Sustainability Scenarios for a Resource Efficient Europe

Appendix D to the Final Report for the European Commission (DG Environment)

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Revision and Authorisation History

Version	Date	Authorised for release by	Description
1.0	8/9/2011	Anthony Baker	Version accompanying draft final report

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Explicit focus on material resource efficiency

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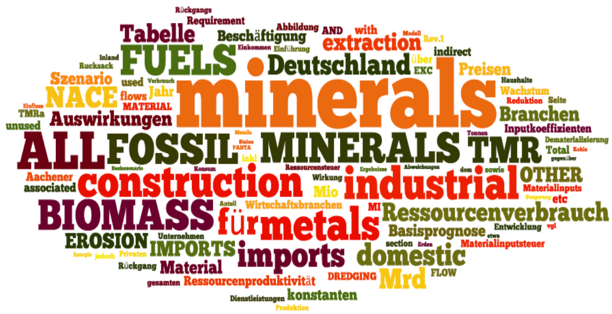
Long-term visions (2050) and broad resource spectrum

Appendix D: Detailed factsheets of selected sustainability scenario studies

Aachen Scenario



Resource productivity as a chance[1]

Aachen Foundation Kathy Beys (2005)

KEY ASSESSMENT

Study	- Forecasting scenarios designed to study the macro-economic impacts of the implementation of consistent policy measures to increase resource productivity by a given amount in the manufacturing sector, construction sector and public service (economic instruments, information instruments and support programs).
Visions and targets	- Overall vision: produce more wealth while using fewer natural resources. - Target for this study: 20% decrease of material and energy costs within 10 years. - Official target for Germany: double resource productivity by 2020.
Policies	- Overall strategy: switch efforts from increasing labour productivity to increasing resource productivity. - Strategy for an absolute decoupling of resource use from economic growth while fostering employment: # Support programs (information, consulting, innovation programs) promoting resource productivity # Societal consensus to separate material/energy productivity gains from labour productivity gains (pay increase is limited to the latter) # Material input tax (MIT, incl. ecological rucksack, excl. water and fossil fuels), combined with a reduction of income tax equivalent to the MIT revenues, introduced after some years to build on the changing mindset induced by the support programs. - Sectors to target in priority with the support programs: # Final use: power, food, and solid fuels (incl. district heating) # Production: energy, metal processing, and construction.
Resource efficiency	Resource productivity is expressed as GDP / TMR (i.e. in EUR/kg)
Cross-cutting issues	Economic cross-cutting issues are modelled (interplay between resource use, turnover, employment, state budget, economic growth)

[1] Source: Aachen Foundation, 2005. Resource productivity as a chance - A longterm stimulus plan for Germany [Ressourcenproduktivität als Chance - Ein langfristiges Konjunkturprogramm für Deutschland]. Aachen: Aachener Stiftung Kathy Beys. http://www.aachener-stiftung.de/index.php?id=57&type=0&jumpurl=uploads%2Fmedia%2Fkonjunkturprogramm_ressourcenproduktivitaet_01.pdf&juSecure=1&locationData=57%3Att_content%3A192&juHash=26b95241818e9b08885e24ea64b10ffbddbbb6ef

Burden shifting	TMR includes the indirect material flows (incl. unused extraction) of imports; therefore issues of burden shifting between Germany and the rest of the world are covered for material use.

DETAILED REVIEW

Type of study		
Scenarios	Baseline scenario	Baseline assumptions regarding exogenous variables are described in other publications presenting the INFORGE model. Modelling results from alternative scenarios are subtracted from baseline results, hence only the difference in the baseline and alternative input assumptions matters.
	Alternative scenarios	- Scenario I 'The world as it is' - Scenario II 'Societal consensus' - Scenario III ' Price competition' - Aachener scenario - Material input tax (MIT) scenario - Combination of Aachener and MIT scenarios
Modelling	Physical models	Physical IO model covering the used and unused material categories.
	Economic models	INFORGE, PANTA RHEI (extension of INFORGE to environmental economic aspects)
Geographical scope	Germany	Domestic used and unused extraction, as well as direct and indirect material use and unused extraction associated with imports are covered.
Temporal scope	Horizon 2020	
Economic scope	59 sectors in Germany + world market	Macroeconomic variables are built bottom-up from the aggregation of the detailed modelling results at the sectoral level. The interdependences between the 59 sectors are modelled.
Resources covered	**Materials**	Total material requirement (TMR) is calculated, which includes metals, construction minerals, industrial minerals, fossil fuels and biomass. TMR consists of domestic extraction (used and unused) and direct and indirect flows (used and unused) associated with imports.
Environmental impacts considered	The study looks at resource input indicators (TMR) and does not calculate output-based environmental impact categories.	
Influencing factors identified	Economic development	Economic growth, tax revenues, state budget
	Production patterns	Investments in consulting, engineering and equipment to increase material and energy productivity
	Institutions	Possibility to establish a societal consensus on the redistribution of productivity gains
Baseline scenario	**Assumptions**	
	Economic development	- Low economic growth between 1.8% and 1.5% per year
	Production patterns	- Decision to phase-out nuclear power. - Decision to reduce hard coal production.
	Institutions	- No new "ecological tax"

	Description	**Summary of what happens in the baseline scenario**
		- Resource use (TMR) increases in absolute terms despite low economic growth. - State budget remains - Nuclear power phase-out happens as was decided. - Kyoto objectives are reached in 2010, a further reduction of 780 Mt CO_2 until 2020 is decided. - Domestic production of hard coal drops from 26 Mt to 16 Mt between 2006 and 2012. - Domestic brown coal extraction remains constant.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	- TMR reaches 6850 Mt per year in 2020 (up from 5800 Mt per year in 2000) - Resource productivity excluding fossil fuels remains constant - Resource productivity including fossil fuels increases slightly (0.8% per year between 2000 and 2020) due to decreasing domestic hard coal extraction.
Alternative scenario 'The world as it is'	**Assumptions**	
	Production patterns	Investments in consulting, engineering (1/3) and equipment (2/3) necessary to decrease material and energy in the manufacturing and public sectors.
	Description	**Summary of what happens in the alternative scenario**
		- Material and energy productivity of the manufacturing industries increases as well as their profits; aggregate wages increase too; goods prices decrease; GDP increases by 10%. - Employment decreases (material and energy producers cut jobs; other industries also because the balance between job creation due to higher consumption and job destruction due to higher productivity – both labour and material/energy – leading to higher wages is negative)
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	Material and energy costs decrease by 20% linearly over 10 years in the sectors considered.
Alternative scenario 'Societal consensus'	**Assumptions**	
	Production patterns	Investments in consulting, engineering (1/3) and equipment (2/3) necessary to decrease material and energy in the manufacturing and public sectors.
	Institutions	Societal consensus to separate material/energy productivity gains from labour productivity gains
	Description	**Summary of what happens in the alternative scenario**
		- Material and energy productivity of the manufacturing industries increases as well as their profits; aggregate wages increase too; goods prices decrease; GDP increases by 10%. - Employment increases, relieving the social system and hence the state budget.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	

	biotic and abiotic	Material and energy costs decrease by 20% linearly over 10 years in the sectors considered.
Alternative scenario 'Price competition'	**Assumptions**	
	Economic development	Productivity gains minus pay increases are fully passed on to the consumers in form of price reductions.
	Production patterns	Investments in consulting, engineering (1/3) and equipment (2/3) necessary to decrease material and energy in the manufacturing and public sectors.
	Description	**Summary of what happens in the alternative scenario**
		- Material and energy productivity of the manufacturing industries increases as well as their profits; aggregate wages increase too; goods prices decrease; GDP increases by 14%. - Employment decreases (material and energy producers cut jobs; other industries also because the balance between job creation due to higher consumption and job destruction due to higher productivity – both labour and material/energy – leading to higher wages is negative)
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	Material and energy costs decrease by 20% linearly over 10 years in the sectors considered.
Alternative scenario 'Aachener scenario'	**Assumptions**	
	Production patterns	Investments in consulting, engineering (1/3) and equipment (2/3) necessary to decrease material and energy in the manufacturing, construction and public sectors.
	Institutions	Societal consensus to separate material/energy productivity gains from labour productivity gains
	Description	**Summary of what happens in the alternative scenario**
		- Costs in manufacturing, construction and public sectors drop. - Suppliers of the resources that are saved see their turnover drop. - Sectors with reduced costs increase their profits while decreasing prices, which has a positive impact on the state's tax revenues and people's income, which in turn drives consumption, which increases turnovers, production and employment. - GDP growth is about 1% higher than in the baseline.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	- Material and energy costs decrease by 20% linearly over 10 years in the sectors considered. - Resource productivity increases three times faster than in the baseline. - Absolute resource use remains constants.
Alternative scenario 'Material input tax (MIT) scenario'	**Assumptions**	
	Institutions	- Material input (incl. ecological rucksack, excl. water and fossil fuels) tax introduced from 2011 (1 EUR / t), linearly increasing to 10 EUR / t) in 2020. - Revenues from the MIT are compensated by a reduction in income tax.
	Description	**Summary of what happens in the alternative scenario**

		- The material input tax (MIT) applies to the new material input (extracted in Europe or imported) in tonnes at each production stage (products and resources from previous production stages are not taxed twice). - Economic growth is 0.1-0.2% lower than in the baseline.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	Total TMR is reduced by 5.5% compared to the baseline, by 10% if looking at minerals only.
Alternative scenario 'Combination of Aachener and MIT scenarios'	**Assumptions**	
	Production patterns	Investments in consulting, engineering (1/3) and equipment (2/3) necessary to decrease material and energy in the manufacturing, construction and public sectors.
	Institutions	- Societal consensus to separate material/energy productivity gains from labour productivity gains. - Material input (incl. ecological rucksack, excl. water and fossil fuels) tax introduced from 2011 (1 EUR / t), linearly increasing to 10 EUR / t) in 2020. - Revenues from the MIT are compensated by a reduction in income tax.
	Description	**Summary of what happens in the alternative scenario**
		Combination and consolidation of both previous scenarios: - Revenues from the MIT are lower due to overall lower resource use. - Employment increases, GDP also (+12% in 2020). - The price level decreases (-6%) which increases available income.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	- Resource productivity largely improves compared to the baseline. - Total resource use decreases by 20% in 2020, i.e. an absolute decoupling from the positive economic growth.

Material Efficiency and Resource Conservation (MaRess)

Quantitative and qualitative Effects of a forced Resource Efficiency Strategy[2]

GWS and WI (2010)

KEY ASSESSMENT

Study	Simulation runs resulting in different forecasts: # 1 reference scenario (or baseline) with reference assumptions regarding world economic development and climate targets in Germany. # 3 alternative scenarios characterized each by the implementation of policy instruments of a given type (i.e. economic instruments, information and consultation instruments, and regulation by technical standards). # 1 alternative scenario combining the three types of instruments.
Visions and targets	- The study did not foresee visions or targets for resource use but rather addressed the following questions: # What are the economic effects of a forced policy to raise resource efficiency? # Which interrelations have to be considered in the macroeconomic context concerning the impacts of different policy instruments? # Is a decoupling of economic growth and resource consumption possible in the long run? - A target is set for the German climate policy in all scenarios: -80% CO_2 emissions in 2050 compared to 1990 levels.
Policies	The following policy instruments and their effects on material use are modelled: - Economic instruments: i) change of rates in value added taxes for transport services and ii) introduction of a resource tax for building materials. - Information and consultation instruments: promotion of best practice technology for material use in the manufacturing sector. - Regulation by technical standards: rules imposing a certain share of secondary materials in the production of non-ferrous metals (in two variants: one where substitution of secondary for primary materials comes at a cost, and one where substitution causes no additional cost thanks to learning effects).
Resource efficiency	- Resource productivity is measured as GDP/TMR. - TMC is calculated
Cross-cutting issues	- Scenario on modified VAT for transport services: shows that energy use decreases

[2] Sources: Distelkamp, M., Meyer, B. and Meyer, M., 2010. Quantitative and qualitative effects of a forced resource efficiency strategy. Resource Efficiency Paper 5.4, Wuppertal. http://ressourcen.wupperinst.org/downloads/MaRess_AP5_3_Zusammenfassg.pdf
Distelkamp, M., Meyer, B. and Meyer, M., 2010. Quantitative und qualitative Analyse der ökonomischen Effekte einer forcierten Ressourceneffizienzstrategie. Ressourceneffizienz Paper 5.6, Wuppertal. http://ressourcen.wupperinst.org/downloads/MaRess_AP5_6_AbschlussBer.pdf

	but not material use (due to fossil fuel use in power generation for rail transport). - Scenario on information and consulting program shows 'Rebound effect'.
Burden shifting	- TMR includes the indirect material flows (incl. unused extraction) of imports; therefore issues of burden shifting between Germany and the rest of the world are covered for material use.

DETAILED REVIEW

Type of study	Forecasting study, no backcasting. The study looks at selected policy instruments for resource efficiency from three groups of instruments. It does not aim at completeness. It has the character of a sensitivity study, i.e. modelling the effects of possible elements of a complete resource policy proposal.	
Scenarios	Baseline scenario	No particular resource policy is implemented
	Alternative scenarios	- Scenario 1: selected economic instruments are implemented. - Scenario 2: an information and consulting program is conducted. - Scenario 3: regulatory standards are introduced. - Scenario 4: the selected instruments from the three types of instruments are implemented together.
Modelling	Physical models	A "material module" is added to the economic environmental model PANTA RHEI. The database for the material module is a data set of the Wuppertal Institute that links the different categories of material consumption with the economy in deep sectoral disaggregation.
	Economic models	PANTA RHEI (developed by GWS mbH): sectorally deep disaggregated economic environmental model that depicts the relations between economic development, resource consumption and emissions. The "economic core model" of PANTA RHEI consists of the macroeconometric input-output model INFORGE (also developed by GWS mbH).
Geographical scope	Germany	Domestic used and unused extraction, as well as direct and indirect material use and unused extraction associated with imports are covered.
Temporal scope	Horizon 2030	Modelling results for every year for the period 1995–2030.
Economic scope	59 sectors in Germany + world market	Macroeconomic variables are built bottom-up from the aggregation of the detailed modelling results at the sectoral level.
Resources covered	**Materials**	Total material requirement (TMR) is calculated, which includes metals, construction minerals, industrial minerals, fossil fuels and biomass. TMR consists of domestic extraction (used and unused) and direct and indirect flows (used and unused) associated with imports.
	biotic	- Domestic extraction: biomass from agriculture, forestry and fishery. - Imports: products of agriculture, forestry and fishery, other products (food, tobacco, wood, paper etc).
	abiotic	# Metals: - domestic extraction: iron ores - imports: ores, semi-finished and finished metal products (iron and non-iron metals) # Non-metallic minerals: - domestic: stones, sand, clay, chemicals and mineral fertilizers, salt

		- imports: processed stones, ceramic, glass, non-metallic mineral processing # Fossil fuels: - domestic: hard coal, lignite, peat, oil and natural gas - imports: coal and peat, oil and gas, coking products, mineral oil products # Other products
Environmental impacts considered	Climate change	CO2 emissions
	Resource depletion, water	No impact category but environmental pressure from total primary material requirement (TMR)
Influencing factors identified	Economic development	Development of the world economy
	Production patterns	Resource efficiency in the manufacturing sector
	Institutions	Instruments of environmental policy, in particular German policies for climate protection
Baseline scenario	**Assumptions**	There are actually three variants of the baseline scenario: - Variant I: moderate climate policy + strong world economic growth - Variant II: moderate climate policy + moderate world economic growth - Variant III: engaged climate policy + moderate world economic growth Variant III, described below, was chosen as reference against which to compare the alternative scenario.
	Economic development	- Moderate long run growth for the world economy which induces an avg. growth rate for German exports of about 3.2%/a.
	Institutions	- Existing policy instruments to foster renewable energies and energy productivity in firms and households are further developed so as to reach the following climate target: -80% CO2 emissions in 2050 compared to 1990 (corresponds to -54% in 2030).
	Description	**Summary of what happens in the baseline scenario**
		World economy between 2009 and 2030: oil price (+50%) and that of other raw materials increase (metals +50%, food + 30%). Demand for German exports increase by around 4.1% / year. For Germany, GDP increases in average at 1%/a (so no negative effect of the strong climate policies), and CO_2 emissions decrease by 54% compared to 1990 level and by 39% compared to 2008.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	TMR decreases by 11.5% between 2008 and 2030. It should be noted that Variants I and II of the baseline scenario see TMR increase: +18.5% and +2.8%, respectively.
	Energy	Strong reduction of end energy use (-19.5% between 2008 and 2030)
Alternative scenario: Economic instruments	**Assumptions**	
	Environmental policy instruments	- Economic instrument: # Value added tax rate for rail road transportation is lowered from 19% to 7%. # Value added tax rate for air transport services is raised from 7% to 19%. # A tax of 2 Euro per ton of extracted or imported building material is introduced in 2012 and increases by 5%/a (reaching 4.8 EUR/t in 2030).

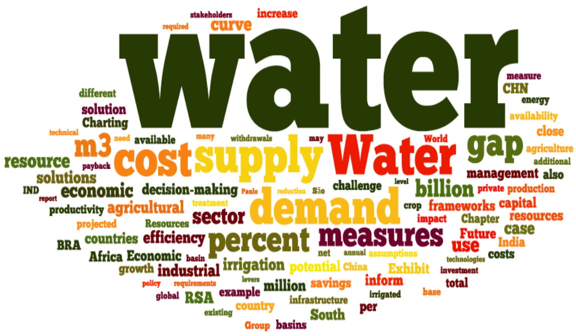
	Description	**Summary of what happens in the alternative scenario**
		- Income tax is lowered so that total tax revenue is unchanged compared to the baseline scenario. - GDP and employment slightly decrease (-0.06% and 0.01%) and disposable income slightly oncrese (+0.07%) compared to the baseline.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	- Changed value added for transport services reduces oil use but also increases electricity use and hence coal and gas use. - Tax on building materials reduces use of non-metallic minerals by 15.6% and total domestic extraction by 9.7%. TMR is reduced by 1.5%.
	Energy	- Changed value added tax for transport services reduces energy use (-0.3%) but not material use.
Alternative scenario: Information instruments	**Assumptions**	
	Environmental policy instruments	- All manufacturing firms participate in an information and consulting program: # Each year, 5% of all manufacturing firms introduce best practice technology for material use (as a result of information provided by consultants etc). # One time additional costs (1/3 consulting costs, 2/3 investments in equipment) arise for the manufacturing firms adopting best practice technology, which equal to one year of savings through material efficient production.
	Description	**Summary of what happens in the alternative scenario**
		- Material-efficient manufacturing firms reduce their production costs. - Producers of raw materials lose sales and production. - Lower imports of resources. - Value added rises in material-efficient firms (they do not reduce their price to the extent they have reduced their production costs). - Income and consumption rise. - International competitiveness improves: rising exports, falling imports. - Real GDP rises by 14.2% compared to baseline and employment by 1.9%, public debt is 10.2% lower than in the baseline.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	- TMR falls by 9.2% compared to baseline (resource productivity rises faster than GDP)
	Energy	- Energy productivity rises by 13.8% (indirect effect of material productivity)
Alternative scenario: Regulation instruments	**Assumptions**	
	Environmental policy instruments	- Regulation instruments: # A certain share of non-ferrous metals contained in all final products (incl. imports) has to come from recycled metals. # The share of secondary metals rises from today's level linearly until 2030 and is multiplied by 3 in 2030 compared to today's level. # Variant 1: substitution comes at a cost (econometrically estimated elasticity of substitution of non-ferrous metals by secondary products is about -0.4). # Variant 2: thanks to learning and rising prices for primary materials,

		substitution comes at no additional cost (elasticity -1).
	Description	**Summary of what happens in the alternative scenario**
		- In both variants economic effects on GDP and employment are positive (domestic value added replaces expenditures for imported resources). - GDP is 0.04% higher than the baseline and employment 0.03%, public is 0.1% lower.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	Biotic and abiotic	- TMR is 8.9% lower than in the baseline. - TMR metals is reduced by 23.5% for a good part due to the avoided indirect rucksack of non-ferrous metals contained in imported goods.
Alternative scenario: Three types of instruments combined	**Assumptions**	
	Environmental policy instruments	- Economic instrument: # Value added tax rate for rail road transportation is lowered from 19% to 7%. # Value added tax rate for air transport services is raised from 7% to 19%. # A tax of 2 Euro per ton of extracted or imported building material is introduced in 2012 and increases by 5%/a (reaching 4.8 EUR/t in 2030). - All manufacturing firms participate in an information and consulting program: # Each year, 5% of all manufacturing firms introduce best practice technology for material use (as a result of information provided by consultants etc). # One time additional costs (1/3 consulting costs, 2/3 investments in equipment) arise for the manufacturing firms adopting best practice technology, which equal to one year of savings through material efficient production. - Regulation instruments: # A certain share of non-ferrous metals contained in all final products (incl. imports) has to come from recycled metals. # The share of secondary metals rises from today’s level linearly until 2030 and is multiplied by 3 in 2030 compared to today’s level. # Variant 1: substitution comes at a cost (econometrically estimated elasticity of substitution of non-ferrous metals by secondary products is about -0.4). # Variant 2: thanks to learning and rising prices for primary materials, substitution comes at no additional cost (elasticity -1).
	Description	**Summary of what happens in the alternative scenario**
		- Compared to the baseline scenario: # +14% for GDP in constant prices, +1.9% for employment, -11% for public debt. # Resource productivity doubles between 2010 and 2030. # The positive economic effect and half the TMR reduction is due to the effects of information instruments.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic and abiotic	TMR sinks by 20% compared to the baseline scenario
	energy	CO_2 emissions remain at the low level of the baseline scenario despite the strong rebound effect.

Charting Our Water Future

Economic frameworks to inform decision-making[3]

2030 Water Resources Group (2009)



KEY ASSESSMENT

Study	Focus on how, by 2030, competing demands for scarce water resources can be met and sustained; no back-casting but comparing today's status quo with future developments in order to design an optimal mix of measures to close the water gap.
Visions and targets	Integrated economic approach to water resource management; technical improvements, increasing supply and improving water productivity under a constant set of economic activities, actively reducing withdrawals by changing the set of underlying economic activities.
Policies	Assessment whether the cost curve can reflect either the difficulty of implementing a technical solution which along with other secondary impacts will inform their policy choices; construct scenarios to assess the impact of policy decisions on water demand; quantify the economics of adoption for end-users.
Resource efficiency	Emerging economies can mitigate rapid growth in water demand in a cost-effective way by instituting aggressive, water-conscious, "new build" programs and enacting water-saving regulatory reforms.
Cross-cutting issues	Food provision, trade
Burden shifting	In some cases, rather than simply deploying technical measures to close a water gap whose size has been predetermined by an existing economic development path, a country could decide to steer its economic activities toward less water-intensive ones, e.g. make a conscious policy choice of relying more heavily on agricultural imports in order to reduce withdrawals, thus effectively substituting the use of domestic water with water from elsewhere.

DETAILED REVIEW

Type of study		
Scenarios	Baseline scenario	Country-level estimates of the gap between the amount of water that can currently be provided, and the water requirements projected into the future under a static policy regime.
	Alternative scenarios	Three types of interventions are investigated: - measures to increase water supply

[3] Source: 2030 Water Resources Group, 2009. Charting Our Water Future - Economic frameworks to inform decision-making.
http://www.mckinsey.com/App_Media/Reports/Water/Charting_Our_Water_Future_Full_Report_001.pdf

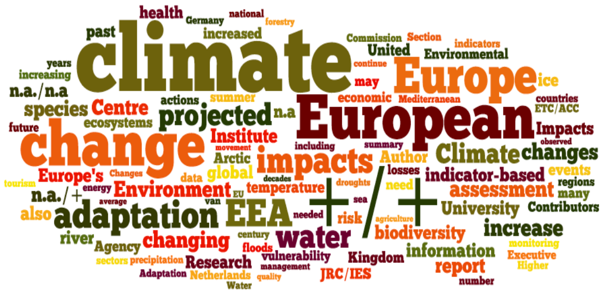
		- measures to improve water productivity - measures to change individual water-using economic activities
Modelling	Physical models	A global water supply and demand model covering 154 basin and countries National water supply and demand models for scenario analyses in the case study countries
	Economic models	A cost-curve of incremental water availability to assess the potential and costs of a set of measures A payback curve to evaluate the returns that any given measure would generate against the capital needed to fund it
Geographical scope	World	Detailed at the country level, including case studies with focus on regions particularly at risk, such as India, China, Sub-Saharan Africa, Brazil etc.
Temporal scope	Horizon 2030	
Economic scope	Demand projections made for four broad sectors: agriculture, industry, municipal and domestic demand.	
Resources covered	**Water**	Water resource availability for consumptive uses at the river basin level
Environmental impacts considered	Resource depletion, water	Gap between water demand and supply
Influencing factors identified	Economic development	Economic growth
	Production patterns	Agricultural production, industrial production, electricity production
	Consumption patterns	Municipal and domestic water consumption
	Demography	Population growth
	Natural systems	Hydrology of the areas investigated, Climate change
	Institutions	Policy interventions
Baseline scenario	**Assumptions**	Business-as-usual assumptions for population and economic growth which drive, under existing policy regime, increased agricultural and industrial production, and a wealth effect that entails greater water use by rising middle classes in emerging economies, whether for urban uses or for peri-urban agriculture.
	Description	**Summary of what happens in the baseline scenario**
		Projection of what a country's or basin's water resource requirements would be if they were unconstrained and, under existing policy regimes, continued into the future at existing levels of productivity and efficiency. Comparison of this projection to the supply of reliable, accessible water available today. Projected future water demand and currently available supply, thus defined, will not match: a gap, or deficit, will arise from future demand exceeding today's supply. Assuming current levels of water efficiency, unconstrained global water demand will grow at around 2% a year
	Outcomes	**Main results of baseline scenario from a resource perspective**

	Water	Water demand in 2030 will be close to double what it was in 2005—and 40% greater than the existing sustainable, reliable water supply.
Alternative scenario: increase supply and improve water efficiency	**Assumptions**	
	Production patterns	- Mix of measures to increase accessible, reliable, environmentally sustainable supply - Mix of measure to improve water productivity: agricultural productivity (irrigation and crop yields on both rain-fed and irrigated lands) and industrial efficiency measures
	Consumption patterns	Mix of measures to improve water productivity: domestic and municipal efficiency measures
	Institutions	No explicit policy decisions influence the economic activities within the respective countries
	Description	**Summary of what happens in the alternative scenario**
		The optimal solutions identified will close 100% of the gap identified, at an annual capital cost (across all the case study countries: India, China, South Africa and Brazil – Sao Paulo) of some $19 billion in 2030.19 When scaled to total global water demand, this implies a capital requirement of approximately $50 billion per annum for integrated supply and productivity solutions to close the projected water gap—just one-quarter of the roughly $200 billion per year that would be required for solutions built solely on an expansion of water supply.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Water	The gap between demand and supply is closed with an optimal mix of technical solutions.
Alternative scenario: reductions in the water-using activities	**Assumptions**	
	Institutions	Different economic development choices are decided by decision-makers and stakeholders. For example: - A shift towards renewable energy could dramatically change the need for water withdrawals from the power sector. - A rural development policy based on increased access to fertilizers and subsidies may be contrasted with a shift towards high-value agricultural products with low-water intensity, or greater reliance on agricultural imports.
	Description	**Summary of what happens in the alternative scenario**
		Based on case studies, the demand-side approach taken in this set of alternative scenarios makes the case for intense stakeholder and decision-maker dialogue, using scenario tools and mixing demand-side decisions with technical solutions on the supply side.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Water	With such demand-side measures the base-gap is not “closed” but (at least in part) “avoided”.

Impact of Europe's changing climate

Chapters 5.4-5.6[4]

EEA, JRC and WHO (2008)



KEY ASSESSMENT

Study	Chapters 5.4 to 5.6 of this study summarise the main findings during the past years regarding relevance, past trends, and projections with respect to the following topics related to water: 1. Marine biodiversity and ecosystems 2. Water quantity, river floods and droughts 3. Freshwater quality and biodiversity Basically, no own data is used, but rather the results of different studies tackling these topics are gathered and analysed.
Visions and targets	No visions or targets are developed. Rather, a projection for future developments is made, in some cases in quantitative in others in qualitative terms.
Policies	No policy has been analysed.
Resource efficiency	The study suggests increased water use efficiency as one necessary adaptation procedures, in the face of the rather uncertain changes related to climate change – specifically mentioning it in the context of increased occurrence of floods and droughts in Europe.
Cross-cutting issues	Land use as well as demographic and socio–economic changes are mentioned as connected issues, without going into further detail.
Burden shifting	

DETAILED REVIEW

Type of study	The study is a review of the main findings during the past years regarding relevance, past trends, and projections with respect to the topics of marine biodiversity and ecosystems, water quantity, river floods and droughts, as well as freshwater quality and biodiversity.
Scenarios	No specific scenarios have been identified
Modelling	For the analysis of past trends different physical models have been used. The study thereby uses results of earlier, more specific, studies. I.e., changes in annual river flow were modelled based on an ensemble of 12 climate models and validated against observed river flows (Milly et al., 2005). Projections of river flows and floods are taken from a study by Dankers and Feyen (2008) who

[4] Source: EEA-JRC-WHO 2008. Impacts of Europe's changing climate - 2008 indicator-based assessment, Chapter 5 Sections 5 - Water quantity, river floods and droughts, 6 - Freshwater quality and biodiversity. EEA Report No 4/2008, JRC Reference Report No JRC47756. http://www.eea.europa.eu/publications/eea_report_2008_4/pp76-110CC2008_ch5-4to6_Water_quantity_and_quality.pdf

	used the LISFLOOD model - a GIS-based hydrological rainfall-runoff-routing model - for their calculations.
Geographical scope	EU-25
Temporal scope	Horizon 2071-2100 for the Model by Dankers and Feyen (2008)
Economic scope	The impact on fisheries is considered, as changes in sea and river temperatures and levels change the geographic distribution of some commercially-relevant species. The adverse effects of changes in river flow and water availability on sectors such as water supply, energy production, agriculture and tourism are also mentioned. However, no economic projections are presented.
Resources covered	**Water** Marine biodiversity and ecosystems - Sea level rise - Sea surface temperature - Marine phenology - Northward movement of marine species Water quantity, river floods and droughts - River flow - River floods - River flow droughts Freshwater quality and biodiversity - Water temperature - Lake and river ice cover - Freshwater biodiversity and water quality
Environmental impacts considered	Climate change / water depletion: The whole report tackles the topic in how far climate change affects different environmental aspects in Europe.
Influencing factors identified	Climate change

Global Water Outlook to 2025

Averting an impending crisis[5]

IFPRI and IWMI (2002)

KEY ASSESSMENT

Study	Based on data on water prices, water use efficiency, population growth, growth in live-stock production etc., with the help of the partial equilibrium model IMPACT-WATER, projections for demand for and the availability of water for the year 2025 are made.
Visions and targets	
Policies	- Invest in infrastructure to increase supply - Conserve water and improve efficiency through reforms in water management and policy - Improve crop productivity through integrated water management and agricultural research
Resource efficiency	Water use efficiency is incorporated in the projection of future water demand
Cross-cutting issues	Agriculture
Burden shifting	The sustainability scenario foresees increased equity in the world through more efficient and better managed water use.

DETAILED REVIEW

Type of study		
Scenarios	Business as usual scenario	Current trends in water and food policy, management and investment remain the same. Governments and water users implement institutional and management reforms in a limited and piecemeal fashion. These conditions leave the world ill prepared to meet major challenges to the water and food sectors.
	Water crisis scenario	A moderate worsening of many of the current trends in water and food policy and in investment could build to a genuine water crisis. Government budget problems worsen. Goverments further cut their spending on irrigation systems.
	Sustainable water scenario	Dramatic increase in amount of water allocated to environmental uses; connection of all urban households to piped water; achievement of higher per capita domestic water consumption while maintaining food production at the levels described in the business as usual scenario; achievement of greater

[5] Source: Mark W. Rosegrant, Ximing Cai, and Sarah A.Cline, 2002. Global Water Outlook to 2025 - Averting an Impending Crisis. Washington,D.C., U.S.A.: International Food Policy Research Institute. Colombo, Sri Lanka: International Water Management Institute.
http://www.greencrossitalia.it/ita/acqua/risorse_acqua/pdf/rapporto%20IWMI%202025.pdf
http://www.ifpri.org/sites/default/files/publications/water2025.pdf

		social equity and environmental protection through careful reform in water sector and sound government action.
Modelling	Partial equilibrium model	IMPACT: International Model for Policy Analysis of Agricultural Commodities and Trade; representing competitive agricultural market for crops and live-stock; demand is function of prices, income, population growth
		WSM: basin-scale model of water resource use Integration => IMPACT-WATER: (1) incorporating water in crop area and yield function; (2) determining water availability, water demand and crop production
Geographical scope	World	Divided into 69 spatial units
Temporal scope	Horizon 2025	Domestic and industrial water demand is function of population, income, and water prices Agricultural water demand is function of irrigation and live-stock production growth, water prices, climate, water use efficiency
Economic scope	Agriculture	The scenarios identify developments in water availability and water use efficiency in the agricultural sector (food and live-stock production)
	Industry	The scenarios identify developments in water use efficiency in the industrial sector.
	Domestic	The scenarios identify developments in water availability and water use efficiency in the domestic sector.
Resources covered	**Water**	Water quantities regarding availability and use efficiency
	Food	Food production in relation to water quantity; harvested areas
Environmental impacts considered	Resource depletion, water	The different scenarios identify scarcity problems and mitigation measures.
Influencing factors identified	Population	Influencing parameter of domestic and industrial water demand
	Income	Influencing parameter of domestic and industrial water demand
	Water prices	Influencing parameter of agricultural, domestic and industrial water demand
	Irrigation and live-stock production growth	Influencing parameter of agricultural water demand
	Climate	Influencing parameter of agricultural water demand
	Water use efficiency	Influencing parameter of agricultural water demand
	Government spending in irrigation / water rights	The different scenarios draw different pictures concerning water rights and responsibilities for operation and management of irrigation systems to communities and water user associations.
	Water management practices	…as a crucial issue, being strongly influenced by governmental/institutional intervention (see water rights above); at the same time influencing water use efficiency, application of new technologies, and environmental protection.
	Urban sprawl	…as important factor regarding domestic water consumption.
Business as usual scenario	**Assumptions**	Current trends in water and food policy, management and investment remain the same. Governments and water users implement institutional and

		management reforms in a limited and piecemeal fashion. These conditions leave the world ill prepared to meet major challenges tot he water and food sectors.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Water	All users place heavy demands on the water system; water withdrawals 1995-2025 increase by 22%, in developing countries +27%, in developed +11%; global water consumption +62%; intensification of water scarcity for irrigation worldwide.
	Food	Slower growth of food production and change in location of food production; slowdown in cereal yield growth in developing countries; crop-harvested area grows slowly; prices for food commodities decline.
Water crisis scenario	**Assumptions**	A moderate worsening of many oft he current trends in water and food policy and in investment could build to a genuine water crisis. Government budget problems worsen. Governments further cut their spending on irrigation systems.
	Outcomes	**Main results of alternative scenario from a resource perspective**
	Water	The developing world pays the highest price in this scenario. Global water consumption increases by 13%; largest consumer: irrigation, due to low efficiency; lower per capita domestic water consumption => less access to water; due to failed technology improvements increasing water demand in industrial sector; remarkably lower environmental water flows.
	Food	10% less food production than under business as usual; decreasing yields at irrigated and rain-fed fields; food prices increase between 40% and 120%; growing food insecurity.
Sustainable water scenario	**Assumptions**	Dramatic increase in amount of water allocated to environmental uses; connection of all urban households to piped water; achievement of higher per capita domestic water consumption while maintaining food production at the levels described in the business as usual scenario; achievement of greater social equity and environmental protection through careful reform in water sector and sound government action.
	Outcomes	**Main results of alternative scenario from a resource perspective**
	Water	Lower water consumption, but greater benefits than under business as usual – 20% less; more water for environmental uses; high water prices and high water efficiency reduce water demand in the irrigation sector; improved domestic water supply; reduced industrial demand due to economic incentives and increased efficiency; transfer of 22% of the global withdrawal under business as usual to environmental uses.
	Food	Increased food production; less harvested area due to less water demand for irrigation; less reliable supply with irrigation water => slightly less yield; declining food prices.

GEO 4

Environment for development[6]

UNEP (2007)

KEY ASSESSMENT

Study	Exploratory scenarios using consistent narrative storylines and modelling quantifications of impacts on the environment and human well-being
Visions and targets	The following targets—developed elsewhere—are considered: - Target to significantly reduce the current rate of biodiversity loss at the global, regional and national levels decided at the 2010 Convention on Biological Diversity - 2015 internationally agreed targets of the Millennium Declaration, such as those on water and sanitation. - Long-term goal to stabilize the levels of greenhouse gas concentrations in the atmosphere.
Policies	The scenarios are shaped by different assumptions on what characterises policy-making and societal choices: - Who is making the key decisions (the dominant actors); - How these decisions are made (the dominant approaches to governance); - Why these decisions are made (the dominant priorities).
Resource efficiency	More or less material-intensive orientation of society and its impact on all resource and impact categories, especially energy and water.
Cross-cutting issues	One message out of the scenario work is that there is a need to address interlinkages among numerous environmental issues, such as air and water pollution, land degradation, climate change, and biodiversity loss.
Burden shifting	The scenarios take into account that what happens in each region is very much influenced by what occurs in other regions and the world as a whole (incl. from an environmental point of view).

DETAILED REVIEW

Type of study	Exploratory study taking for different paths (scenarios) exhaustively described in narratives whose key parameters are consistently quantified with modelling.	
Scenarios	Baseline scenario	No baseline scenario explicitly presented.
	Alternative scenarios	- Market first - Policy first - Security first - Sustainability first

6 Source: United Nations Environment Programme, 2007. Global Environment Outlook 4. Nairobi, Kenya: UNEP. http://www.unep.org/geo/geo4/report/GEO-4_Report_Full_en.pdf

Modelling	A suite of advanced global and regional models, with output from one model being used as inputs to other models, all of the models are calibrated to historical data up to a common base year (2000 for most data). - International Futures: provided population trends and the development in GDP and GDP per capita as well as additional information on value added, household consumption, health and education. - IMAGE (Integrated Model to Assess the Global Environment): provided estimates of energy use, land use, greenhouse gas emissions, and changes in temperature and precipitation. - IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade): generated projections for crop area, livestock numbers, yield, production, demand for food, feed and other uses, prices, trade and childhood malnutrition. - WaterGAP (Water – Global Assessment and Prognosis): provided estimates of water use (for irrigation and in the domestic, manufacturing, and electricity production sectors), water availability, and water stress. - EwE (Ecopath with Ecosim): provided estimates of catch, profits, and quality of marine fisheries. - GLOBIO: provided estimates of changes in mean species abundance for terrestrial ecosystems. - LandSHIFT: provided detailed estimates of land use change for Africa. - CLUE-S (Conversion of Land Use and its Effects): provided detailed estimates of land use change for Western and Central Europe. - AIM (the Asia Pacific Integrated Model): provided additional estimates of environmental change used in the development of the narratives for Asia and the Pacific.	
Geographical scope	Global	With a regional differentiation (seven regions), apparent in the narratives and modelling exercise.
Temporal scope	Horizon 2050	
Economic scope	Results are not systematically detailed sector-wise, global trade development is analysed.	
Resources covered	**Materials**	
	Biotic	Food (highlight on cereals)
	abiotic	Fossil fuels through energy
	Water	
	quality	Water use (water stress)
	quantity	Wastewater treatment
	Land	
	land use	Land for agriculture, biofuels and forests
	land cover	Land degradation (incl. erosion risk)
	Other	
	Biodiversity	Terrestrial and marine biodiversity
Environmental impacts considered	Climate change	GHG emissions, atmospheric CO_2 concentration, sea level rise.
	Acidification	SOx emissions
	Resource depletion, water	Biodiversity loss (decline in mean original species abundance (MSA))
Influencing factors identified	Economic development	Economic demand, markets and trade

	Demography	Demographics
	Institutions	Institutional and socio-political frameworks
	Other	- Scientific and technological innovation - Value systems
Baseline scenario	**No baseline scenario explicitly developed.**	
Alternative scenario: Markets first	**Assumptions**	
	Economic development	GDP grows fivefold until 2050. GDP/cap more than triples. Significant growth of global trade (highest of 4 scenarios).
	Demography	World population reaches 9.2 bn in 2050.
	Institutions	Low mainstreaming of social and environmental policies, e.g. little or no specific climate policy, reactive policies with respect to local air pollutants.
	Other	# Scientific and technological innovation: - focus on economic efficiency for energy technologies; - access and availability of new technologies: What you can pay for, primarily through trade. # Value systems: - relative rank of conflicting priorities in fisheries: profits; - key priorities with regard to protected areas: “Sustainable use”, emphasizing tourism development and some genetic resource protection; - resource demands shift, independent of changing prices and income: follow traditional patterns.
	Description	**Summary of what happens in the Markets First scenario**
		The private sector, with active government support, pursues maximum economic growth as the best path to improve the environment and human well-being. Lip service is paid to the ideals of the Brundtland Commission, Agenda 21 and other major policy decisions on sustainable development. There is a narrow focus on the sustainability of markets rather than on the broader human-environment system. Technological fixes to environmental challenges are emphasized at the expense of other policy interventions and some tried-and-tested solutions.
	Outcomes	**Main results of alternative scenario from a resource perspective**
	Materials	
	biotic	The increasing demands for food, along with greater investments in technology, result in the largest increases in cereal yields and overall food availability.
	abiotic	Rapid growth of oil and natural gas use worldwide.
	Water	
	quality	The total worldwide volume of untreated wastewater from the domestic and manufacturing sectors doubles between 2000 and 2050.
	quantity	- Better material standard of living implies a rapid growth in water use in all socio-economic sectors, resulting in a large increase in withdrawals from surface and groundwaters. - From around 2.5 billion people in 2000 to nearly 4.3 billion people in

		2050 living in river basins with severe water stress.
	Land	The growth in demand for land is partially compensated by technological developments. Small increases in forest area in North America and Europe.
	Other	
	Energy	From 200 EJ in 2000 to over 1000 EJ in 2050 (highest growth) due to rapid income growth and more material-intensive lifestyles.
	Biodiversity	- Terrestrial: highest losses (over -12 measured in MSA changes) with accelerating rate of loss. - Marine: decline due to increased pressure on marine fisheries to meet food demand.
Alternative scenario: Policy first	**Assumptions**	
	Economic development	GDP grows fivefold until 2050. GDP/cap increases 3.5 (highest of 4 scenarios). Significant growth of global trade.
	Demography	World population reaches 8.6 bn in 2050.
	Institutions	High mainstreaming of social and environmental policies, e.g. aims at stabilization of CO2-equivalent concentration at 650 ppmv, proactive policies on local air pollutant.
	Other	# Scientific and technological innovation: - Focus on general efficiency and environmental impact for energy technologies; - access and availability of new technologies: Promotion of technology transfer and diffusion. # Value systems: - relative rank of conflicting priorities in fisheries: Balance between profits, total catch and jobs; - key priorities with regard to protected areas: Species conservation and ecosystem services; Maintenance, then sustainable use, including benefit sharing; - resource demands shift, independent of changing prices and income: Follow traditional patterns for most resources, but some relative reduction in water use.
	Description	**Summary of what happens in the Policy First scenario**
		Government, with active private and civil sector support, initiates and implements strong policies to improve the environment and human well-being, while still emphasizing economic development. Policy First introduces some measures aimed at promoting sustainable development, but the tensions between environment and economic policies are biased towards social and economic considerations. Still, it brings the idealism of the Brundtland Commission to overhauling the environmental policy process at different levels, including efforts to implement the recommendations and agreements of the Rio Earth Summit, the World Summit on Sustainable Development (WSSD), and the Millennium Summit. The emphasis is on more top-down approaches, due in part to desires to make rapid progress on key targets.
	Outcomes	**Main results of alternative scenario from a resource perspective**
	Materials	

	biotic	The increasing demands for food, along with greater investments in technology, result in the largest increases in cereal yields and overall food availability.
	abiotic	Moderate climate policies reduce growth of oil demand, bring down coal use, and stimulate the use of bioenergy and zero-carbon options, such as wind, solar and nuclear power.
	Water	
	quality	The level of wastewater treatment increases from around 50 to about 80 per cent between 2000 and 2050, but because of growing population, the total volume of untreated wastewater still increases by about 25 per cent during this time.
	quantity	- A change in water-use behaviour in households and industries, together with rapid improvements in the efficiency of water use in all sectors, leads to a decrease in water withdrawals in many industrialized countries, and a slower growth elsewhere. - From around 2.5 billion people in 2000 to nearly 3.9 billion people in 2050 living in river basins with severe water stress.
	Land	Total agricultural area is highest, due food availability concerns and higher population levels. Strong targets for the mitigation of GHGs add demand on land for the production of biofuel crops. Latin America and the Caribbean, and Africa see significant declines in forest land, most notably in Africa where nearly all forests are lost.
	Other	
	Energy	Increases from about 400 EJ in 2000 to 600–700 EJ in 2030 and around 800–900 EJ in 2050, mainly due to income growth.
	Biodiversity	- Terrestrial: losses at -7 in MSA changes in 2050 with rate of loss stabilized. - Marine: decline due to increased pressure on marine fisheries to meet food demand.
Alternative scenario: Security first	**Assumptions**	
	Economic development	GDP grows threefold until 2050. GDP/cap less than doubles (lowest of 4 scenarios). Somewhat significant growth of global trade (lowest of 4 scenarios).
	Demography	World populations grows up to 9.7 bn people in 2050 (highest of 4 scenarios) and keeps growing.
	Institutions	Lowest mainstreaming of social and environmental policies, e.g. little or no specific climate policy, reactive policies with respect to local air pollutants.
	Other	# Scientific and technological innovation: - Emphasis on security of supply for energy technologies; - access and availability of new technologies: closely guarded. # Value systems: - relative rank of conflicting priorities in fisheries: total catch; - key priorities with regard to protected areas: Tourism development, and some genetic resource protection; - resource demands shift, independent of changing prices and income: Follow traditional patterns.

	Description	**Summary of what happens in the Security First scenario**
		Government and private sector compete for control in efforts to improve, or at least maintain, human well-being for mainly the rich and powerful in society. Security First, which could also be described as Me First, has as its focus a minority: rich, national and regional. It emphasizes sustainable development only in the context of maximizing access to and use of the environment by the powerful. Contrary to the Brundtland doctrine of interconnected crises, responses under Security First reinforce the silos of management, and the UN role is viewed with suspicion, particularly by some rich and powerful segments of society.
	Outcomes	**Main results of alternative scenario from a resource perspective**
	Materials	
	biotic	Lowest cereal yield increase reflecting slower developments in technology and poorer land management practices.
	abiotic	Growth of oil and natural gas is reduced due to remaining tensions in international energy markets. This is replaced by an increase in coal use.
	Water	
	quality	The volume of untreated wastewater increases by more than a factor of three between 2000 and 2050.
	quantity	- A growing population and neglect of water conservation tends to push water withdrawals upwards. Yet, slower economic growth tends to slow the increase. - From around 2.5 billion people in 2000 to over 5.1 billion people in 2050 living in river basins with severe water stress.
	Land	Agricultural land expansion is the smallest, since low economic growth keeps the increase of human demands for land within limits.
	Other	
	Energy	Increases from about 400 EJ in 2000 to 600–700 EJ in 2030 and around 800–900 EJ in 2050, mainly due to population growth.
	Biodiversity	- Terrestrial: losses over -10 in MSA changes with accelerating rate of loss. - Marine: decrease but lower than Markets or Policy due to lower average incomes as well as slower advances in technology that would allow for greater catches.
Alternative scenario: Sustainability first	**Assumptions**	
	Economic development	GDP grows fourfold until 2050. GDP/cap more than triples. Significant growth of global trade.
	Demography	World population at under 8 bn in 2050 (lowest of 4 scenarios) and flat trend.
	Institutions	Highest mainstreaming of social and environmental policies, e.g. aims at stabilization of CO2-equivalent concentration at 550 ppmv, proactive policies on local air pollutants.
	Other	# Scientific and technological innovation: - Focus on general efficiency, environmental impact for energy technologies; - access and availability of new technologies: Promotion of technology transfer and diffusion, and encouragement of open source technologies. # Value systems:

	- relative rank of conflicting priorities in fisheries: Focus on ecosystem restoration, but also emphasis on jobs and landings; - key priorities with regard to protected areas: Sustainable use, including benefit sharing, then ecosystem services maintenance and species conservation; - resource demands shift, independent of changing prices and income: Slower uptake of meat consumption, energy use, water use and other resource use with rising income.
Description	**Summary of what happens in the Sustainability First scenario**
	Government, civil society and the private sector work collaboratively to improve the environment and human well-being, with a strong emphasis on equity. Equal weight is given to environmental and socio-economic policies, and accountability, transparency and legitimacy are stressed across all actors. As in Policy First, it brings the idealism of the Brundtland Commission to overhauling the environmental policy process at different levels, including strong efforts to implement the recommendations and agreements of the Rio Earth Summit, WSSD, and the Millennium Summit. Emphasis is placed on developing effective public-private sector partnerships not only in the context of projects but also that of governance, ensuring that stakeholders across the spectrum of the environment-development discourse provide strategic input to policy making and implementation. There is an acknowledgement that these processes take time, and that their impacts are likely to be more long-term than short-term.
Outcomes	**Main results of alternative scenario from a resource perspective**
Materials	
biotic	Slightly lower growth in cereal yields and food availability, but this is counterbalanced by a lower overall population. See also land.
abiotic	As a result of stringent climate policy not only is coal use reduced, but so is oil use. Oil is partly replaced by a strong increase in bioenergy use. While natural gas use increases, its consumption in the power sector is, after 2020, mostly combined with carbon capture and storage.
Water	
quality	Treatment capacity manages to keep pace with the increasing amounts of wastewater, such that the total volume of untreated wastewater has changed very little since the turn of the century.
quantity	- Widespread adoption of integrated water management strategies, with strong emphasis on demand management and conservation. These developments, together with slower population growth rates, lead to slower increases in overall water use. - From around 2.5 billion people in 2000 to over 3.6 billion people in 2050 living in river basins with severe water stress.
Land	Demand for land grows because technological developments are counterbalanced by greater concern for food availability. Due to strong targets for the mitigation of GHGs, there is an added demand on land for the production of biofuel crops (effect in the changes in forest land). Latin America and the Caribbean, and Africa see significant declines in forest land.
Other	

	Energy	Increases from about 400 EJ in 2000 to 600EJ in 2050 (lowest growth), due to a less material-intensive orientation and considerably higher efficiency – partly induced by global climate policy – contributes to the lower energy use.
	Biodiversity	- Terrestrial: lowest losses (-6 measured in MSA changes) in 2050 with rate of loss stabilized. - Marine: decrease but less than other scenarios due to the smaller increases in population and shifting diets, is an attempt to fish lower on the food chain, reflecting the goal of maintaining marine ecosystems.

Scarcity and transition

Research questions for future policy[7]

Dutch Ministry of Foreign Affairs and Ministry of Housing, Spatial Planning and the Environment (2010)

KEY ASSESSMENT

Study	A (meta)survey of developing scarcities of food, water, energy, minerals and metals in the world, within the context of climate change, loss of biodiversity and changing geopolitical relations.
Visions and targets	# Visions: - producing enough food for 9 billion people in 2050, produced more sustainably, with less water consumption, despite a changing climate and declining biodiversity (incl. fertile soil); - efficiently generating and using low-carbon energy. # Linked to following targets / agreements: - Climate targets - UN Millenium Development Goals
Policies / Strategies	# Dutch government's medium to long-term prospects for international action: - global agreements within a functioning global governance (e.g. code of best practices for national resource policies); - forming alliances aimed at linking interests of state and non-state actors when the former point does not work because of protectionism, 'resource nationalism' etc. # How to speed up transitions: * In the food and water system: international cooperation for a transition towards sustainable food production and consumption. Single aspects of such a cooperation should address: - institutional and market factors (government interventions, lock-ins); - biobased economy and the effects of increasing use of biomass on food, water and energy systems; - development cooperation, knowledge export, agricultural education and extension; - water and biotechnology in relation to eco-efficient agriculture; - intellectual property rights versus breeders' rights; the open source approach; - consumption patterns and underlying lifestyles; - land use, competing claims on land and water, urbanisation, desertification and land degradation; - increased productivity versus climate and biodiversity.

[7] Source: Dutch Ministry of Foreign Affairs, 2010. Scarcity and transition – Research questions for future policy. http://www.minbuza.nl/dsresource?objectid=buzabeheer:197513&type=org

	* In the energy system: governments must create the right conditions for people and organisations to make the transition towards a radically changed energy system, incl. taking into account: - further needs for fossil fuels and linked dependencies - dependence on specific materials such as lithium - new emerging dependencies (e.g. solar from North Africa) - electricity infrastructure dimensioned for renewable energy sources.
Resource efficiency	"Resource scarcity": in the context of this survey, scarcity means not only an observed shortage of natural resources, but also a perceived dependency on natural resources and fear of their global depletion, i.e. when there are concerns about the future availability, accessibility, utility value and distribution of resources.
Cross-cutting issues (see also table below)	- The study focuses mainly on the interrelations between food, water and energy scarcities (e.g. energy and food, water and energy). - Case of phosphate: food supplies rely on phosphate fertilizers that come from few countries and have an impact on the environment when drained away; growing biofuel crop production drastically worsens the issue. - Energy (fossil fuels) is also an input to agricultural production and the energy intensity of food of biomass production has increased, hence food prices impacted by energy prices. - Policies with compulsory levels of bio-ethanol use for transport have pushed to substitute maize for energy for maize for food. - Cattle meat gets expensive because of feed costs so demand for cheaper proteins such as fish increase, thus leading to scarcity and rising prices of the second source. - Minerals will have to be extracted from lower quality ores in difficult locations, leading to higher energy use: an energy crisis can then lead to a resource crisis and vice versa. - Competing land use for nature (biodiversity), agriculture or drainage. - Competing use of water for nature, food production, drinking, sanitation, energy generation, industry. - A shift in favour of renewable energy sources requires a system change, which in turn could have negative impacts on other resources (e.g. lithium for electric cars).
Burden shifting (see also table below)	# "Solutions to scarcity are not only technological. In fact, in most cases, technological improvements lead to an increase in consumption instead of greater efficiency". # See from the cross-cutting issues above: - substitution of biofuels for conventional fuel - substitution of fish for cattle meat

Further cross-cutting / burden shifting issues from Appendix 1 of the report:

Alex Evans; biodiversity adapted by Hannah Koutstaal

Samenhang tussen en invloed van schaarstevraagstukken Table

Cause... ..effect	Climate	Energy	Land use	Water	Food	Biodiversity
Climate		• Fossil fuel emissions drive climate change • Some air pollution dampens climate change by reducing radiative forcing • Energy security concerns may lead to more coal	Deforestation leads to methane emissions as trees decompose	• Water a highly energy intensive industry (energy • =40% of water cost in developing countries) • Groundwater depletion leads to higher energy • use for extracting / desalinizing water	• CO_2 emissions from • agriculture energy use (cultivation, processing, refrigeration, distribution) • Methane emissions from livestock, rice cultivation	Loss of biodiversity (forests) is loss of CO_2-intake of ecosystems.
Energy	• Climate change demands retreat from fossil fuels, investment in new energy systems. • Extreme weather can impact oil production (e.g. hurricanes in Gulf of Mexico)			• Water highly energy intensive industry (energy = 40% of water cost in developing countries) • Groundwater depletion leads to higher energy use for extracting/ desalinizing water	Agriculture a major consumer of energy, both directly (cultivation, harvest, processing, refrigeration, distribution) and indirectly (fertilizer, other inputs)	
Land Use	Desertification will increase with climate change	• Biofuel cultivation leads to increase in demand for cultivable land • Deforestation for firewood		Changes in water management (dams, irrigation etc.) can affect land downstream	• Increased demand for agriculture land competes with alternative land uses • Deforestation for agriculture	Biodiversity competes with land use for food, feed, fuel

DETAILED REVIEW

Type of study	Literature study and expert judgement to 1) develop knowledge on the interrelated problems of global scarcity of natural resources and changing global geopolitical relations, and 2) explore with narratives the ways to speed up the required transitions for the future from a realistic-constructive perspective.	
Scenarios	Baseline scenario	Baseline assumptions and outcomes from UN, OECD, FAO etc studies
	Alternative scenarios	No specific scenario. Instead, options for policy actions, areas where knowledge should be improved etc are delineated (see policies / strategies above)
Modelling	Economic growth and energy estimations from the International Energy Agency's World Energy Model; population, resource demand and global economic growth projections made by OECD.	
Geographical scope	Global	All resource (scarcity) issues are considered at the global level.
	The Netherlands	Resource policies and strategies are derived for NL within the global context.
Temporal scope	Horizon 2050	
Economic scope	Agriculture	Some discussion of the impact of desertification and water scarcity on agriculture.
	Energy	The impacts of high energy prices on economic growth and consumer prices, particularly in developing countries, are considered.
	Global partnerships	Effects of resource scarcity on global competition and cooperation, i.e. whether regions become more protectionist or whether they cooperate more closely.
Resources	**Materials**	

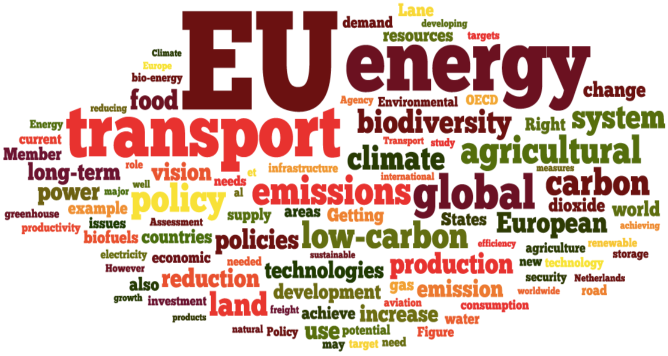
covered	biotic	Food
	abiotic	Minerals (e.g. phosphates), metals, fossil fuels
	Water	
	quality	Clean water can be scarce whereas water is not (utility value)
	quantity	Water availability
	Land	
	land use	Agricultural area
	Other	
	Energy	Mainly via scarcity of fossil fuels
	Biodiversity	'New scarcity': limited resilience to absorb attacks on nature, flora and fauna without irreversible destructive consequences
	Time	"The greatest scarcity we are facing is time."
Environmental impacts considered	Climate change	'New scarcity': restricted capacity of the atmosphere to absorb GHG
	Resource depletion, water	'Long-term scarcity': gradual depletion of finite non-renewable resources
Influencing factors identified	Economic development	- economic growth, increased prosperity, large foreign exchange reserves, devaluations - investments in production capacities, in refining capacities, foreign investment - globalisation, global trade
	Production patterns	- production costs, production efficiency (e.g. unused extraction in fish catches and agriculture) - rapid expansion of production of new products (e.g. biofuels), technological development - water consumption for food production - large unused extraction (e.g. for food production, fisheries)
	Consumption patterns	- lifestyle, meat / dairy products / processed food consumption per capita - growing demand for food in developing countries
	Demography	population growth, urbanisation and migration
	Natural systems	- finite resources, geographical distribution of resources - adverse weather (possibly linked to climate change) - loss of biodiversity, soil fertility
	Institutions	- market factors/dependencies (e.g. quasi-monopolies), market mechanisms (e.g. high prices) - importer policies, exporter policies - institutional, political limitations (e.g. agricultural policies, energy subsidies, trade restrictions)
	Other	- time factor (e.g. time lapse between policy intervention or investment in a new technology and corresponding effects)
Baseline scenario	**Assumptions**	

Economic development	Global economy increases fivefold by 2050 (strongest growth in Asia, Africa and South-America)
Production patterns	Today's water consumption for food production: 5-6 t/d in OECD countries, 1-2 t/d in developing countries
Consumption patterns	50% of food produced is actually consumed
Demography	- 9 billion people in 2050 (strongest growth in Asia, Africa and South-America) - ratio urban:rural population: 2:3 in 2020, 4:3 in 2030
Description	**Summary of what happens in the baseline scenario**
	A larger and richer population will need more food and energy (and hence also more water) at a rate that outstrips population growth. Greenhouse gas emissions increase due to worldwide deforestation and industrialisation.
Outcomes	**Main results of baseline scenario from a resource perspective**
Materials	
biotic	- food: demand almost doubles by 2050
abiotic	- phosphate: different opinions (no physical scarcity but possible shortage due to lower ore quality and concentration of producing countries; or peak phosphorus in 2030)
Water	
quantity	- demand doubles by 50% by 2050 - physical water scarcity expected to rise further (result of increase in demand and changes in rain fall due to climate change) - floods in the seven major river systems in Asia due to melting glaciers.
Land	
land use	- more land need to be cultivated (1.6 billion ha more than today's 1.4 billion)
land cover	- deforestation
Other	
Energy	- demand doubles by 2050
Biodiversity	- loss of biodiversity due to the expansion of agriculture land

Getting into the right lane for 2050

A primer for EU debate[8]

by PBL and SRC (2009)



KEY ASSESSMENT

Study	Backcasting study 1) examining the EU of today, from a global perspective, 2) looking at longterm visions on the world of 2050, and 3) identifying key decisions for today on global land and water resources, and low-carbon energy systems, including transport.
Visions and targets	Global and EU longterm visions (2050) for wise natural resource use: - Land resources (incl. water): producing food for a global population of nine billion while minimising biodiversity loss; - mitigating climate change while enhancing energy security for the EU (at least 80% GHG emissions reduction in the EU); - practical and workable solutions for an EU transport system that is low carbon.
Policies	# Linked to land resources, food and biodiversity: - Put worldwide research investments in agricultural systems back on track, and improve implementation of existing technologies in developing countries. - Invest in diversified agriculture. - Initiate and develop arrangements in a global collaborative setting to prioritise, protect and pay for ecosystems and related ecosystem services. - Contribute to structuring worldwide debate to bridge the diverging perspectives on land, food and biodiversity in the context of globalisation, as has been done on climate change. - Contribute to investment in research programmes, helping to resolve issues in the current debate on intellectual property rights, setting product standards that take biodiversity into account, and supporting multilateral organisations towards coherent policies that go beyond individual policies on land, food, development and biodiversity. - Influence diets (cut meat consumption) and reduce post-harvest losses. # Linked to energy / transport: - Strategic considerations on use of bio-energy (use of biofuels needs to be concentrated in those transport modes in which the greatest contribution can be made to mitigating carbon dioxide emissions and for which no alternatives are available) are over and above concerns about production, which have thus far received most attention. Therefore, a long-term and EU-wide strategy is needed to achieve cost-effective allocation of biofuels in energy and transport. In all probability, it would place different priorities than the current EU policy on biofuels.

[8] Source: Netherlands Environmental Assessment Agency and Stockholm Resilience Center, 2009. Moving into the right lane for 2050 – A primer for EU debate. Bilhoven: PBL. http://www.pbl.nl/bibliotheek/rapporten/500159001.pdf

	- The design and construction of Europe-wide networks for electricity and carbon dioxide (CCS) is a long process, requiring extremely large investments. Therefore, decisions made for the short-term have to be in line with long-term targets and a timely start needs to be made. # Linked to the demand-side: - Without a reversal in the trends of increased meat consumption or in transport intensity in EU production, the vision outlined cannot be achieved, regardless of achievements in eco-efficient production. - The EU can help to structure public debate on consumption issues and to keep them at the forefront. It can use its comparative strength in initiating product standards. - The EU can also promote a sufficiently broad and visionary concept of competitiveness in the framework of the renewal of the Lisbon Strategy and the Sustainable Development Strategy. For example, a target could be to make the EU the world's most transport-efficient economy.
Resource efficiency	Emphasis on the fact that biomass and in particular bio-energy has to be put to use where it is most efficient.
Cross-cutting issues	The three visions are manifestations of the same challenge, namely that global use of natural resources remains within long-term constraints. There is a need to transcend partial analyses, for example, between policies on land and water resources, and on energy and climate resources.
Burden shifting	- A key challenge is to gain recognition of the existence of one global food system, linking national and local food systems and ecosystems. A 'hot potato' to be addressed in this arena is meat consumption. - Burden shifting across time: as land conversion is often irreversible, unnecessary and large-scale conversion of ecosystems. Should be avoided. Large parts of the agricultural expansion in the coming decades may not be needed after 2050. Thus, biodiversity loss due to temporary conversion of natural areas to agricultural land should be as small as possible.

DETAILED REVIEW

Type of study	Backcasting study (normative) looking at ways for the EU to participate to and gain from the achievement of three broad global visions regarding food production and biodiversity, energy systems, and transport.	
Scenarios	Baseline scenario	The 'no new policies' baseline in the 2008 'OECD Environmental Outlook to 2030' is used. Its core assumption is that rates of improvement in labour productivity in economies around the world will gradually converge. Baseline results from other existing assessments are used to show the need for action.
	Alternative scenarios	No internally consistent alternative scenario is being developed; rather possible or necessary strategies to reach the visions are described.
Modelling		The use of models is not detailed in the study.
Geographical scope	Global	For the visions
	EU-27	For the policies / actions to be undertaken in the global context
Temporal scope	Horizon 2050	Long-term visions on the world

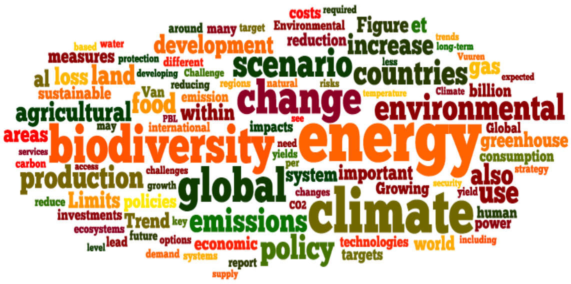
	Today + 5 to 10 years	Timeframe for decision-making at EU level in the short-term, necessary towards the long-term visions
Economic scope		Broad categories are considered, such as agriculture, industry, transport, private consumption
Resources covered		Land resources, water, energy, biodiversity
Environmental impacts considered	Climate change	A main component of the visions
	Resource depletion, water, land	Constraints on natural resources is the common denominator throughout the study
Influencing factors identified	Economic development	Economic growth "beyond GDP"
	Production patterns	Technological development
	Consumption patterns	Diet, transport intensity, energy and material intensity of consumer goods etc.
	Demography	Ageing population
	Natural systems	Climate change
	Institutions	Role and measures that the EU is willing to take.
Baseline scenario	**Assumptions**	**Based on existing studies, including the 'no new policies' baseline in the 2008 'OECD Environmental Outlook to 2030'**
	Economic and demographic development	- EU makes up about 16% of world GDP in 2050 against around 21% in 2010. - Global per capita income more than doubles. - 9 billion people in 2050 (+50% compared to today).
	Description	**Summary of what happens in the baseline scenario**
		By 2050, the EU will be equalled, economically, by new players and outgrown in terms of population. But as a major importer of goods and services from economic blocks such as India and China, the EU is likely to exert considerable influence on production standards worldwide. Furthermore, the EU's global weight in 2050 could arguably include its 'neighbourhood', giving it greater leverage in issues such as agriculture. In addition, as one of the world's most affluent regions, the EU will be a very desirable place to live, with a diversity of landscapes and cultures.
	Outcomes	**Main results of baseline scenario from a resource perspective (literature review from existing studies, not own scenario development)**
		# Biomass, water, land, biodiversity: Increased demand for agricultural products including food, feed and bio-energy will increase water consumption and agricultural land use worldwide by 2050, leading to significant additional loss of global biodiversity.
		# Climate, energy, fossil fuels: Global use of fossil energy is expected to continue to increase rapidly. Without emission control policies, greenhouse gas emissions will further increase. The EU faces challenges with security of energy supply including availability of energy sources, energy prices and import dependency

Alternative scenario	**Assumptions**	
	Institutions	- Long-term coherent strategy for the EU; - Choices made in the short-term in order for the EU to get into the right lane. => With implications for all the other influencing factors.
	Description	**Summary of what happens in the alternative scenario**
		The future EU is a pro-active and consistent player on the world stage. The EU acts on the basis of values that go ‘beyond GDP’ and with a reputation for regional integration and global interest.
	Outcomes	**Main results of baseline scenario from a resource perspective**
		The suggested strategies are expected to have put the EU on the right lane with regard to achieving the three visions.
		# Biomass, water, land, biodiversity: The EU produces the same quantity and quality of agricultural products as today, but in more diverse landscapes that host more biodiversity. Crop yields have increased sustainably, worldwide, and human diets contain less animal products, making them also healthier. Furthermore, the EU has reduced its footprint – regarding land, water and energy use – on other parts of the world.
		# Energy, fossil fuels: A low-carbon energy system implies a considerable reduction in fossil energy use and an increase in security of energy supply through diversification of energy sources. The end-use of energy is based predominantly on non-carbon energy carriers such as electricity or hydrogen from low-carbon sources or biofuels.

Growing within Limits

A Report to the Global Assembly 2009 of the Club of Rome[9]

Netherlands Environmental Assessment Agency (2009)



KEY ASSESSMENT

Study	Study built around two scenarios: one exploratory (forecasting) business-as-usual ("Trend") and one normative (backcasting-like) fundamentally different alternative ("Challenge").
Visions and targets	# General conditions and uses for visions and targets: - Short-term decision-making requires long-term visions and associated targets to avoid lock-in and endorse fundamental changes; - Any future vision would be greatly enhanced by an attractive guiding narrative, to mobilise people and politicians for the challenges ahead (focus on opportunities rather than on crisis rhetoric). # Normative targets considered : - climate target of a maximum temperature increase of 2°C - expansion of agricultural land will be limited in order to avoid further loss of biodiversity, from 2020 onwards
Policies	# General conditions to take into account when developing a policy strategy for meeting climate and biodiversity challenges and deflecting from the path of the Trend scenario towards the more sustainable Challenge scenario: - a long-term perspective, - a balance between market-based and regulatory instruments, - a balance between top-down and bottom-up strategies, - to take into account the conflict of multiple (national) interests and thematic interlinkages. # A sound long-term policy would indicate the general direction (vision), invest in robust measures, and preclude unwanted outcomes, while keeping options open for a variety of technical and political solutions. # There are trade-offs between efficiency and diversity, but strategic policy-making would strike a balance between the short-term competitive need for efficiency and the long-term need to maintain diversity for dealing with unexpected events.

[9] Source: PBL, 2009. Growing within Limits - A Report to the Global Assembly 2009 of the Club of Rome. Bilthoven: Netherlands Environmental Assessment Agency. http://www.pbl.nl/bibliotheek/rapporten/500201001.pdf

Resource efficiency	Not measured as such but addressed from the angle of increasing resource scarcity and environmental stress due to resource use. The question is whether the growth in material flows could remain within the limits for climate change and biodiversity loss, i.e. whether the collective outcome of such a world is indeed a continuing smooth increase in quality of life for the average person, or whether it will meet its limits.
Cross-cutting issues	Co-benefits and trade-offs between climate system, land use, agriculture, energy and biodiversity need to be considered, in particular: - Implications for land use require a careful approach to bio-energy; - Preserving natural forests helps to protect biodiversity and limits climate change; - Intensification of agriculture requires consideration of possible trade-offs: a significant increase of agricultural yields is required, in order to avoid deforestation and to prevent further biodiversity loss as well as climate change; nevertheless, higher yields may imply increased use of energy (mechanisation) and fertilisers (may lead to higher N2O emissions from agriculture, contributing to climate change; potentially higher consumption rate of phosphor fertilisers, a non-renewable resource); - A less meat-intensive diet helps to avoid climate change and to protect biodiversity; - Raising food production to eradicate hunger would only marginally increase land use.
Burden shifting	Although interim solutions may appear to form a bridge to fundamental restructuring in 2050, they may sometimes prove to be a dead end. For example, energy security considerations for the 2020-2030 period, when taken in isolation, could easily lead to investment in coal-based technology that would be long-lived and incompatible with the vision for a low-carbon economy, by 2050.

DETAILED REVIEW

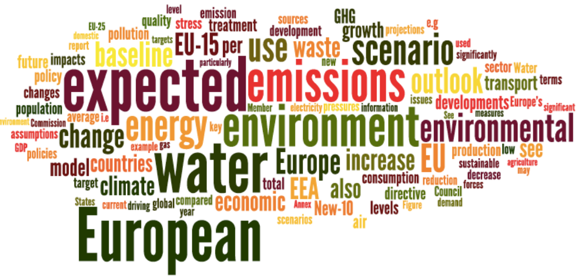
Type of study	Exploratory study based on one forecasting business-as-usual scenario and one backcasting exercise.	
Scenarios	Baseline scenario	“Trend” scenario: a smooth and business-as-usual continuation of past trends
	Alternative scenarios	“Challenge” scenario: fundamentally deflects from the “Trend” pathway, actually more a collection of various options to achieve the targets than a single scenario (backcasting-like approach)
Modelling	Physical models	IMAGE modelling framework: describes the chain of global environmental change for both climate and land use and includes world energy use and food production, as well as the planet’s biochemical cycles, climate impacts and land cover.
	Economic models	Agricultural demand, trade and production data are either obtained from an agricultural economy model linked to IMAGE, or included from other studies.
Geographical scope	Global	
Temporal scope	Horizon 2050 to 2100	
Economic scope	Focus on the agricultural sector (both in terms of how it is adversely effected by climate change, and also the extent to which it can aid the achievement of targets since it is a key contributor to GHG emissions), investment projections to achieve climate and biodiversity targets, estimates of GDP and employment impacts of environmental policies.	
Resources covered	**Materials**	
	biotic	Agricultural production

	abiotic	Fossil fuel use
	Land, soils	In relation to agricultural production
	Biodiversity	In relation to agricultural production
Environmental impacts considered	Linked to fossil fuel use	depletion, climate change, air pollution
	Linked to agricultural production	deforestation, biodiversity loss, soil degradation
Influencing factors identified	Economic development	Economic growth, income level
	Production patterns	Energy mix
	Consumption patterns	Consumer preferences
	Demography	Growing / ageing population
Baseline scenario: Trend scenario	**Assumptions**	
	Economic development	- Economic growth higher in low-income countries than in high-income countries (rapid economic growth in some major world regions, notably China), but without this resulting in income convergence; - Strengthening of corporate capitalism and market mechanism, rapid globalisation of goods and financial markets, a new technological wave in the form of ICT.
	Production patterns	Continuing increase in material goods and services, driven by the same entrepreneurial and market dynamics which the world has experienced over the last decades.
	Consumption patterns	Increase in material welfare for billions of people (in OECD countries and outside), plethora of high-tech products enter the global market place, satisfying demand from the rich and the poor, but meanwhile, a huge and partly unsatisfied demand for low-tech elementary goods and services remains.
	Demography	Increasing to 9 billion around 2050, and slowly declining to around 8 billion by 2100.
	Institutions	No explicit policies to address main environmental challenges
	Description	**Summary of what happens in the baseline scenario**
		With business as usual, fossil-fuel use will increase globally, over the next decades, to meet energy demand for human development. More people need more food and increased food demand is likely to lead to an increase in land use. Both climate and biodiversity targets are not met.
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Linked to fossil fuels	Annual growth rates are projected to be in the order of 1% (oil) and over 2% (coal and natural gas). For oil and natural gas, depletion and resulting price increases around the middle of the 21st century are expected to lead to stabilisation or even a peak in production, with production concentrated in only a few resource-rich regions. For coal, however, resource scarcity is not expected to limit production or cause cost increases, in the foreseeable future.

		As a result, it is likely that coal use will strongly increase. At the same time, non-fossil energy production will increase substantially, also under the Trend scenario, including nuclear, biomass and other renewables.
	Linked to agricultural production	Growth numbers in food production of between 50 and 65%, compared to 2000, in the period up to 2030 and beyond. About 70% of the production growth would come from yield increase, but cropland would still expand from 1.5 billion hectares today to more than 1.6 billion hectares, by 2050. This would be mostly due to a net expansion of cropland in Africa, Latin America and Southeast Asia. During the same period, there would also be some decrease in agricultural areas in temperate zones. An expansion of the global area used for bio-energy of up to 2 million km^2 is assumed for 2050, which would account for around 10 to 15% of the total crop area. The increase in agricultural areas is projected to lead to a further loss of biodiversity. Moreover, other factors, such as climate change and infrastructure expansion are expected to increasingly contribute to biodiversity loss.
Alternative scenario: Challenge scenario	**Assumptions**	
	Economic development	Economic growth assumed the same as in “Trend”
	Demography	Population growth assumed the same as in “Trend”
	Institutions	The mix of various options that would allow to meet the targets is actually the outcome of the backcasting exercise (see below under ‘Outcomes’).
	Description	**Summary of what happens in the Challenge scenario**
		The long-term targets on global warming and biodiversity loss are met.
	Outcomes	**Main results of alternative scenario from a resource perspective**
	Linked to fossil fuels	A low-carbon economy could be achieved with currently identifiable technologies. The first steps would be to improve energy savings, increase use of renewable energy and carbon capture and storage, reduce deforestation, and reduce non-CO2 emissions. An attractive route is based on a further electrification of energy use. In that sense, considerable investments in the power grid would be needed. In the transport sector, energy efficiency could reduce emissions, in the short term. In the long term, however, a dramatic shift towards electric (or hydrogen) vehicles is required.
	Linked to agricultural production	Expansion of agricultural land can be limited and biodiversity loss stopped by combining the following strategies: - Protect valuable ecosystems and their goods and services; - Increase agricultural yields; - Reduce post-harvest losses; - Promote dietary change, away from animal products; - Manage bio-energy demand; - Accelerated productivity gains; - Develop a clear international strategy for biodiversity protection. These strategies require ambitious action at different levels of scale and different policies in different areas. For example to answer: Where to increase the yield to the maximum? Where to combine higher production with more biodiversity? And which areas to protect?

European environment outlook[10]

EEA (2005)



KEY ASSESSMENT

Study	- No backcasting - Explores plausible future developments (baseline) and plausible alternative scenarios
Visions and targets	- No visions are developed; - Baseline projections are assessed against the following EU policy objectives: # The indicative policy targets for renewable energy sources and CHP (12% of total energy use in 2010, and 18% of gross electricity production, resp.) are not expected to be met by EU-25 as a whole. # The indicative targets from the Biofuel Directive (2% in 2005, 5.75% in 2010) are not expected to be met. # In line wit the policy target, passenger and freight transport demand are both expected to relatively decouple from economic growth.
Policies	Explicitly tested policies: - extended CAP reform: continued liberalisation in the context of WTO negotiations for animal product markets; the quota regime for milk is abolished in 2025; market interventions and tariffs meat and eggs are eliminated; gradual drop of tariffs for dairy products from 2011 onwards;
Resource efficiency	- Material use is reported as DMC for fossil fuels and DEU for minerals and biomass, resource productivity is expressed as a whole in euro GDP / kg resource used; - Resource efficiency is not expressed for more disaggregated resource categories, and also not on a sectoral level; - The efficiency of the use of water and land is not quantified (absolute use only).
Cross-cutting issues	- The 'Best practice scenario for fertiliser handling' looks at the substitution of organic fertilizers for mineral fertilizers; - The impact of climate change on biodiversity (number of plant species) is estimated in the baseline and 'Low GHG emissions' scenarios.
Burden shifting	System boundaries are the geographical borders of Europe, resource use outside these borders are not considered except partially through the imports of biotic and abiotic materials to Europe. Imports of fossil fuels are explicitly calculated. Imports of other abiotic materials and related burden shifting are mentioned in the narratives. Indirect flows, water and land use outside Europe are not considered.

DETAILED REVIEW

[10] EEA, 2005. *European environment outlook*. European Environment Agency, Copenhagen. EEA Report No 4/2005. http://www.eea.europa.eu/publications/eea_report_2005_4

Type of study	- Projections (baseline scenario): benchmark against Europe's policy objectives, identification of main influencing factors; - Policy testing (alternative scenarios): identification of appropriate response options.	
Scenarios	Baseline scenario	Differs from a business-as-usual scenario in that baseline assumptions reflect current expectations, including where these differ considerably from past trends (e.g. new technologies, commodity price changes).
	Alternative scenarios	- 'Extended CAP reform', 'Best practice scenario for fertiliser handling', 'A stronger Euro': for biotic resources (detailed) and mineral fertilisers; - 'Low GHG emissions' scenario: for resources 'fossil fuels', 'water' and 'biodiversity'; - 'Low economic growth variant': for resources 'materials' and 'water'; - 'Non-convergence of per-capita water use in the New-10': for resource 'water'.
Modelling	Physical models	- PRIMES and POLES: for resources 'fossil fuels'; - CAPSIM: for biotic resources (detailed), mineral fertilizers, land use; - a macro-econometric waste and material flows model: for resources 'biomass (aggregated)' and 'industrial minerals, ores, construction minerals'; - WaterGAP: for resource 'water (quantity)'.
	Economic models	Assumptions for population growth, macroeconomic and sectoral activity, household expenditure, energy flows and number of and average size of households developed through extensive stakeholder consultation for the DG TREN baseline projections 'Energy and Transport Trends to 2030'.
Geographical scope	EEA-31	- water abstraction
	EU-15	- biotic resources and mineral fertilisers - industrial minerals, ores, construction minerals - fossil fuels
	New-10	- aggregated industrial minerals, ores, construction minerals - fossil fuels - water abstraction
	New-8	- biotic resources and mineral fertilisers
	BG, RO, TK	- aggregated industrial minerals, ores, construction minerals - water abstraction
	Northern Europe, Southern Europe	- water abstraction
Temporal scope	Horizon 2020	- biotic resources and mineral fertilisers, industrial minerals, ores, construction minerals (baseline scenario,
	Horizon 2030	- fossil fuels (baseline and 'Low GHG emissions' scenarios) - water abstraction (baseline and 'Low GHG emissions' scenarios)
	Horizon 2100	number of plant species (baseline and 'Low GHG emissions' scenarios)
Economic scope	Sectoral disaggregation for the driver 'economic development'	
Resources covered	**Materials**	
	biotic	- biomass (aggregated); - crops: cereals, oilseeds and pulses, other arable crops, permanent crops and paddy, fodder; - meat: beef, poultry, pork;

		- dairy products.
	abiotic	- fossil fuels - industrial minerals, ores, construction minerals - mineral fertilisers (N, K, P)
	Water	
	quantity	- water availability, water abstraction
	Land	
	land use	- arable land: set aside and fallow, cereals, oilseeds and pulses, other arable crops, permanent crops and paddy, fodder
	Other	
	Biodiversity	number of plant species
Environmental impacts considered	Climate change	- midpoint: aggregated GHG emissions using GWP weighting scheme; - average temperature increase, frequency of extreme weather events, length of the growing season and biomass production; - endpoint: effects on ecosystem composition (number of plant species).
	Acidification	- midpoint: acid deposition above critical loads (area of exceedances) for forests, semi-natural ecosystems, catchment areas of freshwater bodies
	Eutrophication	- midpoint: exceedances of nitrogen depositions
	Human toxicity	- endpoint: loss of statistical life expectancy (due to emissions of $PM_{2.5}$), premature deaths (due to ground level ozone emissions)
	Ecotoxicity	- midpoint: excess ozone
	Resource depletion, water	water stress approximated by the water exploitation index
Influencing factors identified	Economic development	GDP, income distribution, fossil fuel prices, market liberalisation
	Production patterns	- Overall: technologies for production (e.g. energy, transport), resource use efficiency (e.g. water, energy, land); - Energy and transport: primary energy supply, power generation, energy use in transport sector, industrial energy use (e.g. steel, construction sector), transport infrastructure; - Agriculture: crop and livestock production systems, manure management and fertiliser use, pesticide use, irrigation; - Forestry: timber production/forestation; - Service sector: energy use, water use, tourism;
	Consumption patterns	Households' Energy use, households' water use, tourism, diet
	Demography	Population (number, age), households (number, average size), geographical distribution of population
	Other	Waste management, waste water management
Baseline scenario	**Assumptions**	**Baseline assumptions expand on DG TREN baseline projections 'European energy and transport trends to 2030'**
	Economic	- Sustained moderate economic growth: 2.4% /a for 2000-2030 in EU-25 (2,%

development	for EU-15, 3,5% for EU-10); - Further predominance of the service sector (70% of GVA in 2004, to continue growing at 2.7%/a); - At the global level, trade agreements underpin economic growth, productivity gains (physical and labour capital) and competitiveness.
Production patterns	- Moderate technological progress but essential in key areas (energy, agriculture, water), no technological breakthroughs; - No major alternative to liquid fossil fuel-based vehicles reaches a significant market penetration; - Learning rates assumed for power generation technologies, decreased capital costs for renewable energy sources; - Agriculture: significant increases in crop yields with large differences between EU-15 and EU-10 (+21% cereals, +17% oilseeds and pulses) and milk yields (+25% over 2001-2020), stable yields for meat and eggs production; - Any new power plant uses tower cooling (40 times less water abstraction than once-through cooling);
Consumption patterns	- Social and cultural values and preferences adjust to reflect the ageing population, and the further development of the service-oriented society (especially relevant for education and social mobility); - Assumptions on food, housing (incl. settlement patterns), personal travel and tourism (see EEA report 'Household consumption and the environment'), e.g.: # +53% km/cap 2000-2030 # shift from beef, potatoes and cereals to poultry, pork, vegetables and fish to continue # consumption of pre-prepared and organic food is growing rapidly.
Demography	- Stabilising (migration first contributor to population growth): # 2004-2030: +<1% in EU-25, +1.5% in EU-15, -7% in EU-10, +3% in EEA-31) # 2030-2050: -27 million inhabitants in EU-25 - Ageing: share of 65+ people in 2030: 25% in EU-15, 22% in EU-10 (up from 15% and 10%, resp.) - Size of households: <2.5 people/HH in 2030. Leads to a marked increase in the number of households;
Institutions	- No shifts in sectoral or environmental policies targeted at European production and consumption patterns; - Decrease over time of subsidies for renewable energy sources; - Introduction of decoupling of payments associated with mid-term review of the CAP and overall reduction in the level of support of cereal production.
Description	**Summary of what happens in the baseline scenario**
	Follows the trend set by the DG TREN study.
Outcomes	**Main results of baseline scenario from a resource perspective**
Materials	
biotic	- Biofuels: 4.5% of transport final energy demand in 2030; - Biomass still a large contributor to material flows: 1.6 billion tonnes per year by 2020; - Crops 2002-2020 in EU-25: +20% for cereals, +31% for oilseeds and pluses, -4% in permanent crops and paddy.

	abiotic	- Gas makes 24% of final energy demand of EU-25 in 2030 against 20% in 2000; - Net imports of gas and solid energy carriers expected to more than double. - Mineral fertilizers in EU-8 2000-2020: +35% (N), +52% (P) and +41% (K). - Resource productivity (actually material productivity) to increase on average by 2%/a in EU-10: +50% in 2020 (+25% for EU-15); - Construction minerals still the largest contributor to material: 3.8 billion tonnes per year by 2020.
	Land	
	land use	- Relative stability of the area of arable and harvested land. - Slightly decreasing area for cereal production
	Other	
	Energy	- Total energy consumption to grow on average 0.6%/a until 2030; - Final energy demand: relative decoupling from GDP growth for all sectors but still absolute growth (especially for transport: +35% energy demand 2000-2030); - Household final energy consumption: +20% in EU-15, +40% in EU-10. - Energy intensity improves by 1.8%/a.
Alternative scenario 'Low economic growth'	**Assumptions**	
	Economic development	+1.6%/a (EU-15) and +3.2%/a (EU-10) over 2000-2030
	Outcomes	**Main results of alternative scenario from a resource perspective**
	Materials	
	abiotic	Low economic growth: decrease on average of 15% of the material flows (and waste flows)
Alternative scenario 'A stronger euro'	**Assumptions**	
	Economic development	A stronger euro of 0.75 EUR/USD (instead of 0.9 EUR/USD in the baseline)
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic	Rather small effect in the short and medium terms on cropping patterns, herd sizes and environmental pressures because prices are stabilized between global and EU markets by import tariffs, level of administrative prices and quota regimes (milk).
Alternative scenario 'Extended CAP reform'	**Assumptions**	
	Economic development	Continued liberalisation in the context of WTO negotiations for animal product markets
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials, land	
	biotic, abiotic, land	Prices for animal products adjust with the global market and herds adjust accordingly (-5% pigs, -11% poultry). The reduced herds lower demand for fodder and allow a reduction of fodder area (2%), which in turn leads to an expansion of other crops (1% cereals). N, K, P surpluses decrease by 4-5%.
Alternative	**Assumptions**	

scenario 'Best practice for fertiliser handling'	Production patterns	Ammonia losses cut by half; in crease availability of N, P, K from organic fertilisers by 80%; over-fertilisation rate decreased (5%)
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	biotic, abiotic	The use of organic fertilisers increases sharply (60-80%) substituting for mineral fertilisers (reduction of 30-60%)
Alternative scenario 'Low GHG emissions'	**Assumptions**	
		Compared to 1990 levels: -20% in 2020, -40% in 2030 and -65% in 2050
	Outcomes	**Main results of baseline scenario from a resource perspective**
	Materials	
	abiotic	-13% fossil fuel use in 2030 in EU-15, -30% in EU-10 compared with 2000, i.e. 23% and 28% less than baseline. -35% in domestic extraction compared to baseline, -20% of net trade