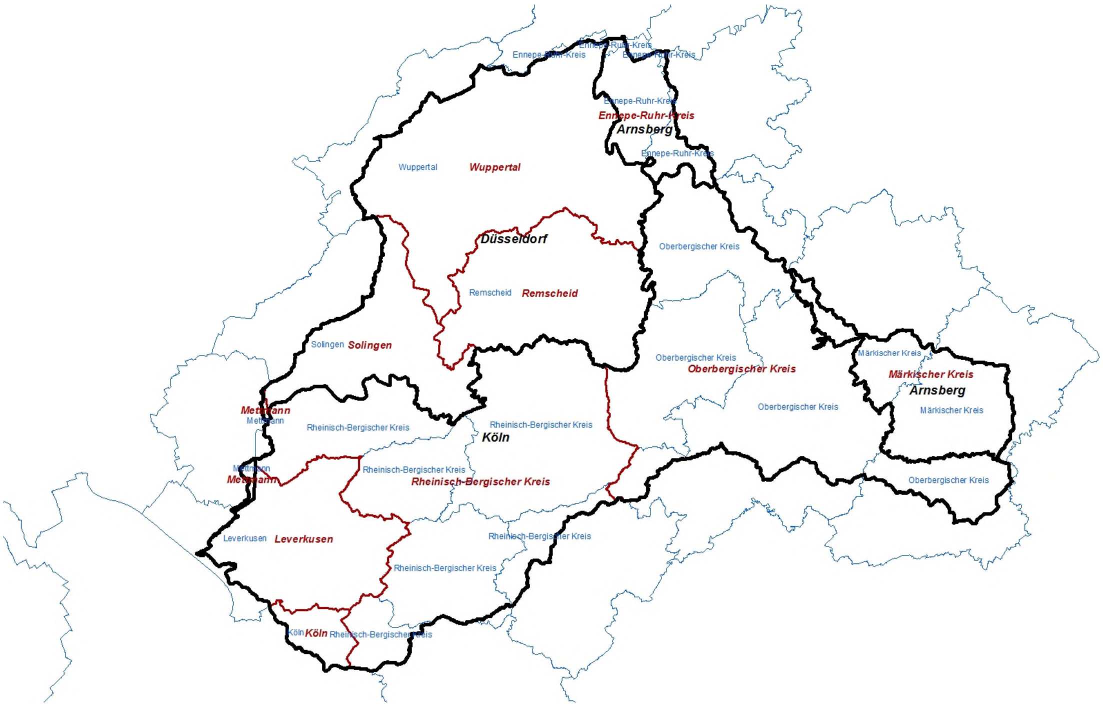

Figure 9: Administrative units of the Wupper River Basin

Table 28: Administrative units and area percentage of each district within the Wupper River Basin

DISTRICT / DISTRICT-FREE CITY (KREIS / KREISFREIE STADT)	GOV. DISTRICT (REG.-BEZ)	DISTRICT TOTAL AREA [KM²]	DISTRICT - AREA INSIDE THE WUPPER BASIN [KM²]	FACTOR [%]
Remscheid	Düsseldorf	74,60	74,51	99,9
Wuppertal	Düsseldorf	168,39	136,48	81,1
Leverkusen	Cologne	78,87	62,68	79,5
Solingen	Düsseldorf	89,54	54,26	60,6
Rheinisch-Bergischer Kreis	Cologne	437,32	200,85	45,9
Oberbergischer Kreis	Cologne	918,84	190,00	20,7
Ennepe-Ruhr-Kreis	Arnsberg	408,46	28,77	7,0
Märkischer Kreis	Arnsberg	1061,06	52,95	5,0
Cologne	Cologne	405,17	10,67	2,6
Mettmann	Düsseldorf	407,22	1,72	0,4

3.4.2 Land use

The main land use units within the Wupper River Basin are summarized as follows: agricultural areas (farmland plus grassland); forest areas (deciduous[7], coniferous[8], and mixed forest); and sealed areas.

[7] In German: Laubwald
[8] In German: Nadelwald

Future land use scenarios for the Wupper River Basin

Consulted sources

The following sources were consulted:

- Martin Klingenhoff – Forest Management Unit, Dhünn reservoir (pers. comm. 31.08.2016)
- Martin Spettmann – Forest Management Unit, Kerspe reservoir (pers. comm. 01.09.2016)
- Nannette Hoof – Referat VIII-2 "Anpassung an den Klimawandel, Flächenpolitik, Mobilitätskonzepte, Konversion"[9] (pers. comm. 02.09.2016)
- Heinz Niete – Flächenentwicklung/Flächenbewirtschaftung "Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen (LANUV)" (pers. comm. 02.09.2016)
- Landesbetrieb Information und Technik Nordrhein-Westfalen (IT.NRW)[10]
- http://www.flaechenportal.nrw.de/
- http://www.flaechenportal.nrw.de/index.php?id=5
- https://www.lanuv.nrw.de/umwelt/landwirtschaft/flaechenbewirtschaftung/
- TopagrarONLINE "Landwirtschaftsfläche in NRW verringert sich immer weiter"[11]

Protected forest areas within the Wupper River Basin

There are three protected forest areas within the Wupper River Basin. These areas are located around the Dhünn, Kerspe, and Herbringhausen drinking water reservoirs. Table 29 presents the characteristic trees and corresponding forest units in the Wupper River Basin.

Table 29: Characteristic trees and corresponding forest units in the Wupper River Basin

GERMAN TERM	ENGLISH TRANSLATION	CORRESPONDING FOREST UNIT (DE)	CORRESPONDING FOREST UNIT (EN)
Fichte	Spruce	Nadelwald	Coniferous forest
Buche	Beech tree	Laubwald	Deciduous forest

3.4.4.3 Information provided by Martin Klingenhoff – Dhünn reservoir protected forest area

According to Klingenhoff (pers. comm., 2016), the long-term objective in the Dhünn reservoir protected forest area is to transform coniferous forest into deciduous forest since the latter is considered to be the original vegetation of forestry areas before human intervention.

The total forest area has not changed significantly in the last years and is expected to remain constant in the next 15 years. The following information was provided:

- In 1995, coniferous forest corresponded to 43% of the total Dhünn reservoir protected forest area
- In 2005, coniferous forest was diminished ca. 38%
- In 2015, coniferous forest has been reduced about 34%

The goal for the next 15 years is to replace between 10 and 15 ha of coniferous forest with deciduous forest.

Information provided by Martin Spettmann – Kerspe reservoir protected forest area

The long-term objective in the Kerspe reservoir protected forest area is to transform coniferous forest into deciduous forest as well.

[9] Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen (MKULNV)
[10] https://www.it.nrw.de/statistik/a/daten/index.html
[11] http://www.topagrar.com/news/Home-top-News-Landwirtschaftsflaeche-in-NRW-verringert-sich-immer-weiter-3881614.html

In accordance with Spettmann (pers. comm., 2016), the total Kerspe reservoir protected forest area has increased around 1% (corresponding to ca. 9 ha) in the last 15 years, replacing grassland surface from agricultural areas. The same is expected for the next 15 years, i.e., by the end of 2030.

The following information was provided:

- In 2000, the coniferous forest corresponded to 60% of the total Kerspe reservoir protected forest area
- In 2015, the coniferous forest has been reduced about ca. 40%
- By 2030, the coniferous forest is expected to have been reduced ca. 25%

Agricultural and non-protected forest areas in NRW (2000 – 2015) and population growth

The total area of NRW is ca. 34.077 km². According to LANUV[12] (2016), ca. one fourth of NRW was covered by forest in 2014, with fast half of its total surface used for agriculture (see Figure 10). Of this portion, a surface of 10.552 km² was used as farmland and ca. 3.890 km² corresponded to grassland. The demand for more surface to be used as settlements, traffic infrastructure, and industrial purposes, etc. has caused a diminishing of agricultural areas of 1.246 km² from 1994 to 2014.

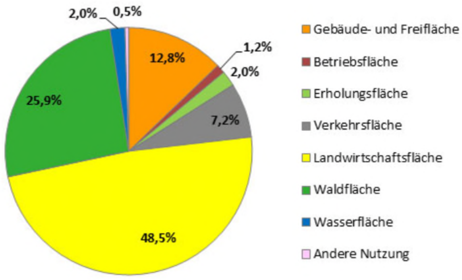

Figure 10: Land use in NRW, 2014 (source: LANUV, 2016)

In NRW, ca. 9,3 ha are being sealed at a daily basis (TopagrarONLINE, 2016). As a result, agricultural areas remain to be the most affected, with an estimated reduction of ca. 3,6% (608 km²) from 2006 to 2016. Apparently, farmland areas have even been replaced by forest areas in some regions of the state.

Forest areas reveal a general tendency to grow in the whole state of NRW. The only municipalities within the Wupper catchment showing a diminishing in forest areas from 2000 to 2015 are Bergisch Gladbach, Burscheid, Kürten, Leichlingen, Odenthal, and Schwelm (IT.NRW, 2015). On the other hand, agricultural areas have decreased in all municipalities between 2000 and 2015.

Population will rise in NRW according to projections up to 2040; nonetheless, the only municipalities within the Wupper research site expecting a population growth rate are Cologne, Leverkusen, Solingen, and Wuppertal (IT.NRW, 2015).

Information provided by Nannette Hoof (MKULNV)

Hoof (pers. comm., 2016) confirmed the facts found on TopagrarONLINE, 2016, providing the following information:

- Agricultural areas are being reduced at an approximate sealing rate of 9,3 ha per day
- The goal is to diminish this rate to ca. 5 ha per day by 2020
- Agricultural areas correspond roughly to farmland[13] and grassland[14]
- It has not been quantified/differentiated whether the land being daily sealed correspond to farmland or grassland
- It was confirmed that forest areas are less impacted by the sealing rate

[12] https://www.lanuv.nrw.de/umwelt/landwirtschaft/flaechenbewirtschaftung/

[13] In German: Ackerland

[14] In German: Grünland / Wiese

Information found at IT.NRW

Information describing the changes in forest areas (i.e., deciduous, coniferous, and mixed forest areas) as well as sealed and agricultural areas is available for each municipality, from 2000 to 2015. Projections are only available for population growth (2015 – 2040).

3.4.3 Water use

The main water use categories within the Wupper River Basin are summarized as follows: service water[15], domestic water, and process or industrial water[16]. Raw water[17] is the sum of domestic water and process or industrial water.

Service water refers to water used for reservoir and flood management and ecological flow regulation (e.g., reservoir storage); in this case, it corresponds to the direct withdrawal from the Wupper River. Domestic water is used for indoor and outdoor household purposes (including drinking water) as well as for small businesses[18]. Process or industrial water is utilized e.g., for "cooling purposes" at power plants. Energy production falls roughly into the "process or industrial water" category.

Future water use scenarios for the Wupper River Basin
Consulted sources

The following sources were consulted:

- Landesbetrieb Information und Technik Nordrhein-Westfalen (IT.NRW)
- Dr. Gerta Mentfewitz – Kommunales Abwasser (LANUV), pers. comm. 02.09.2016
- Dr. José F. Fernández – Industrielles Abwasser (LANUV), pers. comm. 02.09.2016
- Mathilde Niessner – Trinkwasser (LANUV), pers. comm. 02.09.2016
- Öffentliche Wasserversorgung in Nordrhein-Westfalen[19] (per district and district-free city)
- Total withdrawal per year from the Wupper River to the Wupper reservoir to estimate service water

Information provided by Gerta Mentfewitz - Kommunales Abwasser (LANUV)

According to Mentfewitz (pers. comm., 2016), the relatively new, environmental friendly culture of "saving water" has also negative impacts on the wastewater system. Wastewater has become thicker, making its treatment more difficult. On the other hand, sediment deposits have affected the pipes since there is less water flowing; even fresh water has to be used sometimes in order to clean them up. There is no need of saving more water.

Information provided by Mathilde Niessner – Trinkwasser (LANUV)

According to Niessner (pers. comm., 2016), water use has sunk in the last years due to the "saving water" culture and new devices (low consume toilettes, etc.). However, it has reached a constant value and is expected to remain relatively constant. Water use for NRW is ca. 138 l per person, per day. Future projections for water use have not been estimated; however, water use is likely to be further reduced to 120 l per person, per day.

3.4.4 Definition of economy first and sustainability eventually scenarios

The compiled information presented in previous chapters allowed to achieve a general insight of the current and factual situation of NRW state and the municipalities within the Wupper catchment. SCENES storylines

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[15] DE: Brauchwasser
[16] DE: Betriebswasser
[17] DE: Rohwasser
[18] DE: Kleingewerbe
[19] Public water supply in North Rhine-Westphalia (https://www.it.nrw.de/presse/pressemitteilungen/2015/pdf/313_15.pdf)

were combined with this information in order to define the *economy first* and *sustainability eventually* scenarios.

Economy first scenario

The following assumptions were made:

- Population growth rate is higher than expected due to immigration. Consequently, the demand of paved surfaces increases, i.e., the sealing rate of 9,3 ha per day does not diminish to 5 ha per day by 2020 as planned.
- Population growth also causes a higher raw water consumption; water consumption (in litres) per person/per day remain constant (at ca. 138 l per person, per day).
- Since response to societal needs are not effectively met by the government, agricultural areas continue to be reduced. This affects negatively local food production, being necessary to import more food. Farmland and grassland keep decreasing according to the linear trends identified for each municipality.
- Coniferous forest areas are expected to expand due to its rapid growth rate. Spruce trees are used for construction material.
- Deciduous forest keep growing according to the linear trends identified for each municipality as well as total forest area. Therefore, mixed forest decreases accordingly.

Sustainability eventually scenario

The following assumptions were made:

- Population growth rate remains as projected. The goal of diminishing the sealing rate to 5 ha per day by 2020 is achieved.
- Total raw water consumption diminishes according to population growth rate; also, water consumption (in litres) per person/per day decreases, reaching 120 l per person, per day and then remaining constant due to environmental friendly tendencies of “saving water”.
- Initiatives for local food production are supported. Agricultural areas do not diminish as significantly as with a higher sealing rate, thus, favouring social sustainability. This is consistent with reduction of food demand and increment of crop productivity, leading to a decrease in the sum of farmland and grassland.
- Total forest area is assumed to remain relatively constant from 2020 onwards as well as mixed forest to promote greater biological diversity. Coniferous forest is replaced slowly by deciduous forest for the whole study area, i.e., the common goal for the protected forest areas is applied to all forests of the whole Wupper River Basin.

Methodology for the establishment of future land use scenarios

In order to establish the land use scenarios only for the Wupper research site area, the followed approach was implemented:

1) All available information provided by IT.NRW was downloaded for each municipality within the Wupper River Basin (see Table 27), from 2000 to 2015
2) The information was sorted and organized for the years 2000, 2005, 2010, and 2015
3) For each land use unit and each municipality, the linear trends from 2000 to 2015 were identified.
4) For each municipality, the following sub-categories were aggregated (see Table 30):

Table 30: Aggregated sub-categories for agricultural areas

CATEGORY (GERMAN TERM)	GERMAN TERM	ENGLISH TRANSLATION
Ackerland	Ackerland	Farmland
Grünland	Grünland / Wiese	Grassland
Gartenland	Grünland / Wiese	Grassland
Weingarten	Grünland / Wiese	Grassland
Moor	Grünland / Wiese	Grassland
Heide	Grünland / Wiese	Grassland
Obstanbaufläche	Ackerland	Farmland
Landwirtschaftliche Betriebsfläche	Ackerland	Farmland
Brachland	Ackerland	Farmland
Landwirtschaftsfläche, nicht weiter untergliedert	Ackerland	Farmland

5) Column charts were generated for each land use unit with the corresponding linear trend equation (see Figure 11)

Figure 11: Column charts containing linear trends (example for Bergisch Gladbach municipality)

6) The future areas of each land use unit were determined based on the corresponding linear trend equation for the years 2020, 2025, and 2030, consistent with the *economy first* scenario
7) For *sustainability eventually* scenario, the following assumptions were considered, based on Klingenhoff and Spettmann (pers. comm., 2016):
    a. The total forest area remains constant as of 2020
    b. Coniferous forest for the whole Wupper catchment decreases at a higher rate (in proportion to increment of deciduous forest for protected forest areas)
    c. Mixed forest was calculated = total forest area – coniferous forest – deciduous forest
8) Future sealed areas for *sustainability eventually* scenario increases only at a rate of 5 ha per day
9) Total agricultural areas are estimated according to future forest and sealed areas (*sustainability eventually* scenario), with grassland areas decreasing proportionally
10) Farmland was calculated = total agricultural area – grassland

Table 31: Future land use in Wuppertal in km²

WUPPERTAL LAND USE										
scenario	year	agricultural (total area) [km²]	farmland [km²]	grassland [km²]	forest (total area) [km²]	deciduous forest [km²]	coniferous forest [km²]	mixed forest [km²]	urban + settlement [km²]	Total [km²]
	2000	328,36	116,17	212,19	238,66	95,28	27,14	116,25	246,02	813,04
	2005	319,29	113,03	206,26	243,12	98,70	30,97	113,45	250,63	813,04
	2010	306,67	105,60	201,06	247,85	108,37	41,19	98,28	258,53	813,04
	2015	299,40	100,31	199,09	251,37	112,92	46,63	91,81	262,27	813,04
Economy First	2020	267,47	84,19	183,28	255,96	119,64	54,92	81,40	289,61	813,04
Sustainability Eventually	2020	276,54	86,96	189,59	272,68	115,12	44,44	113,12	263,82	813,04
Economy First	2025	257,84	80,75	177,09	260,24	121,87	60,16	78,21	294,95	813,04
Sustainability Eventually	2025	273,78	86,81	186,97	272,68	119,26	40,30	113,12	266,58	813,04
Economy First	2030	248,21	77,31	170,90	264,53	122,82	65,41	76,30	300,30	813,04
Sustainability Eventually	2030	269,53	86,66	182,87	272,68	122,42	37,13	113,12	270,83	813,04

Note: agricultural (total area) = farmland + grassland

Methodology for the establishment of future water use scenarios

In order to establish the water use scenarios only for the Wupper research site area, the followed approach was implemented:

1) Domestic and raw water were provided for each district and district-free city, for the years 2000, 2005, 2010, and 2015[20]
2) For the years 2000, 2005, 2010, and 2015, the total domestic and raw water for the Wupper catchment was estimated considering the area percentage of each district within the study area (see Table 28)
3) Process or industrial water was calculated = raw water – domestic water
4) Service water was obtained with the yearly withdrawals from the Wupper River to the Wupper reservoir, for 2000, 2005, 2010, and 2015
5) For *economy first* and *sustainability eventually* scenarios, the corresponding increment and reduction of all water use categories were estimated proportionally to SCENES data

[20] Source: Öffentliche Wasserversorgung in Nordrhein-Westfalen (Public water supply in North Rhine-Westphalia) https://www.it.nrw.de/presse/pressemitteilungen/2015/pdf/313_15.pdf)

Table 32: Future water use in Wuppertal

WUPPERTAL WATER USE					
scenario	year	domestic water	process or industrial water	raw water	service water
	2000	48,17	7,21	55,38	189,21
	2005	44,08	5,74	49,83	180,45
	2010	43,29	6,11	49,40	162,40
	2015	43,86	4,46	48,33	183,16
Economy First	2020	49,12	4,49	53,61	194,27
Sustainability Eventually	2020	39,09	3,89	42,99	157,10
Economy First	2025	54,40	4,50	58,90	205,99
Sustainability Eventually	2025	34,39	3,35	37,74	161,22
Economy First	2030	53,63	4,73	58,36	219,52
Sustainability Eventually	2030	40,47	2,75	43,22	188,28
Note: raw water = domestic water + process or industrial water					

3.5 Tagus

The Tagus case in WP3 consists of six subcases that are reported separately:

Agriculture

- Tagus Estuary
- Tagus tributaries from Sorraia river basin
- Tagus river (between Constanca and Valada)
- Ota-Alenquer aquifers
- Castelo de Bode Reservoir

Floods

- Trancão river basin

For each of the cases three scenarios are analyzed: a 'Minimalist' scenario (equivalent to Sustainability Eventually), a Business as Usual scenario (no changes) and a 'Maximalist' scenario (equivalent to Economy First).

3.5.1 Land use

For the five agricultural cases, an increase in irrigated area for each time period (2016-2021, 2021-2027) is assumed for all three scenarios.

For the flood case, changes are expected in the size of the impervious areas. It is expected that construction areas (residential, commercial and industrial) while increase slightly. No relevant changes are expected for forest/agriculture areas. Table 33 shows the % changes in impervious areas for three scenarios and two time periods. The changes are based on the development of additional infrastructure in the outskirts of Lisbon, such as roads and highways. This increase is strongest in the Maximalist Scenario.

Table 33: Future land use Trancão River Basin

LAND-USE FUTURE SCENARIOS (IN % OF AREA TO BECOME IMPERVEOUS)		
Minimalist (eq. Sustainability Eventually)	2016	0.2
	2021	2.0
	2027	4.0
Business as Usual	2016	1.0
	2021	3.0
	2027	5.0
Maximalist (eq. Economy First)	2016	2.0
	2021	6.0
	2027	8.0

The land use scenarios can affect the river flow that reaches the Tagus Estuary. However, the potential future changes in land use are not considered in the analyses of the estuarine dynamics (inundation and salinity intrusion). Regarding the inundation of the estuarine margins, BINGO only addresses the effect of tides and storm surges on extreme water levels. River floods are a different problem that is analyzed separately for the Trancão watershed. Regarding the salinity intrusion, we considered that the river flow under drought conditions depends on human decisions on the release of water from the main dams in the watershed. Hence, the scenarios established to study salinity intrusion were not based on the precipitation and the land use, but rather on past extreme events and conventions between Portugal and Spain.

3.5.2 Water use

Water use is only analyzed for the agriculture cases, since it does not affect flooding. Overall an increase water efficiency is assumed of 2,5 % for each of the time periods. The differences between the scenarios in the Sorraia Tributaries and the Tagus river are based on additional optimization, crop changes and additional investments in infrastructure. In the Maximalist scenario, temperature increase is also considered in requiring more water for crop irrigation. In the Ota-Alenquer aquifers and the Castelo de Bode Reservoir, water use changes are partly caused by economic growth and water efficiency increase.

Table 34: Future water use Tagus

WATER USE SCENARIOS (% CHANGE IN WATER USE)			
WP3 – Tagus tributaries from Sorraia river basin WP3 – Tagus river (between Constança and Valada)	Minimalist (eq. Sustainability Eventually)	2016	-14.8
		2021	-7.9
		2027	-8.9
	Business. as Usual	2016	-4.7
		2021	-4.5
		2027	-3.3
	Maximalist (eq. Economy First)	2016	-3.9
		2021	0.05
		2027	0.3
WP3 – Tagus Ota-Alenquer aquifers	Minimalist (eq. Sustainability Eventually)	2016	-2.5
		2021	-4.7
		2027	-6.3
	Business as Usual	2016	-1.2
		2021	-1.9
		2027	-2.1
	Maximalist (eq. Economy First)	2016	-0.2
		2021	0.7
		2027	2.0
WP3 – Tagus at Castelo de Bode reservoir	Minimalist (eq. Sustainability Eventually)	2016	-3.2
		2021	-6.2
		2027	-8.5
	Business as Usual	2016	-1.5
		2021	-2.5
		2027	-3.0
	Maximalist (eq. Economy First)	2016	-0.2
		2021	0.9
		2027	2.5

3.6 Veluwe

3.6.1 Local developments based on scenarios

Table 35 and Table 36 show the local developments at the Veluwe, based on the two SCENES scenarios and their impact on land use and water use. The PESTLE development are the result of discussion with Teun Spek, a senior policy advisor at the Province of Gelderland, the main stakeholder in the region. As a short summary, Economy First shows increased globalization, increased economic growth and less government control. Sustainability Eventually shows more government control, a more local orientation and less market pressures.

Table 35: Economy First PESTLE Veluwe

ECONOMY FIRST		LAND AND WATER USE EFFECT
POLITICAL	Less control on developments	More market influence possible, land use change for economic development is permitted within legal framework of Natura 2000.
ECONOMIC	More economic activity globally oriented, more leisure, more pressure on use of forests in production and more demand for water for domestic use. Veluwe will be used as a water source. Land owners will be paid for water production	More demand for drinking and industrial water. More pressure on natural areas and forests. Water company has to invest to protect water sources and increase in demand. Water company will pay for more groundwater producing land use. Pine forests change in savannah or not to dense broadleaf trees. Water demand for leisure increases. Streams should remain flowing and relief heat in villages and towns. Increase in groundwater demand in drinking water, livestock and leisure
SOCIOLOGICAL	More individuality, globally oriented, less interest in environmental protection	Water reduction projects for domestic use are not successful. Demand will increase
TECHNOLOGICAL	More innovation in technology with industrial direction	Innovation will result in stable water use under growth.
LEGAL	Less Legal constraints	Land use change is possible
ENVIRONMENTAL	Climate change will increase plant production potential. Market will react on this. Water demand will increase for globally oriented agriculture with still environmental problems.	In current expectations groundwater availability will increase. This increase will not be enough for the increase in demand.

Table 36: Sustainability Eventually PESTLE Veluwe

SUSTAINABILITY EVENTUALLY		LAND AND WATER USE EFFECTS
POLITICAL	More control on developments by local groups. Government more goal oriented than regulation.	Within goal setting land use change is permitted
ECONOMIC	Economic activity more local oriented. Forest will be used sustainable and multifunctional. Water for domestic use will remain at current levels.	Decrease in timber production, increase in biodiversity, health and food production. One species pine forest will be replaced by mixed forests more shrubs and broadleaf trees.
SOCIOLOGICAL	More social attitude, local oriented, more interest in environmental protection	Population is aware of environment, water use will not increase with economic growth
TECHNOLOGICAL	More solutions in balance with natural processes	Landowners at the Veluwe use natural processes in forest and nature management, more shrubs and broadleaf trees
LEGAL	Same level of legal constraints as now but more room for local solutions.	Local permaculture possible
ENVIRONMENTAL	Climate change will increase plant production potential. Local society will use this in a sensible manner. There is room for permacultures and the wolf. Water demand for plant production will increase without environmental problems	In current expectations groundwater availability will increase, because winter rainfall increases. Growing season increases, temperature increases more biomass production potential. Maybe more evapotranspiration. No problem because drinking water demand does not increase.

3.6.1 Land use

Table 37 shows the future land use in the different scenarios. The Veluwe uses additional land use categories, based on the classification from Landelijk Grondgebruik Nederland (LGN 2016). The increase in urban settlement is at the expense of grassland. The increase in crops in both scenario is also assumed to be at the expense of grassland. The increase in Woody Savannah in the Economy First scenario, goes at the expense of Pine Forest. This increase is also the most notable difference between the scenarios. Broadleaf forest, heathland and open sand only change moderately, since they enjoy legal protection in the coming 18 years.

Table 37: Future land use Veluwe

SCENARIO	YEAR	URBAN + SETTLE-MENT	CROPS	IRRIGATED AREA	GRASSLAND	BROADLEAF	PINE	OPEN SAND	HEATHLAND	OTHERS (OPEN WATER +INFRASTRUCTURE)	WOODY SAVANNAH	NATURAL	WETLANDICESNOW	TOTAL
	1997	281	186	0	678	167	526	8	143	86	0	126	1	2202
	2004	300	214	0	634	172	522	9	143	24	0	143	1	2162
	2008	287	222	0	612	238	485	13	178	76	0	131	5	2247
	2012	298	205	0	624	247	474	12	180	65	0	130	5	2240
Economy First	2020	300	205	0	622	250	429	14	180	65	40	130	5	2240
Sustainability Eventually	2020	298	210	0	618	250	471	12	180	65	0	130	6	2240
Economy First	2025	302	210	0	614	255	382	16	180	65	80	130	6	2240
Sustainability Eventually	2025	298	220	0	611	255	463	12	180	65	0	130	6	2240
Economy First	2030	304	210	0	618	260	329	18	180	65	120	130	6	2240
Sustainability Eventually	2030	298	230	0	604	260	455	12	180	65	0	130	6	2240

The most extreme land use changes are the conversions of ‘pine forest’ into ‘broad leaf forest’ and ‘woody savannah’. These changes will be applied in the modelling. For practical use in MetaSWAP, the land use class ‘woody savannah’ has been interpreted as a mixture of ‘open sand’ and ‘dry nature’. Since the other land use changes were negligibly small (e.g. changes in grass and heather only cover 2 km^2) or in protected land use classes, they were not included. The exact locations of the land use changes were based on interviews with the province of Gelderland and the location of protected regions, where land use change is not likely. The locations of the changes in land use for each scenario are shown in Figure 12 and Figure 13.

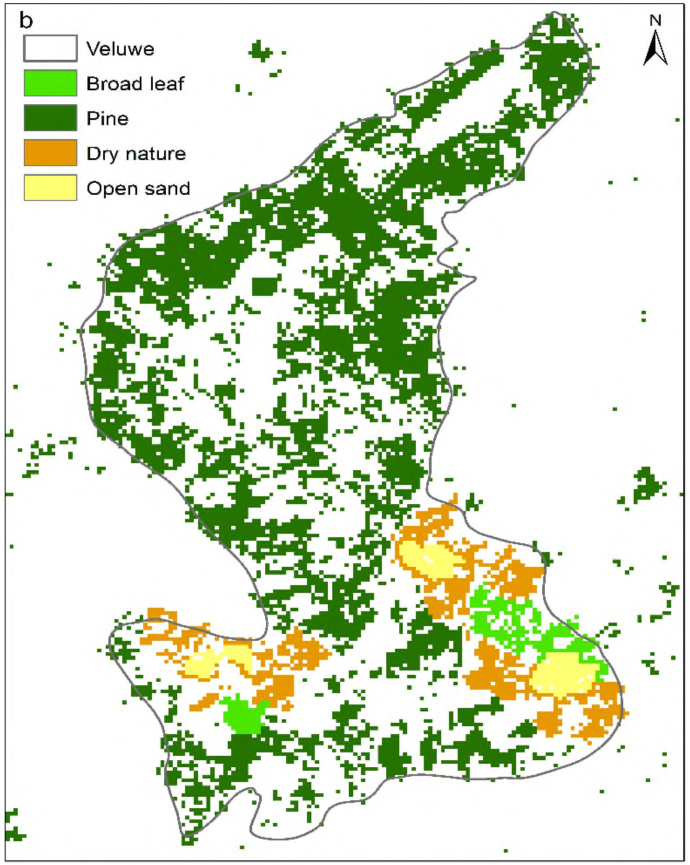

Figure 12: Land use Economy First

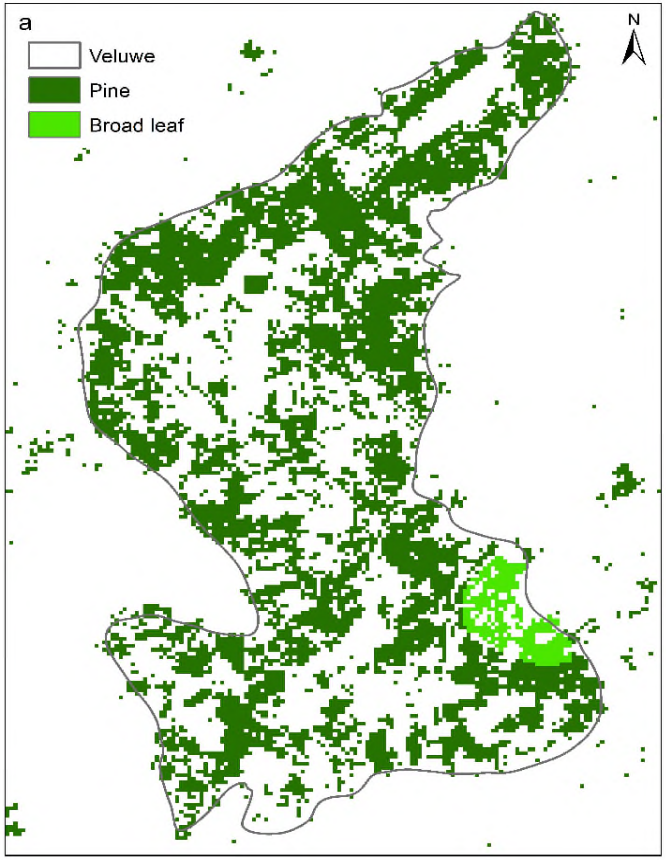

Figure 13: Land use Sustainability Eventually

3.6.2 Water use

Table 38 shows the expected water use for the two scenarios. “Nature” is added as a category, since evapotranspiration by trees and brushes is an important parameter in the Veluwe case. Evapotranspiration in the Economy First scenario is reduced by 8Mm^3 every 5 years, because of the transformation of Pine Forest into Woody Savannah. Included in “domestic” are also famers that use water from the potable water network.

Table 38: Future water use Veluwe

SCENARIO	YEAR	DOMESTIC	INDUSTRIAL	LIVESTOCK	IRRIGATION	ENERGY	NATURE (EVAPOTRANSPIRATION)*
	2000	70	20	0	3	0	443
	2005	70	20	0	3	0	443
	2010	71	20	0	3	0	443
	2015	72	21	0	3	0	443
Economy First	2020	75	22	0	4	0	435
Sustainability Eventually	2020	74	21	0	3	0	443
Economy First	2025	77	23	0	5	0	427
Sustainability Eventually	2025	73	21	0	3	0	443
Economy First	2030	80	24	0	6	0	419
Sustainability Eventually	2030	70	20	0	3	0	443
* surface area (91300 hectares) x rainfall (850) - groundwater recharge 365mm							

4. SUMMARY AND OUTLOOK

4.1 Comparison of translation of SCENES Storylines

In this paragraph we compare the impact of the SCENES storylines on local developments as identified at the research sites.

Economy First

In the Cyprus-case we see the Economy First scenario translated primarily into higher economic growth and a faster expansion of the urban area. This comes mostly at the cost of irrigated areas and forest lands.

The city of Bergen shows a similar development. Here also the increase in population and the growth of the economy is high. Added to this are liberal policies that lead to a decrease in regulation of the forests surrounding Bergen. All in all this also leads to an increase in the built-up area at the expense of forest and a strong increase in water use.

The city of Badalona expects, to the contrary, a decrease in economic growth in this scenario. This is primarily due to the disregard of environmental issue such as CSOs and declining water quality of bathing waters, leading to a decrease in tourist activity. Because of the political situation SUDS are not being developed and the soil of the non-urbanized area will be semi-permeable. Since no restrictions on water use are being enacted, it is not expected to change significantly.

In the Wuppertal we see an increased population growth because of immigration. This will lead overall to an increase of non-permeable (sealed) areas and an increase in water consumption. Since response to societal needs are not effectively met by the government, agricultural areas continue to be reduced. This affects negatively local food production, being necessary to import more food. The economic use of spruce trees leads to a growth in coniferous forest areas due to increased economic growth. The expansion on deciduous forest is in line with local linear trends.

The Tagus the effect of the scenario is primarily translated into the increase of the impervious area, which is set at 8% for 2027. A moderate increase in water use is caused by economic growth and temperature increase, despite a 2,5% improvement in irrigation effiency.

At the Veluwe this scenario leads to an increased economic exploitation of the area. This results in increased leisure activities, increased wood production and increased use of the groundwater sources. Because of less legal restraints it is possible to apply significant land use change at the Veluwe primarily changing pine forest in broad leaf forests or savannah to increase ground water infiltration. Failure to implement water saving measures leads to increase in demand, which is only slightly off set by technological innovations.

Sustainability Eventually

Compared to the *Economy First* scenario this scenario shows for the Cyprus case a more moderate economic growth and thus a slower expansion of the urban area, leaving more of the irrigated and forested areas in place.

This is quite similar to the situation in Bergen, where the built-up area is expected to decrease with 2%. This is mainly because some industry is being replaced by housing with more emphasize on greening the environment. Also, due to stricter regulation, the forest area is protected against urban expansion, which goes at a slower rate anyway due to moderate economic and population growth. There is an increase in water use, but that is fully compensated by a reduction in leakages.

This greening of the environment (in particular green roofs) is also visible in Badalona, where, due to the implementation of SUDS, 6% of the roofs will be green and permeable soils. In this scenario political efforts are focused on sustainable and green initiatives with a positive effect on economic growth, unemployment, environmental quality and a significant reduction in water use in all sectors.

In the Wuppertal the population growth rate remains as projected with which an diminishing of the sealing rate to 5 ha per day by 2020 is achieved. Environmental policies lead to a decrease in the individual water consumption and a more modest population growth results in a lower water consumption overall. Because of initiatives for local food, agricultural areas do not diminish as significantly as with a higher sealing rate, thus, favouring social sustainability. The reduction of food demand and increment of crop productivity, leads to a decrease in the sum of farmland and grassland. Coniferous forest is replaced slowly by deciduous forest, because the common goal for the protected forest areas is applied to all forests of the whole Wupper River Basin.

The Tagus the effect of the scenario is primarily translated into a slower increase of the impervious area (4% for 2027). The agricultural areas show a decrease in water use, due to less temperature rise, less economic growth and an improvement of efficiency.

At the Veluwe developments are more sustainable and locally oriented. Part of the pine forest is converted to broad leaf with the potential also for food production. The overall stress on the Veluwe is much lower, so large scale land use change to increase infiltration is not necessary.

Table 39 and Table 40 show a brief summary of the most important changes in land and water use at the research sites.

Table 39: Summary of land use changes for 2030

SUMMARY OF LAND USE CHANGES FOR 2030		
SITE	ECONOMY FIRST	SUSTAINABILITY EVENTUALLY
Cyprus	50% increase in urban area	18% increase in urban area
Bergen	10% increase in built-up area	2% decrease in built-up area
Badalona	Non-urbanized area becomes semi-permeable	Non-urbanized area becomes permeable + 6% of roofs become permeable
Wuppertal	18% decrease in agriculture, 5% increase in forest, 14% increase in urban area	10% decrease in agriculture, 8% increase in forest, 3% increase in urban area
Tagus	8% increase in impervious area	4% increase in impervious area
Veluwe	25% of Pine Forest becomes Woody Savannah	12% increase in crops area

Table 40: Summary of water use changes for 2030

SUMMARY OF WATER USE CHANGES FOR 2030		
SITE	ECONOMY FIRST	SUSTAINABILITY EVENTUALLY
Cyprus	N/A	N/A
Bergen	20% increase in total water use	No change in total water use
Badalona	No change in total water use	19% decrease in total water use
Wuppertal	20% increase in total water use	No change in total water use
Tagus	0,3 – 2,5% increase in water use	6,3% - 8,9% decrease in water use
Veluwe	2% decrease in water use	0,5% decrease in water use

The strongest drivers for land use and water use change are economic growth and population growth, mediated by public policy. At most research sites, this leads to an increase of urban areas, usually at the expense of forest or nature. Economic growth can also lead to an increase in irrigated area, unless the economic situation favors imports of food an increase in timber production, such as in the Wupper case.

Land and water use do not differ much across the research sites for the chosen time periods between the two SCENES scenarios. Changes are usually between 0-10%, with some larger values in case of specific policies applied. The main drivers in the scenarios, across all research sites, are the pressures of population growth, economic development and environmental policy.

4.2 Comparison of land use classes used at the research sites

Because the land use data serves as input for the hydrological models used at the research sites (which are different for most research sites), they were given the option of using their own land use classes and data instead of the ones provided by SCENES.

In the Cyprus case the Corine Land Cover (CLC) classification was used, but it was translated to the matching SCENES categories for this report. The primary focus is on the conversion of irrigated land and forest into urban area, as it changes the permeability of the soil which may have an impact on the consequences of flooding.

In the Bergen flood case Badalona and Tagus flood case, the focus is also on the permeability of the soil, which is reflected in the land uses classes applied in the analyses. For Bergen this is the distinction between ‘built-up and ‘forest/natural’. For Badalona the category ‘roofs’ is added to show the effect of green roofs (being part of the ‘permeable’ category. In the Tagus case, the expansion of infrastructure is classified as an increase of the impervious area.

The Veluwe and the Wupper cases provide a more detailed classification of land use, because in these cases both infiltration and evapotranspiration as well as permeability play a role. In the Wupper case different types of forest are identified because the transition from coniferous to deciduous forest is part of long term policy in the Wuppertal. Also, the different types of forests have different evapotranspiration rates. This is also a central theme in the Veluwe case. Although a broad range of land use classes can be identified (including heathland, specifically added as a class for the Veluwe), the main transformation is that of pine forests to either broad leaf forests and woody savannah, which is reflected in the land use maps.

4.3 Outlook: application of land and water use scenario

The data from the land and water use scenarios can be used as input for modelling for D3.4. It will be merged with the results from T3.1 to allow an overview of water conditions under a combination of different possible scenarios, both of climate change (including extremes) and land use. These results are important inputs to WP4 and WP5.

To distinguish between the effects of climatic and anthropogenic factors, different model runs can be done:

1. Climate change with constant land/water use
2. Climate change with land/water use in Economy First
3. Climate change with land/water use in Sustainability Eventually

By calculating the differences between the runs, the impact of land use and water use can be compared to the impact of climate change. Also, the impact of the different scenarios can be compared.

Including land use and water use in the models serves two purposes:

1. It allows the research sites to make better estimates of the future state of the hydrological systems, since land use and water use are expected to have a significant impact on it.
2. It allows the research sites to distinguish between climatic factors and anthropogenic factors in their effect on the hydrological system, providing a basis for the analysis of adaptation measures in WP5.

For the Veluwe and the Badalona case the anticipated land use changes actually represent adaptation measures that are analyzed as part of WP5. At the Veluwe, the land use transformation from pine forests to broad leaf or open sand is considered as an adaptation measure to drought, because the new types of vegetation increase the infiltration rate and thus the ground water levels. In the Badalona case, the 6% increase in green roofs are part of the SUDS measures that are meant to reduce the likelihood and impact of CSOs.

5. ANNEXES

5.1 SCENES Storylines

Scenario: Economy First

Overview

General
Globalization and liberalization are embraced in order to reduce the barriers to trade and create new enterprises and opportunities. Technological and business innovations spread quickly, both within the region and around the globe. Economic growth rates are promising, but income inequality grows over time due to massive cutbacks in social security systems. Less people can afford university education, which results in shortages in the high-skilled labour force. This trend is exacerbated further by the ageing population. Increased immigration fills gaps in the workforce but creates social and ethnic tensions. The ability of governments to regulate markets and respond effectively to societal and environmental problems diminishes. European integration remains restricted to the completion of the internal market; and regulatory competencies are cut back.

International institutions and regimes are weakened. Governments rely mainly on market based instruments (voluntary agreements, tax incentives) rather than legislation. Multinational companies dictate environmental standards/ progress. With growing income inequalities, a relatively few rich people enjoy their lives while it becomes harder and harder for the majority to keep their living standards. In the first half of the scenario, there is a rapid diffusion of knowledge and innovations around the globe, but basic research in some areas struggles with lack of funds.

High levels of education are achieved, but there is some targeting of opportunities to people who can afford to pay; this is seen in part by the increasing number of private universities. There are no equal opportunities for education. Europe experiences a brain drain to other regions later in the period.

Storyline In Three Periods

Beginning (2008-2015)
Although some countries and other interests are increasing their opposition to the Water Framework Directive, it still maintains strong public and governmental support. Therefore, the EC forges ahead in implementing the Directive through its first phase, despite increasing opposition to it from.

By 2015 public opposition to the EU's Common Agricultural Policy has grown significantly because of rising opposition to the economic protectionism and strong government intervention embodied in the Policy.
The growing global demand for food commodities from Europe drives further intensification of its agriculture.

Because of high labour costs in the original EU states, manufacturers continue to move their operations to the south-eastern part of Europe.
Rising fear of climate change impacts motivates strong public and governmental support for reducing greenhouse gas emissions in Europe. As a result, the government and private sector work together to introduce non-fossil fuel and non-nuclear alternatives to Europe's energy system. A side effect is that fewer new thermal power plants are constructed.

Trends in the domestic water sector from the previous decade are continued – Per capita water use increases along with increasing income in the East while it levels off or declines over the rest of Europe. What is the situation for the WFD in Europe? In each country a few river basins, stretches of rivers, and/or lakes achieve compliance with the WFD, especially those areas where outdoor tourism is important (e.g. in alpine and rural areas). However, the majority of basins and stretches do not comply at all with the WFD. No country achieves full compliance.

Middle Period (2015-2030)
High material consumption continues with increases in resource use per capita. Due to market-driven gains in efficiency, the economy becomes a bit less material intensive. Sustainable production patterns are established when they are profitable and competitive under market conditions.

Meanwhile, the move towards strong international climate policies slows down as the public becomes unwilling to accept the costs of climate change mitigation. The Kyoto Protocol is only incompletely enforced and there is no stringent follow-up action. Total greenhouse gas CO2 emissions increase by over 50 per cent between 2000 and 2030 and climate change impacts become increasingly visible. Energy consumption/capita is very high, but due to market drives for energy efficiency, energy intensity of GDP decreases a bit.

One consequence of these developments within Europe is that the trend towards solar and wind electricity slows down, and more and more thermal power plants are built, powered by remaining fossil fuels and nuclear fuel. Governments are less involved in regulating the energy industry and as a result laws regulating thermal discharges from power plants are also weakened.

During this period fossil fuels begin to run out worldwide, leading to much higher fuel prices. Private industry sees the opportunities in the depletion of fossil fuels and organizes international consortia to build high-tech alternatives to fossil fuels such as fusion-based electrical generation plants and facilities to produce hydrogen as a transport fuel. Governments provide rich subsidies for these private ventures.

Another trend is to increase the capacity of hydroelectricity. However, feasibility studies commissioned by several water agencies indicate that new large facilities will not be possible because of the lack of suitable remaining sites and expected public opposition to the social and ecologic impacts of large dams. Instead, many new small-scale "run-of-the-river" hydropower facilities are built in medium to large sized rivers.

Planning for hydropower is affected by another factor, namely, the observed long-term decline in precipitation south of the Alps. Because of more frequent low flows, even small-scale hydropower facilities are not built in this region. Two major trends lead to a significant change in the distribution and type of agriculture in Europe. The first is that the EU further weakens CAP and the subsequent decrease in agricultural subsidies leads many farmers to abandon their farms where lack of water and infertility of soil makes crop production uneconomic. This is particularly important in Southern Europe. On the other hand, the demand for food exports and political targets for biofuel production lead to an intensification of crop production on the most productive land, i.e. land with high soil fertility and adequate water supplies.

Since policies that protect agricultural production in ‘Less Favoured Areas’ are no longer in place, most of the abandonment takes place in currently valuable, diverse landscapes with mostly extensive forms of agriculture and high biodiversity values. These abandoned farmlands are no longer managed and the nature value of the re-growth is generally of lower value than the prior landscape. Overall, this leads to a less diverse and more homogeneous landscape.

Large agricultural areas are abandoned in Southern and Eastern (Central) Europe but intensified in other parts of Europe. For example, new areas are opened up for cultivation in fertile soil regions of the Baltic countries and this leads to deforestation in some areas. Some irrigated areas in other parts of Europe are abandoned, freeing up water for other uses. At the same time, irrigation is used more intensively in other areas, increasing the pressure on water resources. In this way, the spatial distribution of areas of water scarcity and surplus in Europe change during this period, as well as water quality (see below.)

The situation is different in the easternmost parts of Europe ("Eastern Europe – East"). Here land is cheap and productive which attracts private investment for its "improvement". Hence, agricultural production begins to increase in this region. One side effect of agricultural development here is the increase in diffuse agricultural pollution (especially nutrients and pesticides) from cultivated fields which degrades water quality especially in surface waters.

Since water is of prime concern in profit-seeking agriculture, farmers begin to experiment with re-using return flows from irrigated farms. These return flows are given a low level but affordable level of treatment which removes some but by far not all of its pollutants. The partially-treated wastewater is then used for irrigation. More and more farmers adopt this practice.

A report is published by a group of municipal water providers that kindles opposition to the second cycle of compliance of the Water Framework Directive. The report claims that the first phase of the WFD failed in achieving its goals of restoring the ecological integrity of Europe’s waters. The report further dramatizes the high costs of further implementing the directive and points out that the EC failed to integrate the goals of the WFD with its policies regarding manufacturing and agriculture in Europe.

A report of the European Environment Agency published in 2020 shows that virtually all river basins are further from compliance with the WFD than in 2010. In Europe as a whole, the trend in water quality is very patchy – Where agricultural activity is reduced and where industries have left Europe, water quality improves. Also water quality is improving in parts of northern and western Europe, where environmental consciousness is high, and in some alpine and rural areas scattered through Europe, where outdoor tourism is important. Water quality continues to degrade or remain at a poor level over the remaining territory of Europe.

As part of the overall trend towards free markets, governments weaken their regulation of wastewater discharges of manufacturers. Pollutant discharges from manufacturing continue to decrease but at a slower pace.

Aging of the population and changes in family status lead to many more single-person households and this affects overall average per capita water use in the domestic sector. Also in the domestic sector, municipal water supplies are privatized at a rapid rate and overall investments in water infrastructure are curtailed. Higher water prices are introduced and this slows down the growth of per capita water use somewhat. At the same time, the declining emphasis on environmental values includes a decline in water education and overall lower water-saving consciousness. These factors, together with the slower diffusion of water-efficient technology across borders, have the cumulative effect of slowing the improvement in water use efficiency.

Final Period (2030-2050)
More and more ecological and public health scandals are caused by the discharge of untreated or partially treated sewage into rivers and lakes by industry. Indeed, during this period a new wave of chemical pollution reaches crisis proportions in Europe. One cause is the response of the European pharmaceutical industry to the increasing variety of diseases worldwide and the demand for more effective and cheaper medicaments. Responding to this demand, the industry begins synthesizing a wide range of novel medicines composed of new organic compounds; many of these compounds are toxic to humans and aquatic biota and eventually find their way into surface and groundwater because of inadequate wastewater treatment.

Likewise, the production of new energy technologies responding to the energy crisis has also led to the discharge of new trace metal compounds to receiving waters. The modern agro-industries and biotech industries have produced new organic compounds, some of which are toxic, and many of these compounds have also found their way into groundwater and surface water. These developments have caused many new, toxic substances to accumulate in virtually all freshwater systems in Europe over the last several years. They have not been detected because monitoring of the environment has been neglected for some decades. As a result, these pollutants have slowly but steadily accumulated in river sediment, in the water column, and in aquatic biota.

The first hint of this alarming situation emerged from studies of a small number of case study rivers in Germany, conducted by the Natural Science Faculty of the University of Kassel, and of a sample of lakes and groundwater in the Netherlands, carried out by the Water Science Faculty of the University of Wageningen. Shocking results from these studies quickly stimulated studies of other water systems in other parts of Europe. The consensus of this research was that an unprecedented high level of contamination existed in surface waters and groundwaters throughout Europe, caused by new trace toxic substances.

Finally, public health officials had an explanation for the ever-increasing number of poisoning incidents that they observed in different parts of Europe. Another consequence of this contamination was that the WFD goals for ecological integrity of freshwater systems were now even more difficult to achieve.

Eventually the media has become aware of the scientific reports and brought these shocking findings to the attention of the public. Alarming stories suddenly began appearing in all forms of media – print, radio, television and internet. The public was informed about the connection between different contamination incidents occurring in different parts of Europe. Public health officials reported on the extent of sickness and even fatalities stemming from these incidents.

Public protests began taking place at chemical plants and the head offices of chemical companies. Eventually these protests found their way to government buildings, and the public began demanding greater governmental control over the water pollution caused by industry. But for many industries the public embarrassment was enough to motivate them to reduce their untreated wastewater discharges. After many months the scientific findings, media reports, and public protests finally had their effect on public policy:

- A new EU Health Agency was founded which began monitoring all new products produced within the EU or imported to the EU to ensure that all new toxic substances associated with the product were identified and then either minimized in the production phase or removed before wastewater was released to the environment. This agency did not have a regulatory function.
- On the regulatory side, the EC passes stringent new controls on discharges of both new and conventional pollutants. These regulations are much stronger than earlier ones and include a wide safety margin to protect public health.

Some industries do not want to make the investments necessary to adequately treat their wastewater discharges and decide to move out of Europe to where water pollution control is lax. On the other hand, some branches of industry now see new opportunities in the strict pollution regulations. -- Some new high-

tech industries, with low water intensity and low pollution discharges, have moved into Europe because they now have a competitive advantage. Similarly, some industries begin to market chemicals that they guarantee are non-toxic and safely biodegradable.
After years of agricultural intensification and declining extensive agriculture, the population moves from rural to urban areas causing urban sprawl. One result is the fragmentation of agricultural land and natural areas near urban centres. The impact of these changes is very diverse across Europe. Terrestrial biodiversity steadily decreases as a result of these and other factors.

Because of the large profits of industrial farms, agriculture is able to outcompete other water using sectors for local water resources. It becomes common practice to subject irrigation return flows to a low level of treatment and to recycle these flows for further irrigation. The farm industry manages to convince the public that crops using treated wastewater are more “ecological” than other crops because they are grown with “recycled” water rather than scarce water resources.

The trend towards privatization of municipal water supplies gains speed and a large fraction of total domestic water supply is controlled by private companies. Higher prices continue to slow the growth of domestic water use, and municipalities compete intensively in some locations with irrigation projects for increasingly scarce water resources.

Industrial agriculture becomes entrenched in Europe. Where these farms rely on irrigation, they cause local “hot spots” of high pressure on Europe’s water resources.
As the economy grows, most communities build wastewater treatment plants. Unfortunately the construction of treatment plants can just keep pace with the increase in wastewater produced by growing water use in Eastern Europe. As a result the volume of wastewater increases in Eastern Europe, leading to an overall increase in Europe between 2000 and 2050. Water pollution is severe in various other local “hot spots” throughout Europe where population and industry are concentrated. In the energy industry, the use of nuclear and fossil fuel power plants also becomes entrenched. Because of higher water prices, there are increased incentives to adopt water-saving technologies and behaviour.

In Southern Europe, water scarcity increases as global warming leads to a drier climate. Water use reaches a saturation point and then declines in Western Europe while it rapidly increases over the rest of Europe because of economic growth. As a whole, the number of people living where water stress is severe only slightly increases between 2000 and 2050.
A series of market and government failures causes strong public mistrust and, after 2030, there are calls for tighter control of markets and companies. Decreasing private investments in energy grids and transport networks have increased the fault liability of energy supply and safe and reliable public transport. Frustration is especially high in Eastern Europe. Acceleration of extreme weather events and insufficient responses intensify these calls. The need to build up capacities for adaptation management to global climate change is apparent. Governments are under enormous pressure and hastily implement many new measures including tax increases. This mitigates against the social gap but weakens the competitiveness of companies and slows economic growth. Technology development is shrinking, too.

In 2040 unemployment rises beyond recent historic levels. Europe experiences a deep economic recession; and many companies start to relocate to other regions. In 2045 a mega-summit of European governments, industries, NGO and other representatives of civil society sets up a comprehensive review of policies to strengthen quality and efficiency of regulation. The administrative and tax burden is relieved again. Slowly, companies start to regain competitiveness and provide new employment opportunities. A new balance starts to emerge in which government works in partnership with industry and civil society representatives to renew economic prosperity and social coherence in Europe.

The energy and other resource requirements of transportation greatly increase in Eastern Europe due to the greater mobility of its population. The volume of freight transport, mostly by rail, also grows. To satisfy fish consumption in the region, fish harvests are boosted over 50 per cent in the Northeast Atlantic Ocean and Mediterranean Sea between 2000 and 2050 (Figure G-17). The result is a reduction in the diversity of the Northeast Atlantic fishery and a decrease in the quality of fish retrieved from the Mediterranean.

Sustainability Eventually

Overview

General Points
Sustainability Eventually is a scenario that sketches the transition from a globalizing, market-oriented Europe to environmental sustainability, where local initiatives are leading and where the landscape becomes the basic unit. This fundamental change in human behavior, governance structures, and level of

decision making, is projected to come about through a phase of strong top-down policies ("quick change measures"), accompanied with a set of "slow-change" measures that bear fruit in the long run.

In other words, decisive government initiatives attempt to reach specific long-term social and environmental goals. However, the attempt to simultaneously address this wide variety of goals practically results in a large number of important trade-offs – between economic benefit, environmental protection, and social welfare – that need to be made. As time progresses it becomes clear that tradeoffs favor environmental and social sustainability, at first glance on the expense of the economy. However, a simultaneous fundamental shift from centering on economic growth and employment to a wider focus on quality of life, results in a different perspective on this shift.

Nevertheless, the economy is characterized by slow growth, with some regions especially in the North continuing to display the highest economic growth rates. EU policy is less regulatory and built on consensus. Besides, there are many multi-scale partnerships and an open institutional consultation process is initiated. Generally, the process towards sustainability is more diverse than at the beginning of the period. The same goal is often reached through a very different process across Europe.

Importantly, regional and spatially there will be large and increasing differences. This leads to different processes in different regions, which in turn leads to a paradigm shift that is not likely to take place across Europe and certainly is not taking place at the same speed. This is especially apparent between the South and the rest of Europe. The fundamentally different water-related issues and the different regional solutions that are being advocated result in a split between 'water rich' and 'water poor' countries. This split is not carried through to political levels, but does involve far-reaching collaboration between countries in the Mediterranean on many issues beyond those that are related to water.

Internal migration will be very strong. Ageing of the population, longevity, and fading borders within the EU result in a strong migration flow into those countries with enjoyable climate conditions. With the improvement of water scarcity problems, this flow intensifies.

The shift towards a landscape-oriented management style has consequences especially for land use. Natura 2000 sites are better managed and environmental protection is integrated into other sectoral policies. Direct agriculture subsidies are phased out and replaced by policies aimed at environmental services by farmers, such as support for farmers in less favorable areas with high-nature value farmland and accompanied by effective spatial decentralisation policies. Decreasing food demand and increasing crop productivity lead to a decrease in the sum of cropland plus grazing land. Land use changes in general promote greater biological diversity.

EU environmental regional initiatives are strong and many technology centers are developed. Efforts are made to share technological benefits so that the overall benefit is felt. European inspired environmental standards are also introduced in Eastern Europe. A level of sufficiency in terms of material possessions is attained for most people in the region, despite widespread decreases in real income.
Water demand is strongly reduced by water savings and behavioral changes. Towards 2050, a balance is reached between water supply and water demand. Similarly, water quality improves strongly. This translates to a growing importance for water for food and water for people, with water for energy and manufacturing becoming less important. In changing water demand, water pricing becomes more and more a key instrument. Besides a direct water tax, more ecosystem services are explicitly included in the 'polluter pays principle'.

Key to the fundamental transition from a focus on employment and profit to a focus on quality of life are a number of events whose combined impact is strong enough to kick start the process of change.

Storyline in Three Periods

Beginning (2008-2015)

At the beginning of the period, market forces continue to be strong in a globalizing world. However, it is now clear that the credit crisis that started around 2005 is leading to a prolonged economic recession. Additionally, leaders in Europe are divided on the best course of action, and increasingly initiatives are national rather than European. On top of this, a number of other events take place. Following the melamine scandal in China, stricter regulations reveal similar problems, also from within the EU, e.g. pesticides on grapes in Italy. This in turn triggers a media attention that reveals a number of similar incidents, while the worldwide recession continues unabated. Together these events damage consumers' confidence in the economy as well as raising serious suspicion on the beneficial effects of globalization, particularly in relation to food.

This increased consumer distrust combined with the failure of politicians to adequately deal with the economic crises, leads to the rise of the green political parties across Europe. With Green governments coming to power, a number of measures is agreed to that will have strong and lasting impact in the long term. In general, all measures have in common that they geared to landscape and watershed oriented approaches. Special education starting at primary school and continuing up until university to help appreciating the multifunctional landscape, ecosystems and their influence on human wellbeing. Regional planners are similarly trained. Increasing (local) knowledge transfer becomes important.

Simultaneously, existing initiatives are altered to increase the focus on spatial planning, not in the last place related to the WFD. Despite its current focus on the river basin, the framework is not sufficiently far-reaching, nor sufficiently top-down. Even before the deadline of 2015 to meet environmental criteria, the WFD is updated with stronger water-pricing mechanisms, stronger environmental criteria, making it a leading instrument also in relation to for example the Lisbon strategy. On top of that, In the second decade of the 21st century, droughts increase in frequency and duration, while occurring ever more widespread. This leads to an increase in water stress, a decrease in water quality, and therefore an increased impact of wetlands and other ecosystems. This results in a stronger alignment of the water poor countries, which as a result exert a strong influence over the adaptations to the WFD. Integrated spatial planning is introduced as key instrument in several countries. Because of the lack of such triggers elsewhere, the water rich countries lag behind.

Water-related policies become more integrated and better harmonized. However, they need to be powerfully enforced. The ‘polluter pays principle’ (PPP) is implemented and enforced for tourism. A very slow start is made to implement PPP for a number of other sectors including households. Understanding that changes will only succeed when accompanied with a bottom-up acceptance, a new specific educational program is started that targets all aspects of sustainable development. Specific R&D activities are initiated to improve water saving technologies in different sectors (specifically agriculture, energy, and industry).

Similarly, a split between water-rich countries and water-poor countries has not materialized yet. Some changes, however, have already become apparent. In **water-poor countries** migration flows especially from Western European countries (UK, Germany, the Netherlands) are intensifying. At the same time, the number of droughts and heat waves is intensifying, while total precipitation is decreasing. The increased water demand by migration and decreasing water supply, particularly in summer months, leads to severe problems with water availability in all water-poor countries. At the same time, **water-rich countries** experience further slowing birth rates and an increasing out-migration leading to a total population that starts decreasing by 2015. Water problems related to climate change intensify (predominantly floods), but seldom lead to catastrophes. The effects of climate change are by and large viewed as being positive, for example because a longer growing season that leads to higher agricultural production.

The speed with which political changes, laws and treaties are implemented outpaces the bottom-up change towards sustainable behavior. As a result, part of the new laws and policies are top-down enforced in the first phase, and are only partly (but increasingly) accepted. Simultaneously, a fundamental shift from the traditional government system to a governance structure takes place. By 2015 this process is still in its preparatory phase for implementation.

Moreover, the effect of none of these measures is directly visible. A set of short-term measures are implemented to yield a direct impact, namely tax increases. These include a lowering of labor tax and increase of resource tax for various industries. Income tax is also increased. Needless to say that overall this period is not very pleasant for most. Economic recession and tax increases reduce income, while environmental disasters shatter consumers’ confidence. It is because of the lack of alternatives and the decisive attitude of the newly emerging political powers that the general public accepts these changes. It is particularly because of the increased recognition of the importance of local networks, that acceptance is facilitated.

Middle Period (2015-2030)

This phase is crucial for the transition to a sustainable, regionally governed society, while combating a deep economic recession. In general, the pace of bottom-up behavioral changes maintains to be slow, while top-down enforcement of a large number of new laws continues unabated. Although these measurements are met with increasing approval, there are strong regional differences and partly failures. Consumption patterns for instance do not change yet, which puts considerable pressure on water demand, and land needed for agriculture. Yet, the first signs of a true ‘bio-economy’ become apparent, incorporating other ecosystem services, e.g. recreation and biodiversity, besides economic production.

A first pivotal step in the transition is the establishment of so-called ‘Trust-based networks’. These networks are rooted in the confidence in local solutions and local partnerships, reinforced by the growing political interest in spatial planning and landscape-oriented approaches. A second aspect is the decrease of power of the EU, while national policy makers are increasingly being informed by local initiatives. Key in this transition are the NGOs. These organizations are growing larger and stronger and do not operate along the traditional levels of power, and are thus able to relate to municipalities as well as to national governments. Initiated by the discussions around the new WFD, and particularly the lack of effective control, a group of NGOs introduces the ‘environmental watchdogs’.

This sustainability police is given substantial budget to monitor and report environmental problems. However, in this phase, most new initiatives are at the national level, even though at the same time local governments become more active as well. The new developments still largely build on existing partnerships. National governments, inspired by the early success of the trusted-based networks and the operating procedures of the NGOs, initiated measures that undermine the position of both the EU and the nation state. Key words are decentralization, integration, coordination, stakeholder participation, and increased transparency. To maintain their influence, nations initiate collaborations with key NGOs and seek a role in the variety of new networks, which is not always successful.

Towards 2025 the shift in education results in a widespread acceptance of the PPP. Notably, however, conservation policies are not implemented in some sectors, especially in agriculture and for most of the industries. Nevertheless, despite sectoral and regional set-backs, developments in general are positive and important goals to achieve sustainable development are set in motion under a broad general acceptance. Important aspects that contribute to the positive outlook is the swift further development of (water saving) technologies and the rapid transfer of these technologies. The role of technology, however, varies strongly between sectors and regions. In general, the impact of technological improvements becomes less important over time. For example, the share of water used by the agricultural sector becomes much more (up to 70%), and in water poor countries the sector is relatively high-tech, so not much can be gained. By 2025, structural change, changing behaviour and improving (water) infrastructure, have become larger contributors to the decreasing water demand from all sectors.

Important is the increasing divergence in management practices to fit the diversity of local situations, which leads to a far-reaching integration of water-poor countries. As a result, differences between water-rich and water-poor countries are increasing.

Reinforced by the continued impacts of climate change, droughts, and resulting wetland deterioration, the water poor countries form strong alliances to deal with the issue of water scarcity. Also inspired by the successful negotiations on the new structure of the WFD, providing more decisive power at the river basin level, the interest on watershed-based management is further triggered. At first, water quantity is the driving force behind the unification of water poor countries. Over time, however, water quality linked specifically with ecosystem goods and services becomes equally important. In water poor countries, all measures will have a “climate check”.

The slow measures initiated in the early 2010s start showing concrete results. For the new generation it goes without saying that environmental protection measures are needed, that landscapes are crucial to protect, and that spatial planning is an essential instrument for this. However, the transition from the old, top-down, employment-oriented paradigm to this new way of living is painful, slow, and does not succeed everywhere. In various water rich countries there is strong resistance. Western Europe is not ready to give up their base of power, while strongly growing economies in Eastern Europe claim a need for prolonged economic growth to catch up. Implementation of environmental measures is therefore slower.

Water-poor countries
The problems with droughts, increasing water demand and water shortage continue. Because of this common struggle, a strong region-specific water governance starts building. Moreover, the widespread water problems result in a relatively fast shift in behaviour at all levels. This results in a governance structure that functions well and successfully integrates decision making across scales and sectors, with a broad stakeholder participation. Partly because of this, PPP in agriculture and for households is fully implemented. Despite these successes, however, some of the devastating negative consequences of climate change cannot be prevented. Specifically natural water systems suffer and some of them collapse.

Water-rich countries
Problems with natural water systems and the effects of climate change are much less dramatic in the water-rich countries. Though generally positive, these smaller signals of environmental problems hamper the successful completion of the ‘green’ educational programme. Similarly, the new governance structure suffers of diverging interests of the various sectors. As a result, the behavioural change towards the new sustainability paradigm is relatively slow. Compared to the water-poor countries, decision making is slower and more problematic.

Final Period (2025-2050)
In the final phase of the scenario, most of the key changes have been set in motion and increasingly strong positive impacts are becoming apparent. First and foremost, the Trusted networks have now become leading. Their character is increasingly local, with a fading role of national governments which is replaced by NGOs and local governments, but where necessary tapping into European and even global resources. One of the leading countries is Italy where the glocalisation movement from the 2000s has shown how small companies with short production lines can form strong collaborations. In general, widespread water policies are implemented; consumption patterns start changing noticeably; and other

behavioural changes become apparent. As a result, PPP in water-related issues is fully implemented for all major sectors, also with the support of an educated society. The division in Europe between water-poor and water-rich countries is now complete. Many environmental issues are now dealt with by (eco)region rather than by country, under an EU umbrella. The EU thus continues to exist, but merely to foster, structure, and stimulate national and local initiatives. Likewise, the power of the nation states further diminishes.

Not all is positive in this new Europe. The past 50 years have seen strong and fundamental changes that did not take place with the same speed everywhere.
Certain nation states (Germany, France, UK) continue to have a strong position; some of the new access states from the 2000s are reluctant to invest in natural capital on the expense of the economy, arguing that quality of life cannot be achieved without a strong focus on employment and economic growth. They argue that the new paradigm is strongly favouring old member states with a higher economic starting point, thus deliberately weakening the position of Eastern European countries. Furthermore, there are strong geographical differences. In general, water poor countries were more successful.

A good example of where this new structure is partly failing is the Danube river basin. Running through 10 countries and including 11 more in its watershed, a predominantly bottom-up management strategy did not work. The mix of interests was simply too diverse, and the geographical area too large for local trust-based networks to function well. Note, however, that by 2050 conflicts and tradeoffs cannot always be measures with the same criteria as were in use in the early 2000s. Criteria based on local livelihoods, landscape values, and local sustainability tell a different story of the Danube watershed. The decrease in consumer demands (“Onwards to the past”) that is starting to take hold now might ensure that despite the failure of linked networks, a collection of mostly unlinked networks might also achieve the new quality of life goals.

Water-poor countries
In the water-poor countries, the effects of climate change lessens while society has increased its coping capacity. Simultaneously, an effective region-specific water governance is now in place. Moreover, the flow of migrants from the north of Europe slows and by 2050 population is stable. Additionally, the irrigation area used for agriculture strongly decreases both because of behavioural changes and because of a decreasing demand from within the region and elsewhere in Europe. Nevertheless, huge water problems remain. People from within the newly formed Sunbelt have a much higher water demand, and overall water supply remains low. Towards 2050, new technological breakthroughs in the field of water desalination finally hold the promise for a sharp increase of cheap water availability.

Water-rich countries
As before, changes in the water-rich countries lag behind those in the water-poor countries. Yet, by the end of the period an effective water governance structure is in place, as is a set of successful adaptation strategies to combat the impacts of climate change. Because of the lesser impact of the effects of water-shortage and climate change, the changes in the water-rich countries are equally successful.