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Jennifer Hauck (UFZ, CoKnow), Christian Schleyer (UNI-KLU), Jörg A. Priess (UFZ), Roy Haines-Young (Fabis), Paula Harrison (CEH), Rob Dunford (UOXF), Marcel Kok (PBL), Juliette Young (CEH), Pam Berry (UOXF.AF), Eeva Primmer (SYKE), Clara Veerkamp (PBL), Györgyi Bela (ESSRG), Angheluta Vadineanu (UB-DSES), Jan Dick (CEH), Rob Alkemade (PBL), and Christoph Görg (UNI-KLU)

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Executive Summary

The future of the natural environment is highly uncertain: our climate is changing, and there are numerous different pathways for future interactions between the natural environment and (global) societies. Scenarios and models allow our assumptions about those potential futures to be explored; Scenarios allow decision makers to explore and define the implications of assumptions about future societies in different social, political, and environmental contexts through, for example, storylines. Integrated assessment models provide a useful way to quantify both, the identified scenarios and the impacts, also considering the interactions between different land use sectors. The combination of different storylines and quantified impacts can be used as a means of anticipating the effects of alternative policy interventions by looking at the projected consequences for nature and ecosystem services (ES) and their benefits to people. However, to understand how future environmental change can be managed, it is important to understand the ways of governing in general, and which (types of) policies in particular, will work in these different scenario worlds. Being able to examine policy options will enhance the usefulness of scenarios for policy-makers, which is necessary for developing long-term strategies and solutions with pressing urgency although there are high uncertainties and knowledge gaps with respect to biodiversity, ecosystems, and the provision of ES under future conditions. In order to further support policy, scientists suggest the development of integrated approaches for linking scenarios and models of indirect and direct drivers, nature, nature's benefits to people, and good quality of life to better account for important relationships and feedbacks between those components. Also policy maker welcome this, as shown by the recent example of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

In OpenNESS, substantial work has been carried out on this topic, analysing the relevant EU policies influencing biodiversity and ES in Task 2.1. In parallel, four EU level scenario storylines were developed and drivers were quantified (Task 2.3). Further, the impacts of the scenarios on land-use change and subsequently biodiversity and ES change on EU level were assessed using the CLIMSAVE and IMAGE-GLOBIO models, while the latter was also used to account for interactions with the rest of the world (WP3). The aim of this Deliverable is to analyse how these different strands of research contribute to a better understanding of policy options and policy impacts and how policy analysis can be combined with scenario processes and modelling. We use four integrated assessment model-quantified scenarios exploring different trajectories of ES provision across Europe which were developed in an earlier phase of OpenNESS: UnitedWeStand, WealthBeing, EcoCentre, and RuralRevival. Through these scenarios, we assess changes in cropland, forest cover, and grassland, and identify and explore (types of) policy options that may have triggered (or at least fostered) these changes.

1. Introduction

The future of the natural environment is highly uncertain: our climate is changing, and there are numerous different pathways for future interactions between the natural environment and (global) societies. Scenarios and models allow our assumptions about those potential futures to be explored, providing a thereby powerful tool for policy and decision support. Scenarios allow decision makers to explore and define the implications of assumptions about future societies in different social, political, and environmental contexts through, for example, storylines (Kok et al., 2014; O'Neill et al., 2013). Integrated assessment models can provide a useful way to quantify the identified scenarios and examine the impacts in a quantitative approach that considers the interactions between different land use sectors (Dunford et al., 2015; Stehfest et al., 2014). The combination of different storylines and quantified impacts can be used as a means of anticipating the effects of alternative policy interventions by looking at the projected consequences for nature and ecosystem services (ES) and their benefits to people (Harrison et al., 2013; Dunford et al., 2015; Ferrier et al., 2016). However, to understand how future environmental change can be managed, it is important to understand the ways of governing in general (e.g., Primmer et al., 2015), and which (types of) policies in particular, will work in these different scenario worlds. Being able to examine policy options will enhance the usefulness of scenarios for policy-makers, which is necessary for developing long-term strategies and solutions with pressing urgency although there are high uncertainties and knowledge gaps with respect to biodiversity, ecosystems, and the provision of ES under future conditions (Brown et al., 2015).

The research on biodiversity and ecosystem services has produced many scenario exercises focusing on the impact of direct drivers such as land use or climate change (Hauck et al., 2015). Indirect drivers and more specifically policy options are usually not directly considered or explicitly assessed. Exceptions are found at the global level, such as the Global Biodiversity Outlooks (e.g., Secretariat of the Convention on Biological Diversity, 2014), the OECD's environmental outlook (OECD, 2012), and rethinking global biodiversity strategies (PBL, 2010). In addition, many policy analyses focus on policy options but, in accordance with short term policy cycles, rarely take a long-term perspective and often fail to analyse the (future) impact of certain options on biodiversity and ecosystems or ES.

In order to further support policy, scientists suggest the development of integrated approaches for linking scenarios and models of indirect and direct drivers, nature, nature's benefits to people, and good quality of life to better account for important relationships and feedbacks between those components (Pichs-Madruga et al., 2016). The need for this type of comprehensive approach is welcome by policy makers, as shown by the recent example of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), where policy makers have raised the following question: "What are the actual and potential impacts of various policies and interventions on the contribution of biodiversity, ecosystem functions and ecosystem services to the sustainability of the economy, livelihoods, food security and good quality of life in the regions?" (IPBES, 2015: 33).

In the EU-FP7 research project OpenNESS (www.openness-project.eu/), substantial work has been carried out on this topic, analysing the relevant EU policies influencing biodiversity and ES (Schleyer et al., 2015; Bouwma et al., 2017). In parallel, four EU level scenario storylines were developed and drivers were quantified (Priess et al., forthcoming). The impacts of the scenarios on land-use change and subsequently biodiversity and ES change on EU level were assessed using the CLIMSAVE and IMAGE-GLOBIO models, while the latter was also used to account for interactions with the rest of the world (Dunford et al., 2015; Veerkamp et al., forthcoming).

The aim of this Deliverable is to analyse how these different strands of research contribute to a better understanding of policy options and policy impacts. The idea of synthesising these two strands of research was not envisioned from the very beginning of the project. However, the idea to synthesise both was pursued as an opportunity for further interdisciplinary learning leading to the second aim of this Deliverable: to illustrate how policy analysis can be combined with scenario processes and modelling; the ambition here is to explore the insights of each scenario, whilst being aware of their limitations in terms of improving the policy-relevant messages. We use four integrated assessment model-quantified scenarios exploring different trajectories of ES provision across Europe which were developed in an earlier phase of OpenNESS (Priess et al., forthcoming; see Annex 1):

- UnitedWeStand, where a focus of society is on equity and justice as well as on exploitation of natural resources
- WealthBeing, where economic growth is at the heart of development efforts and social and environmental standards are less important
- EcoCentre, where the focus is sustainability driven by a strong EU
- RuralRevival, which is dominated by many diverse bottom-up initiatives across Europe aiming at more sustainable lifestyles

Through these four scenarios, we assess changes in cropland, forest cover, and grassland, and identify and explore policy options, or rather types of policies, that may have triggered (or at least fostered) the respective changes.

In Section 2, we present the synthesis process, integrating a detailed policy analysis with the scenario analysis and modelling. In Section 3, we present the results of this synthesis by describing the land-use changes under the different scenarios and by connecting them to policy options. We also discuss the 'fitness' of certain (types of) policy options, applicable in different scenarios, across these scenarios. We then reflect, in Section 4, on methodological limitations but also other lessons learned both, for an academic audience and for policy makers, and draw some conclusions.

2. Integrating policy analysis, exploratory scenarios and modelling

In this Section, we briefly introduce the policy analysis, the scenario, and the modelling work and then outline the synthesis process as well as the testing of 'fitness' of policy options across scenarios.

2.1 Policy analysis, scenarios, and modelling work

2.1.1 Policy analysis

Within OpenNESS, a policy analysis was undertaken to identify and investigate opportunities and challenges for mainstreaming the concept of ES into EU level policy making (Schleyer et al., 2015; Bouwma et al., 2017). Given that there is no specific EU policy devoted to governing ecosystem services, we evaluated the adoption of the ES concept by reviewing twelve EU policies covering the policy fields of biodiversity, forest, climate, water, and rural and urban areas, as well as a mobility and infrastructure-related policy. More precisely, we reviewed the coherence at the level of definitions, objectives, and implementation. Coherence is considered as the degree to which policy goals and associated instruments of different laws or policies are in line with one another or form a meaningful ensemble (May et al., 2006; Mickwitz, 2003). In our work, we found that

although the ES concept is already embedded in recent EU (environment-related) policies, such as the Biodiversity Strategy 2020 and the Invasive Alien Species Regulation, the overall coherence is moderate, and policies showing very high coherence, for example in terms of reflecting the ES concept also in the design of measures, are confined to the policy arenas that address natural ecosystems, forestry, or agriculture. This extensive policy analysis served as a basis for developing policy options for the different scenarios and helped to assess the robustness of the policy options across the scenarios, based on expert judgement.

2.1.2 EU level scenarios and modelling approaches

The EU level OpenNESS scenarios were developed aiming to facilitate (i) the assessment of the influence of different drivers of change on natural capital and ES; (ii) the testing of policy options for ES operationalization; and (iii) providing a common set of assumptions for the OpenNESS case studies to facilitate synthesizing analyses across regions (for more details, see Priess et al., forthcoming and Annex 1). The four scenario storylines UnitedWeStand (UWS), WealthBeing (WB), EcoCentre (EC), and RuralRevival (RR) were developed based on ex-ante input from OpenNESS case studies, the scenario team, the EU-level stakeholders, and a review of drivers (Hauck et al., 2015). Some initial, very crude policy assumptions were also developed (see Annex 5). These crude policy assumptions inherent in the storylines of the scenarios are summarized in Figure 1. They provided the larger or general policy context and, thus, served as a basis for developing more detailed policy options within the scenarios.

Figure 1: Summary of storylines of the scenarios focussing on governance paradigms

UnitedWeStand: General policy tendencies: European policy approaches, sectoral policies; European Dream" through strong social change and EU policies towards equity and justice; Strong EU economy & competition for labour force; Substitution of ES by technological solutions (flood protection; CCS; fracking, GMOs, intensification, etc.) but nevertheless long-term decrease of ES supply due to high demands by multiple users; strong exploitation of natural and geological resources (mining); Due to increasing numbers of (skilled) immigrants and strong social and family-friendly policies, slight increase in birth rates; Ecosystems with high cultural value kept in museum-like state.

WealthBeing: General policy tendencies: sectoral policies and large differences between members states (MS); Reducing social and environmental standards which results in further degradation of ecosystems and agricultural and aquatic systems on the long-term; Deregulation of markets and Nationalism; Strong individualism and consumerism; preference for urban lifestyle, rural areas neglected; High tourism and recreation demand, especially in artificial environments; Unsustainable use of all ES, but focus on provisioning services (especially meat production and renewables) with strong intensification; Potential conflicts with nature conservation; Strong focus on economic growth by agricultural intensification, high technical efficiency and strong alliance between agrarian and industrial lobbies; shrinkage of European population is ongoing.

EcoCentre: General policy tendencies: European policy approaches; cross-sectoral integration; From co-design of EU policies to decentralized decision making; Strong environmental EU policies with complementary approaches: ES and Rewilding; European wide environmental education campaigns; Voluntary reduction of consumption and movements towards sustainable lifestyles; Climate and biodiversity friendly; Technology development towards efficiency and recycling; Focus: ecosystem service concept to promote sustainable management of natural resources; Agricultural production often converted to organic or sustainable farming.

RuralRevival: General policy tendencies: little to no EU policies and little coordination in Europe, but national cross-sectoral policy initiatives; Large differences between MS; Intrinsic motivation for nature conservation; Low consumption lifestyle and strong social pressure for sustainability; Green, idealistic citizen movement; less wealth-oriented; Strong decrease of population; Little to no urban sprawl and land sealing; Revival of rural life; Growing networks of exchange for old crop varieties, vegetables, fruits and old livestock races; Policies and institutions move towards more cooperation; "back to nature"

After finalizing the storylines in an iterative review process (Alcamo et al., 2008; Priess and Hauck, 2014), the drivers described in the narratives were quantified iterating between the scenario development team and the modelling experts. Quantified values drew on the team's experience of driver quantification from previous, similar assessments (Harrison et al., 2013; Kok et al., 2014; Dunford et al., 2015). The final values selected were used to provide input for the modelling approaches (Priess et al., forthcoming; Annex 3).

Two models were used: 1) the CLIMSAVE Integrated Assessment Platform (IAP) (Harrison et al., 2015) and 2) the GLOBIO model operating within the global Integrated Assessment modelling Framework IMAGE 3.0 (Stehfest et al., 2014). Both models are capable of exploring combined socio-economic and climatic changes and their consequences for land use, biodiversity, and ES (Alkemade et al., 2009; Schulp et al., 2012; Dunford et al., 2015). IMAGE-GLOBIO, a global modelling framework, considers global connections between world regions, while CLIMSAVE is customized for the European context and needs to make assumptions about the interactions with the rest of the world such as import and exports of commodities. Although the two models differ in their modelling approaches and geographical scope, comparing the results of both models allows the identification of common trends, as well as taking uncertainties into account arising from different

conceptualizations and simplifications of the real world (for more details, see Veerkamp et al., forthcoming; Annex 4)

2.2 Synthesis: developing policy options and testing their robustness

The elements of the integrated scenario and modelling system provide different elements that can help users explore potential futures. The scenarios provide a storyline that details the ethos of a given future. They provide an understanding of the goals of different scenario worlds (e.g., for a return to simple rural livelihoods), the factors that drive them (e.g., a meat crisis that destroys public trust in animal-based foods), and a context to understand the modes of governance that may be enabled and disabled in the different scenarios (e.g., a distrust in top-down international policy). The modelling provides a 'sense check' on the biophysical practicalities of the environmental changes – is it possible to still meet food demand in a world where the population is increasing, and yet there is a move away from the import of food and a rejection of technological advancement? However, models are imperfect and limited in the way that they represent the environmental futures: how can a model based on the optimization of land use across Europe or the world represent scenarios where localization is the key driver of the population's actions?

The aim of this Deliverable is to demonstrate how policy analysis can be combined with scenario processes and modelling in a way that builds on the insights of each whilst also building on an understanding of the limitations of each to improve the policy-relevant messages for decision makers.

To assess the viable policy options within each modelled scenario, a synthesis group was formed based on the researchers involved in the policy analysis, the scenario development process, and the two modelling approaches. In a series of meetings, we examined scenario results, i.e. the figures and maps showing the relative changes between 2010 and 2050 for cropland, forest, and grassland under the four scenarios. Based on the extensive review of regulatory frameworks accomplished with the policy analysis (Schleyer et al., 2015), a list of policy options was developed (see Table 3.3) that could have led to, i.e. triggered or at least fostered, these changes. We also checked that the policy options were consistent with the scenario storylines used as input to the modelling approaches.

This list of plausible policy options was developed using a two-step approach. First, a table was developed where, by scenario, policy options were summarized that were consistent with both the scenarios storylines and quantified drivers and the insights from the resulting changes in land use that resulted from the modelling. Land-use change across the two models was summarized in terms of change in cropland, forest, and grassland in the particular scenario.

In a next step, we used the list of plausible policy options selected or developed for one particular scenario and explored how they would 'fit' into the other scenario paradigms and societal attitudes associated with the scenario storyline, and scored them as low, medium, or high, following a framework developed by Brown et al. (2015). From this table, we were able to identify those policy options, which had 'positive' impacts (across scenarios) and discuss how they could be realized in other scenarios, i.e. which changes would be necessary.

3. Results

In this Section, we first describe the land-use changes projected by the two modelling environments used and present the results by scenario. Subsequently, we provide – hopefully, plausible – narratives linking the

predicted land-use changes in the scenarios to policy options that may have triggered or – at least – fostered these changes. Finally, we condense the policy options used in the different scenarios into a set of six distinct types of policy options and assess their respective 'fit' across scenarios.

3.1 Land-use change under different scenarios

Figure 2 summarizes the land-use changes for cropland, forest, and grassland under the four scenarios projected by the modelling environments IMAGE-GLOBIO and CLIMSAVE.

Figure 2: Land-use changes under different scenarios – Modelling results of IMAGE-GLOBIO and CLIMSAVE

3.1.1 Modelling results for United-We-Stand (UWS)

Both models estimate strong cropland loss in UWS with up to 40% cropland decrease relative to the baseline situation in 2010. This reduction is caused by increases in crop production efficiency through improved land management (agricultural intensification) and a moderate increase in international trade. The two models also produced similar forest trends. Forest area increases in IMAGE-GLOBIO (+14%) due to the conversion of natural forests (e.g., Northern Europe) and abandoned cropland (e.g., Eastern Europe) to managed forests. The CLIMSAVE model also shows an increase in forestry. However, this increase is considerably larger (+80%) as, with limited pressure to produce food, and technology enabling a sufficient production in smaller areas, agricultural land is abandoned and natural forest allowed to grow.

While CLIMSAVE and IMAGE-GLOBIO show similar trends in the arable and forestry sectors, the models diverge in their results for grasslands. IMAGE-GLOBIO projected an increase (+9%) in both, natural and managed grasslands through the conversion of abandoned croplands. The CLIMSAVE model, however, shows decreases across all grasslands (-35%), particularly managed grasslands. This reflects the fact that 10% more food is imported so that less EU livestock production is required to meet food demand, which causes a reduction in managed grassland, replaced by unmanaged forest in many locations. All in all, in this scenario, there is limited pressure on the production side of forestry and agricultural systems.

3.1.2 Modelling results for Wealth-being (WB)

Apart from grassland, both models produce similar results under the WB scenario. With respect to cropland, as with UWS, IMAGE-GLOBIO predicts a strong decrease (-20%) due to increased production efficiencies. However, greater meat consumption, population growth, and a globalized trade resulted in continued cropland utilization. Under CLIMSAVE there was little overall net change (-3%) in cropland area at the European scale. Yet, there is a notable shift in the distribution of croplands from areas most affected by climate change (e.g., the Mediterranean and South Eastern Europe) to northern parts of France, Italy, Germany, and Eastern Europe.

Both models projected increases in forest area (+9% and +23% with IMAGE-GLOBIO and CLIMSAVE respectively) with CLIMSAVE showing land converted to forest from cropland that is no longer profitable due to climate change. In addition, IMAGE-GLOBIO simulated the conversion of natural forest areas to managed forest to satisfy economic needs.

Regarding grasslands, CLIMSAVE calculated a decrease (-19%) and redistribution as former managed grasslands became unprofitable, and natural grasslands were lost in some areas, such as Eastern Europe. IMAGE-GLOBIO estimated a slight increase (+5%) of total grassland areas driven by the expansion of managed grassland (on former cropland and natural grasslands) to satisfy meat demand.

3.1.3 Modelling results for Eco-Centre (EC)

Model results within the EC scenario exhibited quite substantial heterogeneity compared to other scenarios. For croplands, IMAGE-GLOBIO results indicated a decrease (-18%) driven by a moderately increased productivity and reduced meat consumption, while CLIMSAVE shows an increase (+16%), due to increased biofuel demand and arable land set-aside for nature, a reduction in imported food and low levels of agricultural technology relative to WB and UWs. Forest area grows (+7%) in IMAGE-GLOBIO as abandoned croplands underwent conversion into managed forests in Eastern Europe and natural forests grew in Southwest Europe. There is little overall net change in forest (-2%) in CLIMSAVE, and both natural and managed forest lose area to the expanding croplands – although to a lesser extent than is seen in Rural

Revival as the existence of technological improvements provides more options for land management. Grasslands shrink due to diet change and cropland expansion; and some natural grasslands in the north of Europe are lost to forestry in CLIMSAVE (-9%). IMAGE-GLOBIO simulated slight increases (+6%) in both, natural and managed grasslands driven by cropland decline.

3.1.4 Modelling results for Rural Revival (RR)

Under the RR scenario, the two models estimate different trends. Croplands increase in CLIMSAVE (+20%) due to an increased focus on self-sufficiency reducing imports (-20%) and due to low agricultural efficiency, an increase in biofuels, and land set aside for nature on arable land. Without technology and irrigation improvements climatic pressures will be playing a role here and croplands dominate Central and Eastern Europe and push into southern Sweden and Finland. IMAGE-GLOBIO cropland area decreased (-11%) because of the low overall crop demand which is a result of reduced meat consumption combined with population decline.

Forest areas also show different trends between the models. In CLIMSAVE, forests areas are lost (-12%) as croplands expand. In fact, within this scenario it is only possible to meet 77% of the timber demand due to the pressure from agricultural expansion. In IMAGE-GLOBIO, a slight increase in forest areas (+5%) is projected with trees planted on croplands abandoned due to the reduced demand. Grassland area shows slight increases in both models. Within IMAGE-GLOBIO, a significant reduction in meat consumption results in the strong decrease in managed grassland while natural grassland increases. CLIMSAVE shows an overall increase in grassland which is driven by increases in managed grassland needed to meet the food demand from lost imports, agricultural land being used for biofuel and set-aside instead of food, climatic pressures, and poor farming technology. Some natural grassland area is lost in Scandinavia and in the Mediterranean due to forest expansion as forest pushes north into previously unmanaged land and croplands creep into the more southern areas.

3.2 Connecting policy options and land-use change

3.2.1 Cropland

A number of policy options were developed by the expert group that could have led to – or contributed to/fostered – the changes in cropland projected by GLOBIO and CLIMSAVE modelling frameworks for the UWS scenario, such as a decreased agricultural demand through supply-side gains in productivity, as well as demand-side changes in consumption behaviour. Agricultural productivity gains were made possible by sustainable intensification through a strong EU agricultural policy (CAP). CAP subsidizes the implementation of technologies, such as precision farming, modern harvesting, modern irrigation, and genetic engineering, as well as land consolidation and incentives to set-aside grasslands and expand managed forests for second generation biofuels. Coupled with liberal trade policies these measures resulted in a reduction in cropland area as crop yields increase and consumption decreases.

However, some policy options result in slight cropland increases, namely the stimulating role of national bioenergy policies on energy crop production and rural development policies that cause small reductions in agricultural productivity in RR. A very small increase is also projected by CLIMSAVE which could be fostered by Ecosystem Services Framework (ESF) payments for regulatory services within the agricultural sector in EC.

3.2.2 Forest

Policy options within the forest sector are characterized by subsidies to promote woody biomass production in UWS and WB spurring afforestation. ESF payments oriented toward fostering multi-functional forests result in afforestation and particularly growth of multifunctional forests to meet biomass targets in EC. These policies result in substantial conversion of abandoned and unprofitable cropland to managed forests, particularly in South East Europe.

3.2.3 Grassland

In general, the majority of policy impacts result in a reduction of grassland area due to subsidized expansion of forestry and agricultural sectors. As would be expected, however, set-aside premiums for grassland and decreased meat consumption had large contrasting impacts on natural grassland and pasture, increasing the former at a cost to the latter. Woody biomass production incentives and forest-related ESF payments resulted in the expansion of managed forests which in turn led to small decreases of grassland areas. Rural development policies supporting less input-intensive land management have the effect of spurring agricultural extensification to account for lower agricultural productivities.

3.3 'Fit' of (types of) policy options across scenarios

Policy makers design or select specific policies to induce or prevent certain activities or decisions of targeted actors which are then expected to help to reach certain societal objectives or goals. Often they need to make their decisions under uncertainty, i.e. with a lack of knowledge about the potential consequences of their decisions. Depending on the specific details of the policy design, as well as the overall societal context / framework conditions, some (types of) policy options are more likely to reach the intended objectives than others, and to be selected or designed in the first place. These decisions can be informed by analyses, for example, using scenarios, modelling, and expert judgment to provide a broader perspective on what could happen and how viable the policy options are under different assumptions about the future.

This subsection is based on experts' assessments of the likelihood that the policy options developed in the respective scenarios will be able – or not – to reach their objective(s), or at least contribute positively to it, not only in the scenario they were developed in/for, but would be selected and effective in some – or all – other scenarios, i.e. that they would be 'robust' under different scenario-dependent framework conditions. It is important to note that is unlikely that respective policy options would be designed exactly and in all details in the same way in all scenarios. Thus, we rather refer to *types of policy options* allowing for some scenario-dependent variations in detail, such as targeted actors or regions, premium levels or production ceilings/restrictions.

3.3.1 Subsidies for technology-driven intensification of agricultural production

This policy option was developed in UWS mainly to satisfy increasing demands for agricultural produce, to reduce land cover needed for agriculture in order to have more land available for woody biomass production, and to reduce water used for agricultural production purposes by improving or developing appropriate (production) technologies. According to the experts' assessments, this policy type would be likely to be selected and effective in WB, although perhaps with a lesser focus on water savings. What is more, while this policy option might take the form of direct subsidies to farmers and other land users in UWS, in WB the policy might rather work through incentives to establish Public-Private-Partnerships or financing respective research. The experts also expect this type of policy options to only play a modest role concentrating on the water-saving effects of new technologies to allow for a more sustainable (less intensive/organic) farming. In

RR, however, this policy option is not likely to be of any importance due to the 'back-to-nature' and, by and large, 'technological extensification' approach characteristic for this scenario.

3.3.2 Liberal trade policy

This originally UWS-based/-featured policy option pursues, amongst others, the objectives to increase overall economic prosperity by putting hardly any restrictions on export and import activities – focusing, however, on trade activities between EU Members States, while indeed establishing some measures to protect the EU market from negative impacts. Further, it aims at satisfying an increased demand for agricultural products within the EU, despite an increased share of agricultural land turned into areas for the production of woody biomass. This policy option is also featuring prominently in WB as a means to foster (national) economic prosperity and before the background of a deregulation of markets, yet the concrete design of this policy option, and, thus, the degree of 'liberalism' in trade is likely to strongly vary among European countries. Liberal trade policies are assumed also to play some role in EC, where trade policies are not really at the centre of activities, yet international trade – at least within the EU – in general is encouraged. Again, this policy option is not relevant in RR, with its focus on the promotion of local and regional level activities.

3.3.3. Direct payments for woody biomass production

This policy option has its origin in both, scenarios UWS and WB, in both cases with the objective to meet an increased energy demand triggered by economic prosperity and improved life-styles in a more or less climate-friendly, yet profitable way. However, while in UWS this policy option is embedded in – or at least accompanied – by a strong EU Common Forestry Policy, there are rather diverse national policies in place. Respective payments are also expected by the experts to play a significant role as part of the ESF in EC fostering, among others, multifunctional forestry. Perhaps at a somewhat smaller scale, regional-specific types of these direct payments are likely to be observed also in RR.

3.3.4. Subsidies for energy crops other than woody energy crops

Subsidies for non-woody energy crops play an important role in RR as well as in EC aiming at climate-protection. In WB and UWS, in turn, energy-crops and respective policies almost exclusively take the form of woody-biomass payments, thus this policy option will not feature prominently here.

3.3.5. Integrated Ecosystem Services Framework policy: Payments for providing regulating services and promoting multifunctional forestry

The ESF policy option has its origin in the scenario EC and aims at a (more) balanced provision of all categories of ecosystem services, in particular taking regulating services into account. The experts assume that similar, yet national-/regional-focused policies for an integrated provision of ecosystem services can also be expected in RR. In turn, there will be no ESF-policies in UWS and WB: WB does not feature EU-level-based integrated policies and does not have a focus on regulating ecosystem services and multifunctional forestry; the latter also holds for UWS.

3.3.6. Rural development policies supporting agricultural extensification of cropland

Rural development in its non-intensive way of producing agricultural products and the decentralized policy approach makes it an important policy in RR with the objective of fostering environmentally-friendly ways of farming, and to some extent also in EC. However, due to the strict focus of agricultural intensification in UWS and WB the experts do not predict this policy to be of any relevance in UWS and WB.

4. Discussion and conclusions

This Deliverable is based on synthesizing two strands of research: policy analysis and a scenarios and modelling approach. Our synthesizing exercise reveals a number of lessons learned that could be of interest for policy makers, and are outlined in Section 4.1. In Section 4.2, we discuss the shortcomings of our approach and the methodological lessons learned for future work on integrating policy analysis with scenarios and modelling approaches. We conclude by reflecting on our personal interdisciplinary learning.

4.1 Lessons learned for policy makers

More concretely, we discuss which policies are robust across many different scenarios and which policies work only under certain conditions. The maps, as an important outcome of the modelling exercise, help visualise the changes in land use, based on assumptions of what impact different policies could have. Yet, before we discuss particular findings, it is important to point out that our findings should not be considered as recommendations, but rather as 'food for thought' when looking at future policy making. In other words, our findings cannot be translated into concrete advice such as "if you implement this policy, change in grassland/arable land/forest will be X%". Methodological uncertainties of this approach, and of many scenario and modelling approaches in general, do not allow for direct policy advice. Uncertainties are increased by the rather long time horizon of our approach to 2050.

The issues with uncertainties become particularly visible when looking at the different modelling results for grassland. Due to differences in underlying assumptions of the two modelling approaches, outcomes in terms of changes in grassland coverage differ significantly, and policies could not be designed that would equally 'fit' to both models. These and other kinds of uncertainties inherent in modelling approaches need to be taken into account when policy makers take results into consideration (see also Ferrier et al., 2016). However, while there are uncertainties concerning grassland, one thing did become clear across scenarios and models: pressure on grassland is significant in all scenarios, and if conservation of grassland is on the agenda, strong protection policies must be designed.

Another more general lesson to be learned is that all scenarios and all modelling results show that policies lead to – or, at least, contribute significantly – to major, diverse/multiple, and 'parallel' changes in land use. This is indicated by the changes in all land uses in all scenarios, which are mostly at least 25% or even bigger. One potential conclusion, which can be drawn from this result, is that policies developed to strengthen one particular land use, can have significant consequences for other land uses, too. This highlights the need for cross-sectoral policy making, or at least for a broad look in policy impact assessment. Here, the ES concept might be helpful (Schleyer et al., 2016; Hauck et al., 2014).

- *Subsidies for technology-driven intensification of agricultural production*: This policy has a rather high fit across all scenarios, except RR. There are certainly different intentions for this policy, and different technologies are supported within the respective scenarios accordingly. However, in three of the four scenarios these kinds of subsidies would contribute to a decreasing demand for cropland (see Annex 4), but may also have side effects on other policy objectives.
- We found an even greater robustness for *subsidies to promote biomass production*, which generally fit with all scenarios albeit with major differences in the type of biomass promoted. This policy could result in a significant increase in forest area indicated in all scenarios (see Annex 4), but may also have side-effects on the management of forest and, thus, on biodiversity.

- *Liberal trade policy* is originally UWS-based and features prominently in WB, but may also play a role within EC. With its focus on fostering production and deregulation of markets, it may strongly vary among European countries. This makes it difficult to assess the overall impact on land use, but probably the pressure on land will increase, albeit its mitigation via intensification. Thus, without regulations balancing potential negative impact on biodiversity and ES, 'negative' effects will prevail.
- *Integrated ESF-policy* does really only fit into one particular type of scenario, the EC scenario. That means: it can operate only under specific circumstances (e.g., European policy approach, cross-sectoral integration, ES-driven policy making) and needs particular efforts. It could, however, result in significant benefits, not so much in the total area of land use changed, but for the management of land use. An ESF policy could be an important tool to ensure that land use is developed towards the provision of multiple ecosystem services not only looking at productivity, but also at the provision of regulating and cultural ecosystem services.
- Another policy with low general fit is the *rural development policy aiming at agricultural extensification* featuring only in RR. The reason is similar to the reason why also other policies have a rather low fit for RR: the governance modes, and, more importantly, the 'scenario philosophy' differs substantially from the other scenarios. In the RR scenario, a large-scale, bottom up transformation is assumed, driven by a societal desire to life in harmony with nature. Changes are driven by voluntary changes in behaviour and policies in general are merely supporting here and there. Top-down governance modes, independent of what they promote, are not appropriate here. Rather, flexibility, participation, and local and regional collaboration are important. Within CLIMSAVE, questions are raised about the challenges of being self-sufficient under climatic scenarios and potential problems that result from turning our backs on technology and that there will be winners and losers, for example, with respect to the consequences of climate change. The RR distribution shows that there is considerable potential in the (European) North to maximize opportunities with regard to crops – and significant challenges in the South where this will no longer be possible.

When looking at our findings, it is important to note that the policy options we suggested are very crude, i.e. they are not concrete instruments or measures, but rather policy types.

4.2 Lessons learned for the scientific community

In this Section, we reflect the methodological lessons we learned for future work on integrating policy analysis with scenarios and modelling approaches and reflections on personal interdisciplinary learning:

- What policy-driven rules can be implemented – considering specific model structures and resolutions – to represent policy assumptions, i.e. how can we better incorporate policies and policy assumptions into models to broaden our range of policies to be tested?
- For the policy analysts who took part in this synthesis exercise it was very helpful to obtain a better understanding of the concrete modelling approaches used, including the underlying assumptions, as well as the algorithms used, to 'project' land-use changes. In particular, capturing the – partly – different assumptions for projecting changes in grassland, and thus the substantial variances in results, proved to be important for finding policies that might have triggered these changes. A better understanding of the modelling approaches also showed the benefits of using modelling approaches for policy analyses, as it required policy analysts to go beyond more traditional policy analyses as conducted, for example, by Schleyer et al. (2015) and Bouwma et al. (2017), and to think about future policy options.

- The scenarios and modelling approaches provided a good boundary object-type (Star, 2010) shared basis for discussing these future options and to think about their robustness. More precisely, by combining scenarios and modelling we could single out the general *types of policy options* among the broad mechanisms that are applied in the governance of biodiversity and ES (Primmer et al., 2015). Discussing this kind of general policy mechanism ideas, Jäger et al. (2014) refer to policy archetypes and define them even in broader governance-mode like terms, which they consider to be robust under several different futures and thus able to 'work' even if uncertainties are high.
- Different modes of governance need to be modelled in different ways. The integrated models used in this paper use particular logics with regard to how land is allocated to meet demand for commodities in ways that assume optimisation across Europe (CLIMSAVE) and the World (IMAGE-GLOBIO). When interpreting scenarios modelled in this way it is important to reflect on the extent to which this logic of allocation fits with the scenario logic. For example, in RR, where there is a strong drive towards localism, the redistribution of land use to meet European food demand could take place – or there might be some countries that 'win', whilst others 'lose'. It would be possible to model decisions at different spatial resolutions, and there are types of models (such as agent based models) that are better designed to model local learning, sharing and competition, but these kinds of ideas are not yet embedded in the state of the art models represented by CLIMSAVE and IMAGE-GLOBIO.
- A very different lesson came from the situation that the EU Commission, represented by the EU Joint Research Centre (JRC) in our project, did not pick up the scenarios although they were meant for policy support in the EU Commission, following earlier experiences (Hauck et al., 2014). The reason for not working with the OpenNESS scenarios was that one of the main axis of the scenarios, the weak vs. strong EU, was not considered plausible, or rather politically inconvenient. This provided an interesting point of discussion in the project, as a weak EU appears very plausible from a scientific perspective, in particular in the current political environment. Thus, the interplay between science and policy creates additional challenges if science does not follow the political considerations of certain pivotal actors. In particular, where political relevant questions are addressed, scientific independence is decisive.

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Annexes

Annex 1: Synthesis paper Scenario Building and its Application (Priess and Hauck 2016)

Scenario Building and its Application

Joerg A. Priess and Jennifer Hauck*
(Helmholtz Centre for Environmental Research – UFZ, Germany, *and CoKnow Consulting)

Introduction and 'State-of-the-art'

Assessing uncertain futures Perceived uncertainties and risks can be considered to be the main motivation behind 'Futures Thinking' or 'Futures Studies' to assess potential economic, environmental, social or technical developments and their expected consequences on society and environment (or from a systems perspective – feedbacks between the components of complex social-ecological systems, e.g. Liu et al., 2007). A broad range of approaches such as Forecasting, Predictions, Trend Analysis, Visions, Collages or Mental Models is used to assess future developments and their consequences on the economy, society or the biophysical environment, of which scenarios are just one, though frequently applied method of 'Futures Thinking' (see: Audience Dialogue, 2014 for a glossary or World Futures Studies Federation, 2015). Many of the approaches and methods can be combined, which is frequently done in practice e.g. (participatory) scenarios and mathematical models. In the context of 'global change – policy – impact assessment' studies (OpenNESS belongs to this category), scenarios are one of the dominant approaches for assessing uncertain futures, for example the IPCC SRES scenarios, the scenarios of the Millennium Ecosystem assessment or UNEP's Global Environmental Outlook.

What are scenarios? The term scenario is widely used in different ways and contexts, making it necessary to arrive at a common understanding of how the term is used. Based on the OpenNESS Glossary (2016), scenarios are defined as "plausible, but simplified descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces and relationships. Scenarios are no predictions of what will happen, but ore projections on what might happen or could happen given certain assumptions about which there might be great uncertainty".

There are several **types of scenarios** that can be distinguished along different lines (van Notten et al., 2003). *Trend scenarios* explore the continuation of (and deviations from) currently dominant trends in society and policy and are often combined with *policy scenarios* to show consequences of future policies, while *explorative scenarios* explore plausible alternative futures. Another option is to develop *normative scenarios*, for instance possible futures versus desired futures. This is often used in combination with *back casting,* aiming at identifying, prioritizing and characterizing management strategies and policies. Which type of scenarios to develop depends on the objectives and the intended use and the users of the scenarios (e.g. quantified drivers as input for models; 'policy-free' storylines to test different policies).

For the **development of scenarios** different *inputs* can be used, e.g. based on stakeholder or expert consultations during workshops, interviews or questionnaires, but also using input from other scenarios or literature in general. Likewise different methods can be applied, like *back casting, visioning, storytelling, fuzzy cognitive maps*, and others (Alcamo et al., 2008; Keune et al., 2013; Kok, 2009). There are also multiple ways to check scenarios for internal consistency, e.g. using *expert rounds, models* or *cross table* approaches. Furthermore, multiple forms exist to present the possible future states, for example as *qualitative storylines* or visualized as sketches, pictures or (hypothetical) maps, or quantitatively as tables or graphs. The applications of scenarios are likewise manifold, common uses include: scenarios as research or decision support tools, for example, to assess possible impacts of alternative climates, impacts of policies or socio-economic changes on ecosystems and ecosystem services, integration of different knowledge domains or the establishment of scientifically based consensus (Acreman, 2005; Kok et al., 2011; Biggs et al., 2007; Liu et al., 2008; Mahmoud et al., 2009; Palomo et al., 2011). In order to ensure legitimacy and relevance of scenarios for the intended users it is considered advantageous to include/involve decision makers and other stakeholders in the identification and selection of key drivers,

the development of assumptions and corresponding scenarios (Alcamo et al., 2008; Kok, 2009; Priess and Hauck, 2014, Hauck et al., 2015), while in practice stakeholder involvement may vary between expert consultation and full collaboration. In subsequent steps scenarios maybe quantified e.g. using simulation models. Evaluation of simulation results, and in some instances also model development may be components of the participatory discussion process.
This short introduction already shows that many options exist to develop and use scenarios and we do not intend to provide an exhaustive methodological overview here. Instead, we will lay out the approach that we suggest for this cross-cutting methodology in OpenNESS, and explain the suggested approaches.

Scenario development in OpenNESS

Thematic focus of the OpenNESS scenarios: The EU level OpenNESS scenarios show the influence of different drivers of change on natural capital, ecosystems and their services (for an analysis of drivers please see Hauck et al., 2015). The question which policies are considered as relevant drivers is addressed at different levels. First, a team scenario developers, policy analysts and modellers established links between the policy frameworks and governance options at EU and national scale, to determine which policies might have led to the situation described in the various scenarios. Second, the user groups, primarily the OpenNESS case studies, identified and linked policies considered to be relevant at their scale (mostly sub-national or local) for their specific case.

Scenario design: The OpenNESS scenarios serve different purposes. Therefore, the scenario team (of OpenNESS scientists) considered a generic set of EU level scenarios in the form of **storylines** and **quantified drivers** as the most useful approach. Drivers and uncertainties identified by the primary users and the scenario team were organised along axes of key-uncertainties, similar to the IPCC or the GEO4/5 scenarios. Previous studies and scenario-manuals repeatedly pointed out that a low number of scenarios (3-6) is advantageous in participatory processes in order to avoid overburdening voluntary participants, scientists to be consulted, as well as the scenario team (Henrichs et al., 2010). In OpenNESS, four scenarios were developed along two axes of key uncertainties The OpenNESS scenarios (WealthBeing, UnitedWeStand, EcoCentre, RuralRevival) are explicitly addressing midterm (until 2030) and longterm changes (until 2050). The conceptual framework and methods for integrative scenario development mainly followed Priess and Hauck (2014). They based their participatory scenarios on three components of a scenario framework: 1) User and stakeholder participation, 2) Knowledge integration, and 3) Quality control, all of which are considered prerequisites to developing integrative scenarios that serve as common boundaries for case studies as well as for decision making needs at different levels. Scenarios typically are developed in a series of steps, e.g. the procedures suggested by Alcamo (2001) or Kok (2009). Similarly, a six step procedure has been followed for the participatory scenario development in OpenNESS, including iterative cycles / components: Establishing a scenario team - Review of drivers (Hauck et al., 2015)- Selection of drivers (and indicators) - Development and review of storylines - Application of scenarios at EU / case study levels – Synthesis and feedback to case studies and EU level. Considering the degree of participation as a range between expert rounds (low) and full co-design (high), stakeholder involvement in the OpenNESS development process can be considered intermediate. The scenarios are built on a priori results identifying drivers of change from case study questionnaires and repeated discussions with case studies and an EU-level stakeholder workshop, while most of the details and the quantification of drivers have been elaborated in an iterative quality assurance process by the scenario team involving additional experts, mainly experienced scenario developers and modellers.

Open Problems/Issues to be

1. The development of scenarios in the case studies has been supported by the scenario team during workshops and via repeatedly providing support during the individual processes. Saliency and relevance of the scenarios at the case study scales and the utility of scenario methods in different decision-making contexts will be discussed in the end of the OpenNESS project.
2. As mentioned above, currently drivers of ecosystem change at EU level are being analysed, especially considering the added value of including ES/NC in current (or potential new) EU regulatory frameworks in

view of the goals the EU wants to achieve, but also the external impacts of the EU policies on regions outside Europe. The analyses involve policy analysts, scenario developers and modellers of different OpenNESS teams and shall provide input for the recommendations to decision makers planned as one of the key outreach products of OpenNESS also serving as input to the IPBES Regional Assessment on Europa and Central Asia (Hauck et al. in preparation). Inputs from different stakeholders and experts are expected to ensure relevance and saliency, firstly for the OpenNESS case studies, and secondly for other potential users (Alcamo and Henrichs, 2008; Priess and Hauck, 2014), for example, at EU or other levels.
3. Finally, by providing common boundary conditions for case studies and simulation models (Priess et al. forthcoming) such as CLIMSAVE and GLOBIO / IMAGE, we increased comparability of model simulations (Veerkamp et al. forthcoming) and case studies and facilitate integrative analyses across Europe.

Significance to OpenNESS and specific Work Packages

WP1 (Key challenges and conceptual frameworks): The scenarios and their applications address the four challenges. Beyond, it is expected that the application and stress-testing of the scenarios will reveal different strategies and policy frameworks addressing NC and / or ES.

WP2 – 3 (Regulatory frameworks and drivers of change and Biophysical control of ecosystem services): In WP 2 the scenarios were developed (task 2.3) and also serve as an example in the scenario guidelines (task 2.4). WP3 scientists contributed significantly to scenario development, co-designing the list of scenario drivers and leading their quantification for input into the simulation models of WP3 and others.

WP2 - 5: The objective of Task 2.3, as described in the proposal, is to develop an integrative multi-scale scenario approach to analyse drivers of ecosystem change on the EU level and (Task 2.4) to develop guidelines for undertaking a participatory scenario approach at case study level. Together, tasks 2.3 and 2.4 are called the cross-cutting methodology "**Participatory Scenario Building Methodology**". Thus, the scenarios contribute to achieving the use of common assumptions about factors driving ecosystem change or changes in ecosystem service provision, indicators and methods at EU level, across WPs 2-4, while WP5 case studies can use the OpenNESS EU level scenarios as a starting point for participatory scenario building processes at their regional / local levels, e.g. via adapting / downscaling them to their scales and thematic foci. The final goals of the scenarios are to facilitate and enable synthesizing, e.g. impacts of different modes of governance on different ecosystem services, or compare indicators across regions and cases.

WP6 (Integration: Synthesis and Menu of Multiscale Solutions): The scenarios are being made available on OPPLA and may also serve as input into additional outreach or dissemination processes within and beyond OpenNESS.

Relationship to the four challenges

Governance: The storylines facilitate a (participatory) prioritisation and evaluation of policies and regulatory frameworks ensuring the relevance and usefulness of the scenarios for the intended users. Furthermore, the common framework of scenario assumptions facilitates testing the robustness of policies (Hauck et al. in preparation) e.g. via comparative analyses across OpenNESS case studies.

Human well-being: The OpenNESS case studies and modelling approaches focus on different contributions to human well-being from ecosystems influenced by different drivers of change. The participatory approach ensures that these drivers are addressed in the scenarios. Subsequently, participatory scenario workshops could explore the human wellbeing of different stakeholders across scenarios.

Sustainable Ecosystem Management: In the scenarios very different types of land and ecosystem managements are assumed to assess a broad range of their potential positive and negative impacts. (See simulation results (Veerkamp et al. forthcoming; Priess et al. forthcoming).

Competiveness: The OpenNESS scenarios make explicit assumptions about changes in different sectors of the economy, lifestyles, demography, urban and rural areas etc., several of them with potentially strong impacts on competiveness. It is envisaged that case studies and modellers will analyse the multiple impacts on NC, ES, human well-being etc. in the different scenarios, and their impacts on competitiveness. (See simulation results (Veerkamp et al. forthcoming; Priess et al. forthcoming)

Recommendations for the OpenNESS consortium

User and stakeholder participation: In order to achieve the benefits associated with the scenario development process, such as joint learning, the development of consensus about goals or to improve the ability to deal with uncertainty in decision making, it is necessary to involve the relevant stakeholder groups in the development process (case study leaders, modellers, EU-level stakeholders). So far we have been involving all groups as envisaged, but especially at EU level to a lower degree than originally foreseen, i.e. limited to one though intensive workshop in Brussels.

Knowledge integration: Scenarios integrate knowledge from different disciplines (e.g. developer teams) as well as scientific and other forms of knowledge, e.g. contributed by (inter-)national/local stakeholders. Especially interdisciplinary knowledge integration worked extremely well, most probably benefiting from previous experiences of most of the participants. Some caveats we had to overcome were e.g. related to differing perceptions of what scenarios are (key-components, purpose), and their applicability in some of the case studies, related to differing ideas how detailed or how generic storylines and drivers and the assumptions therein should be (policies, thematic issues).

Scenario application: Case studies, modellers and policy analysts were strongly encouraged to apply and stress-test the scenarios, to increase comparability and facilitate integrative analyses including the identification of promising policies or policy frameworks both at EU and case-study level. Currently, scenarios are being applied in all contexts envisaged, but it is too early to derive final conclusions, e.g. whether they contributed to facilitate case study syntheses. So far, different models parameterized with the OpenNESS scenarios already produced promising results addressing land use changes in Europe and their impacts on several ecosystem services. Additionally, a larger team is working on the links between policies and the pathways assumed in the scenarios.

Three 'Must Read' Papers:

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Disclaimer: This document is the final version of the Synthesis Paper on the topic within the OpenNESS project. It has been consulted on formally within the consortium in 2015 and updated in 2016.

Annex 2: Description of scenarios

Wealth-Being – WB (Sectoral policies; dispersed responsibilities)

Trigger of change

With a conventional strategy of ***sectoral policies in combination with semi- dispersed responsibilities and*** a consequent deregulation of markets, based on international trade agreements, governments in Europe, as well as in the rest of the world, manage to overcome the economic crisis temporarily maintaining political stability in most countries. However, some European countries manage to regain a leading position in the global economy.

Mid-term developments (until 2030)

Political, societal and economic change: The economic success is accompanied by giving up the European objectives of achieving comparable living standards all over the EU, and in general by reduced social and environmental standards reflected in decreasing ambitions of EU environmental policies, with issues increasingly being handled by national legislation. In Europe, private investments supported by several national policies foster the growth of export sectors especially for industrial and agricultural commodities. Economically and politically, Europe and the rest of the world develop along the same lines, and Europe continues to attract immigrants. As within Europe, at the global scale large differences in economic growth remain, particularly in Africa.

Urban, rural and grey infrastructure development: The combination of neglected rural infrastructure and continued mechanisation and intensification of agricultural and forest production lead to ever increasing unemployment in rural areas and migration to urban, industrial centres. Nevertheless, a substantial fraction of Europeans benefit from the growing prosperity, and increasingly use their incomes for leisure and off-time activities. Among young urban professionals the new "Nature Domes®" become fashionable, which are built close to urban centres.

Land use and environmental conservation: High technical efficiency combined with low environmental and social standards decrease costs and enable exports of meat and other agricultural goods and services, which are driven by strongly increasing demands mainly in Asia and Latin America. In addition, within and beyond Europe, the demand for renewable raw materials such as rapeseed oil, ethanol, etc. rises, due to the rapidly increasing price of fossil fuels and the strong growth in industrial production. Consumerism is the leading life style all over Europe, and the majority of Europeans enjoy the benefits of the flourishing economy. This preference also includes growing demands for ecosystem services, related to tourism and recreation, but also for rare natural products such as truffle, game, certain wild berries and herbs, and fish from ever-diminishing stocks. Simultaneously, an alliance between agrarian and industrial lobbies additionally weakens policies protecting the environment and preserving nature.

Long-term developments (until 2050)

Even in the long run, energy provision in Europe and the world follows a very conventional pathway mainly based on fossil fuels. At the same time, the massive exploitation of provisioning services and associated regulating services related to soils and water purification, leads to a widespread degradation of agricultural and aquatic systems and the services they provide. From the 2030s onwards, consumerism is still the dominant lifestyle. The ongoing shrinkage of the European population, is outpacing immigration, which is regulated by demands from the labour market. The shrinking population somewhat reduces the pressures on natural resources. Due to growing production and ongoing technological development, some European countries / companies become world leaders in bioenergy and biochemistry related technologies and materials, going hand in hand with the increasing area of wood plantations due to the high need for bioenergy. In turn, prices for all land intensive commodities continue to rise, due to the increasing demands within and beyond Europe. Step by step, a growing fraction of the population is affected by increasing prices for energy, food and nature-related ES. The continuous consumption and leisure-oriented lifestyles leave an increasing number of people with few available options than to fulfil their recreation and outdoor demands nearby in the growing number of "Nature Domes®" popping up all over Europe, while the wealthier continue to enjoy the still mostly unspoiled nature of Northern Europe and other scenic & sparsely populated regions.

United-We-Stand - UWS (Sectoral policies; concentrated responsibilities)

Trigger of change

In order to overcome the crisis of the 1st decade of the 21st century, member states develop a United-We-Stand mentality, leading to the reinforcement of the "European Dream", where individuals find security not through individual accumulation of wealth, but through connectivity, social justice, and respect for human rights and a considerable strengthening of European institutions and organisations.

Mid-term developments (until 2030)

Political, societal and economic change: Part of the United-We-Stand mentality is a strong focus on prosperity of all member states and all policies developed are aligned with this goal. An increasing number of EU states join the Euro-zone increasing EU-internal trade and cooperation. While the idea of equally prospering states is expanded to include goals of equally prospering societies within Europe, it stops at the borders of Europe due to strong competition with other globally successful economic players. Although Europe remains open and does not move to austerity, repeated complaints are phrased about Euro-centric visions and policies. Economically, Europe and the world are developing at a comparable moderate pace. Successful application of existing and new technologies (CCS, fracking, soil remediation and others) to deal with (environmental) problems, strengthen the general belief in technical solutions. This strong belief in technological solutions and in Europe's leading role in technology development, make this the most important motor for prosperity. Profound investments are made all over Europe in technical education to supply the various industries with skilled personnel. However, global demand for labour is also increasing and together with a continuing low birth rate in Europe this results in strong competition for labour. In order to remain attractive for employees the EU designs and implements strong social policies in accordance with the idea of equal prosperity in Europe. These lead to a substantial increase in minimum wages, but also social policies to develop social capital, such as networks, social trust-building and socio-cohesion. The strong trust in technical solutions and extreme focus on equal prosperity leads to other areas being neglected, including environmental concerns amongst others. Progress in moving from fossil fuels to renewables is slower than expected, mainly focusing on technical solutions such as tidal and geothermal power plants, which benefit, like all other sectors, from general technological progress and increasing efficiency.

Urban, rural and grey infrastructure development: The strong focus on technological development requires the development of associated industries and infrastructures and consequently leads to a concentration of population around centres of technology development and subsequent urban sprawl.

Land use and environmental conservation: While the leading lifestyle is dominated by consumerism, the importance of regulating services such as natural flood regulation, water purification or climate regulation is decreasing, due to technical solutions. However, the production of all the technologies goes hand in hand with an increase in greenhouse gas emissions, land-use change and exploitation of mineral resources, for transportation, industrial production and housing. In countries specializing in agricultural production, the use of provisioning services is dominated by technological developments, e.g. via GMOs, agricultural production in multi- storey buildings, hydroponics, etc. In accordance with the United-We-Stand mentality, European citizens prefer to stay in Europe for their holidays and visit areas of important European cultural ES. Apart from these few ecosystems with high cultural value, which are kept in a museum like state, the state of ecosystems all over Europe is subordinated to other interests.

Long-term developments (until 2050)

On the one hand societal progress and prosperity in Europe attract increasing numbers of (skilled) immigrants and strong social and family-friendly policies even lead to a slight increase in birth rates after 2030. On the other hand the degradation of ecosystems in some European regions push technical solutions to their limits and require increasing amounts of money. Increasing environmental problems motivate the transition from fossil fuels to renewables, with a strong focus on technical solutions and less on bio-based options. Simultaneously, the growing demand for provisioning services such as agricultural commodities and base materials is satisfied by imports from outside Europe, triggering an increase in agricultural areas outside Europe. This development also balances to some extent the huge trade surplus based on the export of industrial products and technologies.

Eco-Centre - EC (Cross-sectoral policies; concentrated responsibilities)

Trigger of change

The ecosystem service concept is at the heart of a European-wide campaign for environmental education and awareness raising for alternative ways of live, addressing all levels of society including administration, schools, universities, responsible employers and industries, sports clubs and many more. Thus a strategy of ***cross-sectoral policies and concentrated responsibilities wins through.*** While Europe is the front runner in these developments, the positive effects are realized around the globe and other countries follow.

Mid-term developments (until 2030)

Political, societal and economic change: The campaign starts to pay off and younger people especially start to demand more careful and sustainable management of natural resources and ecosystem services. Facilitated by the developments in new social media, movements such as attac and blockupy are turning into successful mass movements, leading to the voluntary reduction of consumption and the use of ecosystem services motivated by the shift of environmental self-identity. Demands also include environmental justice, i.e. the equitable distribution of environmental risks and benefits; participation in (environmental) decision-making; social acceptance of different ways of life, local knowledge, and cultural difference; and the capability of communities and individuals to function and flourish in society. Apart from voluntary reductions in consumption, the social movements also facilitate strong European policy making. Policy making is generally developed towards integrated policies rather than sectoral approaches, in which environmental issues are strongly mainstreamed with the help of the ES concept and more concretely with ecosystem service offsetting, quotas, and restoration. Taxes on labour are reduced and compensated by an increase of taxes on consumption. Further, the Gross Domestic Product (GDP), as a measure of economic growth, is replaced by the Genuine Progress Indicator, to account for environmental and social factors. Another new development is to experiment with the co-design of policies between policy makers at the European level and policy takers or implementers across different levels, to facilitate implementation of policies towards sustainable ecosystem management. While Europe has an inspiring effect on other parts of the world, economic developments and associated decreasing levels of poverty lead to an increase in overall global consumption.

Urban, rural and grey infrastructure development: Urban development is determined by all kinds of greening, e.g. guerrilla gardening is developed into widespread practices of urban gardens going hand in hand with the conversion of urban brown fields into new urban green. These technological changes are facilitated by an increasing Open Source-mentality clearing the way for multi-facetted developments targeted towards efficiency and the loss-preventing use of raw materials.

Land use and environmental conservation: The shift of preferences towards a reduction of consumerism has especially strong effects. Much of agricultural production is converted into organic farming or sustainable integrated farming and reduced consumption of animal products and increased productivity of ecological farming lower the pressure on land resources. Environmental conservation has two components. On the one hand the ES concept is mainstreamed into agricultural, water and forestry policy to ensure sustainable use. On the other hand, the idea of ”rewilding” is promoted as a complementary strategy.

Long-term developments (until 2050)

In the last two decades most of the environmental movements and NGOs supported national governments and the EU administration in their efforts to develop and adapt environmental legislation, including the twofold increase of protected areas. However, the unsuccessful trials of participatory policy design at the EU level, due to immense administration and considerable limits in feasibility. While the EU continues to be a strong actor, its role changes towards an institution which facilitates regional approaches and pan-European knowledge exchange.

Rural Revival - RR (Cross-sectoral policies; dispersed responsibilities)

Trigger of change

After several food, feed and spoiled meat scandals during which hundreds of people were hospitalized and millions of livestock had to be killed and destroyed, waves of concern, angst and distrust in national and European politics shook Europe. Local, but coordinated responses win through by the development of cross-sectoral policies and dispersed responsibilities.

Midterm-developments (until 2030)

Political, societal and economic change: Green, idealistic citizen movements and all sorts of religious and social splinter groups call for a simple life and extreme shifts in lifestyles, which gain high popularity and support almost overnight. Established political parties, industrial production and conventional agriculture lose their dominant societal roles, and are increasingly replaced by more cooperative and less wealth-oriented policies, organisations and companies, which rapidly leave the small niches they occupied during the last century. Local and regional manufacturing and agricultural production increasingly dominate markets. In spite of the dwindling EU institutions, the "back to nature" movement seems to provide stronger European cohesion and sense of place than previous periods. As side effects of the drastic changes in lifestyles and preferences, criminal activities and violence fall to the lowest ever levels. On the other hand, outmigration of those who do not want to change their lifestyles is increasingly outpacing immigration to European countries. European economic development falls behind the rest of the world, also because agricultural scandals happened in Europe and globally consumers have less trust in European products.

Urban, rural and grey infrastructure development: Step by step urban brownfields are converted to urban green and mostly small-scale subsistence agriculture. Yet, while in the bigger cities different lifestyles and forms of production coexist, many rural areas are increasingly gaining social and economic importance benefiting from well adapted back to nature strategies. In rural areas all over Europe, regional green IT-networks are replacing the old internet, spreading and sharing successful back to nature strategies, providing communication channels and dealing in regional products. The resulting social and economic changes are dramatic, as increasing fractions of the population turn away from urban centres and gainful employment and look for rural places, safe food and different types of work and sustainable lifestyles.

Land use and environmental conservation: An increasing number of experienced and new farmers and cooperatives start to diversify production, at lower levels of land-use intensity and mechanisation. Initial difficulties make imports of agricultural commodities from outside the EU necessary. Europe's temporary agricultural imports only partly compensate for the huge amount of feed and other products imported before the crisis, causing a net reduction in trade and revenues outside Europe. In the 2020s hot debates between long established environmental NGOs, traditional political parties and new but relatively strong political parties related to back to nature movement occurred concerning the design and goals of protected areas. While all agree on a doubling of protected areas, disagreement remains on whether to allow partial use of the areas or complete human exclusion.

Long-term developments (until 2050)

After the European economy and many EU institutions dwindled in the late 2020s and early 2030s, Europe has been losing power and many of its leading roles in politics and the economy. However, many branches of the back to nature movement have been wise enough to coordinate the countless applications and research in re-establishing and promoting numerous of the well adapted varieties of almost forgotten crop types, vegetables, fruits, old livestock races and sustainable management strategies on regional and national levels. Some of the larger cooperatives gain importance in Europe and beyond in production and distribution of robust seeds, livestock, but also technologies adapted to sustainable production. While successful regional organisations / cooperatives are increasingly trading with similar cooperative organisations, which are gaining popularity in other parts of the world, some of the less organised regions seem to be left behind. In contrast, many of the large multi-national companies and agro-industries move out of Europe, while several others adapt strategies, technologies and company structures to better match new demands and markets. After the recovery of the restructured economy, inner-European and international trade slowly increases to moderate levels.

Annex 3: Quantified drivers

OpenNESS scenario drivers

The table shows the relevant drivers which were needed as input for the two model GLOBIO and CLIMSAVE to estimate land use, ecosystem services and biodiversity change in 2050 under different future environments.

For each driver, the WP2 team discussed the change of driver per scenario qualitatively (+/-), derived from the logic of the scenario storyline. Based on this information the modelling team quantified the drivers with numbers (e.g. -6/+10) based on the state-of-the-art global simulation models. GLOBIO based the quantification on the Shared Socio-economic Pathways (the 'new' IPCC scenarios) but adjusted the drivers (e.g. change in dietary preferences, PA, biofuels) for Europe[1] to be in line with the OpenNESS storylines. We tried to quantify the drivers with the same numbers in both models, however, some drivers are different between the same models due to different model environments (e.g., GLOBIO cannot adjust population and GDP changes but follows IIASA and OECD projections resp.).

Table A3-1: Quantified drivers

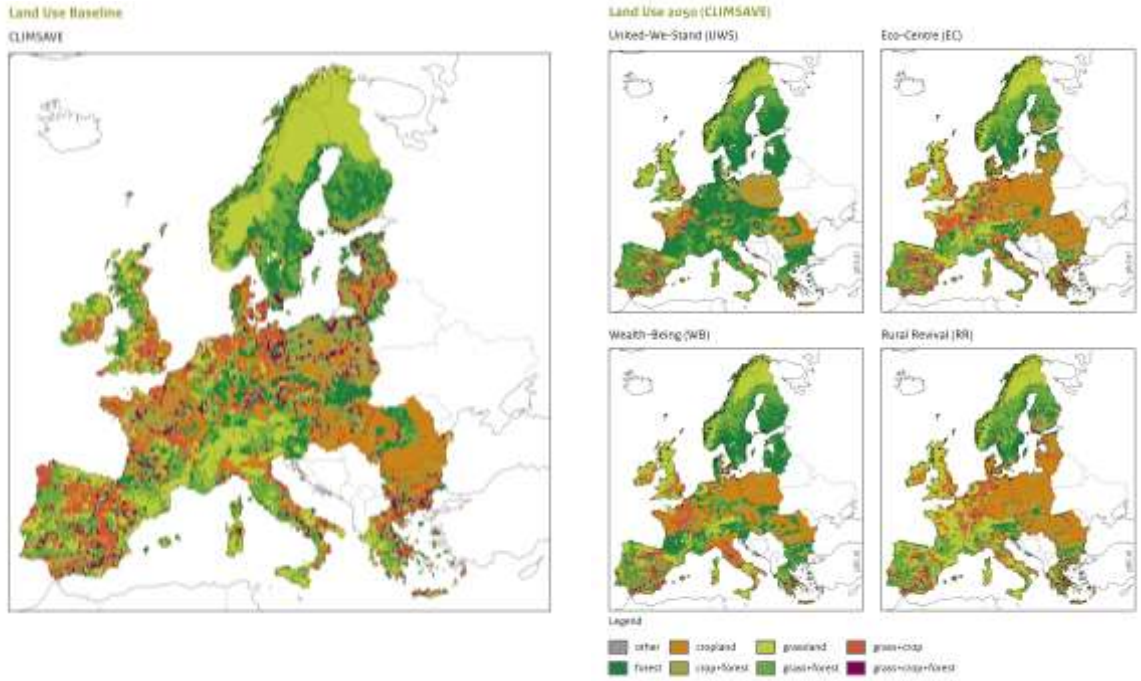
DRIVER	MODEL	WEALTH BEING (WB)	UNITED WE STAND (UWS)	ECO- CENTRE (EC)	RURAL REVIVAL (RR)
Population **change (%f from current[2])**					
	WP2	-	+ → 0	0 → -	--
	GLOBIO	+23	+10	+7	-8
	CLIMSAVE	+10	+1	-6	-16
Change in dietary preferences **(% from current)**					
	WP2	++	+	-	--
	GLOBIO	+20	+10	-20	-40
	CLIMSAVE	+20	+10	-20	-40
Change in agricultural mechanization **(% from current)**					
	WP2	++	++	-	--
	GLOBIO	/	/	/	/
	CLIMSAVE	+75	+75	+10	0
Change in agricultural (crop) yields **(% from current)**					
	WP2	++	++	+	-
	GLOBIO	+50	+50	+15	-10
	CLIMSAVE	+50	+50	+15	-10
Change in irrigation efficiency **(% from current)**					
	WP2	+	++	++	0
	GLOBIO	Medium improvement	High improvement	Medium improvement	Low improvement
	CLIMSAVE	+26	+58	+55	0

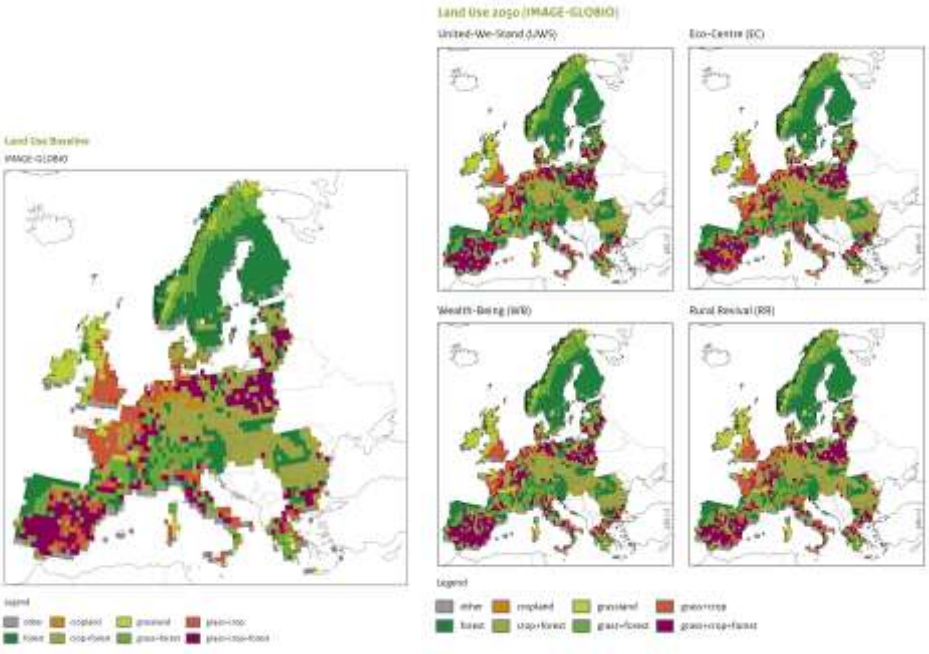
[1] Definition Europe: IMAGE/GLOBIO = OECD Europe countries + Eastern Europe; Climsave = ???

[2] Current = 2010

Change in bioenergy **production from crops (% from current – proportion of arable or crops used for bioenergy)**					
	WP2	+	0 → +	++	+
	GLOBIO	+9	0	+3	+8
	CLIMSAVE	+10	0	+20	+10
Change in food import **(% from current)**					
	WP2	-	0 → +	0 → -	+ → -
	GLOBIO	High international trade, with regional specialization	Moderate international trade, focus on globalization	Moderate international trade, semi-open globalized economy	Strong constrains, de-globalization
	CLIMSAVE	-20	+10	-10	-20
GDP **change (% from current) per capita**					
	WP2	++	+	- → 0	--
	GLOBIO	+43	+50	+53	+62
	CLIMSAVE	+70	+35	0	-20
Oil prices **($/barrel) (variables is relative increase: calculated relative to 2010 $77.1)**					
	WP2				
	GLOBIO	91 (+118%)	88 (+114%)	91 (+118%)	98 (+128%)
	CLIMSAVE	200 (+260%)	150 (+190%)	80 (+100%)	100 (+130%)
Changes in PA **(relative to Natura2000) (% from current)**					
	WP2	-	0	++	+
	GLOBIO	0	0	+86	+39
	CLIMSAVE	-50	0	+100	+100
Change in climate **(emission target 2100)**					
	WP2				
	GLOBIO	*8.5 W/m²* (without climate policy)	*5.4 W/m²* (without climate policy)	*6.5 W/m²* (without climate policy)	*6.5 W/m²* (without climate policy)
	CLIMSAVE	SRES A1, IPCM4, Medium climate sensitivity	SRES A1, IPCM4, Medium climate sensitivity	SRES A1, IPCM4, Medium climate sensitivity	SRES A1, IPCM4, Medium climate sensitivity

Annex 4: Modelling results land-use changes





Annex 5: Developing policy assumptions for EU-level OpenNESS scenarios

Input from

1. OpenNESS WP2 meeting, November 2014, in Berlin,

Session on: **Linking Policy Analysis & Scenarios**, and

2. OpenNESS-Stakeholder workshop, January 2014 in Brussel,

'Mainstreaming ecosystem services into EU regulatory frameworks'

Contributors: OpenNESS-WP2 and participants from the Brussels-Workshop

Aim of this document: This document aims at linking policy analysis of EU regulatory frameworks and policies and practical policy expertise with the EU-level OpenNESS-scenarios. From a *scenario perspective*, EU policies are considered to be amongst the most important drivers for ecosystem change.

The inputs from the meetings in Berlin and Brussels yielded expert opinions on how existing and potential new EU policies might play out in the four scenarios. (Inputs from both meetings were combined in the tables below). From a *policy analysis* perspective, the exercise contributed to reflect on different future developments of current EU regulatory framework as well as on different ways of mainstreaming the concept of ecosystem services.

Contents:

- Types of mainstreaming of ES&NC in the different scenarios
- Agricultural and Cohesion Policies
- Environmental Policies
- Rural and urban development policies

For most of the discussion the scenario horizon was 2050. In other words, some of the policies might already be in place and operational in 2030 or even earlier, while other developments will evolve until 2050 or even later. The latter is particularly relevant for those developments that entail more comprehensive societal or infrastructure changes including massive re-structuring in different sectors (transport, urban and other) infrastructure components like those expected in the scenarios 'Wealth-Being' and 'Rural Revival'.

Results: In most discussions participants realized that the scenarios leave room for a range of possible developments. Therefore more general assumptions were usually developed to be able to guide the development of more particular assumptions.

General assumptions on (policy) mechanisms:

United we stand

- European policy approaches
- Economically, Europe and the world are developing at a comparable moderate pace.
- Generally regulations are dedicated towards human needs and rather supportive of technical solutions
- Sectoral policy making, focus on economic and social well-being
- Industries and companies have strong lobby groups and are setting the best practice standards
- Strong command and control

Wealth Being

- Politically and economically, large differences between members states

- Very liberal scenario, which lobby groups dominating policy processes
- Focus on technological fixes

Eco-Centre

- Mixture between of bottom up, participatory/communication and information strategies on the one hand and strong command and control on the other hand
- High demand for sustainable products
- Cross-section goes beyond environmental policy integration towards joint development and co-evolvement of policies

Rural Revival

- Large differences between member states; cross-sectorial integration.
- Economically, Europe falls behind the rest of the world.
- There are many policies, but they are often not considered legitimate, as there are to many, divers interests groups. Therefore, implementation is rather weak, also due to a lack of financial means for implementation

Mainstreaming the concept of ecosystem services in the different scenarios:

A range of different degrees of mainstreaming are plausible:

- Weak definition: Starting with "ecosystem services" being a word to be dropped in the policy text or integration of a particular (environmental) issue/policy goal into other policy domains.
- Medium definition: while there is no "policy on ecosystem services" on its own, every policy is analysed for ecosystem-services. To some extend such an ecosystem services-check already exists in the form of an Environmental Impact Assessments. However, outcomes of these assessments are not taken into consideration, i.e. EIA are not very powerful (yet).
- Strong definition: policy coherence: coherence check across the whole policy area/sectors and for upcoming new issues. This does only concern public policies, but is mainstreaming in private policies (more governance perspective) as well.

These different types of mainstreaming can be understood as steps of a process but can also be associated to the different scenarios.

	United we stand	Wealth Being	Eco-Centre	Rural Revival
Type of main-streaming the ES concept	• Weak definition of mainstreaming • if ES are good for the society (e.g., health), the ES concept is used	• Weak definition of mainstreaming • ES concept used where it is helpful to promote innovation, or in win-win-solution • mainstreaming as happy coincidence	• Strong definition of mainstreaming • ES check for all (new) policies • Integrated co-design of different policies (e.g., social infrastructure, environment) • Policies and instruments balance trade-offs also with other regions	• Dominance of environmental concerns beyond mainstreaming of ES • Strong integration of conservation goals in all policies, not (only) ES

Outlook for further discussion: risks and opportunities for mainstreaming in different scenario's, in relation to policy frameworks and also for a longer term perspective until 2050.

Environmental policies in the different scenarios:

Closely linked with the assumptions concerning mainstreaming are assumptions concerning EU environmental policies. First some more general assumptions will be introduced, followed by concrete examples of the Birds and Habitats Directive, the Water Framework Directive, the Renewable Energy Directive and the Biodiversity Strategy.

Policies	United we stand	Wealth Being	Eco-Centre	Rural Revival
General assumptions concerning environ-mental policy	• Sectoral nature based solutions focusing on the utilitarian side of nature and not necessarily sustainable • Environmental regulation is dedicated towards human needs and rather supportive of technical solutions • Beyond immediate human use only weak Environmental policies with limited implementation = lip service	• Some differences in MS (rich-poor), • low environmental standards • Payments for Ecosystem services where private, economic interests are concerned	• Cross-section goes beyond Environmental policy integration towards joint development and co-evolvement of policies • Strict policy implementation	• There are many policies, and rather high standards but they are often not considered legitimate. • Different levels of resources in MS for tackling environmental issues

Policy	United we stand	Wealth Being	Eco-Centre	Rural Revival
Water policy and Water Framework Directive (WFD)	• Generally water policies are dominated allocation justice • WFD is weakened as the "good ecological status does not matter anymore, only if it is affecting humans. The chemical status of the water becomes more important: for drinking water, and bathing water, • Where technical solutions are feasible they are preferred. Possibly stronger: nitrate and bathing water directives due to direct relevance to humans • In the longer run (2050) WFD is fading-out	• Water policies are adjusted to the water demands for agricultural production, e.g., irrigation development policies; • WFD develops towards PES, where companies pay e.g. farmers for their management practices if they interfere with the drinking water quality • In the longer run the WFD fades out	• Policies focus on protection of water based ES, but in close collaboration with agricultural and other policies; • WFD is expanded and integrated with many other directives	• Regional approaches in water management; • No change of the WFD itself as compared today, but no implementation anymore
Climate policies and Renewable Energy Directive	• Focus on cheap energy for all • Highly volatile support of technologies that seems to be most promising at the time; • Support for the development of technologies such as CCS	• Markets drive developments of technologies, thus developments are significantly slower. • RED is still there but rather weak; • Overall low consideration of climate issues	• Strong EU regulation and funding, but integrated with other policies; • Strong European goals for emission reduction and strict conservation of climate relevant areas like moors	• Individual climate policies in different MS

Agricultural, rural and urban development policies in the different scenarios:

A third block of assumptions about EU policies encompasses agricultural policies and in particular assumptions about direct payments, agri-environmental schemes, and cohesion policy. This section contains assumptions about rural and urban development policies, including grey infrastructure, too.

Policy	United we stand	Wealth-Being	Eco-Centre	Rural Revival
Direct Payments	• focused on agricultural production, with 'social security' component (marginal or subsistence farmers) and focus on minimizing differences between MS • Budget: lower than WB	• focused on agri-cultural production in marginal areas; and support for production of high value agricultural products (e.g. meat, renewable materials) • Budget: Shifting from EU to national; implying increasing differences between MS; low(er than today) and fading out until 2050/60; • Depends on MS, strong	• a) PES scheme for ES bundles b) for organic production a) and b) as part of cross-sectoral frameworks in rural and urban contexts • Budget: unspecified	• a) payments to facilitate adapted solutions, innovation and local diversity in rural areas and at a later stage support inter-regional collaboration b) emergency fund for payments in case of failures, hazards, etc. Budget: very low
Agri-Environ-mental Schemes	• Cross-compliance with increasing social focus and decreasing environmental focus	• reduced cross-compliance demands	• a) PES scheme b) very strong cross-compliance regulations; • a) and b) targeted towards protecting nature and biodiversity, specifically fostering approaches in urban areas	• targeted towards protecting nature and biodiversity
Cohesion Policy	• powerful policy instruments, aiming at minimizing differences between MS / regions in Europe • Budget: substantial	• weak, not very strict, 'tolerating' large differences between MS / regions in Europe • Budget: relatively low	• powerful policy instruments, aiming at minimizing differences between MS / regions in Europe • Budget: substantial, but less than UWS	• weak, 'tolerating' large differences between MS / regions; focus on supporting local diversity and adapted solutions (adapted 'best practice'), for example, in rural areas • Budget: very low
Rural and urban develop-ment policies, including grey infrastruc-ture	• Regional cohesion policy to balance strengths and weaknesses of urban and rural development across Europe	• Growth driven development (e.g. investments in infrastructure) and highly competitive within and beyond Europe; no efforts in rural development	• Regional development is integrated in agricultural and other policies; • inclusion of ES necessary part of regional development funding	• Focus on rural development but, themes and foci are different and not harmonized between MS