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

D2.1
WATER-LAND-ENERGY-FOOD-CLIMATE NEXUS: POLICIES AND POLICY COHERENCE AT EUROPEAN AND INTERNATIONAL SCALE

LEAD AUTHOR: Stefania Munaretto

OTHER AUTHOR: Maria Witmer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement NO 689150 SIM4NEXUS

PROJECT	Sustainable Integrated Management FOR the NEXUS of water-land-food-energy-climate for a resource-efficient Europe (SIM4NEXUS)
PROJECT NUMBER	689150
TYPE OF FUNDING	RIA
DELIVERABLE	D.2.1 Policy areas relevant to the nexus water-land-energy-food-climate
WP NAME/WP NUMBER	Policy analysis and the nexus / WP 2
TASK	2.1
VERSION	4
DISSEMINATION LEVEL	Public
DATE	15/11/2017
LEAD BENEFICIARY	PBL
RESPONSIBLE AUTHOR	Stefania Munaretto
ESTIMATED WORK EFFORT	16,5 person-months
AUTHOR(S)	Stefania Munaretto (PBL), Maria Witmer (PBL), with contributions by Janez Susnik (UNESCO-IHE), Claudia Teutschbein (UU), Martina Sartori (UB), Anaïs Hanus (Acteon), Ida Terluin (WUR), Kees van Duijvendijk (WUR), Doti Papadimitriou (UTH), Nicola Hole (UNEXE), Robert Oaks (UNU), Georgios Avgerinopoulos (KTH), Roos Marinissen (PBL), Jan Janse (PBL), Tom Kram (PBL), Henk Westhoek (PBL).
ESTIMATED WORK EFFORT FOR EACH CONTRIBUTOR	PBL: 7 person-months, WUR 1,5 person months, all others 1 person month.
INTERNAL REVIEWER	Maïté Fournier (Acteon-environment), Daina Indriksone (BEF, Baltijas Vides)

DOCUMENT HISTORY

VERSION	INITIALS/NAME	DATE	COMMENTS-DESCRIPTION OF ACTIONS
1	SM/STEFANIA MUNARETTO	16-05-2017	FIRST DRAFT TO INTERNAL REVIEWERS
2	SM/STEFANIA MUNARETTO	24-05-2017	SECOND DRAFT, REVISED ACCORDING TO COMMENTS BY REVIEWERS. TO SIM4NEXUS PROJECT LEAD
3	SM/STEFANIA MUNARETTO	30-05-2017	FINAL REPORT TO SIM4NEXUS PROJECT LEAD
4	SM/STEFANIA MUNARETTO	15-11-2017	FINAL REPORT UPDATED ACCORDING TO 1ST YEAR REVIEW RECOMMENDATIONS

Version 4 of the report follows from the comments of the project reviewers, received on 12 October 2017. The table below illustrates how the comments have been addressed.

Review comments 12/10/2017	Adjustments in report
The inclusion of two summaries in the deliverables deserves some thoughts: one more technical (scientific or technical audience) and one less technical (non-technical audience, policy makers).	The 'short summary of results' on page 7 was adjusted to better address the general public.
In the executive summary conflicting policy objectives are well elaborated, while synergies are only called "more prominent", but not elaborated with the same level of detail (to focus not only on the negative aspects but also on the positive ones). It would be useful to add key-synergies identified in this analysis.	The executive summary now contains a paragraph highlighting the synergies. More synergies were also added to the conclusions in section 7.3.1.
Policies related to air pollution, energy poverty are not mentioned. The reasons were well explained, it would be useful just to mention it in the report.	Energy poverty was added to table 5 and air pollution to table 6. Furthermore, the reasons why these policies are not part of the coherence analysis are explained on page 27.
Table 2 focuses a lot on supply. Behaviours should be better covered.	The consumption perspective, education, awareness, attitudes and lifestyle were added to Table 2.
Table 2 should mention the ecological status of water and land, which are key concerns of and addressed in several regulations and policies and SDGs. Climate is addressed in a very generic fashion and clear links of adaptation/mitigation to the nexus domains are lacking. Please revise and be more specific.	Ecological status was included in Table 2 and adaptation and mitigation were better specified in the same table. More explanation is also provided on page 27-28.
Figure 2 displays multilateral relations, but calls them bilateral. This discrepancy should be clarified.	The caption of Figure 2 was adjusted, and a clarifying sentence was added to section 2.3.

Table of Contents

Executive summary

This deliverable identifies and reviews the policies at international and European scale that are relevant to the water-land-energy-food-climate nexus (WLEFC-nexus). Besides the policies directly aiming at these five nexus domains, other policies are relevant, especially in the context of strategies for a resource efficient and low-carbon economy in Europe. These are policies in the domains of economy, investment, R&D and innovation, ecosystems and environment, EU regions, development, risk & vulnerability and trade. Other policies may also be relevant, depending on the issues at stake, e.g. policies for economic sectors that have a key role in the SIM4NEXUS cases.

At international scale, two key policy documents are leading for the WLEFC-nexus:

- the UN 2030 Agenda for Sustainable Development;
- the UN Framework Convention on Climate Change (and related Kyoto Protocol and Paris Agreement).

Around the goals set by these documents numerous objectives have been formulated and many instruments exist to achieve them. Often, these are soft means, but there are also economic instruments that parties can use to achieve the goals such as emission trading, Joint Implementation and Clean Development Mechanisms in the context of the UNFCCC. In the food and climate sector, investment in developing countries is an important instrument.

European policies concerning the WLEFC-nexus are established by directives, regulations, decisions, road maps, plans and programmes. Coherently with the international policy arena, the EU policies integrate two key goals, namely sustainable development and resilient human and natural systems.

Synergies are more prominent than conflicts among European policy objectives that are relevant for the WLEFC-nexus. There are numerous objectives showing a high density of positive interactions with other objectives in the WLEFC-nexus. These are in general related to the sustainable use of resources, provision of ecosystem services and climate change resilience. If pursued with cross-sectoral, integrated policies, progress in the achievement of these objectives could have a cascade of positive, synergist effects in the whole WLEFC-nexus. For example, the objectives 'Ensure sufficient supply of good quality surface water and groundwater for people's needs, the economy and the environment' and 'Restore degraded soils to a level of functionality consistent with at least current and intended use' and 'Prevent soil degradation' reinforce each other, serve production of energy, facilitate climate change adaptation, reduce greenhouse gas emissions, and may help increase farm incomes and support rural areas economy. Furthermore, in the agricultural sector, if the greening and cross-compliance mechanisms are fulfilled, the objective 'Contribute to farm incomes' supports the achievement of water, land and climate objectives. Finally, the objective 'Promote resource efficiency in the agriculture, food and forestry sectors' supports water and energy efficiency and water availability, may prevent land degradation and indirect land use change, and supports the development and uptake of low-carbon technology.

Synergies among European policy objectives may reveal coherence problems when specific objectives and measures are articulated and implemented at national and regional scale. For this reason, the next step of the SIM4NEXUS policy analysis will focus on the implementation of WLEFC-nexus policies in 10 case studies at national and regional scale.

There are also policy objectives that are in conflict with most other EU policy objectives in the WLEFC-nexus. These are 'Increase of biofuel production', 'Increase hydro-energy production', 'Improve competitiveness of agricultural sector' and 'Support the development and uptake of safe CCS

technology'. Policy-makers should be aware that progress in achieving these objectives come at the expenses of other objectives in the nexus.

Two EU policy objectives showing high density of interactions and high relevance to the SIM4NEXUS case studies were assessed in more detail. These are: 'Increase of biofuel production' and 'Ensure sufficient supply of good quality water for people's needs, the economy and environment'. Direct and indirect interactions, coherence between policy means and vertical coherence with international policies were investigated for these two objectives. Also, the recognition of the interactions among policy objectives in policy documents, reflected by the presence (and quality) of references that policy documents make to other policy domains, was assessed. Some conclusions drawn from this analyses are:

- Potential conflicts that biofuel production may have with water quality are tackled in the European common agricultural policy (CAP). Conflicts with water quantity within the EU and water quality outside the EU are addressed in the EU renewable energy policy through voluntary reporting schemes. As a result, compliance of biofuel production to water related standards depends on strong water management at the production location and on the willingness of actors in the supply chain to reduce impacts on water resources. Potential conflicts caused by biofuel production with land use objectives are well addressed in the EU policy.
- Negative effects of hydropower on aquatic ecosystems, water quality and water quantity are not addressed in EU policies for renewable energy.
- EU policies for biofuels are generally coherent with international policies, except for the food security and affordable food prices goals in the context of poverty reduction, central issues in international food policy and in the Sustainable Development Goals (SDGs). The effects of biofuel production on these goals are weakly addressed in EU policies. According to the EU policies for renewable energy, the EC will monitor effects of biofuel production on food prices and security, but no concrete actions are mentioned if unwanted effects would be observed.
- The international objective 'Fully consider water and ecosystem footprints of alternative climate change mitigation measures' is not referred to in EU energy and climate policies, nor in international climate policies.

Interesting opportunities to share the SIM4NEXUS results at EU level are represented by the review of the EU energy package, the Water Framework Directive, the Common Agricultural Policy, the EU strategy on adaptation, the EU structural and development funds and the EU LIFE Programme. Identifying and seizing key windows of opportunity over the coming years to share the SIM4NEXUS results in the discussion of these policies is an important follow-up activity of the policy analysis.

Changes with respect to the DoA

No changes to the DoA

Dissemination and uptake

This deliverable is targeted at the general public, stakeholders in the global and European policy fields related to water, land, energy, food and climate, participants in the SIM4NEXUS project.

Short Summary of results

Water, land, energy, food and climate are interconnected, and European policy objectives in these sectors may interact with one another as well as with policies in other sectors. In this study we found that synergies are more prominent than conflicts among European policy objectives in the water, land, energy, food and agriculture, and climate sectors. Synergies can be found among objectives that

pursue the sustainable use of resources, provision of ecosystem services and climate change resilience. However, conflicts in these domains may start to manifest when more specific objectives and measures are articulated and implemented at national and regional scale. There are also European policy objectives that are in conflict with the achievement of many others. These include increasing biofuel and hydro-energy production, improving the competitiveness of the agricultural sector and supporting the development and uptake of safe carbon capture and storage technology. Finally, the European water, land, energy, food and climate policies are generally coherent with global policies, with the exception of the European biofuel policy that is not fully aligned to international food security and food price policies related to poverty reduction. The upcoming review of the EU water policy, EU agricultural policy, EU climate adaptation policy, EU regional funds policy and EU environmental policy (LIFE programme) offer the opportunity to share these results, thus contributing to policy change discussion.

Evidence of accomplishment

Submission of report. Publication of report on SIM4NEXUS website.

Glossary / Acronyms

Acronyms

CAP	Common Agricultural Policy
CCS	Carbon Capture and Storage
DG	Directorate General
EC	European Commission
EU ETS	European Emission Trading System
EU	European Union
FAO	Food and Agriculture Organization
GHG	Green House Gas
IWRM	Integrated Water Resource Management
MS	Member State
NCO	Nexus Critical Objective
NCS	Nexus Critical System
OECD	Organisation for Economic Co-operation and Development
SDG	Sustainable Development Goal
UN	United Nations
UNFCCC	United Nation Framework Convention on Climate Change
WEF	Water-Energy-Food
WFD	Water Framework Directive
WLEFC	Water-Land-Energy-Food-Climate

Glossary of terms

Policy goals	Policy goals are the basic aims and expectations that governments have when deciding to pursue some course of actions. They can range from abstract general goals (e.g. attaining sustainable development) to a set of less abstract objectives (e.g. increase energy efficiency) which may then be concretized in a set of specific targets and measures (e.g. achieve 10% renewable energy share).
Policy means	Policy means are the techniques/mechanisms/tools that governments use to attain policy goals. Similarly to goals, means range from highly abstract preferences for specific forms of policy implementation (e.g. preference for the use of market instruments to attain policy goals); to more concrete governing tools (e.g. regulation, information campaigns, subsidies); to specific decisions/measures about how those tools should be calibrated in practice to achieve policy targets (e.g. a specific level of subsidy in the renewable energy sector).
Policy process/ policy cycle	the policy process, often referred to as policy-cycle, is a set of interrelated stages through which policy issues and deliberations flow from inputs (problems) to outputs (policies). A typical model of the policy process includes: *agenda-setting* (problem recognition by the government); *policy formulation* (proposal for solution in the government); *decision-making* (process of selection of solution); *policy implementation* (how government puts solution into effect); *policy evaluation* (monitoring results, which may lead to reconceptualization of problems and solutions).
Policy interactions	Cause-effect relationship between policies and occurs when the content of one policy (goals, means, implementation practices) influences the performance of another policy such as the achievement of its objectives or the implementation of its instruments. Type of interactions between policy objectives:

	• Cancelling: Progress in one objective makes it impossible to reach another objective and possibly leads to a deteriorating state of the second. A choice has to be made between the two (trade-off). • Counter-acting: The pursuit of one objective counteracts another objective. • Constraining: The pursuit of one objective sets a condition or a constraint on the achievement of another objective. • Consistent: There is no significant interaction between two objectives. • Enabling: The pursuit of one objective enables the achievement of another objective. • Reinforcing: One objective directly creates conditions that lead to the achievement of another objective. • Indivisible: One objective is inextricably linked to the achievement of another objective.
Policy conflict and related trade-offs	Policy conflicts manifest when goals and instruments of one policy are in contrast with goals and instruments of another policy. When conflicts arise, choices should be made about the related t*rade-offs.* This implies choosing to reduce or postpone one or more desirable outcomes in exchange for increasing or obtaining other desirable outcomes in return. This choice requires political compromise.
Policy synergies	Policy synergies manifest when the combined efforts of two or more policies can accomplish more than the sum of the results of each single policy separately. Policies reinforce each other.
Policy coherence	An attribute of policy referring to the systematic effort to reduce conflicts and promote synergies within and across individual policy areas at different administrative/spatial scales.
Nexus as analytical approach	A systematic process of inquiry that explicitly accounts for water, land, energy, food and climate interactions in both quantitative and qualitative terms with the aim of better understanding their relationships and providing more integrated knowledge for planning and decision making in these domains.
Nexus as governance approach	As governance approach, the WLEFC-nexus approach provides guidance for policy decisions through an explicit focus on interactions between water, land, energy, food and climate policy goals and instruments in order to enhance cross-sectoral collaboration and policy coherence, and ultimately promote resource efficiency and the transition to a low carbon economy.
Nexus as a discourse	As emerging discourse, the WLEFC-nexus approach emphasizes the synergies, conflicts and related trade-offs emerging from the water, land, energy, food and climate interactions at bio-physical, socio-economic, and policy and governance level, and encourages agents to cross their sectoral and disciplinary boundaries.
Nexus approach	A systematic process of scientific investigation and design of coherent policy goals and instruments that focuses on synergies, conflicts and related trade-offs emerging in the interactions between water, land, energy, food and climate at bio-physical, socio-economic, and governance level
Nexus Critical Objective (NCO)	It is the policy objective that shows high (potentially the highest) number of interactions with other objectives in the WLEFC-nexus (issue density) and that is most relevant to achieve resource efficiency and low carbon economy in Europe in the long-term.
Nexus Critical System (NCS) or hotspot	A nexus critical system includes a nexus critical objective and the policy objectives that directly interact with it (meaning only first order interactions) as well as the policy means for the achievement of the NCO and of the other objectives directly interacting with it. It is the node in the WLEFC-nexus with a

	high density of interactions, where trade-offs and synergies are likely to coexist, and for which an integrated approach for the identification of nexus compliant solutions is required.
Nexus compliant solutions	Nexus compliant solutions and policies are those managing trade-offs and exploiting synergies.
Serious Gaming	Serious gaming is a method for exploring high-stake problems in which key uncertainties depend on people's choices and actions. The main purpose is education and training where users' learning goals are established. Serious games are experi(m)ent(i)al, rule-based, interactive environments, where players learn by taking actions and by experiencing their effects through feed-back mechanisms that are deliberately built into and around the game. Serious games can be computer based.

1 Introduction

1.1 Objectives of Task 2.1

Policy analysis is a leitmotiv in the Horizon 2020 SIM4NEXUS project, complementary to the modelling of interlinkages between the Nexus sectors. Policies will feed into the models and will be the switches of the Serious Game. Work package 2 makes an inventory of policies that are relevant for the water-land-energy-food-climate (WLEFC) nexus and analyses policy coherence at different scales and different phases of planning and implementation. It does so for policies directly targeted at the five nexus domains and policies that indirectly influence or are influenced by the nexus domains.
This deliverable is the result of Task 2.1 of Work package 2. The objectives of this task are, according to the Grand Agreement:

- To identify and review the most important policy areas for the nexus and the relevant policy interactions between sectors connected to the nexus domains. Bilateral biophysical and socioeconomic interactions between the nexus domains were investigated in Task 1.1;
- To gather current information on policies relevant to the nexus at European scale and on related policies at global scale;
- Analyse interactions, coherence and conflicts between these policies, their degree of 'nexus compliance' and support of a resource efficient Europe;
- Detect windows of opportunity to influence European policy making relevant for the nexus.
- Make a database of summarised relevant policy documents at EU and global scale.

1.2 Disclaimer and follow up

The analysis described in this report is based on desk study, with a small input from experts in the scoring of policy coherence between objectives, described in Chapter 6. The conclusions of the coherence analysis are based on policy goals, objectives and means described in policy documents. In the next phase of the project, these results and conclusions will be verified with stakeholders, policy makers, policy target groups and experts of the WLEFC domains. The implementation of policies, when incoherence becomes manifest, will be investigated in the national and regional case studies of the SIM4NEXUS project. Here, a bottom-up approach will be applied. First, the synergies and conflicts that exist between the nexus domains in practice will be investigated. Second, the connections with regional and national policies will be mapped. National and regional WLEFC policies are mainly based on EU policies, so at these levels the top-down approach described in this report and the bottom-up approach in the cases will come together.

2 Defining the 'nexus'

2.1 The emergence of the nexus

Nexus is the 'new' popular buzz word. Present in the sustainable development discourse for nearly three decades, the concept is not new (Boas and Biermann, 2015; Allouche et al., 2014). However, it has gained momentum in the scientific, policy and political circles only over the last ten years, especially in relation to the water-energy-food (WEF) domains under the increasing pressure of population growth and climate change. It has also reached the scientific agenda because of its potential to operationalize the planetary boundaries concept (Steffen et al., 2015) by providing integrated assessments and holistic approaches to multi-agent and multi-scale problems.

A commonly acknowledged ground breaking moment of the nexus discourse is the 2008 World Economic Forum and the subsequent book on the interlinkages between the WEF and climate domains (WEF, 2011). Acknowledging the problem of resource scarcity and allocation, the World Economic Forum has formulated the nexus as an approach to improve resource efficiency and in turn resource security (Allouche et al., 2014). Since then, in the run up of the Rio+20 conference on sustainable development, the nexus as an approach to address water, energy and food security has found its way into global negotiations through a number of initiatives and publications (see Leck et al. 2015 for a synthesis of the most relevant initiatives occurred between 2009 and 2014). One important event framing the nexus thinking has been the 2011 Bonn conference on the WEF nexus, whose background paper (Hoff, 2011) and the conference policy recommendations (2011) paved the way to further elaboration of the nexus discourse. Although the Rio+20 failed to formally pick up the nexus language, the discussion remained nevertheless alive in the academic and political arenas in the subsequent years. The most recent example of the relevance granted to the nexus is found in the implementation of the 2030 agenda for sustainable development, where a nexus approach is deemed necessary for policy makers to develop coherent policies to achieve the SDGs in a sustainable manner. The discussion in this context focuses on tools and approaches to assess the interaction among the SDGs to identify potential conflicts (and related trade-offs) and synergies. This is meant to help policy makers to devise policies and strategies aiming to minimize trade-offs and exploit synergies (Nilsson et al. 2016a; Nilsson et al., 2016b; Weitz et al. 2014).

The nexus concept is related to the increasing recognition that different sectors are inherently interconnected and must be investigated and governed in an integrated, holistic manner (Hoff, 2011). Accordingly, the nexus literature emphasizes the complexity of interactions occurring across sectors and the need to overcome silo approaches in knowledge generation, and resource management and governance. A nexus approach is deemed necessary to highlight interdependences, exploit potential synergies, and identify critical trade-offs to be negotiated among the affected parties (Hoff, 2011; Allan et al., 2015). The ultimate goal is to improve resource efficiency and thereby ensure a sustainable management of scarce resources.

Many scholars, however, emphasize the lack of agreed definitions and conceptual clarity about the nexus (Benson et al., 2015; Wichelns, 2017). There seems to be in the literature two lines of thought: one that views the nexus as a research and policy analysis approach for resource management and governance (e.g. Boas and Biermann, 2015); and the other one that sees the nexus as a number of strongly interrelated sectors which need to be managed in an integrated fashion (e.g. Hoff, 2011). The difference bears implications, especially from a governance perspective. In fact, depending on how the nexus is defined, different governance strategies may apply. For example, if the nexus concerns a number of strongly interrelated sectors (e.g. water-energy-food) needing to be treated as one integrated sector, from a governance perspective this may entail the creation of *ad hoc* governance structures such as for example a supra-ministry of water-energy-food. In contrast, if the nexus is an

analytical tool to disclose critical interconnections in selected systems, then solutions may not require major institutional changes, but rather only more coordinated action among existing institutions and agents. Hence, clearly establishing what the nexus is and what are its boundaries is crucial.

The analytical and practical usefulness of the nexus concept has recently begun to attract some criticism (see e.g. Smajgl et al., 2016; Foran, 2015; Wichelns, 2017). First, according to Wichelns (2017), the selection of the boundaries of the nexus is somewhat arbitrary. While the vast majority of the literature is concerned with WEF as the nexus par excellence, there are also studies emphasizing other critical interrelations such as for example water-soil-waste (see e.g. Kurian and Ardakanian, 2015) or energy-water-soil-food (Subramanian and Manjunatha, 2014). Furthermore, increasingly the WEF nexus has been extended to also comprehend climate change. By drawing the boundary of the investigation, all these different definitions of the nexus arbitrarily cut out many important variables and interactions. Secondly, although in theory one of the distinguishing features of the nexus is the equal footing that is given to all sectors (Wichelns, 2017), in practice, water is often taken as entry point in WEF frameworks (Allouche, 2014), thus making the nexus not dissimilar to integrated water management. This observation resonates with the recurring criticism that if the nexus is about integrated, holistic management of multiple interconnected sectors, it is not clear how it is different from other integrative approaches (Smajgl et al., 2016). Thirdly, Foran (2015) argues that the existing nexus conceptualizations fail to acknowledge the politics of decisions and in particular the power and interest structure of stakeholders in decision-making processes (in Smajgl et al., 2016). Fourthly, Dupar and Oates (2012) warn that a simplistic reading of nexus thinking may lead to the commodification of resources and overlooking of long-term environmental externalities, such as biodiversity protection, pollution or climate change. Finally, Wichelns (2017) contend that the nexus approach may not always be appropriate as there may be instances in which a sharp research focus is required, there may be sectors where there is little need of interdisciplinary interaction, or contexts lacking institutional capacity, human capital or the finance to support inter-sectoral policy discussions. Related to this latter point is the fact that integrated policy making can increase complexity of processes to the point that decisions are delayed and slowed, finally resulting in inertia (Mitchell et al., 2015).

Besides the scepticism, the literature also reveals a number of distinguishing features of the nexus and provides useful insights for consolidating its conceptualization. Based on this literature, the next section illustrates the SIM4NEXUS conceptualization of the nexus.

2.2 Towards a conceptual definition of the nexus

In line with Keskinen and colleagues (2016) we believe three different perspectives on the nexus can be recognized in the literature: an analytical, a governance and a discourse perspective. Accordingly, the definition of the WLEFC-nexus in the SIM4NEXUS project is provided in Table 1.

Table 1. Definition of the WLEFC-nexus in the SIM4NEXUS project

Perspective	Definition
Analytical	As **analytical approach**, the WLEFC-nexus approach is a systematic process of inquiry that explicitly accounts for water, land, energy, food and climate interactions in both quantitative and qualitative terms with the aim of better understanding their relationships and providing more integrated knowledge for planning and decision making in these domains.
Governance	As **governance approach**, the WLEFC-nexus approach provides guidance for policy decisions through an explicit focus on interactions between water, land, energy, food and climate policy goals and instruments in order to enhance cross-sectoral collaboration and policy coherence, and ultimately promote resource efficiency and the transition to a low carbon economy.
Discourse	As **emerging discourse**, the WLEFC-nexus approach emphasizes the synergies, conflicts and related trade-offs emerging from the water, land, energy, food and climate interactions at bio-physical, socio-economic, and policy and governance level, and encourages agents to cross their sectoral and disciplinary boundaries. In this regard, the WLEFC-nexus acts as a boundary concept (Leigh Star and Griesemer, 1989). Evidence of it is the SIM4NEXUS project itself which brings together a wide range of disciplines from natural to political science and informatics and has a strong focus on stakeholder co-design of tools and solutions.

Source: adapted from Keskinen et al., 2016

The SIM4NEXUS project integrates these three perspectives (as recommended by Keskinen et al., 2016). Accordingly, the analytical framework of the WLEFC-nexus approach adopted in the SIM4NEXUS project is depicted in Figure 1 and is described as:

> *a systematic process of* ***scientific investigation*** *and de****sign of coherent policy goals and instruments*** *that focuses on* ***synergies, conflicts and related trade-offs*** *emerging in the interactions between water, land, energy, food and climate at bio-physical, socio-economic, and governance level.*

Defining and distinguishing **features of a WLEFC-nexus approach** are:

- equal weight given to all sectors in the nexus;
- focus on relationships:
  - relationships are bilateral (A → B interaction is different from B → A interaction);
  - relationships can be synergistic or conflicting and thus generate trade-offs;
- focus on interdisciplinary knowledge generation;
- focus on cross-sectoral governance decisions.

Scientific investigation generates quantitative, model-driven assessments that help identify bio-physical and socio-economic interconnections. Policy and governance analysis identify relevant key stakeholders, policies and legislative frameworks as well as the politics of decision making processes, i.e. the power and interest structure that steer decisions. Such analysis reveals nexus critical systems or **hotspots** defined as the nodes in the WLEFC-nexus with a high density of interactions, where trade-

offs and synergies are likely to coexist, and for which an integrated approach for the identification of nexus compliant solutions is required. **Nexus compliant solutions and policies** are those managing trade-offs and exploiting synergies.

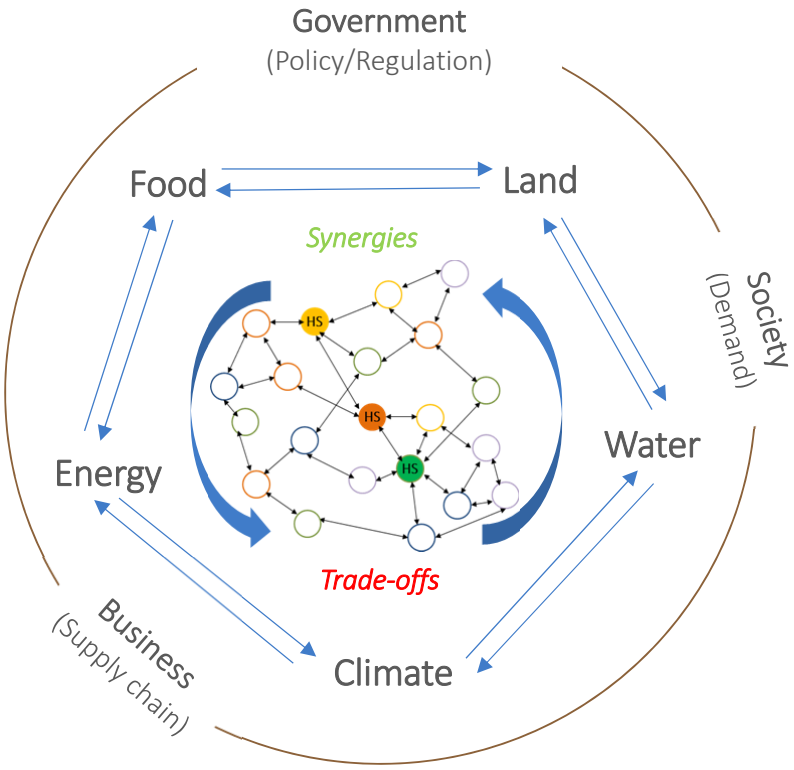


Figure 1. WLEFC-nexus framework in the SIM4NEXUS project (adapted from Mohtar and Daher, 2016)

2.3 The SIM4NEXUS WLEFC-nexus

The Water-Land-Energy-Food-Climate system, abbreviated as 'WLEFC-nexus', is the object of study in this research project. The WLEFC-nexus was defined as study object because of the strong interlinkages between the five domains in this nexus and their relevance for a resource efficient and low-carbon economy in Europe. An integrated approach for the WLEFC policies is assumed necessary to reach these goals.

Water, land, energy, food and climate are catch-all terms. Laspidou et al. (2017) defined these terms in more detail and analysed the bilateral biophysical and socio-economic interlinkages between these domains. The term 'bilateral' is used because relations between two domains have two directions, the influence of domain X on domain Y differs from the influence of domain Y on domain X. Knowledge about these bilateral linkages is important input for the coherence analysis of policies, described in Chapter 6. In addition to knowledge about the bilateral linkages, it is relevant to know how the nexus domains are related to each other in consumption and production systems. Supply chains are important socio-economic networks and the processes connected to them create linkages between the nexus domains that are relevant for policies. For example, agricultural policies affect food security via the supply chain and food policies affect the use of water, land and energy. From the viewpoint of

production, consumption and supply chains, the bilateral connections between nexus components are part of more complex systems with multiple relations. Figure 2 illustrates this.

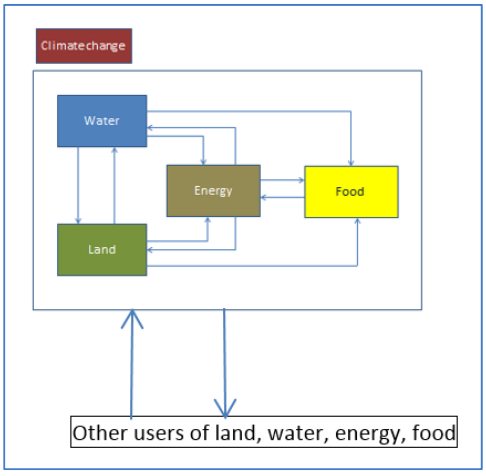


Figure 2. Bilateral relations between WLEFC-nexus components, constituting the complex production and consumption system with its multiples relations.

The definitions of water, land, energy, food and climate given in Laspidou et al. (2017) describe different aspects of and perspectives on these domains. These in turn are connected to different areas of special interest for policies, see Table 2. The interest areas were the base to make the inventory of relevant policy domains for the WLEFC-nexus described in section 3.2.3.

Table 2. Perspectives on WLEFC domains and connected interest areas for policy

Nexus domain	Perspectives	Interest areas for policy
Water	Water system	Aquatic ecosystems and ecological status, hydrological cycle, drainage basin
	Natural resource	Services, withdrawal and use, consumption, efficiency, footprint, IWRM
	'Dustbin'	Emissions
	Spatial phenomenon	Room for activities, spatial planning, transport
	Water consumption	Water saving, water efficiency, life styles, awareness of water consumption patterns and implications
Land	Land and soil system	Terrestrial ecosystems and ecological status, soil fertility, soil biodiversity
	Natural resource	Services, carbon sequestration, land use, degradation.
	Space	Spatial planning, room for activities, landscape
	Property	Land tenure
	Consumption	Recreational use, no-littering behaviour
Energy	Supply chains	Fossil and renewable energy, primary and secondary production and consumption, efficiency, technology and innovation, market and trade, energy security
	Consumption	Energy saving, energy efficiency, informed choice of energy supplier, awareness of energy consumption patterns and implications, life styles

Food	Supply chains	Agriculture, food industry, retail, consumption, efficiency and waste, market and trade, food security
	Consumption	Dietary preferences, food waste
Climate	Temperature Long term weather patterns	Adaptation of water infrastructure and management practice, land-use practice, agricultural practice, energy production and consumption, risk prevention - preparedness - response concerning droughts, floods and other weather disasters
	GHGs	Mitigation: emission reduction in industry, energy, transport, waste, housing, agriculture, forestry, land use (REDD+, LULUCF), , climate friendly products, climate friendly behaviour

3 Policy coherence in the WLEFC-nexus

3.1 What is policy coherence?

Policy coherence is a key feature of a WLEFC-nexus approach. Unfortunately, the literature is not consistent in definition of terms that suggest similar concepts such as coherence, integration, and consistency (den Hertog and Stross, 2011; Nilsson et al 2012). Much work exists on policy integration (for a review see Jordan and Lenschow, 2010) and policy interactions (e.g. Oberthur and Gehring 2006) in the environmental domain. The focus of this scholarship is on the upstream policy making processes and the associated institutional arrangements. In this context, Oberthur and Gehring (2006) define policy interaction as a causal relationship between two policies in which one policy exerts influence on the other either intentionally or unintentionally. Other scholars suggest an increasing degree of policy coherence along the continuum cooperation-coordination-integration where cooperation pursues more efficient sectoral policies, coordination adjusts sectoral policies to deliver coherent and consistent outcomes, and integration jointly designs policy goals and instruments (Stead and Meijers, 2009).

Another line of inquiry has focused on procedural aspects of policy making (see section 3.2 on the distinction between procedural and substantive elements of policy). Most notably the OECD (2002) has identified criteria such as stakeholder involvement, knowledge management, commitment and leadership as criteria in the policy-making process to attain better policy coherence. In this vein, the OECD (2015) defines policy coherence in the context of development as an approach and policy tool for integrating the economic, social, environmental and governance dimensions of sustainable development at all stages of domestic and international policy making in order to foster synergies across economic, social and environmental policy areas; identify trade-offs and reconcile domestic policy objectives with internationally agreed objectives; and address the spill-overs of domestic policies.

In contrast, other studies have taken a more substantive approach by focusing on the content of the policy (e.g. den Hertog and Stross, 2011; Nilsson et al 2012). These studies tend to define policy coherence as an attribute of policy or a systematic activity aimed at reducing conflicts and promoting synergies between and within individual policy areas to achieve jointly agreed policy objectives (Nilsson et al, 2012; den Hertog and Stross, 2011).

In the following section, we illustrate the definition and the boundaries of policy coherence analysis in the SIM4NEXUS project.

3.2 Policy coherence analysis in the SIM4NEXUS project

Policies can be viewed from a **substantive** and **procedural** perspective. A substantive perspective focuses on the content of policies; whereas a procedural perspective is concerned with the processes through which policies are made. From a substantive/content perspective, public policies are composed of policy goals and policy means which are articulated at different level of abstraction (Lasswell, 1958; Howlett, 2011). **Policy goals** are the basic aims and expectations that governments have when deciding to pursue some course of actions. They can range from abstract general goals (e.g. attaining sustainable development) to a set of less abstract objectives (e.g. increase energy efficiency) which may then be concretized in a set of specific targets and measures (e.g. achieve 10% renewable energy share). **Policy means** are the techniques/mechanisms/tools that governments use to attain policy goals. Similarly to goals, means range from highly abstract preferences for specific forms of policy implementation (e.g. preference for the use of market instruments to attain policy goals); to more concrete governing tools (e.g. regulation, information campaigns, subsidies); to specific decisions/measures about how those tools should be calibrated in practice to achieve policy targets (e.g. a specific level of subsidy in the renewable energy sector).

From a procedural perspective, a number of different models of the policy-making process exist. In short, the **policy process**, often referred to as **policy-cycle,** is a set of interrelated stages through which policy issues and deliberations flow from inputs (problems) to outputs (policies). A typical model of the policy process includes five stages (Howlett, 2011): *agenda-setting* (problem recognition by the government); *policy formulation* (proposal for solution in the government); *decision-making* (process of selection of solution); *policy implementation* (how government puts solution into effect); *policy evaluation* (monitoring results, which may lead to reconceptualization of problems and solutions). From the standpoint of policy-making as a social and political process (as opposed to a rational-technical process), goals are defined at different stages including the policy formulation, policy-making and policy-implementation stage, whereas means include activities located in all stages of the policy process.

The investigation of policy coherence in the SIM4NEXUS project focuses on the analysis of the substantive aspects of the policies in the nexus. When looking at a typical policy framework with policy inputs, processes, content, implementation, outcomes and impacts (see Figure 3), the policy coherence in the SIM4NEXUS analysis concerns the policy content – where policy goals and instruments are substantiated in policy documents – and the policy implementation in practice. In general, efforts in the policy processes domain to integrate goals and instruments are expected to result in higher policy coherence; hence recommendations to improve coherence should address this dimension. In turn, the degree of coherence between two or more policies is expected to affect outcomes and impacts. Policy outcomes and impacts then influence the design and re-design of policy goals and instruments. Changes in contextual factors and unexpected events can influence both the policy process (and in turn the policy content and implementation) as well as outcomes and impacts. The coherence of international and European policies is assessed at the level of goals and instruments whilst the project case studies at regional and national scale will investigate the coherence also at the level of implementation practices, which is where conflicts are more likely to arise.

Focusing the coherence analysis on the substantive aspects of the policies in the nexus has two advantages. Firstly, it provides relevant information for the development of the SIM4NEXUS Serious Game. Information about policy trade-offs and synergies are necessary for the development of the game as one of the characteristics of the game is to provide the players information about the consequence of the policy choices that they make while playing. Secondly, identifying synergies and conflicts among policy goals and instruments across sectors is necessary for the implementation of a nexus governance approach to policy-making.

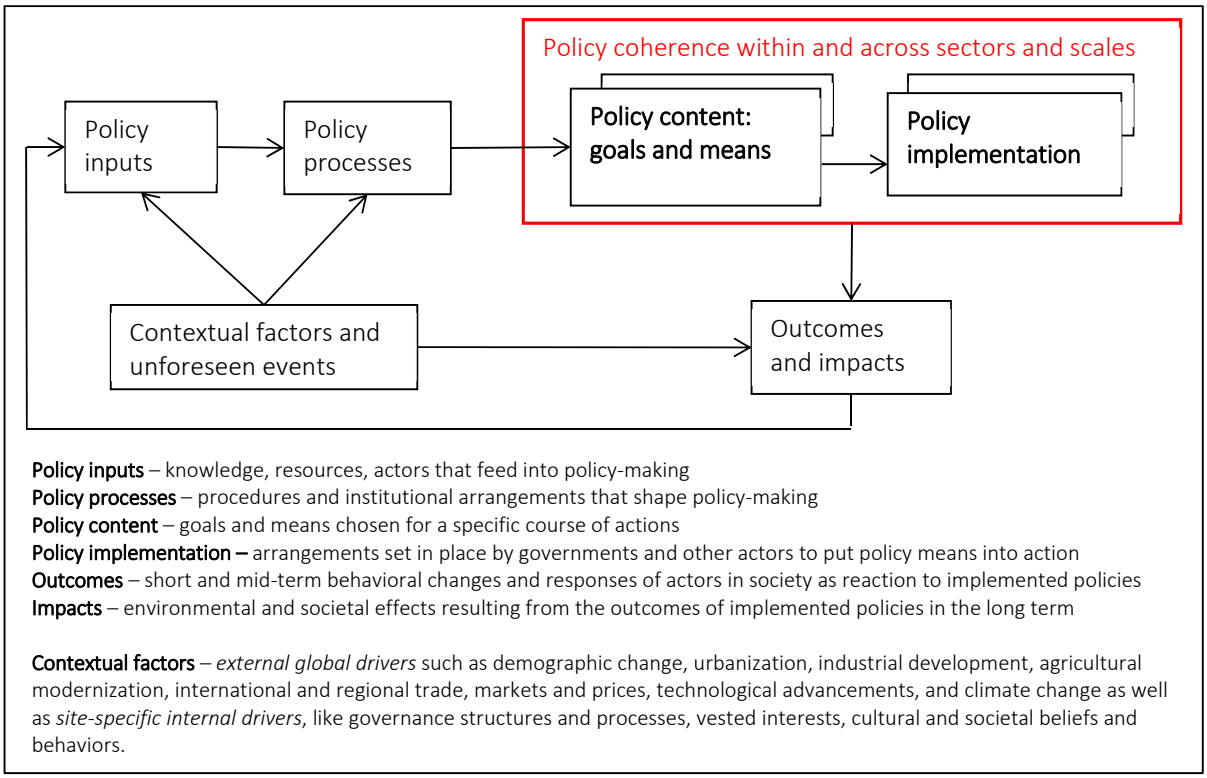
Exploiting synergies and managing trade-offs (thereby enhancing policy coherence) requires deliberation actions at the level of policy-making processes (see Figure 3). These include for example political bargaining, organizational arrangements and mandates, administrative procedures such as impact assessments. Windows of opportunity for improving policy coherence are for example policy reviews such as the review of the EU Water Framework Directive (WFD) by 2019 and of the EU common agricultural policy (CAP) by 2020. When critical synergies and trade-off are revealed, specific recommendations can be formulated about how policy-making processes could be changed to improve policy coherence.

Accordingly, drawing from the definition of Nilsson et al. (2012), in the SIM4NEXUS project policy coherence is defined as:

> *an attribute of policy referring to the systematic effort to reduce conflicts and promote synergies within and across individual policy areas at different administrative/spatial scales.*

Policy synergies manifest when the combined efforts of two or more policies can accomplish more than the sum of the results of each single policy separately. Policies reinforce each other. For example, the combination of investment in research and in pilot innovation projects, with a clear emission target, may give a boost to innovation and uptake of new clean technologies, whereas the investments without a clear target or a target without the investments would not have this effect.

Policy conflicts manifest when goals and instruments of one policy are in contrast with goals and instruments of another policy. When conflicts arise, choices should be made about the related t*rade-offs.* This implies choosing to reduce or postpone one or more desirable outcomes in exchange for increasing or obtaining other desirable outcomes in return. This choice requires political compromise.



Policy inputs – knowledge, resources, actors that feed into policy-making
Policy processes – procedures and institutional arrangements that shape policy-making
Policy content – goals and means chosen for a specific course of actions
Policy implementation – arrangements set in place by governments and other actors to put policy means into action
Outcomes – short and mid-term behavioral changes and responses of actors in society as reaction to implemented policies
Impacts – environmental and societal effects resulting from the outcomes of implemented policies in the long term

Contextual factors – *external global drivers* such as demographic change, urbanization, industrial development, agricultural modernization, international and regional trade, markets and prices, technological advancements, and climate change as well as *site-specific internal drivers*, like governance structures and processes, vested interests, cultural and societal beliefs and behaviors.

Figure 3. Boundaries of policy coherence analysis in the SIM4NEXUS project (adapted from Nilsson et al., 2012)

3.2.1 Policy interactions: definition and typologies

When investigating conflicts and synergies between policies one comes across the question of how policies interact. Policy interaction refers to a *cause-effect relationship between policies and occurs when the content of one policy (goals, means, implementation practices) influences the performance of another policy such as the achievement of its objectives or the implementation of its instruments*.

'Policy area A to policy area B' interactions are different from 'policy area B to policy area A' interactions. For example, in the water to food interaction, water is an input for food production and water scarcity represents a threat to food security; the other way around, i.e. the food to water interaction, the use of fertilizers and pesticides in food production generates water quality problems and the production of food crops subtracts water resource to other users.

Interactions take place within the context of external global drivers, such as demographic change, urbanization, industrial development, agricultural modernization, international and regional trade, markets and prices, technological advancements and climate change as well as more site-specific internal drivers, like governance structures and processes, vested interests, cultural and societal beliefs and behaviours.

Interactions can be studied within and across policy areas as well as within and across administrative/spatial scales (Nilsson et al, 2012). The combination of these options generates 4 types of interactions that can be investigated (see Table 3): horizontal/internal; horizontal/external; vertical/internal; and vertical/external coherence.

Table 3. Policy interactions at different levels

Policy area	Administrative/spatial scale	
	Horizontal	Vertical
Internal	e.g. EU climate mitigation targets vs EU carbon emission cap, or vs EU burden sharing or vs EU ETS	e.g. global climate policy vs EU climate policy
External	e.g. EU food production policy vs EU climate mitigation policy	e.g. global trade policy vs EU climate policy

Furthermore, interactions also occur across the different elements of the policy and in the implementation phase. For example, to facilitate the adoption of decisions, conflicts are often hidden at high levels of abstraction such as when formulating goals and objectives (Nilsson et al, 2012). These conflicts can then manifest in the selection and implementation of instruments. Regarding implementation, research has shown that administrators and bureaucrats tend to filter, interpret, distort, adapt formal policy sometimes to the point that outcomes may be different from the legislator intention (Pressman and Wildavsky, 1973; Nilsson et al, 2012). Similarly, potential for synergistic effects exist in all these levels as well. To capture these interactions, a multi-layered approach is adopted, following Nilsson et al., 2012 (see Figure 4). This layered approach allows to investigate interactions among two or more set of goals as well as among means and implementation practices against policy goals.

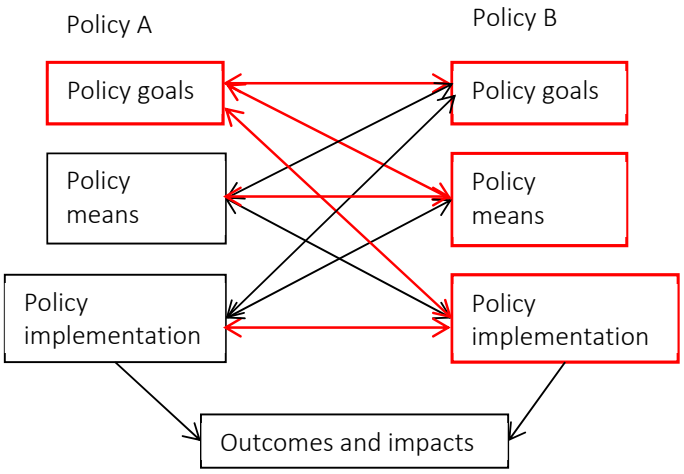


Figure 4. Interactions among elements of policy from goals to implementation (adapted from Nilsson et al, 2012)

The interplay of interactions across policy areas and scales and among policy elements leads to a complex reality to investigate. Specifically:

- The **horizontal/internal coherence analysis** investigates the interaction of goals, means and implementation practices within a policy area (e.g. objectives/instruments of EU energy policy; objectives/instruments/implementation practices of global nature conservation policy).
- The **horizontal/external coherence analysis** investigates the interaction of goals, means and implementation practices across multiple policy areas at the same administrative scale (e.g. water/food at EU level; water/energy/food at national level, etc.).

- The **vertical/internal coherence analysis** investigates the interaction of goals, means and implementation practices between one policy area across multiple administrative scales (e.g. global/EU climate policy; global/EU/national climate policy, etc.).
- The **vertical/external coherence analysis** investigates the interaction of goals, means and implementation practices across multiple policy areas across multiple administrative scales (e.g. global climate policy/EU energy policy; global climate policy/EU energy and transport policy, etc.).

The combination of these options with the WLEFC-nexus policy domains generates a multitude of potential interactions to investigate. However, not all interactions are equally important and the specificity of the context is likely to determine the level of relevance of different interactions. Consequently, it is possible to rank interactions according to their relevance in a specific context and select those that are worth in depth investigation. Furthermore, different typologies of interactions can be identified. Table 4 illustrates the typology of policy interactions used in this study.

Table 4. Typologies of policy interactions

Type of interaction	Description
Cancelling	Progress in one objective makes it impossible to reach another objective and possibly leads to a deteriorating state of the second. A choice has to be made between the two (trade-off).
Counter-acting	The pursuit of one objective counteracts another objective.
Constraining	The pursuit of one objective sets a condition or a constraint on the achievement of another objective.
Consistent	There is no significant interaction between two objectives.
Enabling	The pursuit of one objective enables the achievement of another objective.
Reinforcing	One objective directly creates conditions that lead to the achievement of another objective.
Indivisible	One objective is inextricably linked to the achievement of another objective.

Source: Nilsson et al. 2016a; Nilsson et al. 2016b

3.2.2 Defining nexus critical objectives (NCOs) and nexus critical systems (NCSs)

The goal of the SIM4NEXUS project is to deliver tools for policy makers to be able to make informed decisions about policies that can place Europe on the path of resource efficiency and low carbon economy. Not all interactions of policy objectives are equally important for the achievement of these goals. Furthermore, those objectives that manifest a high density of interactions with other objectives are the ones that could most likely manifest significant trade-offs and/or synergies in the WLEFC-nexus. Given the multidimensionality and complexity of the space of policy interactions, we defined nexus critical objectives and related nexus critical systems as unit of analysis of horizontal coherence among means and of vertical coherence between international and European policy objectives in the WLEFC-nexus.

A nexus critical objective (NCO) is defined as *the policy objective that shows high (potentially the highest) number of interactions with other objectives in the WLEFC-nexus (issue density) and that is most relevant to achieve resource efficiency and low carbon economy in Europe in the long-term*.

A **nexus critical system** (NCS) *includes a nexus critical objective and the policy objectives that directly interact with it (meaning only first order interactions) as well as the policy means for the achievement of the NCO and of the other objectives directly interacting with it*.

Figure 5 illustrates the two concepts.

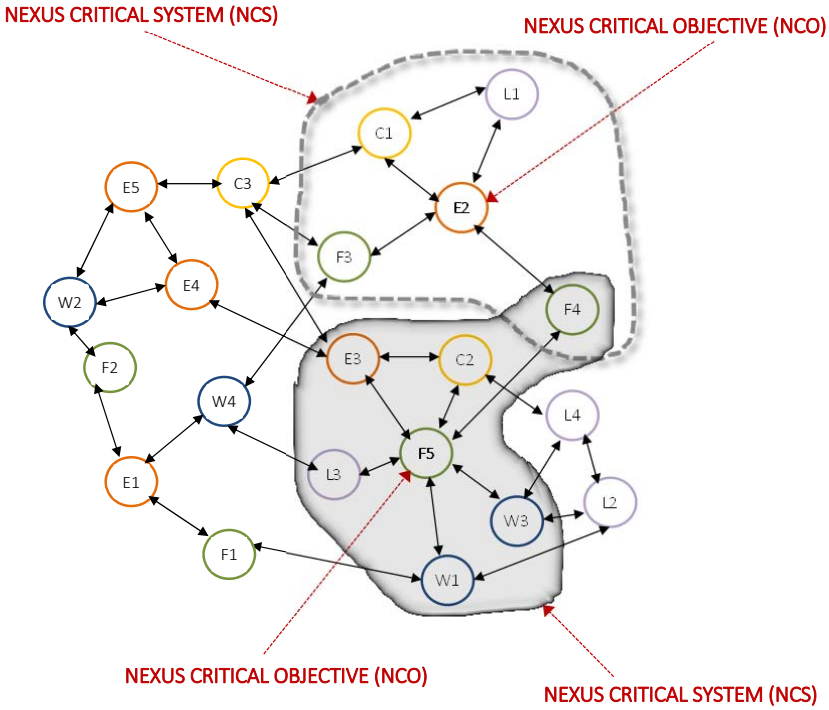


Figure 5. Representation of nexus critical objectives and nexus critical systems

3.2.3 Policies in the WLEFC-nexus and policies indirectly affecting the WLEFC-nexus

The definition of nexus in the nexus approach is context specific, depending on the issues, questions and problems at stake. 'Nexus' are defined parts of the socio-economic and biophysical system and do not have natural boundaries. According to Hoff (2011) 'the green economy itself is the nexus approach par excellence.' In our view the nexus scope is even broader, as a nexus approach also includes ecosystems, the services they deliver and the limits to their capacity to keep doing this under pressure. This means that the policy domains connected to a nexus are also context specific and depend on the issues at stake. For the WLEFC-nexus, we first focus on the policies that consciously aim at influencing the five nexus domains, as defined in Table 2 in section 2.3. In addition to these, policies directed at other domains may influence the nexus (see Figure 6). For example, OECD/IEA/NEA/ITF (2015) argue that the economy as a whole, and more specific policies for investment and finance, taxation, trade, and research and innovation, are important for the transition towards a low-carbon economy. A nexus approach is mentioned in connection to development policies and the SDGs (Weitz, 2014). The Bonn2011 Conference synopsis (Bonn2011, 2012) adds to these labour and product markets, security, environment and biodiversity as relevant policy domains connected to the water-energy-food security nexus.

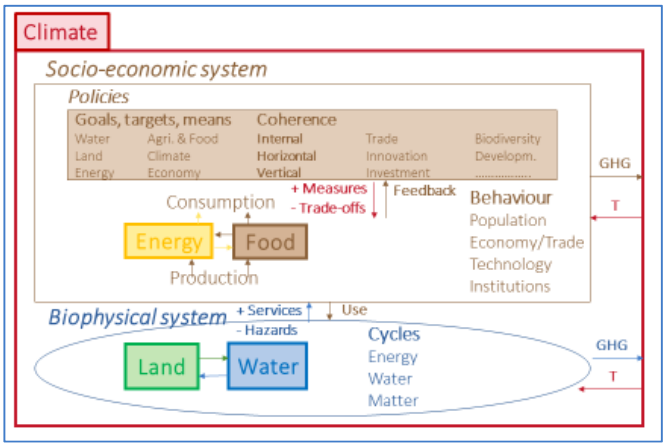


Figure 6. Policies aim at changing the socio-economic system in a desired direction, but may have unexpected trade-offs or may mutually interfere and influence each other's effectivity. Because the WLEFC-nexus is in many ways connected to the rest of the socio-economic and biophysical systems, policies not directly aimed at the nexus domains may nevertheless influence them.

3.2.3.1 Policy domains in the WLEFC-nexus at EU and Global level

In this study, we selected the following policy domains, because these policies consciously aim at influencing the WLEFC sectors. The overview of policy domains was constructed using information from the websites of governments and governmental organisations, e.g. DGs from the European Commission and UN departments and Assemblies, and by collecting policy documents and analysing a key selection of these documents (see Chapter 5).

Table 5. Policy domains at EU and Global level, within the WLEFC-nexus

WLEFC-nexus domain	Policy domains
Water	**EU policies** Ecological and chemical water quality Emissions to surface water and groundwater International agreements and protected areas Surface water and groundwater quantity, incl. water scarcity Sustainable water use, efficiency and re-use Flood risks and climate change adaptation **International policies** Water management, incl. water availability, water quality, water scarcity Drinking water and water related health Transboundary waters Sustainable water use and water efficiency Sanitation, wastewater treatment and re-use Freshwater ecosystems, incl. benefit sharing Climate change adaptation and mitigation
Land	**EU policies** Sustainable land use incl. indirect land use change (ILUC) Soil protection and sustainable use Forest management, incl. timber **International policies** Desertification

	Management of forests, incl. timber
Energy	**EU policies** Renewable sources of energy Energy efficiency Internal energy market and competitiveness Energy supply security Innovation and technology Energy poverty
Food and agriculture	**EU policies** Food production and security Natural resources and climate action Territorial development and regional funds Food supply chain, incl. food waste, consumption and food-related health **International policies** Food security Sustainable food consumption and production incl. food waste Food market and trade Climate change mitigation and adaptation
Climate	**EU policies** Greenhouse gas emissions in ETS sectors Greenhouse gas emissions in non-ETS sectors Low-carbon technology, incl. CCS Land use, incl. forestry and agriculture Climate change adaptation **International policies** Greenhouse gas emissions Financing Technology Capacity building Climate change adaptation

3.2.3.2 Policies indirectly affecting the WLEFC sectors

Table 6 lists the policy domains that are strongly linked to the WLEFC-nexus and that are strongly related to the goals of a resource efficient and low-carbon Europe with an economy that stays 'within the limits of the planet'. We are interested in whether these goals are incorporated in the policies for these domains, and whether these policies take the goals and objectives of WLEFC policies into account. Also, there may be interference between policy measures and instruments within and outside the WLEFC policy domains.

Policy documents for these 'external' policy domains (with the exception of air quality) have been collected and put into the database (Digital appendix). The analysis of these documents will be carried out in a next phase of this work package as part of the development of integrated strategies and approaches towards a resource efficient and low carbon Europe.

In this phase of the policy analysis, we focus on policies at European and global scale in the water, energy, food and agriculture, land and climate sectors. Concerning climate, our investigation is

inevitably more detailed on mitigation rather than adaptation policy, due to the fact that adaptation is an issue mostly dealt with at national scale while the EU only sets the general policy framework with the EU adaptation strategy (included in our analysis). In a similar vein, spatial planning and taxation are not the responsibility of the EU but of the member states and therefore are not included in this report.,. Other sectoral policies, such as those for industry, transport, building, tourism, will be addressed at the national and regional scale when relevant for the case studies. In these cases, policies will be investigated bottom-up, starting from the implementation in practice. Finally, air quality will not be investigated in this project as it is out of the nexus scope and it is not addressed by any of the project case studies.

Table 6. Policy domains relevant for the WLEFC-nexus

Policy domain	Relevance for WLEFC-nexus
Economy including circular economy and waste	Water, land, energy are key production factors and food is a key sector in a broader economy. Climate change has been and will be caused by production and consumption. Strategies and approaches towards a resource efficient and low carbon economy can only be investigated in the context of existing and planned policies for the economy.
Investment and financing	Several WLEFC policies mention steering of financial flows at all levels of investment in private and public sectors as key factor to reach a shift towards sustainability goals. There are policies and guidelines for investments of e.g. multinationals and investors like banks and funds to meet sustainability criteria. Do they take WLEFC linkages into account? The shift towards a resource efficient and low carbon economy needs investment in research, innovation and upscaling of alternatives to replace existing practices.
Innovation and research	In all WLEFC domains and in the total WLEFC-nexus, innovation and research play a key role to move on to goals.
Air quality	Nitrogen deposition pollutes land, water and ecosystems. Production of energy and food may emit other pollutants than greenhouse gases; policies to increase production efficiency and reduce GHG-emissions may also reduce emissions of these other pollutants into the air.
Ecosystems, biodiversity, nature and forestry	Ecosystems deliver key services to support humanity. Exploitation of and negative side effects on water and land, and climate change should stay within the boundaries of sustainable use.
Environment	Water and land are part of the broader environment. Environmental policies may address WLEFC issues.
Regional EU policies and funds	WLEFC policies are implemented in regions. Here all WLEFC policies come together in one area and here potential conflicts and synergies are encountered in practice.
Development	The water-energy-food nexus approach is often applied in development policy. Policy coherence is a prominent issue for the implementation of the SDGs in which the WLEFC domains are addressed.
Risk and vulnerability	Risk policies are relevant to address the consequences of climate change for the other WLEFC domains. Prevention, preparedness and response to risks in the WLEFC domains should take interlinkages between domains into account to be effective.
Trade	Trade barriers and protectionism may hinder the distribution of technologies and undermine investments in and uptake of new technologies.

4 Methodological approach

The analysis of policy coherence in the WLEFC-nexus was conducted with a mix method approach that included content analysis of primary policy documents, expert judgment of interactions of objectives and means in the WLEFC-nexus, and review of secondary literature about policy coherence in interactions in the WLEFC-nexus. Primary policy documents are for example the EU communications, roadmaps, regulations, directives, green and white papers, UN protocols, agreements, declarations, action plans. The research design anticipated a step-wise approach to the analysis which included the following steps:

1. Collection of primary and secondary documents per each nexus policy domain and other nexus relevant policy areas at international and EU level
2. Content analysis of primary documents: mapping of the key policy goals and means per each WLEFC-nexus policy sectors in other nexus relevant policy areas
3. Selection of the policy objectives to include in the assessment of interactions in the WLEFC-nexus at EU level
4. Assessment of the interactions of policy objectives across the WLEFC-nexus domains at EU level
5. Selection of nexus critical objectives (NCOs) and nexus critical systems (NCSs) for further investigation
6. Further investigation of NCOs and NCSs concerning:
    a. The horizontal coherence of objectives within the selected NCSs
    b. The horizontal coherence of means within the selected NCSs
    c. The level of integration in primary policy documents (prescriptive policies) of the synergies and conflicts identified in the NCSs
    d. The vertical coherence between international policy objectives in the WLEFC nexus and the NCSs.

The policy coherence analysis *per se* consisted of steps 4, 5 and 6.

In the following a detailed explanation of these steps is presented.

4.1 Inventory of policy goals and means in the WLEFC-nexus

Primary and secondary literature about the WLEFC-nexus and related policy areas at international and European scale was collected, organized per policy domain and stored in a shared on-line storage space.

Primary literature included binding and non-binding legislative (EU directives, EU regulations, international agreements, etc.) documents and other policy documents such as plans, programs, strategies, road maps, etc. released by governmental/intergovernmental authorities, as well as discussion documents concerning policies under review/preparation (e.g. EU green or white papers). The most up to date documents were selected, meaning the final approved, consolidated documents for approved legislation, and the most recent discussion documents for policies under review/preparation.

Secondary literature included documents assessing individual EU policies and global agreements (ex-ante and ex-post), and documents assessing policy interactions and policy coherence among different global and EU policies/levels in the WLEFC-nexus (either released by governmental organizations or other organizations including scientific literature). Examples include Impact Assessment studies, Integrated Assessment studies, Sustainability Assessment studies, assessment of interaction of multiple policies in the nexus, scientific literature on nexus interaction or on policy coherence, etc.. 131 primary policy documents concerning 13 policy domains were selected (for the list of the policy domains see section 3.2.3). A content analysis of these documents was performed. An excel template was first created for the storing of relevant information which included: policy goals, policy means, policy horizon, financing, reference in the document to other nexus domains, expected revision of the policy and meta-data about the document.

This database formed the basis for developing the inventory of policy goals and means in the WLEFC-nexus presented in Appendix I. Information stored in the database was also used to analyze the level of integration of synergies and conflicts in the NCSs and to identify windows of opportunity to address critical trade-offs and potential synergies.
Information stored in the excel database complemented with information retrieved from the websites of official institutions (e.g. European Commission, UN, WTO, OECD, etc.) was used to reconstruct the structure of the policy domains in the WLEFC-nexus and to build the inventory of policy goals and means.

Figure 7 shows the structure of the policy domains and the level at which the coherence analysis was conducted. Per each nexus policy domain, the main policy sub-systems and issue areas were identified. Then key policy goals were identified at the level of policy domain, overarching objectives at the level of policy sub-systems and objectives at the level of issue area. The analysis of coherence was performed at the level of issue area among objectives and means identified in the WLEFC-nexus.

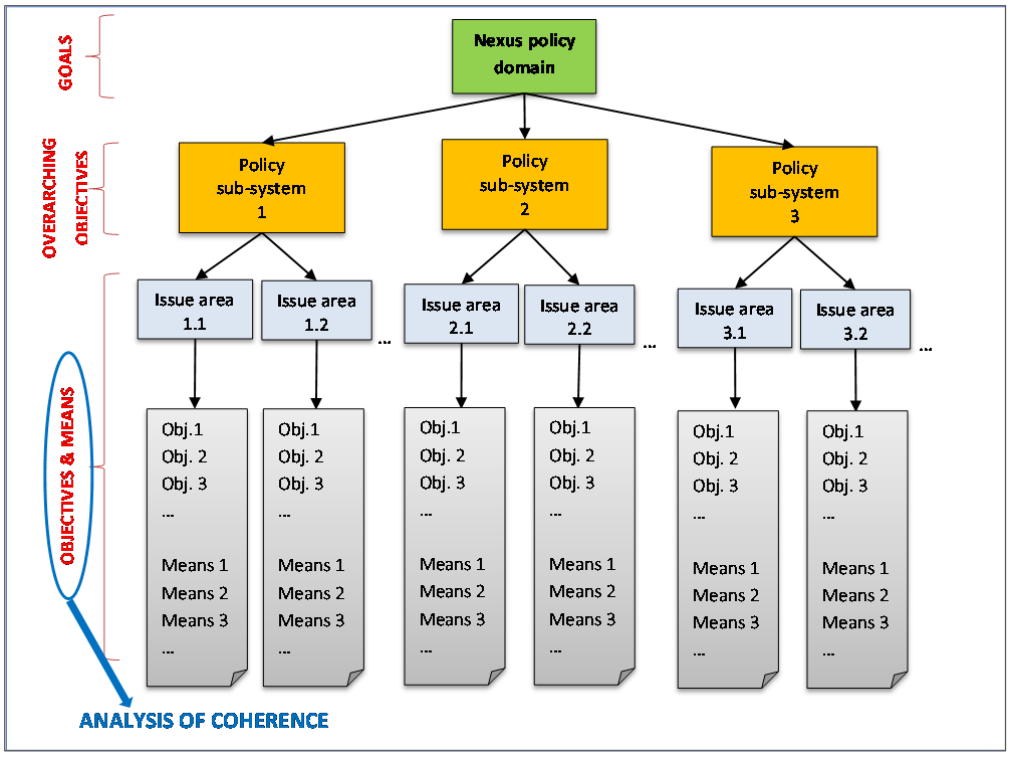


Figure 7. Schematic representation of the structure of the policy domains and the level at which the coherence assessment was conducted

Once the inventory was completed, we selected the objectives to include in the coherence assessment. Given the multitude of potential interactions among policy objectives, choices had to be made to keep the assessment manageable. Accordingly, only a sub-set of all identified objectives was selected for the coherence assessment. The selection was guided by the following criteria:

- Relevance of the objectives to the SIM4NEXUS project: this led to prioritize the assessment at EU scale since SIM4NEXUS is an EU funded project and to focus on those objectives that have relevance for the achievement of a low carbon and resource efficient Europe (the goal of the project).
- Potential of the objectives to have a high number of interactions, either positive or negative, in the WLEFC-nexus.
- Unambiguous and clear definition of the objectives. This implied rewording the objectives in a different way from the exact phrasing included in the primary documents. While rewording attention was paid in preserving the meaning of the objectives.

As a result of the selection process, we identified 33 objectives which are presented in Table 7.

Table 7. Selected policy objectives for the assessment of interactions in the WLEFC-nexus

EU WATER POLICY	
W1	Achieve good water quality status
W2	Ensure sufficient supply of good quality surface water and groundwater for people's needs, the economy and the environment
W3	Increase water efficiency
W4	Reduce water consumption
W5	Assess and manage flood risk and mitigate flood effects
W6	Address and mitigate water scarcity and drought
EU ENERGY POLICY	
E1	Increase production of biofuel
E2	Increase consumption of biofuel
E3	Increase production of energy from biomass (excluding biofuel)
E4	Increase consumption of energy from biomass (excluding biofuel)
E5	Increase hydro-energy production
E6	Increase hydro-energy consumption
E7	Increase energy efficiency
E8	Reduce energy consumption
E9	Push forward important energy infrastructure projects (grid, network, interconnectors, etc.)
E10	Achieve energy supply security
EU LAND USE POLICY	
L1	Restoring degraded soils to a level of functionality consistent with at least current and intended use
L2	Prevent soil degradation
L3	Maintain and enhance forest cover
L4	Prevent indirect land use change from nature to productive use
EU FOOD AND AGRICULTURE POLICY	
F1	Contribute to farm incomes (if farmers respect rules on environment, land management, soil protection, water management, food safety, animal health and welfare - 'cross-compliance')
F2	Improve competitiveness of agricultural sector (including sector-specific support and international trade issues)
F3	Ensure provision of environmental public goods in the agriculture sector
F4	Support rural areas economy (employment, social fabric, local markets, diverse farming systems)
F5	Promote resource efficiency in the agriculture, food and forestry sectors

F6	Reduce and prevent food waste
F7	Reduce intake of animal protein in human diet (non-binding objective; expressed intention on a research phase)
EU CLIMATE POLICY	
C1	Reduce GHGs emissions to keep global temperature increase within 2 degrees
C2	Increase efficiency of the transport system
C3	Support the development and uptake of low-carbon technology
C4	Support the development and uptake of safe CCS technology
C5	Incentivize more climate-friendly land use
C6	Promote adaptation in key vulnerable EU sectors and in MSs

4.2 Assessment of the interaction of policy objectives in the WLEFC-nexus

To examine the extent to which the nexus policy domains are coherent in the EU policy landscape, we used the analytical framework proposed by Nilsson and colleagues (2012). The framework juxtaposes the nexus policy domains in a screening matrix where assessment of policy interactions is made for pairs of policy objectives.

A scoring scale was used to assess the interaction between pairs of objectives (see Figure 8). The scores are associated to the typology of interactions illustrated in Table 4. Negative scores identify conflicts between pairs of objectives; positive scores identify synergies between pairs of objectives. The score 0 indicates the absence of a significant interaction between pairs of objectives. A score of +3 indicates coherence between two objectives; a score of -3 indicates incoherence between two objectives. See Table 4 in section 3.2.1 for definitions of the terms used in Figure 8Figure 8. Each typology of interaction is unique.

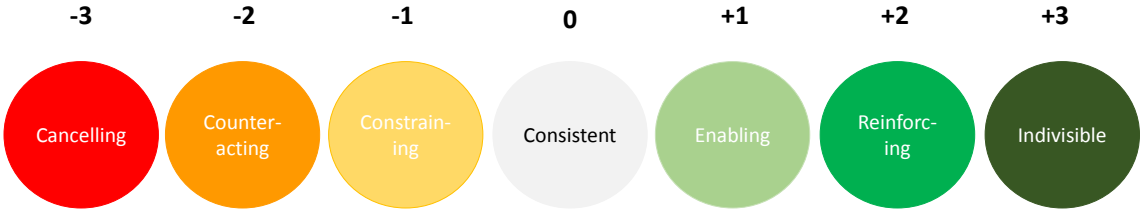


Figure 8. Scoring system for assessing the interaction of policy objectives

The scoring of interactions was performed in a step-wise, iterative fashion, using multiple sources of information. The approach consisted of the following steps:

1. Individual scoring of interactions conducted by two researchers with expertise in the nexus domains. Calibration of the assessment was ensured by extensive discussion between the two researchers about the meaning and the use of the scoring scale.
2. Comparison of the individual scoring. Whenever a difference in the scoring was detected, the two researchers discussed their scoring argument and agreed, providing motivation, on a score.
3. Discussion of the most controversial interactions in a team of PBL researchers with disciplinary expertise on water, energy, food and agriculture, land use and climate change. The group discussion led to the revision of several scores.

When scoring interactions, the researcher answered the following question: *What happens to objective X if we make progress on objective Y?* Furthermore, the scoring was guided by the following principles:

- Consideration of only direct interactions. Indirect interactions and re-bound effects were not included when scoring. Indirect interactions were expected to emerge from the network representation, which will be described in section 6.2.1.
- Consideration, whenever relevant, of to what extent the interactions are affecting the long-term objectives 'resource efficiency' and 'low carbon economy'.
- Consideration, when relevant, of the context; this implies that, for the same pair of objectives, the interaction can be different across different geographical, political, socio-economic, bio-physical domains. Therefore, clear specification of the context accompanied the assigned scores.
- Justification of scores for the most controversial interactions.

The scoring was based on the following sources of information:

- Expert knowledge: PBL researchers with expertise on policy, socio-economic and bio-physical interactions in the different nexus domains.
- When necessary, evidence or predictions of policy outcomes and policy interactions available in the secondary literature.
- When necessary, information on bio-physical and socio-economic interactions provided by SIM4NEXUS WP1.

As next step in the process of policy coherence analysis, we plan to discuss the screening matrix and the relative scores with a number of relevant stakeholders including European Commission and UN officers, NGOs and industry representatives in the different nexus domains.

4.3 Selected NCOs: assessment of horizontal coherence of objectives and means, of vertical coherence of objectives, and of level of integration in policy documents

The next step in the analysis consisted on identifying the nexus critical objectives and critical systems for further investigation of the horizontal and vertical coherence of objectives and means. The selection of the NCOs was based on two criteria:

1) high density of interactions in the WLEFC-nexus;
2) relevance of the objectives for the SIM4NEXUS project.

For the selected NCOs, the horizontal coherence of the objectives and of the means within the respective NCS was investigated. The assessment of the coherence among means was based on the information stored in the database of primary data as well as on additional information retrieved from the website of institutions. The coherence of means was assessed in a descriptive fashion and by scoring the interactions among pairs of means using the above described scoring system (see Figure 8).

As for the assessment of the vertical coherence between EU and international policies, we chose to use the SDGs and UN primary policy documents to collect reference objectives of international

policies in the WLEFC-nexus. The vertical coherence of objectives was assessed in a descriptive fashion.

Finally, the extent to which primary policy documents (prescriptive policies) account for the interactions of objectives identified in the NCSs was assessed using the information stored in the database of primary data. A scoring system was developed and used to assess the level of integration of WLEFC objectives in the EU policy documents. The scoring system is illustrated in Table 8.

Table 8. Scoring system for the assessment of the level of integration of WLEFC objectives in the EU policy documents

0 = no integration	1 = low integration	2 = moderate integration	3 = strong integration
The document does not refer to other nexus sectors.	The document generically mentions the need to coordinate/integrate its objectives and/or instruments with other nexus policies	The document prescribes the integration/coordination of its objectives and/or instruments with other nexus policies but there is no provision of how to do such integration	The document prescribes conditions of measures to take to minimize impacts or harness synergies in other policy sectors. *E.g. direct payment to farmers under the EU CAP is conditioned to the implementation of good environmental practices in agriculture*

4.4 Two challenges in the assessment of policy coherence

Two key challenges exist in the analysis of policy coherence. Both are not addressed in the literature.

The first challenge concerns **time frames** and specifically the problem of how to reconcile the timing of the investigation with the timing of the policies. In principle, the focus of the SIM4NEXUS project is on both existing policies and policies under political discussion. There is in general no problem when studying goals and instruments as the coherence analysis can capture both existing and under discussion policies in documents and legislation. However, when it comes to investigate coherence at the level of implementation practices, we are confronted with the time lag between policy adoption and policy implementation. This means that, for example, for more recently adopted policies we may not be able to investigate coherence at the implementation level in the case studies.

The second challenge concerns the i**nteractions between multiple policies**. This is a critical issue that has been recognized in the literature as central in policy analysis but for which there is not satisfying solution at present. Policy coherence studies are typically conducted for pairs of policy areas and there are no instances of structured, quantitative methods to study multiple interactions among policies. In our investigation, we tentatively addressed the whole range of interactions across the goals and instruments in the nexus critical systems in a descriptive fashion.

5 Inventory of goals and means in the WLEFC-nexus at international and EU level

In this chapter, a schematic illustration of the nexus policy domains at international and EU scale is presented. The colours in the scheme indicate the various levels of the policy space, namely the policy domain, the policy sub-systems and the issue areas. General goals were identified at the level of policy domain; overarching objectives at the level of policy sub-systems and objectives at the level of issue areas (see section 4.1 for the overall structure). Policy instruments were identified at the level of issue area. The main policy documents defining policy goals and instruments were identified.

5.1 International policies in the WLFC-nexus

In the following a short description of the policy space of the water, land, food and climate nexus domain is provided. Energy is excluded because there is not an international energy policy domain (beside some specific actions which however do not establish an international energy domain). Detailed information about policy goals, means and related policy documents can be found in the inventory of policy goals and means in Appendix I. For ease of use in the appendix tables, the different policy levels are represented with the same colour system used in the schemes below.

5.1.1 Water

At international level the water domain (Figure 9) is strongly linked to the development agenda. Water is in fact tackled by the UN Sustainable Development Goals, by the UN and UNEP water strategy documents, as well as by the 1992 Convention on the Protection and Use of Transboundary Watercourses and the related Protocol on Water and Health. Key goals in the international water policy domain include:

- SDG 6 Ensure availability and sustainable management of water and sanitation for all
- SDG 15 Protect, restore and promote sustainable use of terrestrial ecosystems (incl. inland freshwater ecosystems), sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss
- Well-managed, healthy freshwater systems supporting sustainable development and human well-being
- Protection of human health and well-being, both individual and collective, within a framework of sustainable development, through improving water management and through preventing, controlling and reducing water-related diseases
- Resilience to climate change.

These goals revolve around four main water policy sub-systems, namely: water supply and quality; water sanitation; freshwater ecosystems; water and climate change. As for water supply and quality, key issue areas comprise drinking water and health, water scarcity (which links to the Desertification Convention), water quality, transboundary waters (essentially through the 1992 Convention on Transboundary Waters) and water use. Sanitation is linked to SDG 6 and deals essentially with access and waste water treatment and re-use, whereas the freshwater ecosystem issues are linked to SDG 15 and concern protection, invasive species migration, illegal trading of protected species and fair sharing of benefits deriving from the use of genetic resources. Finally, international water policy is concerned with the relation between climate change and water, particularly with adaptation (key objective is building resilience to climate change) and mitigation (key objective is considering water and ecosystem footprints of alternative climate change mitigation measures).

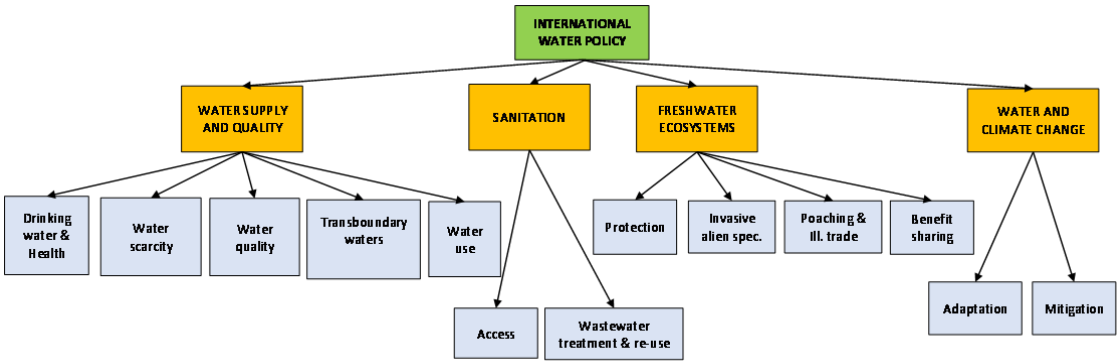


Figure 9. Schematic representation of the international water policy space

5.1.2 Land

International land use policy (Figure 10) revolves around two main policy sub-systems: desertification and forestry. Desertification policy is essentially covered by the UN Desertification Convention signed in 1994. The Convention aims to combat desertification and to mitigate the effects of drought in countries experiencing serious drought and/or desertification. To achieve these objectives, the Convention focuses on two main issue areas: droughts, and land and soil productivity with a number of soft instruments including cooperation among parties, promotion of multi-lateral institutions and financial mechanisms among affected parties.

As for forestry, the overarching objective 'sustainable management of forests and trees' is pursued with action from the UN and the FAO which have developed strategies for forestry management, an international agreement on tropical timber and several non-legally binding instruments. The key issue areas addressed by these documents are tropical timber, use of forest and illegal forest activities.

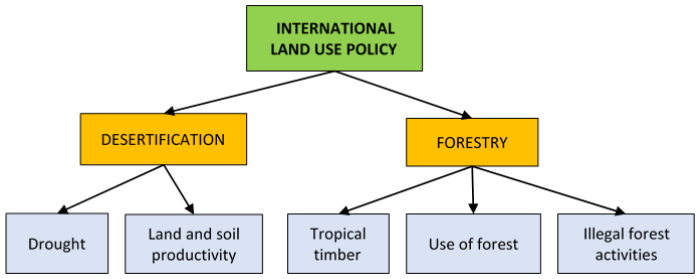


Figure 10. Schematic representation of the international land use policy space

5.1.3 Agriculture and food

Similarly to water, food and agriculture policy at international level (Figure 11) is linked to the development agenda and in particular to the SDGs. Other relevant documents include the UN FAO 2009 Declaration of the World Summit on Food Security and the UN FAO 1996 World Food Summit Plan of Action, the International Treaty on Plant Genetic Resources for Food and Agriculture, and the OECD FAO 2016 Guidance for responsible agricultural supply.
The main goals laid down in these documents are:

- SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- SDG 12: Ensure sustainable consumption and production patterns

- Pursue resilient agricultural practices that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters
- Pursue mitigation in agriculture

The key policy sub-systems that are delineated by these documents and goals are: food security, food production and consumption, and the relation between food and climate change. As for food security, relevant issue areas include: hunger and malnutrition (end it by 2030); food production, especially agriculture productivity and income of small-scale food producers; and genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species. Production and consumption is concerned with sustainability issues, food waste, consumption patterns (essentially information and awareness), and market and trade (in particular to limit food price volatility). Finally, mitigation and adaptation focus on implementation of resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

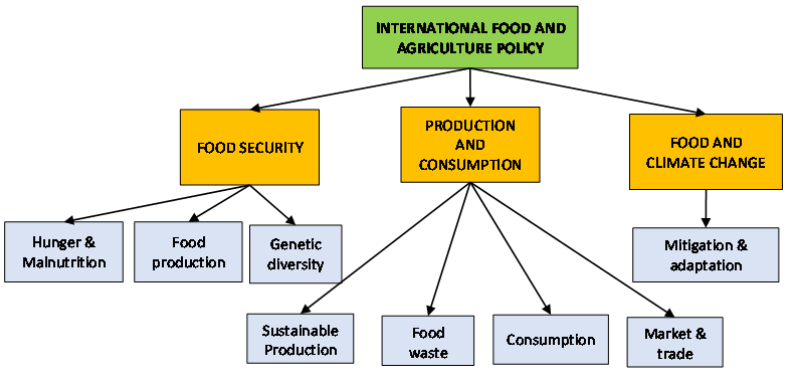


Figure 11. Schematic representation of the international food and agriculture policy space

5.1.4 Climate

Climate change at international level (Figure 12) is regulated by the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol (now in its second phase 2013-2020) along with the numerous agreements reached by the Conference of the Parties (COP), the last of which being the Paris Agreement signed in 2015. The goal of the UNFCCC is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. To this purpose, the Kyoto Protocol, as amended by the Doha Amendment, established new national emission reduction targets that should achieve the overarching objective of reducing GHGs emissions by 18% below 1990 levels between 2013 and 2020. Next to it, in 2016 in Paris, the Convention parties agreed to take action to keep the global temperature well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

The climate change international agreements regulate 5 main policy sub-systems: GHGs emission; financial support to developing countries for climate change mitigation and adaptation; technology development and transfer; capacity building actions to enhance the ability of individuals, organizations and institutions in developing countries and in countries with economies in transition to identify, plan and implement ways to mitigate and adapt to climate change. Emission reduction is pursued through national emission targets and economic instruments including emission trading, joint implementation

and clean development mechanisms. Next to it, other two important issue areas that are regulated are forestry and agriculture in developing countries (REDD+) and developed countries (LULUCF).

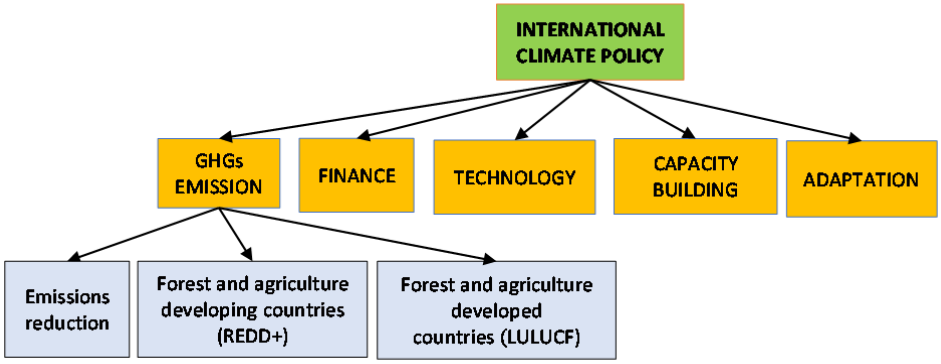


Figure 12. Schematic representation of the international climate policy space

5.2 European policies in the WLEFC-nexus

5.2.1 Water

Several European directives, action plans and strategy documents regulate 4 key policy sub-systems in the water domain, namely: water quality, water quantity, water use and flood risk (Figure 13). The EU water framework directive and the groundwater directive regulate the water status by establishing the objective of 'good water quality' for both surface water and groundwater. These directives together with the urban waste water directive and the EU action plan for circular economy also regulate substances released in water bodies by defining list and standards for priority substances and hazardous substances and for waste water treatment and re-use. The water framework directive also integrated in the EU legislation the international water agreements such as the agreement on transnational waters and the one on the protection of the marine waters.

As for water quantity, the objective of ensuring a sufficient quantity of good quality water for people's needs, the economy and the environment throughout the EU is addressed in three issue areas: actions for safeguarding water resources, actions for ensuring groundwater quantity and actions to tackle water scarcity.

Issue areas related to water uses are efficiency and re-use through measures such as guidance on the integration of water reuse in water planning and management, best practices, support to innovation (through the European Innovation Partnership and Horizon 2020), and legislative proposal on minimum quality standards for water reuse in agricultural irrigation and aquifer recharge.

The flood risk directive, the 2016 Action Plan on the Sendai Framework for Disaster Risk Reduction and the EU Parliament and Council decision on Union Civil Protection Mechanism are concerned with flood risk, prevention, preparedness and response through measures aimed at assessing and managing flood risk and measures for enhancing disaster preparedness and response.

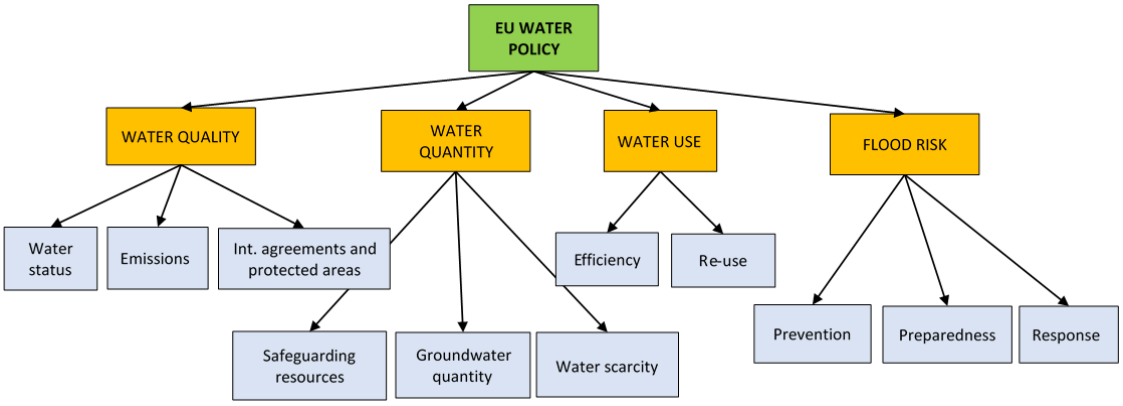


Figure 13. Schematic representation of the European water policy space

5.2.2 Land

Sustainable land use is the goal of the European land use policy (Figure 14). This goal is pursued through actions in three main policy sub-systems: forestry, soil and land use change. Sustainable forest management and the multifunctional role of forest is pursued through actions combating illegal timber logging in the EU (2003 EU Forest law enforcement governance and trade action plan) and with rules for sustainable use of forest resources (EU forest strategy).

Protection and sustainable use of soil is concerned with soil damage and soil protection. In particular, the EU land use policy aims to reduce quantitative and qualitative soil damage, prevent further soil degradation and restore degraded soils to a level of functionality consistent at least with current and intended use.

Limiting indirect land use change is a key issue of the EU land use policy. Actions in this area are laid down in the Renewable Energy Directive, the Fuel Quality Directive, and the Directive to reduce indirect land use change for biofuels and bioliquids.

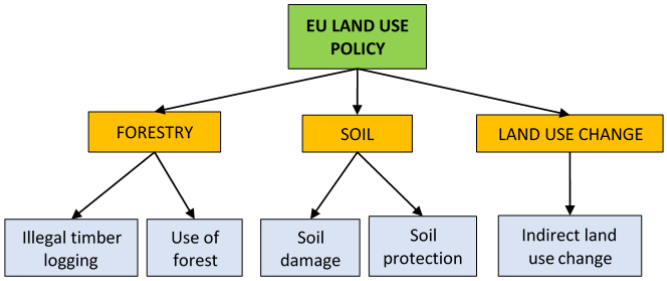


Figure 14. Schematic representation of the European land use policy space

5.2.3 Energy

The EU energy policy (Figure 15) is strongly interlinked with the EU climate policy and it is regulated by several EU directives, road maps, action plans and strategy documents. Key policy-subsystems are renewable sources, efficiency, internal market and competitiveness, supply security and innovation and technology.

Renewable sources include general rules, as well as rules for biofuels and biomass. General provisions for renewable sources include the objectives of: reaching a 20% share of energy from renewable

sources in the EU by 2020; reaching at least a 27% share of renewable energy consumption by 2030; achieving national targets for raising the share of renewables in MSs energy consumption by 2020. Key biofuel policy aims to reach 10% of biofuel in the transport sector by 2020; reduce indirect land use change for biofuels and bioliquids; ensure sustainable supply of biofuels; and get the aviation industry to use 2 million tons of biofuels by 2020. Key biomass policy objectives revolve around removal of barriers, creation of market-based incentives and sustainable supply.

Energy efficiency is regulated by the energy efficiency directive which sets the target of increasing energy efficiency by 20% by 2020 and the 2030 energy package that establishes the target of increasing energy efficiency of at least 30% by 2030 in the EU. Other rules are established for efficiency in buildings, and in products and services and for electricity co-generation.

The internal market and competitiveness sub-system essentially establishes common rules for the completion and competitiveness of the EU energy market and it prioritizes important energy infrastructure projects including those that will lead to achieve an electricity interconnection target of 15% between EU countries by 2030.

Energy security is pursued with actions in the gas, oil and electricity areas and through general rules to ensure a stable and abundant supply of energy for European citizens and the economy.

Finally, innovation and technology is supported through R&D initiatives at EU level aimed at the development and deployment of clean energy technologies, the lowering of the costs of new technologies, and the cooperation amongst EU countries, companies, research institutions and the EU. Transfer of technology to developing countries is pursued through actions for mobilizing private investment in small-scale energy efficiency and renewable energy projects in developing countries.

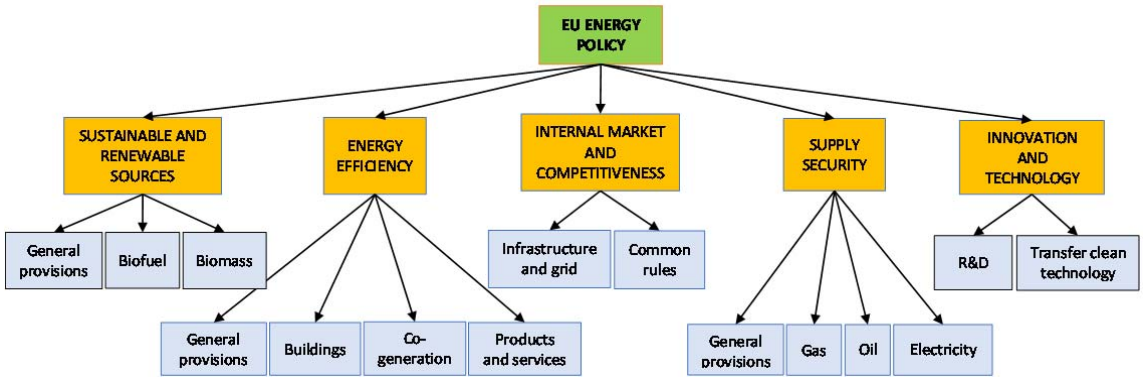


Figure 15. Schematic representation of the European energy policy space

5.2.4 Agriculture and food

The European food and agriculture policy (Figure 16) is regulated by numerous EU regulations, directives, action plans, and strategies. The key policy is the Common Agricultural Policy 2014-2020 which establishes three main goals that define three policy sub-systems: viable food production, sustainable management of natural resources and climate action, and balanced territorial development. Next to that, a fourth policy sub-system is supply chain. Food production and security revolves around two issue areas, namely farm income and farm competitiveness which are addressed with the allocation of financial resources through the first pillar of the CAP. Natural resources, climate action and territorial development are addressed with the allocation of financial resources through the second pillar of the CAP, i.e. rural development.

Functioning of the supply chain, food-related health issues in the supply chain, protein consumption, and food waste in the supply chain are the issue areas in the supply chain sub-system. Overarching objectives in this sub-system include: improve efficiency of food supply chain; fair trade practices; prevent diet-related diseases and deaths; address growing global demand for proteins; reduce and prevent food waste.

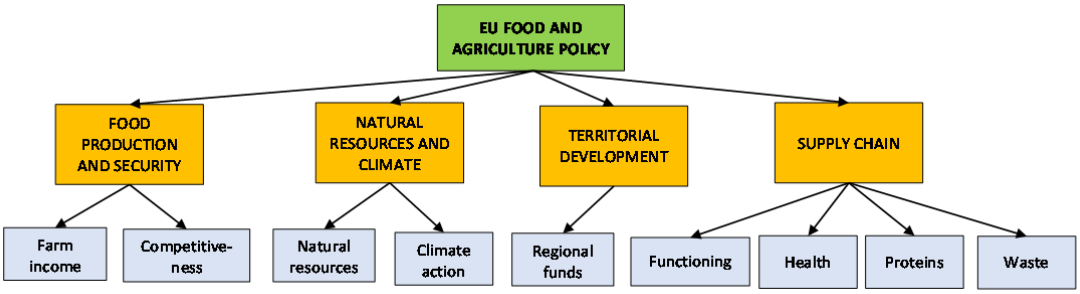


Figure 16. Schematic representation of the European food and agriculture policy space

5.2.5 Climate

The EU climate policy (Figure 17) is strongly interlinked with the EU energy policy and is regulated by several EU directives, road maps, action plans and strategy documents. Key policy-subsystems are identified: industry; housing, agriculture, waste and transport in member states; and transport; energy; low carbon technology; forest and agriculture; and adaptation at EU level.
Goals of the EU climate policy are: 20% GHGs emissions reduction (from 1990 levels) by 2020; 40% GHGs emissions reduction (from 1990 levels) by 2030; and 80-95% GHGs emissions reduction (from 1990 levels) by 2050. These goals are achieved through measures in different sectors at EU and member state level.

The EU industry sector is subject to rules for the reduction of GHGs emissions. The objective is to reduce GHGs emissions from large-scale facilities in the power and industry sectors by 21% compared to 2005 by 2020. To this purpose an EU-wide Carbon Emission Trading System (ETS) has been established. Other rules regulate fluorinated GHGs emissions to achieve the objective of cutting EU's F-gas emissions by two-thirds compared with 2014 levels by 2030.

Member states must meet their annual national emission reduction targets (established by the EU burden sharing decision) in the non-ETS sectors (housing, agriculture, waste, transport). The goal is to achieve by 2020 a reduction of about 10% in total EU emissions compared with 2005 levels.

As for the EU transport sector, key issue areas include road transport, fuel, shipping and aviation. As for road transport, the EU aims to increase efficiency, speed up the deployment of low-emission alternative energy for transport, and remove obstacles to the electrification of transport. Concerning fuel, the EU aims to reduce the GHG intensity of the EU fuel mix by 6% by 2020 in comparison to 2010, improve fuel quality and remove inefficient fossil fuel subsidies. The shipping sector should cut emissions from maritime transport by at least 40% from 2005 levels by 2050, and if feasible by 50% (not binding). The international aviation sector should stabilise CO2 emissions at 2020 levels (EU aviation is included in the EU ETS).

Energy efficiency and renewable sources are discussed in the EU energy policy in section 5.2.3.

Carbon Capture and Storage (CCS) and clean energy technology are the key issue areas in the technology sub-system. Clean energy technology is discussed in section 5.2.3. As for CCS, the EU supports the uptake of innovative and safe CCS technology. The topic is controversial and research has only recently started. Only a few experiments are currently undergoing and the production of evidence about the safety of this technology is in progress.

As for forest and agriculture the EU complies with the provisions in the UNFCCC for land use change in developed countries (LULUCF) and carbon emission and storage in forest in developing countries (REDD+). Illustration of these issue areas can be found in section 5.1.4.

Finally, climate adaptation is a key policy sub-system in the EU climate policy regulated by the EU climate adaptation strategy. With this strategy, the EU aims to promote adaptation in key vulnerable EU sectors, ensure more resilient infrastructure in the EU, and address gaps in adaptation knowledge. MSs are required to develop national adaptation plans.

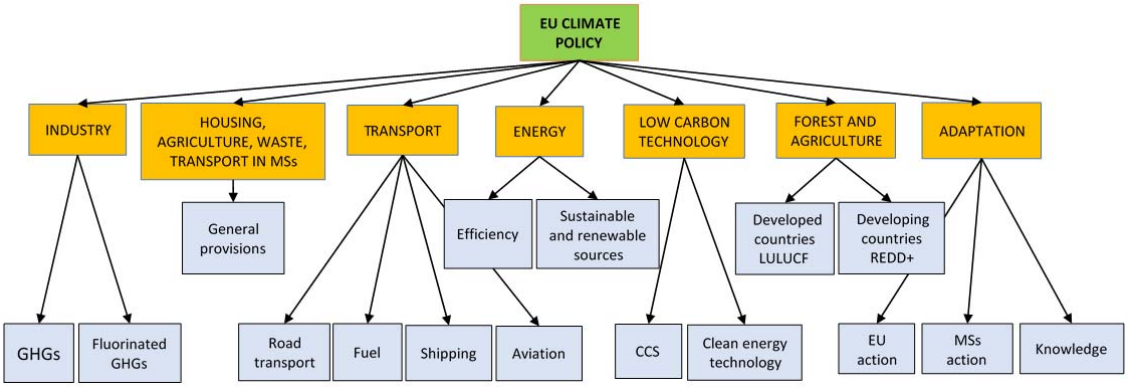


Figure 17. Schematic representation of the European climate policy space

6 Assessment of policy coherence in the WLEFC-nexus

6.1 Interaction of European policy objectives in the WLEFC-nexus: synergies and conflicts

This chapter illustrates the assessment of the interactions of the selected WLEFC European policy objectives. Ultimately, such assessment reveals the level of coherence between policy objectives in the nexus: highly synergistic interactions imply coherence between pairs of objectives whereas highly conflicting interactions imply incoherence between pairs of objectives. The description of the selected objectives and objective codes used in the tables in this section can be found in Table 7 in section 4.1.

Table 11 shows the scoring of the interactions for pairs of policy objectives in the WLEFC-nexus. Summary tables with the counting of the scores have been produced to facilitate the reading of the scoring table.

The first summary table (Table 9) shows the counting of the interactions per pairs of policy domains. In general, the highest density of interactions is found in the food/land (86%), food/water (79%) and land/water (71%) domains. Most of these interactions are synergistic. Specifically, progressing land use and water objectives have essentially only positive impacts in the nexus. Similarly, progressing objectives in the agriculture sector has also potential to act synergistically with the other objectives in the nexus, provided that the conditionality and the other instruments established by the common agricultural policy are properly functioning. Land/water are inextricably linked and progress in one domain benefit the other domain and the other way around.

Table 9. Frequency of interactions per pairs of policy domains

	Interactions			Synergies		Conflicts		Synergies & conflicts
	Actual interactions	Possible interactions	%	+	0/+	-	0/-	+/-
E → W	16	60	*27*	4	3	8	0	1
W → E	19	60	*32*	7	0	0	0	12
L → W	17	24	***71***	16	1	0	0	0
W → L	15	24	*63*	14	0	1	0	0
F → W	33	42	***79***	26	1	0	0	6
W → F	25	42	*60*	16	0	0	0	9
C → W	21	36	*58*	14	0	3	0	4
W → C	7	36	*19*	5	2	0	0	0
L → E	12	40	*30*	7	2	2	0	1
E → L	8	40	*20*	0	0	5	3	0
F → E	16	70	*23*	8	0	2	4	2
E → F	23	70	*33*	14	4	3	1	1
C → E	25	70	*36*	15	4	4	0	2
E → C	26	70	*37*	11	0	11	1	3
F → L	24	28	***86***	17	2	2	2	1
L → F	16	28	*57*	13	0	2	0	1
C → L	11	24	*46*	10	0	0	0	1
L → C	12	24	*50*	12	0	0	0	0
C → F	23	42	*55*	18	1	0	0	4
F → C	23	42	*55*	17	3	3	0	0

Table 10 shows the counting of the interactions per each objective. Looking at the density of interactions, the highest numbers are present in the climate, land and energy domains when objectives affect the WLEFC-nexus and in the water, agriculture and climate domains when objectives are affected by the WLEFC-nexus. Specifically, when affecting the WLEFC-nexus, biofuel production (E1), GHGs emission reduction (C1), climate adaptation (C6) and indirect land use change (L4) show the highest density of interactions. In particular, of all possible interactions, E1 has the highest number (74%) and most of them are negative. C1 and C6 have the second highest number (70%) and most of the interactions are positive. As for affected objectives, water supply (W2) shows the highest number of interactions (74%), along with GHGs emission reduction (C1; 74%) and farmers income (F1; 74%).

Turning now to the type of interaction, the first important result of the assessment is that synergies are more prominent than conflicts. For example, progress in all land use objectives may have positive, synergistic effects on all other nexus domains. Restoring degraded soils (L1) and preventing soil degradation (L2) could contribute to improve water quality (W1) and storage in the ground (W2), support agriculture productivity (F1, F2, F3, F4, F5) and contribute to store carbon and therefore reduce GHGs emissions (C1). Similarly, maintaining forest cover (L3) and preventing indirect land use change (L4) could contribute to improve water quality (W1) and storage in the ground (W2), provide biomass for energy production (E3), contribute to store carbon (C1), incentivize more climate friendly land use (C5) and support climate change adaptation (C6).

Progressing water objectives also act synergistically with most objectives in the nexus, especially with land (L1, L2, L3) and agriculture objectives (F1, F2, F3, F4, F5), although the impact may depend on the context conditions (hence numerous +/- scores). A typical example is the fact that improved water quality and quantity is positive for agriculture production if the newly available water is not diverted to other uses such as human consumption. The latter may happen for example in water scarce areas. In this case, agriculture would be penalized.

Another example of positive interactions is provided by objective W6. Addressing water scarcity and droughts (W6) acts synergistically with energy production (because water is needed to produce energy) and also with restoring and maintaining soil quality (L1, L2); it certainly enables agriculture productivity (F1, F2); and it is a necessary condition for the provision of ecosystem services in agri-environments (F3) and for climate adaptation (C6).

Increasing energy efficiency (E7) and reducing energy consumption (E8) work synergistically with water, agriculture and climate objectives. Without energy efficiency and reduced consumption, it is impossible to achieve GHGs emission reduction (C1) and efforts in this direction cannot take place without new low carbon technology (C3). Similarly, more efficiency and less use of energy create the conditions for a more viable agricultural sector (F1, F2, F5).

In the food and agriculture sector, synergistic interactions are conditioned to the proper functioning of the conditionality mechanism and of all other instruments established by the common agricultural policy to support rural development. When this is the case, progress in supporting farms' income (F1), in increasing ecosystem services in agriculture (F3), in supporting the rural economy (F4), and in promoting resource efficiency (F5) may enable the achievement of all water and land use objectives as well as climate objectives. Farm competitiveness (F2) is the only objective whose achievement may come at the expenses of water and land objectives, when competitiveness is pursued with intensification of agriculture production (hence with the use of more fertilizers, pesticides and intensive land use techniques).

As for conflicting interactions, the major trade-offs are found in the energy domain and, to a lesser extent, in the agriculture and climate domains. Interestingly, as noted above, biofuel production (E1) shows the highest density of interactions and, contrary to the rest of the objectives, most of these

interactions are conflicting with the other objectives in the WLEFC-nexus. It is important to note that although the EU policy concerns all types of biofuels, bioliquids and biomass (see Appendix I), biofuel production in this study includes only the first-generation biofuels made of food and feed crops. This was done to ensure unambiguous scores. EU policy aims at phasing out biofuels made from food and feed crops used in transport, but as technology for second and third-generation biofuels is still developing, we assume that in the years to come[1], biofuels will still be made of food and feed crops.

Looking at the scores, particularly negative is the impact of E1 on forest cover (L3) and indirect land use change (L4). Progress on E1 makes it impossible to simultaneously progress on L3 and L4, even with sustainable production of biofuels, because the amount of biofuel needed to significantly contribute to the reduction of GHGs is simply too high to not significantly impact land use. The reverse is also true, namely contrasting indirect land use change may occur at the expenses of biofuel production. Progress on E1 also counteracts progress on climate friendly land use (C5), on reduction of water consumption (W4), and on the provision of ecosystem services in agro-environments (F3). The vice-versa also applies as the provision of ecosystem services in agriculture may occur at the expenses of biofuel production.

Another significant trade-off exists between energy and water. Increase of hydro-energy production (E5) makes it impossible to simultaneously progress in water quality (W1) and may have negative impacts on water availability (W2). Hydro-power plants are in fact known for having negative effects on aquatic ecosystems and for subtracting water to other uses. However, if the hydro-power reservoirs act as a water buffer that stores water in wet seasons and supplies water in dry seasons, they may have a positive impact on water supply.

Finally, in the climate domain, supporting the development and uptake of carbon capture and storage (CCS) technology (C4) directly counteract the progression of the water quality (W1) and availability (W2) objectives as water is used in this technology.

[1] The new energy package proposed by the EC in 2016 states: "the contribution from biofuels and bioliquids, as well as from biomass fuels consumed in transport, if produced from food or feed crops, shall be no more than 7% of final consumption of energy in road and rail transport in that Member State. This limit shall be reduced to 3,8% in 2030.....Member States may set a lower limit...". This policy is still in the proposal phase. The aim is to progressively reduce the use of 1st generation biofuel in the transport sector.

Table 10. Counting of direct interactions per each policy objective (excluding interactions within the sector); in red, the first 2 highest number of interactions; % is calculated on the total number of possible interactions

	INFLUENCING What happens in the nexus if we make progress on objective X?							INFLUENCED What happens to objective X if we make progress on other objectives in the nexus?						
	Interac-tions	%	Synergies		Conflicts		Syn & Conf	Interac-tions		Synergies		Conflicts		Syn & Conf
Obj. X			+	0/+	-	0/-	+/-		%	+	0/+	-	0/-	+/-
W1	9	*33*	4	0	0	0	5	17	*63*	12	0	3	0	2
W2	14	*52*	7	0	1	0	6	20	*74*	15	1	2	0	2
W3	7	*26*	5	0	0	0	2	7	*26*	3	1	0	0	3
W4	11	*41*	5	0	0	0	5	16	*59*	8	2	3	0	3
W5	11	*41*	9	1	0	0	1	11	*41*	10	0	1	0	0
W6	14	*52*	11	1	0	0	2	16	*59*	12	1	1	0	2
E1	17	*74*	2	0	13	1	1	15	*65*	4	1	4	0	6
E2	3	*13*	0	0	2	0	1	2	*9*	1	0	1	0	0
E3	11	*48*	5	0	1	4	1	10	*43*	5	3	2	0	0
E4	2	*9*	1	0	1	0	0	1	*4*	1	0	0	0	0
E5	9	*39*	2	0	5	0	2	10	*43*	6	0	0	1	3
E6	2	*9*	1	0	1	0	0	0	*0*	0	0	0	0	0
E7	10	*43*	8	2	0	0	0	10	*43*	5	1	1	1	2
E8	9	*39*	9	0	0	0	0	15	*65*	7	1	0	1	6
E9	3	*13*	1	1	0	0	1	1	*4*	0	0	0	1	0
E10	7	*30*	0	4	3	0	0	8	*35*	8	0	0	0	0
L1	14	*48*	14	0	0	0	0	15	*52*	11	1	2	1	0
L2	14	*48*	14	0	0	0	0	16	*55*	12	1	2	1	0
L3	12	*41*	10	0	1	0	1	16	*55*	12	0	2	2	0
L4	17	*59*	10	3	3	0	1	11	*38*	6	0	2	1	2
F1	16	*62*	13	1	0	2	0	19	*73*	12	1	1	0	5
F2	15	*58*	2	0	5	2	6	18	*69*	11	1	1	0	5
F3	15	*58*	11	0	2	2	0	14	*54*	12	0	1	0	1
F4	14	*54*	10	2	0	0	2	17	*65*	12	2	0	0	3
F5	14	*54*	11	3	0	0	0	17	*65*	13	1	2	0	1
F6	11	*42*	11	0	0	0	0	2	*8*	1	0	0	1	0
F7	11	*42*	10	0	0	0	1	0	*0*	0	0	0	0	0
C1	19	*70*	15	0	2	0	2	20	*74*	15	0	2	0	3
C2	8	*30*	7	0	1	0	0	6	*22*	2	1	2	1	0
C3	12	*44*	10	0	0	0	2	12	*44*	5	1	6	0	0
C4	6	*22*	0	2	4	0	0	0	*0*	0	0	0	0	0
C5	16	*60*	11	1	0	0	4	15	*55*	10	2	3	0	0
C6	19	*70*	14	2	0	0	3	15	*55*	13	1	1	0	0

What happens to objective x → **(affected)**
If we make progress on objective y ↓**(affecting)**

Table 11. Screening matrix of coherence among policy objectives in the WLEFC-nexus domains

	W1	W2	W3	W4	W5	W6	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	L1	L2	L3	L4	F1	F2	F3	F4	F5	F6	F7	C1	C2	C3	C4	C5	C6
W1		+2	0	-1/0	+1	+1	-1/+1	0	0	0	-1/+1	0	0	0	0	0	+1	+1	+1	0	-1/+1	-1/+1	+2	-1/+2	0	0	0	0	0	0	0	0	0
W2	+2		-1	-1	0	+3	-1/+2	0	0	0	+3	0	0	-1/+1	0	+2	+1	+1	+1	-1	-1/+2	-1/+2	+2	-1/+2	-1/+1	0	0	0	0	0	0	0	+1
W3	0	0		+3	0	+2	+1	0	0	0	0	0	-1/+1	-1/+1	0	0	0	0	0	0	+1	+2	0	0	+3	0	0	0	0	0	0	0	+3
W4	+1	+3	+2		0	+2	-1/+1	0	0	0	-1/+1	0	-1/+1	+2	0	0	+1	+1	0	0	-1/+1	-1/+1	+1	0	+2	0	0	0	0	0	0	0	+1
W5	-1/+1	-1/+1	0	0		0/+1	-1/+1	0	0	0	0	0	0	0	0	+2	+1	+1	+1	0	+1	+1	+1	+1	0	0	0	0	0	0	0	0/+1	+3
W6	+1	+3	+2	+3	0		-1/+1	0	0	0	+1	0	0	-1/+1	0	+2	+1	+1	+1	0	+1	+1	+3	+1	+1	0	0	0	0	0	0	0/+1	+3
E1	-1	-1	0	-2	-1	-1		+3	0	0	0	0	0	0	0	+1	-1	-1	-3	-3	+2	0	-2	+1	-1	0	0	-1/+2	-1/0	-2	0	-2	0
E2	0	0	0	0	0	0	+3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1/+2	-1	-1	0	0	0
E3	0	0	0	0	0	0	0	0		+3	0	0	0	0	0	+1	-1/0	-1/0	-1/0	0	+1	+1	-1/+1	+1	+1	-1/0	0	+2	0	-2	0	0	0
E4	0	0	0	0	0	0	0	0	+3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	0	-1	0	0	0
E5	-3	-2/+1	0	-1	0	-2/+2	0	0	0	0		+3	0	0	+1	+1	0	0	-1	0	0	0	0	0	0	0	0	+2	0	-1	0	-1	+1
E6	0	0	0	0	0	0	0	0	0	0	+3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+2	0	-1	0	0	0
E7	0	+1	0/+2	0/+2	0	0	-1/0	-1/0	-1/0	-1/0	-1/0	-1/0		+3	0	+1	0	0	0	0	+2	+2	0	+1	+3	0	0	+3	+1	+3	0	0	0
E8	+1	+1	0	+2	0	0	-1	-1	-1	-1	-1	-1	+3		-1	+1	0	0	0	0	+2	+2	0	0	+3	0	0	+3	+1	+2	0	0	0
E9	0	0	0	0	0	0	0	0	0	0	+1	+1	-1	-1		+2	0	0	0	0	0	0	0	0/+1	+2	0	0	-1/+1	0	0	0	0	0
E10	0	0/+1	0	0	0	0	-1	0	-1	0	-1	0	-1	-1	+1		0	0	0	0	0/+1	0/+1	0	0/+2	-2	0	0	-1	-1	0	0	0	0
L1	+3	+2	0	0	+2	+2	+1	0	+1	0	0	0	0	0	0	0		0	+2	+1	+1	+1	+2	+1	+2	0	0	+2	0	0	0	+2	+2
L2	+3	+2	0	0	+2	+2	+1	0	+1	0	0	0	0	0	0	0	0		+1	+2	+1	+1	+2	+1	+2	0	0	+2	0	0	0	+2	+2
L3	+1	+2	0	0	+1	+2	-1	0	+1	0	-1/+1	0	0	0	0	0	+1	+2		-1/+2	0	0	+1	+1	0	0	0	+3	0	0	0	+3	+2
L4	+1	+1	0	0/+1	+1	+1	-2	0	+1	0	+1	0	0/+1	0/+1	0	0	+1	+2	+3		-1	-1	+2	-1/+1	0	0	0	+2	0	+1	0	+1	0
F1	+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	-1/0	-1/0	0	0	+2	+2	+2	+2		-1/+1	+1	+1	-1/+1	0	0	+1	0	0/+1	0	+1	+1
F2	-1/+1	-1/+1	-1/+1	-1/+1	0	-1/+1	0	0	0	0	0	0	+1	-1/+1	0	0	-1	-1	-1/0	-1/0	+2		-1	+1	+2	0	0	-1	0	+1	0	-1	-1
F3	+3	+3	0	0	+1	+2	-2	0	-2	0	-1/0	0	0	0	-1/0	0	+3	+3	+2	+2	-1/+1	-1/+1		+1	0	0	0	+1	0	0	0	+2	+2
F4	-1/+1	+1	+1	+1	+1	+1	0	0	0	0	0	0	+1	-1/+1	0	0	0/+1	0/+1	+1	+1	+1	+1	+1		+1	0	0	0	0	0	0	+1	+1
F5	0	+1	+3	+2	0	0/+1	0	0	0	0	0	0	+3	+3	0	+1	0	+1	0	+1	+1	+1	+1	+1		+1	0	+3	0/+1	+3	0	+1	0/+1
F6	+1	+1	0	+2	0	+1	0	0	0	0	0	0	0	+2	0	+1	0	0	+1	+1	-1	0	0	-1	+2		0	+2	0	0	0	+1	+1
F7	+1	+1	0	+2	0	+1	0	0	0	0	0	0	0	+2	0	0	+1	+1	+2	-2/+2	-2	0	-1/+1	-1	+2	+1		+3	0	0	0	+1	0
C1	+2	+2	0	+2	+2	+2	-1	0	-1	0	+1	0	0	+1	0	+1	+1	+2	+1	0	-1/+1	-1/+1	+1	+1	+1	+1	0		+3	+3	+3	+3	0
C2	0	0	0	0	0	0	0	-1	0	0	0	0	+3	+3	0	+2	0	0	0	0	+1	+1	0	+1	+3	0	0	+3		+2	0	0	0
C3	0	0	-1/+1	-1/+1	0	0	+2	+2	+2	+2	+2	0	+3	+2	0	0	0	0	0	0	+1	+2	0	0	+3	0	0	+3	+3		+3	0	0
C4	-2	-2	0	-1	0	0	0/+1	0	0/+1	0	0	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+3	0	+3		0	0
C5	+1	+1	0	+1	+1	+2	-1/+1	0	0/+1	0	0	0	0	0	0	0	+1	+1	+1	-1/+1	-1/+1	-1/+1	+3	+1	+1	0	0	+3	0	0	0		+1
C6	+1	+2	-1/+1	-1/+1	+3	+3	0	0	0/+1	0	+1	0	0	-2/+2	0	+3	+1	+1	+2	+1	+2	+2	+2	+1	0/+1	0	0	0	0	0	0	+1	

6.2 Biofuel production and water supply: examples of nexus critical objectives

In this section, we illustrate the in-depth investigation of the horizontal and vertical coherence of objectives and means for two critical nexus objectives that have been selected based on the assessment of interactions and the relevance to the SIM4NEXUS project.

The two selected objectives are E1: Increase of biofuel production; W2: Ensure sufficient supply of good quality water for people's needs, the economy and the environment. These two objectives were selected, according to our methodological approach, for two main reasons: 1) high number of interactions in the WLEFC-nexus (see Table 10); and 2) relevance of the objectives for the SIM4NEXUS project. Specifically, increasing biofuel production directly *affects* 18 objectives (other than energy) in the WLEFC-nexus. This is the second highest number of interactions in the WLEFC-nexus after GHGs emissions and includes almost all water objectives and all land use objectives. As for the objective of sufficient water supply, this is *affected* by 20 objectives (other than water) in the WLEFC-nexus. Furthermore, both water supply and biofuel production are key issues in several of the SIM4NEXUS case studies as well as important for the overall project objective of resource efficiency and low carbon economy. Overall, E1 and W2 represent an interesting example of nexus *problématique* and therefore are considered a good example for testing and illustrating the policy coherence analysis methodology developed in this study.

The following sub-sections illustrate the results of the horizontal coherence analysis conducted at the level of policy objectives and means across the WLEFC-nexus domains and the results of the vertical coherence analysis of these objectives with international policies in the WLEFC-nexus. Furthermore, the level of integration of these objectives in the WLEFC-nexus policies is also presented. For this purpose, we looked at biofuel policy as affecting policy and at water supply as affected policy. We screened if and how EU policy documents for biofuels refer to the other nexus domains and conversely if and how policy documents for the WLEFC domains refer to water supply. For this analysis, we used the data in the excel database with sampled information of 131 policy documents (see Digital Appendix).

6.2.1 Coherence of the objectives 'Increase biofuel production' and 'Water supply' in the WLEFC-nexus

The interaction of the two nexus critical objectives E1 and W2 in the WLEFC-nexus is illustrated in Figure 18. The figure represents the network of interactions for the two objectives, including the direct interactions of each objective in the nexus and the indirect interactions between the two objectives. The arrows represent the direction of the interaction, whereas the numbers represent the strength of the interaction and whether it is a potential synergy or a potential conflict. Representing the coherence assessment in a network gives the possibility to visualize not only the direct but also the indirect interactions between the selected nexus critical objectives. These indirect interactions are represented by the green arrows. The numbers, however, do not express the strength of the indirect interaction but only that of the direct interaction. The sign of the combination of two direct interactions follows the mathematical law in the sense that if both direct interactions are positive or both are negative, the combined indirect interaction is positive. But if one is positive and the other negative, the combined indirect interaction is negative.

Interlinkages between two objectives have two directions, e.g. E1 influencing W2 and vice versa, W2 influencing E1. The coherence score in one direction may differ from the score in the other direction. In the coherence analysis described in section 6.1, the influence of objective E1 on objective W2 is

'constraining' (score -1), which means that progress in E1 sets conditions or constraints to the achievement of W2. It is assumed that increase of biofuel production needs water and may cause pollution of water, and thus puts constraints on sufficient water supply of good quality for all water users. The other way round, the influence of objective W2 on objective E1 is either constraining (score -1) or reinforcing (score +2), the latter meaning that progress on W2 directly creates conditions that reinforce the achievement of E1. The score depends on the context. If water is scarce, there may be constraints on the availability to produce biofuels if other users – e.g. food production, drinking water, industry - have priority. If water supply is sufficient, it creates a favourable condition to produce biofuels.

6.2.1.1 Linkages between objective E1 'Increase biofuel production' with other WLEFC objectives

In general, Figure 18 and Table 12 show how an increase of biofuel production may have substantial negative impact in the WLEFC-nexus (13 out of 17 interactions are negative). It is worth notice that, in spite the overall general observation that there are more synergies than conflicts in the nexus (see section 6.1), objective E1 shows a remarkably high number of negative interactions. In particular, if not sustainably pursued, the increase of biofuel production may: constrain or even counteract the achievement of almost all water objectives; constrain the achievement of soil quality objectives; make it impossible to maintain forest cover and reduce indirect land use change; counteract the provision of environmental goods and services in agriculture; constrain resource efficiency in agriculture; and even constrain the progress of climate change objectives, which should be the primary goal of biofuel production. On this latter point, the impact of more biofuel production on GHGs emission reduction is still controversial in the literature (hence the score -1/+2). Its contribution to the efficiency of the transport system is also debatable: it may be negligible but it may also prove limiting as more biofuel in the market may push back research for greater efficiency because emissions reduction would already be achieved via the biofuel production. The underlying logic of this chain of events is that if the GHGs emission problem were to be largely addressed by more biofuel production, investment in other low carbon sectors would be pushed back. In the same vein, more biofuel production could also counteract the objective of supporting low carbon technology and of incentivizing more climate friendly land use.

Most of these direct negative impacts can have an indirect effect on the other nexus critical objective, i.e. the water supply objective (W2). For example, the negative impact of biofuel production on soil quality, especially when intensive biofuel crop production is practiced, may in turn negatively affect the supply of water as good quality soil plays an important role in water retention. Similarly, a negative impact of biofuel production on GHGs emission reduction may in turn affect the supply of water as more droughts may occur due to climate change. Water supply can also be negatively affected via the reduced environmental services produced in an agricultural sector that practices intensive biofuel production.

Looking at the positive direct impact that E1 may have in the nexus, this is limited to 2 nexus objectives in the food and agriculture sector. Essentially, a policy supporting biofuel production may play an important role in sustaining farm income and the economy of rural areas.

When it comes to being affected, we can observe that E1 could essentially either positively or negatively be affected by water quality, supply, efficiency and consumption depending on the conditions of the specific context. For example, an increase of water efficiency can be positive as it may make more water resources available for crop irrigation; at the same time these newly available good quality water resources could be directed to different, more valuable uses such as human consumption.

Availability of good quality soil may have a positive impact on biofuel production as it may increase productivity. Consequently, progress in restoring degraded soil (L1) and in preserving soil quality (L2) may have a positive effect on biofuel production. Similarly, incentivising climate friendly land use (C5) can also enable soil productivity and therefore biofuel production. At the same time, however, a climate friendly land use practice can be reducing intensive agriculture which may result in less biofuel production (hence the score -1/+1 in C5 → E1).

Supporting the provision of environmental goods and services in agriculture (F3) may also counteract biofuel production if this is practiced in the form of intensive agriculture. In the land use domain, maintaining and enhancing forest cover (L3) and preventing indirect land use change (L4) may directly constrain or even counter act biofuel production as more land is needed for biofuel production and this creates a competition for land.

Finally, progress in water supply can have both direct and indirect positive effects on biofuel production. Biofuel crop is water demanding, hence more water supply certainly directly creates conditions for more biofuel production. However, depending on the context, more water available does not necessarily mean that this water goes for irrigation as other more important uses can be privileged (hence the score -1/+2 on W2 → E1). Also, more water available can enable progress on soil quality which in turn may have a positive effect on soil productivity and therefore biofuel production. In the agriculture domain, more water supply may support farm production and indirectly also biofuel production. However, more water available may also have a negative impact resource efficiency as farmers may over use water. This in turn may result in a negative impact on biofuel production.

6.2.1.2 Linkages between objective W2 'Water supply' with other WLEFC objectives

Looking at what Figure 18 and Table 12 show about W2, we can observe that there are more interactions in the direction of water supply being affected and that most of these interactions are potentially synergistic (15 out of 20). Specifically, furthering all agriculture objectives either enables or creates conditions for progressing the water supply objective. This may sound counterintuitive as water is a natural resource that is heavily exploited in agriculture. The reason lays in the fact that the EU common agricultural policy takes into consideration the impact of agriculture on water by for example establishing conditionality rules for good environmental practices to farmers' direct payment and by supporting environmental friendly agriculture in rural development. Hence, on paper potential synergies are created. However, it is also known that these synergies may fail to materialize in practice.

Conditions for improving water supply are also created in the land domain. As mentioned above, improving and maintaining soil quality (L1, L2), contrasting indirect land use change (L4) and maintaining forest cover (L3) have positive effects on water availability. The reason of the existence of these synergies is however different from the agriculture domain. Differently from agriculture objectives, land use objectives are by definition pro-environment and may have multiple direct and indirect effects including improving water supply. As for the climate domain, emissions reduction (C1), climate friendly land use (C5) and adaptation (C6) all enable or create conditions for improving water supply.

In contrast, CCS (C4) may be water demanding and therefore act negatively on water supply. Finally, given that energy production is water-consuming, relevant negative direct impacts on water availability come from hydropower production (E5) and from biofuel production (E1), whereas the positive interactions are found on increasing energy efficiency (E7) and reducing energy consumption (E8). Indirect negative effects on water availability, occur for example via land use in the production of biofuels as intensive production of biofuel may degrade soil and reduce forest cover which indirectly affect water availability. Other indirect effects are found via agriculture in the production of biofuel.

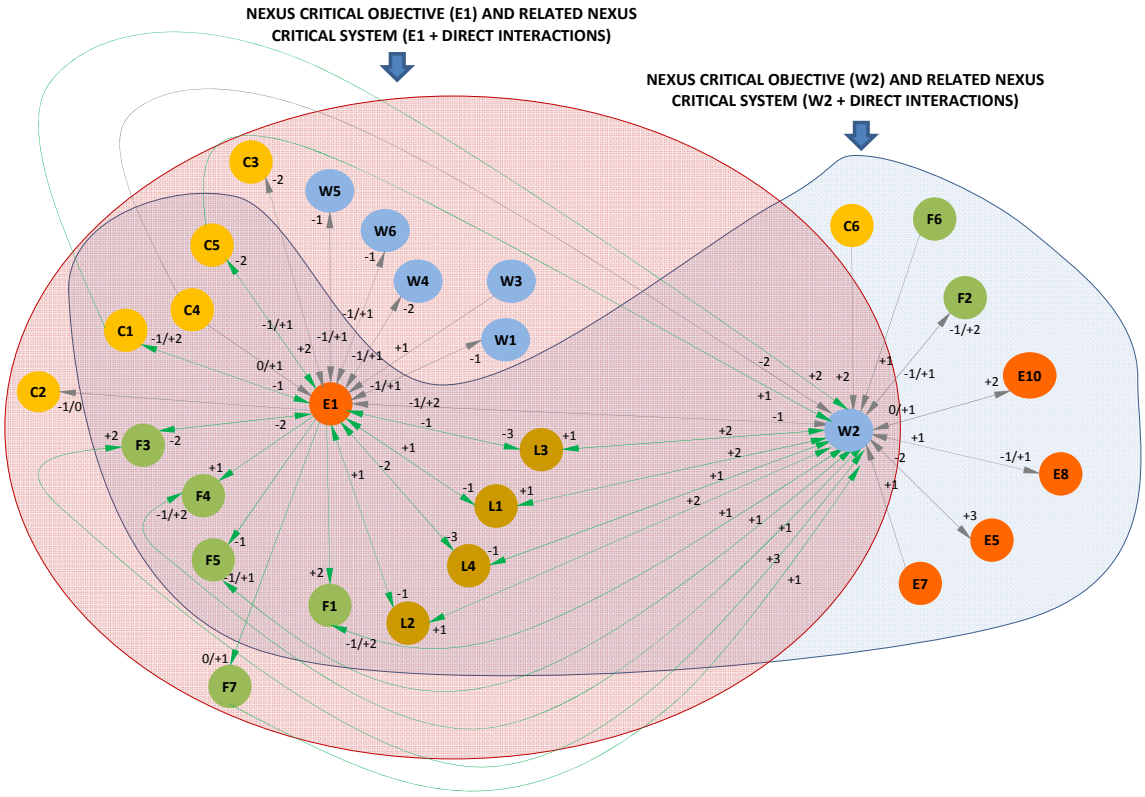


Figure 18. Representation of the network of interactions for the NCOs E1 and W2 (green arrows represent the path of indirect interactions)

Table 12. Counting of interactions for the nexus critical objectives E1 and W2

	Interactions			Potential synergies		Potential conflicts		Synergies & conflicts
	Actual interactions	Possible interactions	%	+	0/+	-	0/-	+/-
E1 influencing	17	23	*74*	2	0	13	1	1
E1 influenced	15	23	*65*	4	1	4	0	6
W2 influencing	14	27	*52*	7	0	1	0	6
W2 influenced	20	27	*74*	15	1	3	0	1

6.2.2 Level of integration of biofuel and water supply objectives in the EU WLEFC policy documents

EU policies take the linkages with other policy domains into account. Impact assessments, for example, are an instrument to investigate these external linkages. Policy documents can refer to other policy domains in different degrees.

We examined the references to other WLEFC domains in the EU policy documents for objective E1, 'Increase biofuel production' and scored them according to the scoring scale described in Table 8 in section 4.3: 0 = no integration; 1 = low integration; 2 = moderate integration; 3 = strong integration. Here again, we looked at objective E1 from the viewpoint of an influencing policy on other policy domains. The other way round, we investigated the references to W2 'Ensure sufficient supply of good quality water for people's needs, the economy and environment' in EU policy documents for other

WLEFC domains than water, looking at W2 from the viewpoint of an influenced policy objective. The results of this assessment are presented in Table 13 and Table 18.

6.2.2.1 References to WLFC policy domains in documents about renewable energy (E1)

Objective E1 'Increase biofuel production' is part of the policies for renewable energy in the EU. The question is if incoherence in these policies with policies for the WLFC domains is addressed in the policy documents, and if opportunities for win-win actions are seized.

Table 13. References to WLFC domains in EU policy documents about renewables*

Policy domain	Reference in renewables policy documents	Score
Water Wetlands	Biofuel from food/feed crop produced within EU: comply with CAP environmental requirements for agriculture, including *protection of groundwater and surface water quality.* The EC may decide that voluntary national or international schemes setting standards contain accurate information on measures taken for *soil, water and air protection*, the restoration of degraded land, the *avoidance of excessive water consumption in areas where water is scarce*, …… Biofuels …….shall not be made from raw material obtained from land……..that had one of the following statuses in January 2008 and no longer has that status: (a) *wetlands*,…	2-3
Land ILUC Biodiversity	See above -….the need to ensure that the annex *does not create additional demand for land* while promoting the use of wastes and residue… -The commission shall monitor the origin of biofuels, bioliquids and biomass fuels consumed in the union and the impact of their production, *including impact as a result of displacement, on land use in the Union and the main third countries of supply.* - ….to present … a comprehensive proposal for a ….. post-2020 policy in order to create a long-term perspective for investment in sustainable biofuels with a *low risk of causing indirect land-use change.* -For the calculation of a member state's gross final consumption of energy from renewable energy sources, the contribution from biofuels and bioliquids, as well as from biomass fuels consumed in transport, if produced from food or feed crops, shall be no more than 7% of final consumption of energy in road and rail transport in that member state. This limit shall be reduced to 3,8% in 2030…..member states may set a lower limit ……. for instance by setting a lower limit for the contribution from food or feed crop based biofuels produced from oil crops, *taking into account indirect land use change.* -The increasing production of agricultural raw materials for biofuels, bioliquids and biomass fuels ….*should not have the effect of encouraging the destruction of biodiverse lands*. -Biofuels, bioliquids and biomass fuels produced from agricultural biomass……..*shall not be made from raw material obtained from land with high biodiversity value*, namely land that had one of the following statuses	3

Carbon stock Peatland Restoration of degraded land	in or after January 2008, whether or not the land continues to have that status:… -Biofuels, bioliquids and biomass fuels produced from agricultural biomass ……. *shall not be made from raw material obtained from land with high carbon stock*, namely land that had one of the following statuses in January 2008 and no longer has that status:……. -If land with high stocks of carbon in its soil or vegetation is converted for the cultivation of raw materials for biofuels or bioliquids, …..*ensure that the greenhouse gas emission saving calculation takes into account the totality of the carbon effects.* -Land should not be converted for the production of raw material for biofuels, bioliquids and biomass fuels *if its carbon stock loss upon conversion could not, within a reasonable period, taking into account the urgency of tackling climate change*, be compensated by the greenhouse gas emission saving resulting from the production and use of biofuels, bioliquids and biomass fuels. -It is appropriate for the commission to develop methodologies with a view to *assessing the impact of the drainage of peatlands on greenhouse gas emissions.* -*Agricultural feedstock from the production of biofuels, bioliquids and biomass fuels should not be produced on peatland* Biofuels, bioliquids and biomass fuels produced from agricultural biomass …….*shall not be made from raw material obtained from land that was peatland in january 2008.* -The sustainability scheme for bioliquids and biomass fuels should *promote the use of restored degraded land* because the promotion of biofuels, bioliquids and biomass fuels will contribute to the growth in demand for agricultural commodities.	
Food Food prices and security Agriculture	see above: *restrictions to production of agricultural biofuels, bioliquids and biomass, restoration of degraded land to provide for extra agricultural land* and *extending in time and reducing cap on % biofuels produced from food or feed crops used in transport*. The commission shall also monitor *the commodity price changes* associated with the use of biomass for energy and any associated positive and negative *effects on food security*. The commission shall…….pay particular attention to the *impact that biofuel and bioliquid production may have on food prices*. In the framework of the *CAP* union farmers should comply with a comprehensive set of environmental requirements in order to receive direct support. *Compliance with those requirements can be most effectively verified in the context of agricultural policy*. -In order to exploit the full potential of biomass to contribute to the decarbonisation of the economy through its uses for materials and energy, the *Union and the member states should promote greater sustainable mobilisation of existing timber and agricultural resources and the development of new forestry and agriculture production systems*. -*Agricultural crop residues are residues and not co-products.*	2-3

Climate GHGs	-*The greenhouse gas emission saving from the use of biofuels, bioliquids and biomass fuels... shall be*: (a) at least 50 % for biofuels and bioliquids produced in installations in operation on or before 5 October 2015; (b) at least 60 % for biofuels and bioliquids produced in installations starting operation from 5 October 2015; (c) at least 70 % for biofuels and bioliquids produced in installations starting operation after 1 January 2021; (d) at least 80 % for electricity, heating and cooling production from biomass fuels used in installations starting operation after 1 January 2021 and 85% for installations starting operation after 1 January 2026. -Land should not be converted for the production of agricultural raw material for biofuels, bioliquids and biomass if its carbon stock loss upon conversion could not, within a reasonable period, *taking into account the urgency of tackling climate change*, be *compensated by the greenhouse gas emission saving* resulting from the production and use of biofuels, bioliquids and biomass fuels. - ...*national system in place for reporting greenhouse gas emissions and removals from land use* including forestry and agriculture, which is *in accordance with the requirements set out in decisions adopted under the UNFCCC and the Paris agreement*. -In calculating the greenhouse gas impact of land conversion, economic operators should be able to use actual values for the carbon stocks associated with the reference land use and the land use after conversion. They should also be able to use standard values. *The work of the IPCC is the appropriate basis for such standard values*.	3

**) EC, 2016. Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast). Brussels, 30.11.2016 com(2016) 767 final 2016/0382 (cod).*
EC, 2009. Directive 2009/28/EC of 23 april 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing directives 2001/77/EC and 2003/30/EC.

If we compare the references to WLFC policy domains in the EU policy documents about renewables, with the results of the policy coherence analysis between WLEFC objectives described in section 6.1, we can draw the following conclusions.

Table 14. Coherence scores E1 > Water

Water	Coherence score E1 > W1, 2 …
W1 Achieve good water quality status	-1
W2 Ensure sufficient supply of good quality surface water and groundwater for people's needs, the economy and the environment	-1
W3 Increase water efficiency	-2
W4 Reduce water consumption	-1
W5 Assess and manage flood risks and mitigate flood effects	-1
W6 Address and mitigate water scarcity and drought	-1

Coherence scores between objective E1 'Increase production of biofuels' and the Water objectives are all negative, meaning incoherence (Table 14). Biofuel production competes for water with other users and may worsen water scarcity. It may also be a source of pollution by pesticides and nutrients.

Negative effects on water quality from biofuel production within the EU are accounted for in the CAP and environmental legislation, but outside the EU this issue is addressed by weaker voluntary schemes. Effects on water quantity are also addressed by weaker voluntary schemes, inside and outside the EU. So, the prevention and mitigation of negative effects on water quantity and on water quality outside the EU, depend on the existence of good water management and strong institutions to protect the water system at the location of production and on the readiness to support sustainable production in the supply chain. Potential negative effects on water efficiency are not addressed in the policy documents.
If biofuel production causes deforestation, it may increase flood risks, an indirect effect. Deforestation and other land use changes are key issues addressed in the policy documents about renewables, see below.

Table 15. Coherence scores E1 > Land

Land	Coherence score E1 > L1, 2 …
L1 Restore degraded soils to a level of functionality consistent with at least current and intended use	-1
L2 prevent soil degradation	-1
L3 Maintain and enhance forest cover	-3
L4 Prevent ILUC	-3

The coherence scores between E1 'Increase biofuel production' and the objectives for Land use are all negative, meaning incoherence (Table 15**Error! Reference source not found.**). The EU policy documents about renewable energy address land issues in great detail by setting strict sustainability criteria to the effects of biofuel production on land, soil and land use change. Also, restoration of degraded land to produce biofuels is indicated. The most fundamental measure is the phasing out of 1st generation biofuels made from food and feed crops for use in transport. Thus, innovation to produce 2nd and 3rd generation biofuels with less negative impacts is an important issue. The crux of the sustainability policies for biofuels will be the implementation, enforcement and control. As in the case of water, success of the policies for sustainable production of biofuels regarding land use and soil fertility, depend on the existence of good land management and institutions at the location of production, and on support in the supply chain.

Table 16. Coherence scores E1 > Food and agriculture

Food and agriculture	Coherence score E1 > F1, 2 …
F1 Contribute to farm incomes, under conditions of cross-compliance and greening	+2
F3 Ensure provision of environmental public goods in agriculture sector	-2
F4 Support rural areas economy	+1
F5 Promote resource efficiency in agriculture, food and forestry sectors	-1

Biofuel production with public support may offer an opportunity for farm incomes and rural economic development in the short and mid-term, but in the long run EU policy strives to phase out biofuels from food and feed crops in transport (Table 16). The potential 'up and down' economic effects on farm incomes and rural areas are not addressed in the policy documents. However, in the documents is stated that 'the Union and member states should promote greater sustainable mobilisation of existing timber and agricultural resources and the development of new forestry and agriculture production systems'. Obviously, with this statement, the Commission aims at other feedstock than food and feed crops.

The potential incoherence between increase of biofuel production and provision of environmental public goods is addressed in the cross-compliance and greening conditions of the CAP.

Table 17. Coherence scores E1 > Climate

Climate	Coherence score E1 > C1, 2 …
C1 Reduce GHGs emissions	-1/+2
C2 Increase efficiency in transport system	-1/0
C3 Support development and uptake of low-carbon technology	-2
C5 Incentivize more climate-friendly land use	-2

The EU policy documents for renewables set strict criteria for the GHG reduction (Table 17) caused by using biofuels compared to fossil fuels, which is coherent with the objective of GHGs reduction. Nevertheless, an increase of the availability of biofuels may hinder the development of a more fundamental efficiency increase in transport. It may also hinder the development and uptake of other low-carbon techniques than the use of biofuels. On the other hand, striving for more biofuels combined with phasing out biofuels made from food and feed crops in transport will stimulate the development of 2nd and 3rd generation biofuels. Despite the strict sustainability criteria for land use change caused by biofuel production in the policy documents, more biofuel production is likely to be incoherent with the increase of more climate-friendly land use.

6.2.2.2 References to objective W2 'Water supply of good quality' in policy documents in the ELFC policy domains

How do policy documents for WLEFC policy domains refer to water objectives, more specifically the objective W2 'Ensure sufficient supply of good quality surface water and groundwater for people's needs, the economy and the environment'? Is incoherence addressed and are opportunities for win-win processes seized?

Table 18. References to objective W2 'Ensure sufficient supply of good quality water for people's needs, the economy and environment' in EU policy documents for the LEFC domains.

Policy domain	References to WP2 in policy documents	Score
Land and soil	-*Soil is interlinked with water and air in such a way that it regulates their quality.* -*Soil functions enormously contribute to marine protection and coastal management*[1)] The Alpine soil shall be preserved in a sustainable manner to allow it to perform its natural functions as an integral part of the ecological balance, *especially with regard to its water and nutrient cycles*, and to perform its natural functions as a conversion and compensating medium to offset inputs of substances, especially due to its *filtering, buffering and storage qualities, in particular for the protection of groundwater.* The contracting parties: - undertake to *take account of the objectives of this protocol in their other policies as well*. In the alpine region, this applies specifically to regional planning, settlement and transport, energy management, agriculture and forestry, raw material extraction, trade and industry, tourism, nature conservation and landscape upkeep, *water and waste management*, and clean air;	1-2

	- should apply *measures to control water erosion*; -agree to *coordinate their national soil monitoring programmes with the environmental monitoring programmes for air, water, flora and fauna.* *In areas specifically designated as drinking water resources, the extraction of mineral resources shall be foregone*.[2)]	
Energy	-It is necessary to set transparent and unambiguous rules for calculating the share of energy from renewable sources and for defining those sources. In this context, *the energy present in oceans and other water bodies in the form of waves, marine currents, tides, ocean thermal energy gradients or salinity gradients should be included.* -…..*electricity produced in pumped storage units from water that has previously been pumped uphill should not be considered to be electricity produced from renewable energy sources.* -Where biofuels and bioliquids are made from raw material produced within the community, they should also comply with community environmental requirements for agriculture, including those concerning *the protection of groundwater and surface water quality* ……[3)] The commission may decide that those schemes contain accurate information on *measures taken for soil, water and air protection*, the restoration of degraded land, the *avoidance of excessive water consumption in areas where water is scarce*…… [4)] District heating' or 'district cooling' means the distribution of *thermal energy in the form of steam, hot water or chilled liquids*, from a central source of production through a network to multiple buildings or sites, for the use of space or process heating or cooling.[5)] Article 9 on metering and article 10 on billing are amended to make them applicable only to gas while complementing them with new, similar and clear provisions applicable only to heating, cooling and domestic hot water supplied from central sources.[6)]	2-3
Food and agriculture Pesticides	CAP: *cross compliance* conditions on good agricultural and environmental practices and the conditions of the *greening* payment.[8)] -The measures provided for in this directive should be *complementary to, and not affect*, measures laid down in directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a *framework for community action in the field of water policy.* -The aquatic environment is especially sensitive to pesticides. It is therefore necessary for *particular attention to be paid to avoiding pollution of surface water and groundwater* by taking appropriate measures, such as the establishment of buffer and safeguard zones or planting hedges along surface waters to reduce exposure of water bodies to spray drift, drain flow and run-off. ……. *Use of pesticides in areas for the abstraction of drinking water*, on or along transport routes, such as railway lines, or on sealed or very permeable surfaces can lead to *higher risks of pollution of the aquatic environment*. In such areas the pesticide use should, therefore, be reduced as far as possible, or eliminated, if appropriate. -*The terms 'surface water' and 'groundwater' have the same meaning as in directive 2000/60/EC.* -*Specific measures, described in detail, to protect the aquatic environment*	3

	and drinking water. -Member states shall ensure that *appropriate measures to protect the aquatic environment and drinking water supplies from the impact of pesticides* are adopted. -Further specified risks for water are part of *training of professional users of pesticides*. [9)]	
Climate adaptation	-*Changes in patterns of water availability.* -There will also be a need for *additional infrastructure*, dedicated to climate protection, such as improved sea defences and flood protection, *interconnections in water supply*, as well as retro-fitting to improve resilience of existing infrastructure. -Reductions in rainfall may affect the *availability and quality of water resources on which industrial assets depend*. -Challenges to operating infrastructure under changing climate conditions include, among others, coping with potentially higher operating temperatures during summer, protecting built environments against floods or *ensuring water and energy supply during consumption peaks* (e.g. cooling in "hotter" summers, heating in "colder" winters). -Apart from the physical destruction of (or damage to) infrastructure in risk zones, *in particular water cycles are expected to change significantly (e.g. increasing/decreasing water availability for hydropower generators*, impacts of climate change, such as an increased frequency of extreme weather events or *changing water and air temperatures have effects on energy* transmission, distribution, generation and demand). -The *generation* of electrical energy is affected by efficiency decreases due to climate change (e.g. *decreasing availability of cooling water for electricity generators*). -The EIB recognises that adaptation to climate change is necessary and aims to actively *promote climate resilience and adaptation in the projects it finances, a.o. water supply projects*. [11)] Furthermore, information on national adaptation actions and support is also important in the context of the integrated national energy and climate plans, especially as regards adaptation to those adverse effects of climate change related to the security of the union's energy supply such as the availability of cooling water for power plants... [7)] -Major utilities, such as energy and *water providers, are also affected.* -Climatic changes will have *consequences for the availability of basic natural resources (water, soil)* leading to significant changes in conditions for agriculture and industrial production in some areas. -… strong emphasis on incorporating win-win, low-cost and no-regret adaptation options. These include *sustainable water management* and early warning systems. Ecosystem-based approaches are usually cost effective under different scenarios. They are easily accessible and provide multiple benefits, such as reduced flood risk, less soil erosion, *improved water and air quality* -The commission will promote adaptation particularly in the following vulnerable areas: ...	1-2

	- mainstreaming adaptation into urban land use planning, building layouts and *natural resources management*; … - *sustainable management of water*; combating desertification and forest fires in drought-prone areas. Adaptation has already been mainstreamed in … *important policy instruments such as for inland water,* biodiversity…[10)]	

[1)] EC, 2006. COM: Thematic Strategy for Soil Protection.
[2)] EU, 2005. Protocol on the implementation of the Alpine Convention of 1991 in the field of soil conservation - Soil Conservation Protocol.
[3)] EU, 2009. Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
[4)] *EC, 2016. Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast). Brussels, 30.11.2016 com(2016) 767 final 2016/0382 (cod).*
[5)] EU, 2010. Directive 2010/31/EU on the Energy Performance of Buildings.
[6)] EC, 2016. Proposal for a directive amending Directive 2012/27/EU on energy efficiency. COM(2016) 761 final.
[7)] EC, 2016. Proposal for a regulation on the Governance of the Energy Union. COM(2016) 759 final.
[8)] EU, 2013. Regulation No 1307/2013 establishing rules for direct payments to farmers under support schemes within the framework of the CAP.
[9)] EC, 2009. Directive 2009/128/EC of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides.
[10)] EC, 2013. An EU Strategy on adaptation to climate change. Brussels, 16.4.2013 COM(2013) 216 final.
[11)] EC, 2013. Adapting infrastructure to climate change, accompanying the document An EU Strategy on adaptation to climate change. Brussels, 16.4.2013, SWD(2013) 137 final. Commission staff working document.

Table 19. Coherence scores Land > W2

Land	Coherence score L1,2 … > W2
L1 Restore degraded soils to a level of functionality consistent with at least current and intended use	+1
L2 prevent soil degradation	+1
L3 Maintain and enhance forest cover	+2
L4 Prevent ILUC	+1

The Thematic Strategy for Soil Protection by the EC mentions the strong dependence of water supply and quality on good soil management, in a general and descriptive way. The Alpine Convention is more detailed and precise in describing the positive connections and more concrete in policy actions, e.g. preventing soil erosion. ILUC and its influence on water supply and quality are not mentioned in these documents.

Table 20. Coherence scores Energy > W2

Energy	Coherence score E1, 2 .. > W2
E1 Increase production of biofuels	-1
E5 Increase production of hydro-energy	-2/+1
E7 Increase energy efficiency	+1
E8 Reduce energy consumption	+1
E10 Achieve energy supply security	0/+1

Except for biofuels, bioliquids and biomass, the positive and negative linkages between energy and water policies are little explored and described in the documents. For example, the negative effects of hydropower on the aquatic ecosystem and natural discharge patterns, water supply and water quality, are not mentioned. There may also be a synergy of hydropower with water supply if the reservoir acts as a water buffer that stores water in wet seasons and supplies water in dry seasons.
Synergies between increase of energy efficiency and reduction of energy consumption on the one hand, and water efficiency and reduction of water consumption on the other hand, are not mentioned in the energy policy documents. In the context of the built environment, a connection between water and energy is mentioned, namely water used for distribution of heat and cooling. But the document fails in mentioning that less demand for heat and cooling means less demand for water.
Water is described as a potential source of renewable energy in the 2009 EC Directive on promotion of renewable energy, but no policy actions are formulated to stimulate this.

Table 21. Coherence scores Food and agriculture > W2

Food and agriculture	Coherence score F12.. >W2
F1 Contribute to farm incomes, under conditions of cross-compliance and greening	+1
F2 Improve competitiveness of agricultural sector	-1/+1
F3 Ensure provision of environmental public goods in agriculture sector	+3
F4 Support rural areas economy	+1
F5 Promote resource efficiency in agriculture, food and forestry sectors	+1
F6 Reduce and prevent food waste	+1
F7 Alternative proteins replacing animal proteins in human diets (Horizon 2020)	+1

Agriculture has major impacts on water quantity and quality. Water quality conditions to agriculture are part of the CAP. Policies for the use of pesticides have a strong focus on surface water and groundwater quality. Potential synergies between objectives for agriculture and sufficient supply of good quality water may be part of the rural development plans in the second pillar of the CAP. The synergy between resource efficiency in the agriculture, food and forestry sector on the one hand and water supply and use on the other hand, is not explicitly mentioned in the general agriculture policy, but resource efficiency is one of the criteria for regional funding. The synergy between reduction of food waste and water quality and availability is not explicitly mentioned either.

Table 22. Coherence scores Climate > W2

Climate	Coherence score E1 > C1, 2 ...
C1 Reduce GHGs emissions	+2
C3 Support development and uptake of low-carbon technology	-2
C5 Incentivize more climate-friendly land use	+2
C6 Promote climate change adaptation in key vulnerable EU sectors and in MSs	+2

The EU policy documents that are analysed mainly describe the effects of climate change on water supply and water quality and the risks of the latter for economic activities and ecosystems. Synergies with nature based solutions are mentioned in the context of climate change adaptation. Changes to the water system that are positive for water supply may be part of these nature based solutions. The synergy with more climate-friendly land-use –also favourable for water supply - is missed, as is the potential negative effects of CCS technology on water quantity and quality.

6.2.3 Coherence between policy means for the objectives 'Increase biofuel production' and 'Water supply'

A policy objective is usually supported by several policy means and instruments (Appendix I). We tested the applicability of the coherence scoring based on Nilsson et al. (2012; 2016a; 2016b) to policy instruments for the objectives 'Increase of biofuel production (E1)' as an 'influencing objective' and 'Ensure sufficient supply of good quality water for people's needs, the economy and environment (W2)' as the 'influenced objective'. At the level of policy means the questions about coherence were comparable to those for the coherence analysis of objectives, namely: *'what happens with objective W2 if we apply the means of objective E1?'* and *'What happens with means W2a, W2b, W2c, ….. if we apply the policy means E1a, E1b, E1c, …..?'*

Policy instruments to achieve objective E1 and W2 are illustrated in Table 23 and Table 24 respectively.

Table 23. Policy instruments implemented to achieve objective E1 'Increase of biofuel production'

Policy instrument implemented to achieve objective E1	
E1a	Binding national targets for raising the share of renewables in MSs energy consumption by 2020 and national plans for renewables till 2030.
E1b	National support schemes, mostly financial instruments, schemes or mechanisms applied by MSs that promote the production and use of energy from renewable sources and give long-term security for investors.
E1c	EU funds for the development and uptake of renewables.
E1d	Encouraging development of advanced alternative fuels for transport and innovative bioenergy, e.g. by investing and supporting international technology and innovation platforms, as well as large demonstration projects.
E1e	Sustainability criteria for biofuels and bio-liquids, e.g. preventing ILUC and negative environmental effects, protecting ecosystems, biodiversity, high nature value areas and biodiversity.
E1f	Transparent information to users about origin of energy source.
E1g	Stimulate local production e.g. by fair deals for self-consumers and local producers.

Table 24. Policy instruments implemented to achieve objective W2 'Water supply'

Policy instrument implemented to achieve objective W2	
W2a	MS shall conduct economic analysis of water services based on long-term forecasts of supply and demand for water in the river basin district.
W2b	MS shall protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater.
W2c	Put the right price tag on water.
W2d	Improved land use planning.
W2e	Financing water efficiency, fostering water efficient technologies and practices, and the emergence of a water-saving culture in Europe.
W2f	Develop drought risk management plans.
W2g	Consider additional water supply infrastructures.
W2h	Research and technological development.

Unlike the objective-objective coherence analysis, if we look at policy means we need to make assumptions about the changes in behaviour, society and economy that the policy means will bring about and how this may influence other objectives and the effectivity of other policy means. Therefore, even more than in the case of objective-objective coherence scoring, the scoring of

coherence between policy means depends on context and interpretation and should be done per case. In this example, we try to give a general impression.

Table 25. Example of coherence scoring at the level of policy means: how 'E1 Increase biofuel production' influences 'W2 sufficient supply of good quality water'.

	W2	W2a	W2b	W2c	W2d	W2e	W2f	W2g	W2h
E1	-1	**0**	-1	**0**	**0**	-1	**0**	+1	+1
E1a	-1	**0**	-1	**0**	**0**	-1	**0**	+1	+1
E1b	-1	**0**	-1	**0**	**0**	-1	**0**	+1	+1
E1c	-1	**0**	-1	**0**	**0**	-1	**0**	+1	+1
E1d	0	0	0	0	0	0/+1	0	0	0/+1
E1e	+1	**0**	+1	+1	+1	+1	+1	-1	+1
E1f	0	0	0	0	0	0	0	0	0/+1
E1g	0	**0**	0/-1	**0**	**0**	-1/+1	0/+1	0/+1	+1

0: no link.
0: neutral link, i.e. no positive or negative effect, but the W2 mean needs to reckon with the mean for E1 or is influenced by it.

The results show that there may be coherence or conflicts between policy means for the chosen objectives E1 in the energy and W2 in the water policy field. Therefore, it is worthwhile to take the linkages into account when developing or implementing policies for the WLEFC-nexus. Policy means that are designed to support the E1 objective in this case got a similar score as the 'objective E1'-'objective W2' coherence score, as it is assumed that these policy means are adequate for their goal. Mean E1e –sustainability criteria for biofuels- is assumed to support the protection of water resources. Innovation in advanced fuels is assumed to support research and technological development in the field of water too. Awareness among users about the energy source (E1f) may influence their choice for renewable energy, but unless the users are also well-informed about the impact of this specific energy source on water, no effect on water policies is assumed.

6.2.4 Coherence of the EU objectives 'Increase biofuel production' and 'Water supply' with international WLEFC-nexus policies

To investigate if EU policies for biofuels and water supply are coherent with international policies, we compared the key objectives of the EU policies with key objectives in related UN policies.

6.2.4.1 Coherence of EU objective 'Increase biofuel production' with international policies

The two overarching objectives of EU biofuel policies are increasing production and consumption to replace fossil fuels on the one hand, and controlling, preventing and reducing negative impacts of biofuel production on environment and society on the other hand, the latter mainly focused on food security. These objectives are coherent with goals and objectives in international policies reported in Table 26, where you also find the duality of the need to increase the use of renewables but in the meanwhile preventing negative effects of biofuel and biomass production on land use, water, forests and food security. The objective in UNEP (2012) 'Fully consider water and ecosystem footprints of alternative climate change mitigation measures' is not referred to in EU energy and climate policies, nor in international climate policies.

Table 26. International policy goals and objectives coherent with E1 'Increase biofuel production'

Goal or objective	Source
'…low greenhouse gas emissions development, in a manner that does not threaten food production.	Paris Agreement (UN, 2015)
Objective of REDD+ 'Reduce emissions from deforestation and forest degradation in developing countries' and LULUCF 'Ensure that greenhouse gas emissions from land use are compensated by an equivalent absorption of CO_2 made possible by additional action in the land use sector, in developed countries.'	UN Framework Convention on Climate Change (UNFCCC), 1992
Maintain and restore land and soil productivity.	Desertification Convention (UN, 1994)
-Fully consider water and ecosystem footprints of alternative climate change mitigation measures -Protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes[1)]	Healthy waters for sustainable development. UNEP Operational Strategy for fresh water (2012-2016) (UNEP, 2012)
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix. 12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle. 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world .	Transforming our world: The 2030 Agenda for Sustainable Development (UN, 2012)

[1)]Mountains, rivers, aquifers, lakes and water-related ecosystems as a whole are not explicitly mentioned in the EU renewable energy sustainability criteria.

Food security and food prices connected to poverty are a central issue in global food policies and SDGs. The references in the EU policy documents for renewable energy to the effects on food prices and food security that the production of biofuels will have are non-binding. The Commission will observe, but it is not mentioned what they can and will do against undesired effects, when effects are so negative that action is needed, and how this will be investigated. According to the renewable energy policy, the use of biofuels made from food and feed crops in transport will be phased out, but in the years to come, they will still play an important role. Food security is an overarching goal of the CAP, but food prices are addressed in the CAP only from the viewpoint of EU farm income, there is a safety net regulation for farmers in the case of very low prices. Food security and food prices are not addressed specifically from the global consumer's viewpoint.

Also, not addressed in the EU policies for renewable energy are the social aspects of the potential competition for land, water and other natural resources, caused by the increasing production of biofuels, bioliquids and biomass. This is incoherent with targets 1.4 and 2.3 of the SDGs, namely:

- "By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources,……"
- "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including

  through secure and equal access to land, other productive resources and inputs, ……".

6.2.4.2 Coherence of EU objective 'Water supply' with international policies

The key issues for EU water supply policies are: good water quality, safeguard surface water and groundwater resources, mitigate water scarcity, increase water efficiency and re-use. All these key issues are also part of international water policies, although the latter are strongly linked with the development agenda, with a focus on safe drinking water and sanitation for all.

Table 27. International policy goals and objectives coherent with W2 'Water supply'

Goal or objective	Source
SDG 6 Ensure availability and sustainable management of water and sanitation for all; By 2030: 6.1 achieve universal and equitable access to safe and affordable drinking water for all 6.3 improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally 6.4 substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity 6.5 implement integrated water resources management at all levels, including through transboundary cooperation as appropriate 6.6 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes 12.2 achieve the sustainable management and efficient use of natural resources SDG 12: Ensure sustainable consumption and production patterns. 12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment 12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	Transforming our world: The 2030 Agenda for Sustainable Development (UN, 2012)
Well-managed, healthy freshwater systems supporting sustainable development and human well-being Mainstream resource efficiency.	UNEP, 2012.Healthy waters for sustainable development. UNEP operational strategy for fresh water (2012-2016)
Forge a global partnership to reverse and prevent desertification/land degradation and mitigate effects of drought in affected areas in order to support poverty reduction and environmental sustainability	UN, 1994.Desertification Convention

7 Conclusions

7.1 Identification and review of the most important policy areas for the nexus

The definition of the WLEFC-nexus is context specific and so are the relevant policies.

In the first place, the policies that are relevant for the WLEFC-nexus are those that directly aim at influencing the water, land, energy, food and climate domains, defined in broad terms and considered from an ecological, spatial, production & consumption, and broader socio-economic perspective.

Secondly, policies that do not directly aim at the WLEFC domains are also relevant especially in consideration of the overall objectives of resource efficiency and low-carbon economy in Europe. These other policies may have several impacts on the WLEFC domains, and policy instruments in these domains may interfere with policy instruments in the nexus. These other relevant domains include policies aiming at economy, investment, R&D and innovation, ecosystems and environment, regions, development, risk & vulnerability and trade. Other policies may also be relevant depending on the project cases (e.g. tourism).

7.2 Inventory of policy goals and means in the WLEFC-nexus at international and European scale

Two key international policy documents pave the way for national action in the WLEFC-nexus:

- the UN 2030 Agenda for Sustainable Development;
- the UN Framework Convention on Climate Change (and related Kyoto Protocol and Paris Agreement).

These acts establish two fundamental goals at global level:

- sustainable development and resource management;
- improving resilience of human and natural systems.

The first is articulated in the policy documents as sustainable water management, sustainable land use management, sustainable management of forest and trees, sustainable agriculture, sustainable consumption and production patterns, clean and sustainable energy. The second is phrased as resilient infrastructure, resilient agricultural practices, resilient cities, resilient water supply systems, resilient energy systems, resilient development, resilient socio-ecological systems.

Around these goals numerous objectives have been formulated. The most important ones for the WLEFC-nexus are listed in Table 28.

Table 28. Key policy objectives at international level in the WLEFC-nexus

WATER
SDT061 - by 2030, achieve universal and equitable access to safe and affordable drinking water for all
SDT063 - by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse
SDT064 - by 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity
LAND
DT152 - by 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests, and increase afforestation and reforestation
SDT153 - by 2020, combat desertification, and restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land-degradation neutral world
ENERGY
SDT071 - by 2030 ensure universal access to affordable, reliable, and modern energy services
SDT072 - increase substantially the share of renewable energy in the global energy mix by 2030
SDT073 - double the global rate of improvement in energy efficiency by 2030
FOOD AND AGRICULTURE
SDG2 - End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
SDT024 - by 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality
CLIMATE
SDT131 - strengthen resilience and adaptive capacity to climate related hazards and natural disasters in all countries
SDT132 - integrate climate change measures into national policies, strategies, and planning
Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels
Reduce GHGs emissions by 18% below 1990 levels between 2013 and 2020
Adapting to the impacts of climate change

Many are the instruments to achieve these objectives. Often they are soft means such as actions aiming at raising awareness, strengthening cooperation among parties, supporting stakeholders' participation, developing knowledge and technology, and building capacity. There are also economic instruments that parties can use to achieve these objectives. For example, in the context of the UNFCCC emission trading, Joint Implementation and Clean Development Mechanisms can be used. In the context of water management, regulatory and planning instruments are supported along with integrated water management, polluter-pays-principle, precautionary approaches, protected areas and technology development. In the forest area, instruments supported include voluntary certification schemes, and forest management and monitoring programmes. In the food and climate sector, investment in developing countries is an important instrument.

The **European policies** concerning the WLEFC-nexus are established by directives, regulations, road maps, plans and programmes. Coherently with the international policy arena, the EU policy integrates the two key goals of sustainable development and resilient human and natural systems. Important objectives are listed in Table 29.

Table 29. Key policy objectives at European level in the WLEFC-nexus

WATER
Achieve at least good water status for each river basin and good groundwater status by 2027
Ensure sufficient supply of good quality surface water and groundwater for people's needs, the economy and the environment
Safe and cost-effective water reuse
Address and mitigate water scarcity and drought in EU
Address flood risks and consequences of floods in EU
LAND
Restore degraded soils and prevent further soil degradation
Maintain and enhance forest cover
Prevent indirect land use change
ENERGY
Reach a 20% share of energy from renewable sources in the EU by 2020 and at least a 27% share of renewable energy consumption by 2030
Have 10% of the transport fuel of every EU country come from renewable sources by 2020
Increase energy efficiency by 20% by 2020 and by at least 30% by 2030
Reduce energy consumption
Ensure a stable and abundant supply of energy for European citizens and the economy
Support the development and deployment of clean energy technologies
FOOD AND AGRICULTURE
Viable EU food production and EU food security (through support to farm income)
Efficiency of food supply chain and competitiveness of agri-food sector
Sustainable management of natural resources and mitigation and adaptation to climate change in agriculture
Support rural areas economy
CLIMATE
20% GHGs emissions reduction (from 1990 levels) by 2020; 40% GHGs emissions reduction (from 1990 levels) by 2030; and 80-95% GHGs emissions reduction (from 1990 levels) by 2050 in EU
Increase efficiency of the transport system
Support the development and uptake of low-carbon technology
Promote adaptation in key vulnerable EU sectors and in MSs

Many are the instruments to achieve these objectives: regulatory instruments especially in the water, land, food and energy sectors (e.g. water quality standards, energy performance standards, water management plans, forest management programmes); financial instruments especially in the agricultural sector (e.g. direct payment to farmers, energy taxes); market instruments especially in the climate sector (e.g. EU ETS); and informational (e.g. eco-labelling on energy products) and voluntary instruments (e.g. environmental conservation measures in rural development) in all nexus sectors.

7.3 Coherence of WLEFC-nexus policies, and their degree of 'nexus compliance' and support of a resource efficient Europe

As a disclaimer to the following conclusions about policy coherence we mention that in this analysis we only investigated policies as described in policy documents at the level of goals, objectives and policy means. We did not analyse how these policies are implemented and may cause synergies or conflicts in practice. This is the task of Deliverable 2.2.

7.3.1 General observations on policy coherence in the WLEFC-nexus at EU level

The results of the assessment showed that synergies are more prominent than conflicts both for the objectives influencing the WLEFC-nexus and for the objectives being influenced by the WLEFC-nexus. Although at first, this may sound surprising, it is in line with the argument of Nilsson and colleagues (2012) who suggest that it is politically easy to reach agreement on general goals. The reality of selecting and implementing instruments and measures to achieve those goals is where conflicts and related trade-offs arise.

The presence of limited conflicts and numerous synergies also suggests a certain level of awareness of the legislator about bio-physical and socio-economic interactions in the WLEFC-nexus. The cross-sectoral sustainability objective and the resilience objective are typical examples of the grown awareness of the interconnection between resource systems and the need to develop integrated policies. Sustainable management of resources is a horizontal policy objective that has entered policy documents in all nexus domains over the past 25 years and it is prompted to remain for the coming decades too. It entails pursuing resource efficiency and integrated resource management. As for the resilience objective, its more recent uptake in international and European policy documents shows capacity, at least at the policy formulation level, to integrate new scientific evidence in policy making processes. Furthermore, similarly to sustainable resource management, resilience is yet another objective that entails resource efficiency and integrated resource management. Therefore, in principle, the inclusion of these goals in policy documents across the WLEFC-nexus implies, at least on paper, nexus compliance of policies. However, as already noted, problems start to manifest when more specific objectives and measures to achieve these cross-sectoral goals need to be articulated and implemented. For this reason, the next step of the SIM4NEXUS policy analysis will focus on the implementation of WLEFC-nexus policies in 10 case studies at regional, transboundary and national scales with the aim to shed light on where policy trade-offs and synergies manifest and how they are addressed.

The overall assessment also revealed a number of objectives that, if pursued with cross-sectoral, integrated policies, could have a cascade of positive, synergist effects in the whole WLEFC-nexus. These are the nexus critical objectives showing a high density of interactions in the WLEFC-nexus and have a positive effect on other objectives. They include:

- W6 - Address and mitigate water scarcity and drought
- L1 - Restoring degraded soils to a level of functionality consistent with at least current and intended use
- L2 - Prevent soil degradation
- F1 – Contribute to farm incomes, under condition that rules on environment and cross-compliance are respected.
- F3 - Ensure provision of environmental public goods in the agriculture sector

- F4 - Support rural areas economy (employment, social fabric, local markets, diverse farming systems) *conditioned to the functioning of the cross-compliance and greening mechanisms*
- F5 - Promote resource efficiency in the agriculture, food and forestry sectors
- F6 - Reduce and prevent food waste
- C1 - Reduce GHGs emissions to keep global temperature increase within 2 degrees
- C5 – Incentivize more climate-friendly land use.
- C6 - Promote adaptation in key vulnerable EU sectors and in member states

Attention should also be paid to those nexus critical objectives that are likely to negatively affect other WLEFC-nexus objectives. Policy-makers should be aware that progress in the achievement of these objectives come at the expenses of other objectives in the nexus. In these situations, a nexus approach involving all affected parties in policy negotiation can help manage the unavoidable trade-offs. These objectives include:

- E1 – Increase of biofuel production (see next section for discussion about it)
- E5 - Increase hydro-energy production
- F2 - Improve competitiveness of agricultural sector (including sector-specific support and international trade issues)
- C4 - Support the development and uptake of safe CCS technology

Finally, attention should be devoted to those nexus critical objectives whose progress may be positively affected by numerous other objectives in the WLEFC-nexus. These are:

- W1 - Achieve good water quality status
- W2 - Ensure sufficient supply of good quality surface water and groundwater for people's needs, the economy and the environment
- W6 - Address and mitigate water scarcity and drought.
- L1 - Restoring degraded soils to a level of functionality consistent with at least current and intended use
- L2 - Prevent soil degradation
- L3 – Maintain and enhance forest cover
- F1 – Contribute to farm incomes, under condition that rules on environment and cross-compliance are respected.
- F2 – Improve competitiveness of agricultural sector
- F3 - Ensure provision of environmental public goods in the agriculture sector
- F4 - Support rural areas economy (employment, social fabric, local markets, diverse farming systems) *conditioned to the functioning of the cross-compliance and greening mechanisms*
- F5 - Promote resource efficiency in the agriculture, food and forestry sectors
- C1 - Reduce GHGs emissions to keep global temperature increase within 2 degrees
- C5 – Incentivize more climate-friendly land use.
- C6 - Promote adaptation in key vulnerable EU sectors and in member states

It should be noted that for all these objectives, the potential synergies are far more than the conflicts when looking at them as objectives influencing the WLEFC-nexus. A nexus approach, by revealing such interactions, could help find a balance between energy production and use, water use and conservation.

7.3.2 Policy coherence for the objectives biofuel production and water supply

Horizontal policy coherence of EU policies

- The EU policy objectives 'Increase biofuel production (E1)' and 'Ensure sufficient supply of good quality water for people's needs, the economy and environment (W2)' have many interlinkages with other EU WLEFC policy objectives, directly and indirectly. E1 causes conflicts with most other objectives in the WLEFC domains, except for the reduction of GHGs if criteria for overall emission reduction during are met, and for farm income and economic development of regions. For this analysis, we narrowed the definition of biofuels to 'biofuels made of food and feed crops', whereas the EU policies use a broader definition. W2 has synergies with most other WLEFC policy objectives, except that it is potentially negatively influenced by increase of CCS, hydropower and production of biofuel crops. Policy means that support the increase of biofuels counteract policy means that protect water resources as well as those aiming at water saving in Europe. However, they have synergies with improving water supply structures and technology development. Assumptions about effects on society of the policy means are crucial for the outcome of this theoretical coherence analysis. The results should be tested by investigation of practical implementation.
- Potential conflicts caused by increase of biofuel production on water quality in the EU are tackled in the CAP. Conflicts with water quantity and water quality outside the EU are addressed in the EU policies for renewable energy through voluntary reporting schemes. As a result, compliance of biofuel production to water related standards depends on strong water management at the production location and willingness of actors in the supply chain to protect water resources. Potential conflicts caused by the increase of biofuel production on land use objectives are well addressed in EU policies.
- The EU policy established strict criteria for the reduction of GHGs emissions to which the production and use of biofuels has to comply.
- The effects of alternative sources of energy on water use and pollution are not generally addressed in EU policies. Neither are the negative effects of hydropower on aquatic ecology, water quality and quantity.

Vertical policy coherence

- EU policies for biofuels are generally coherent with international policies, except for the food security and affordable food prices goals in the context of poverty reduction, central issues in international food policy and in the Sustainable Development Goals - SDGs. The effects of biofuel production on these goals are weakly addressed in EU policies. Prices of agricultural products are addressed in the CAP from the viewpoint of farm income, not from the viewpoint of the food consumer. According to the EU policies for renewable energy, the EC will monitor effects of biofuel production on food prices and security, but no concrete actions are mentioned if unwanted effects would be observed.
- The objective in UNEP (2012) 'Fully consider water and ecosystem footprints of alternative climate change mitigation measures' is not referred to in EU energy and climate policies, nor in international climate policies.

7.4 Windows of opportunity to improve nexus compliance of policies

Policy reviews offer windows of opportunity for the SIM4NEXUS results to be up-taken and integrated in the policy-making process. Table 30 shows the policy reviews expected for a number of policies in the WLEFC-nexus at international and EU level in the coming years. Interesting opportunities to share the SIM4NEXUS results at EU level are represented by the review of the EU energy package, the Water Framework Directive, the Common Agricultural Policy, the EU strategy on adaptation, the EU structural and development funds and the EU LIFE Programme.

Policy reviews are long processes that start much earlier than the expected review date, and opportunities to bring new ideas into the policy revision discussion are many throughout the review process. Indeed, discussion about the review of some of the above-mentioned policies have already started. Typical windows of opportunity in these discussions include consultations with the involved parties, presentations of policy discussion documents, round tables with interested parties, etc. More proactive initiatives include organization of small group meetings with target groups such as policy-makers or affected parties, and bilateral conversations where new ideas are either formally or informally presented. Therefore, identifying and seizing key windows of opportunity over the coming years to share the SIM4NEXUS results in the discussion of these policies is an important follow-up activity of the policy analysis. One window of opportunity that we already aim to exploit is the upcoming interviews with EU stakeholders (public officials, NGO, private sector) for the validation and sharing of our results and conclusions.

Table 30. Windows of opportunity to share SIM4NEXUS results offered by upcoming policy reforms at international and EU level; in red the upcoming windows of opportunity in EU policy reforms

WLEFC-nexus policies	
Water	2019: Water Framework Directive (ongoing discussion)
Land	None
Energy	2016: proposal of a new EU energy package including a number of directives: energy efficiency, renewables, regulation on internal market for electricity, governance of energy union, energy performance of buildings (ongoing discussion of the proposed package)
Food and agriculture	2020: CAP (ongoing discussion) 2020: Action Plan for Organic Production 2020: EU food and nutrition action plan 2015: World Summit Declaration on Food Security and Action Plan (ongoing discussion?)
Climate change	2022: IPCC Sixth Assessment Report 2020: Kyoto Protocol (Paris Agreement enters into force) 2017: EU strategy on adaptation including the annex adapting infrastructure to climate change 2024: Proposal for Regulation on inclusion of GHG emissions and removals from land use
Nexus related policies	
Nature and biodiversity	Convention on the conservation of migratory species: this Convention may be amended at any ordinary or extraordinary meeting of the Conference of the Parties.

	Convention on International Trade in Endangered Species of Wild Fauna and Flora: the Parties shall review the implementation of the Convention at meetings, whether regular or extraordinary. EU biodiversity strategy: targets and measures will be reconsidered as new information becomes available and progress is made on the objectives set in the strategy.
Multiple sectors	2017: EU Green Infrastructure Strategy: the Commission will review progress on developing GI and publish a report on the lessons learnt together with recommendations for future action. 2020: 7th EU Action Programme for Environment to 2020 2017: LIFE Fund 2014 2017 work programme 2019: Eco-design Working Plan 2016-2019 2021: UNEP medium term strategy 2018-2021 2050: A roadmap for moving to a competitive low carbon economy in 2050
EU regional policy and funds	2020: EU structural and development funds
Development	2017: UNDP Strategic Plan 2014 2017 2020: Regulation on the implementation of the 11th European Development Fund 2030: 2030 Agenda for Sustainable Development 2030: Addis Ababa Action Agenda on Financing Development
Vulnerability and risk	2019: Council regulation on emergency support within EU 2020: EU Civil Protection Mechanism 2030: Sendai Framework for disaster risk reduction 2030: Action plan on Sendai framework for disaster risk reduction 2015-2030 2036: UN Habitat III New Urban Agenda

8 References

Allouche J., Middleton C., Gyawali S. (2014) *Nexus Nirvana or Nexus Nullity? A dynamic approach to security and sustainability in the water-energy-food nexus*. Working Paper. STEPS Centre, UK.

Allan T., Keulertz M., Woertz E. (2015) The water–food–energy nexus: an introduction to nexus concepts and some conceptual and operational problems. *International Journal of Water Resources Development* 31(3):301-311.

Benson, D., Gain A.K., Rouillard J.J. (2015) Water governance in a comparative perspective: From IWRM to a 'nexus' approach? *Water Alternatives* 8(1): 756-773.

Boas I., Biermann F., Kanie N. (2015) Cross-sectoral strategies in global sustainability governance: towards a nexus approach. *International Environmental Agreements* 16:449–464.

Bonn2011 (2012). *The Water, Energy and Food Security Nexus – Solutions for the Green Economy*, Conference Synopsis.

den Hertog L, Stross S. (2011) *Policy coherence in the EU system: concepts and legal rooting of an ambiguous term*. Paper presented at the conference "The EU as a Global Player", University Institute for European Studies, Madrid, 7–8 April 2011.

Dupar M., Oats N. (2012) *Getting to grips with the water-energy-food 'nexus'*. Blog post. Available at: https://cdkn.org/2012/04/getting-to-grips-with-the-water-energy-food-nexus/?loclang=en_gb

Dye, T. R. (1972) *Understanding Public Policy*. Prentice Hall, Englewood Cliffs, NJ.

EC (2016) Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on Energy Efficiency. COM(2016) 761 final.

Foran, T. (2015) Node and regime: Interdisciplinary analysis of water-energy-food nexus in the Mekong region. *Water Alternatives* 8(1):655-674.

Hoff, H. (2011) *Understanding the Nexus. Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus*. Stockholm Environment Institute, Stockholm.

Howlett M. (2011) *Designing public policies. Principles and instruments*. New York, NY: Routledge.

Jordan A, Lenschow A (2010) Environmental policy integration. A state of the art review. *Environmental policy and governance* 20(3): 147-158.

Kurian M., Ardakanian R. (eds.) (2015) *Governing the Nexus. Water, Soil and Waste Resources Considering Global Change.* United Nations University, UNU-FORES, Springer

Keskinen M., Guillaume J.H.A., Kattelus M., Porkka M., Räsänen T.A., Varis O. (2016) The Water-Energy-Food Nexus and the Transboundary Context: Insights from Large Asian Rivers. *Water* 8: 193.

Laspidou, C. et al. (2017) *D1.1: Scientific inventory of the nexus*. Deliverable in Horizon 2020 project SIM4NEXUS.

Lasswell H. (1958) *Politics: who gets what, when and how*. New York, NY: Meridian Books.

Leigh Star S., Griesemer J.R. (1989) Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science* 19(3): 387-420.

Hayley Leck H., Declan C., Bradshaw M., Rees J. (2015) Tracing the Water–Energy–Food Nexus: Description, Theory and Practice. *Geography Compass* 9(8): 445–460.

Mitchell B., Bellette K., Richardson S. (2015) 'Integrated' approaches to water and natural resources management in South Australia. *International Journal of Water Resources Development* 31(4): 718–731.

Mohtar R.H., Daher B. (2016) Water-Energy-Food Nexus Framework for facilitating multi-stakeholder dialogue. *Water International* 41(5): 655-661.

Nilsson M., Zamparutti T., Petersen J.E., Nykvist B., Rudberg P., McGuinn J. (2012) Understanding policy coherence: analytical framework and examples of sector-environment policy interactions in the EU. *Environmental Policy and Governance* 22: 395-423.

Nilsson M., Griggs D., Visbeck M., Ringler C. (2016a) *A draft framework for understanding SDG interactions.* International Council for Science.

Nilsson M., Griggs D., Visbeck M. (2016b) Map the interactions between Sustainable Development Goals. *Nature* 534: 320-322.

Oberthur, S., & Gehring, T. (Eds.). (2006) *Institutional interaction in global environmental governance.* Cambridge, MA: The MIT Press.

OECD (2002) *Improving Policy Coherence and Integration for Sustainable Development: a Checklist*. OECD: Paris.

OECD (2015) *Framework for policy coherence for sustainable development (PCSD). A self-assessment tool to design, implement and track progress on mutually supportive policies for sustainable development*. OECD: Paris

OECD/IEA/NEA/ITF (2015) *Aligning Policies for a Low-carbon Economy*. OECD Publishing, Paris.

Pressman, J. & Wildavsky, A. (1973) *Implementation*. Berkeley: University of California Press.

Smajgl A., Ward J., Pluschke L. (2016) The water–food–energy Nexus – Realising a new paradigm. *Journal of Hydrology* 533: 533–540.

Stead D. and Meijers E. (2009) Spatial Planning and Policy Integration: Concepts, Facilitators and Inhibitors. *Planning Theory & Practice*, 10:3, 317-332.

Steffen W., Richardson K., Rockström J., Cornell S.E., Fetzer I., Bennett E.M., Biggs R., Carpenter S.R., de Vries W., de Wit C.A., Folke C., Gerten D., Heinke J., Mace G.M., Persson L.M., Ramanathan V., Reyers B., Sörlin S. (2015) Planetary boundaries. Guiding human development on a changing planet. *Science* 347(6223).

Subramanian S., Manjunatha A.V. (2014) Demystifying the energy-water-soil-food nexus in Indian agriculture. *Ecology, Environment, Conservation* 20:303-312.

UNEP (2012) *Healthy waters for sustainable development. UNEP operational strategy for fresh water* (2012-2016). UNON Publishing Services Section, Nairobi, Kenia.

Weitz,N. (2014) *Cross-sectoral integration in the Sustainable Development Goals: a nexus approach*. Stockholm Environment Institute, SEI, Stockholm.

WEF – World Economic Forum (2011) *Water security. The water-food-energy-climate nexus*. Island Press.

Wichelns D. (2017) The water-energy-food nexus: is the increasing attention warranted, from either a research or policy perspective? *Environmental Science & Policy* 69: 113–123.

Appendix I: Inventory of policy goals and means in the WLEFC-nexus at international and European scale