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Towards a Low-Carbon Economy: A Nexus-Oriented Policy Coherence Analysis in Greece

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Abstract: The sustainable management of natural resources under climate change conditions is a critical research issue. Among the many approaches emerged in recent times, the so-called ‘nexus approach’ is gaining traction in academic and policy circles. The nexus approach presupposes the analysis of bio-physical, socio-economic and policy interlinkages among sectors (e.g., water, energy, food) for the identification of integrated solutions and the support of policy decisions. Ultimately, the nexus approach aims to identify synergies and trade-offs among the nexus dimensions. Concerning policy, the nexus approach focuses on policy coherence, i.e., the systematic identification and management of trade-offs and synergies between policies across sectors. This paper investigates the coherence between policies on the water-land-energy-food-climate nexus in Greece. The systematic analysis of policy documents led to the elicitation of nexus-related policy objectives and instruments. Then, the coherence among objectives and between objectives and instruments was assessed using the methodology proposed by Nilsson et al. A stakeholder (trans-disciplinary) orientation was adopted and the need to incorporate stakeholders’ recommendations as to policy coherence assessment was highlighted. Overall, the findings revealed that climate and food/agricultural policies represent critical future priorities in Greece by stimulating progress in other nexus-related policies (energy, water, land policies) and being positively influenced by them.

Keywords: policy analysis; policy coherence; nexus governance; policy objectives; policy instruments; stakeholder recommendations

1. Introduction

The design, analysis and implementation of policies regulating the terms and conditions under which contemporary spatial systems are developed is undoubtedly linked to economic prosperity, social cohesion and effective use of natural and human assets (e.g., water, land, labour and financial capital). The inherent complexity of such dynamic systems call for policies that incorporate all relevant dimensions likely to affect availability and access to resources. In this sense, policy integration has the potential to effectively eliminate existing gaps across different policy sectors, actors and scales of governance [1].

Resource efficiency, under the threat of climate change, represents a critical challenge, embedded in almost all environmental policies. Water availability and allocation, regulation of land uses, food security and energy production are among the most important factors affecting standards of

living and quality of life. According to European Commission—Environment [2], resource efficiency is strongly related to the sustainable exploitation of limited assets so that impacts on the environment are minimized. Therefore, the goal is to “create more with less and to deliver greater value with less input” [2]. Increasing resource efficiency is a worldwide priority related to the exploitation of natural resources, the consequent environmental impacts, the prices of materials and the supply security [3]. At this point, a critical question is what resource efficiency implies in practice; especially regarding the interconnections among resources and the adoption of a proper framework for investigating trade-offs and synergies. This all needs to be tested and improved in practice by using trans-disciplinary research methods.

The design and implementation of resource-efficient policies require deep knowledge for resource availability and use across multiple stakeholders and sectors. In this context, policy analysis plays an important role as means to provide policy makers with reliable information. In particular, the need for adequate methodologies, approaches and tools for policy assessment is constantly recognized as policies specify the framework under which the available resources may be used by determining not only use restrictions and limitations but also opportunities for future development.

A novel approach targeting resource efficiency is the so-called ‘nexus approach’. In spite of some critiques on its novelty and added value, it has gained traction in the academic and policy domains over the past decade. A key element of the nexus approach is its focus on interactions across different components such as land, food, energy, water and climate. By paying attention to such interactions, the nexus components are addressed as an integrated and coherent system dominated by complex inter-relations. Pressures on one nexus component may entail pressures on the others [4]. Thereby, the management of these components as a unified and integrated system allows for a more sustainable use of scarce and non-renewable resources. In addition, a nexus analysis for understanding bi-directional interconnections can further contribute to the resilience of socio-economic and ecological systems either by making them more connected (e.g., creating synergies among the nexus components) or by breaking vicious circles (e.g., mitigating trade-offs) [5]. Thus, physical interlinkages among nexus components and their impacts on contemporary and future socio-economic systems is recommended to be explored during the implementation of current policies and the design of future ones [6]. Moreover, when considering policy integration and the subsequent complexity that such an attempt implies [7], decision making aiming at the design of sustainable policies, could benefit from the nexus approach in order trade-offs to be managed and synergies across sectors to be encouraged [8].

Academic investigation taking a nexus approach is fast growing and delivering useful insights for policy making. For example, the water-energy nexus in Chinese industries and the relationships between water and energy saving policies have been investigated by Gu et al. [9]. The quantification of interlinkages among such components (e.g., water required for electricity generation, energy demands for pumping and desalination, etc.) revealed several policy gaps and highlighted the need for such interlinkages to be addressed in future policies [9]. The requirement for policy integration in order to efficiently address the nexus water-energy-food has been stressed by Albrecht et al. [10] through the mobilisation of participatory decision-making, the maximisation of synergies and the establishment of socially and politically-feasible strategies [10]. Another example refers to the Duero river basin in Spain where the lack of coordinated policies led to various resource management conflicts in the sectors of water, energy and food [11]. Instead, the analysis of nexus interconnections and the integration of relevant policies could effectively support the mitigation of such conflicts and the management of existing trade-offs [11]. A water-energy-climate nexus approach was implemented for understanding interlinkages (irrigation-electricity supply in agricultural sector-climatic variability) and analysing policies (e.g., pricing policies) in order to address aquifer depletion in Mexico [12]. The socio-ecological nexus water-land-poverty was explored in the river basins of Indus and Ganges where current impacts were assessed and developmental policies were sought in order to improve agricultural productivity, alleviate poverty and reduce climatic vulnerability [13]. Water management strategies and strategies concerning water use in agriculture under climate change conditions were analysed under the umbrella

of water-energy-food nexus in the case of High Plains Aquifer in terms of reducing production risks, establishing innovative strategies, increasing farmers' profits, etc. [14].

This paper aims to contribute to this fast growing body of literature by focusing on the assessment of water-energy-land-food-climate nexus policies in Greece in terms of their coherence both at the level of policy documents and in implementation. Accordingly, the paper investigates: (a) the degree of interactions among identified nexus-critical policy objectives, (b) the degree of interactions between identified nexus-critical policy objectives and nexus-critical policy instruments, (c) the identification of the most influencing objectives and instruments as well as the investigation of the most influenced objectives, and (d) the way such objectives and instruments should be considered during policy design so as to minimize trade-offs and exploit synergies. In this context, the nexus approach and the role of policies in its governance are briefly delineated. Then, the methodological framework adopted for policy analysis is presented. Thereinafter, the proposed framework is tested against a national level case study (Greece) and relevant results are described.

2. The Nexus Approach and the Role of Policies in the Nexus Governance

The nexus approach has been broadly adopted across disciplines in order to investigate complex and non-linear interconnections among the components of socio-economic/physical systems. For example, water-energy-food nexus and their interlinkages were considered in the development of a decision support tool dealing with decisions for water infrastructure investments under complex socio-economic and climate change conditions [15]. Rasul and Sharma [16] explored the interdependencies among water, energy and food in a study where the increasing demand of resources and the respective availability under climate change conditions were analysed. Some other cases include: the development of a modelling approach to support policy decisions having to do with the nexus food-energy-water [17], the analysis of water-energy-land-food nexus to improve resource efficiency [18] and the integrated modelling of the food-energy-water nexus with the support of analytical tools [19].

Among the main advantages of the nexus approach is its systemic thinking; not only bio-physical but also socio-economic considerations are taken into account. Trade-offs and synergies are sought under a trans-disciplinary approach. This means that the different components of a system are not analysed as independent entities but as interlinked elements which affect each other [20]. Putting pressures on one component may affect the others to a different degree, and as a result, integrated solutions for managing the evolution of the nexus are needed. Water needs energy for treatment, pumping and distribution while energy needs water for thermal-plant cooling and hydropower. Energy production by different types of fuel (coal, oil, gas, solar, wind, etc.) has different demands for water, results in different levels of Greenhouse Gas (GHG) emissions and affects climate change in a variable way. Land use, be it cropland-forest-wetland-or artificial, exerts different demands on resources and since increased demands of one resource results in increased demands of other resources, one can see how important it is to recognize direct and indirect interlinkages of resources. Due to this complex 'tree' of interrelations [6], policies that usually target a single sector/component, tend to have cross-sectoral implications, even though it is not so obvious at first.

The adoption of a nexus approach is therefore increasingly recommended for: (i) the analysis of dynamic environmental systems characterised by complex inter-relations among their components and; (ii) the design of policies with a long-term time horizon. In addition, a nexus approach is more appropriate when the focus is on the management of scarce/non-renewable resources and the establishment of a low-carbon economy under climate change conditions [5].

From a policy perspective, the governance of the nexus is characterized by numerous interacting, sectoral policies establishing the institutional framework for the sustainable development of the different nexus components. A key concept when talking about interactions among nexus-relevant policies is that of policy coherence [21,22]. Coherence is an attribute of both policy content and policy process. In terms of policy content, it concerns policy objectives and instruments, and; focuses on the

exploitation of synergies as well as on the management of trade-offs within and across policy areas and spatial scales. Coherence of policy goals and instruments is one of the pillars of the nexus governance as it aims for consistency across different sectors, being the ultimate goal for the efficient management of natural resources. As pillar of the nexus governance, policy coherence is pursued throughout the entire policy making process, from design to implementation. This means keeping a continuous focus on the identification/exploitation of potential synergies and the mitigation of possible conflicts across nexus sectors during policy implementation [23,24].

3. Methodological Approach

The methodological approach adopted in this paper for assessing policy coherence is articulated in a number of steps and builds on the approach proposed by Nilsson et al. [24,25] for assessing coherence among Sustainable Development Goals (2016). Figure 1 illustrates the methodological approach. In detail:

- *Problem identification/Key research questions*: The problem is identified and key research questions are formulated. Problem and related research questions define the boundaries of investigation and the nexus components involved. For example, if the problem is water allocation in a region where there is a power plant, irrigated farm land and populated areas, the nexus object of investigation is that of water-energy-agriculture.
- *Stakeholder mapping*: The participatory dimension is emphasised through the mobilization of stakeholders. Stakeholders interested in or influencing the nexus are engaged in the identification and analysis of the relevant policies. Their role (formal or informal) during policy making and policy implementation is explored through in-depth semi-structured interviews and knowledge elicitation workshops. Relevant stakeholders are invited to contribute to policy mapping and policy coherence assessment.
- *Policy mapping—Nexus goals and instruments*: A policy inventory is conducted. Policy goals and policy instruments, relevant to the problem being investigated, are identified across the nexus sectors. Stakeholders support the process with their experience and expertise (interviews, stakeholders' workshop).
- *Identification of nexus-critical objectives and instruments*: The most critical policy objectives and policy instruments are determined. A 'nexus-critical objective' is highly relevant for the nexus issues investigated and has a significant number of interactions with other objectives taken into consideration [26]. A 'nexus-critical instrument' is highly relevant for the nexus issues investigated and has a meaningful number of interactions with the nexus-critical objectives [26]. Stakeholders contribute to the identification of critical objectives and instruments.
- *Policy coherence assessment/Validation by stakeholders*: Experts conduct the assessment of coherence (qualitative assessment) among objectives and between objectives and instruments using the approach developed by Nilsson et al. [25]. Stakeholders are then invited to validate the results.

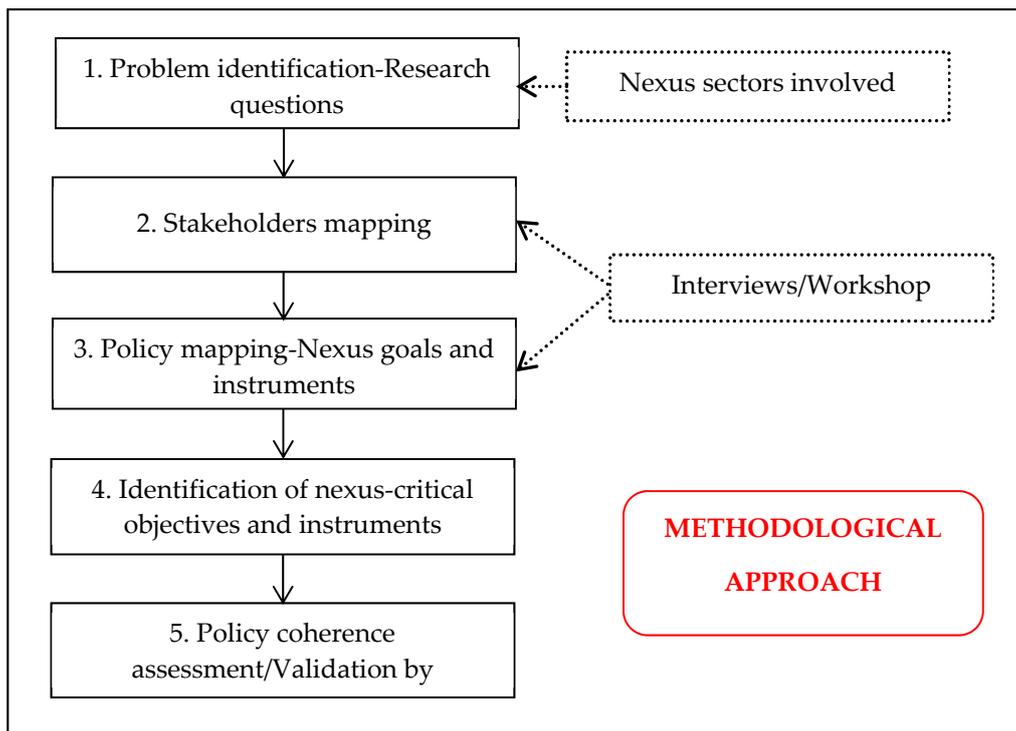


Figure 1. Methodological approach for policy coherence assessment.

In practical terms, nexus critical objectives and nexus-critical instruments are identified per each nexus component. Then, two separate impact matrices are built where the interaction between pairs of objectives and objectives/instruments are scored based on a simple linear scoring scale developed by Nilsson et al. [25]. Such scoring scale defines the level where the implementation of one objective affects, positively or negatively, the pursuit of another, and; the level where the implementation of an instrument affects, positively or negatively, the progress of an objective. Cross-sectoral co-operations and possible competing priorities are revealed. In general, negative scores identify conflictive interactions while positive scores indicate synergistic interactions. The scale follows a seven-point typology [27] where each point indicates the degree of positive or negative interaction existing between a pair of objectives/objective-instrument. The meaning of each value of the seven-point typology is presented in Figure 2.

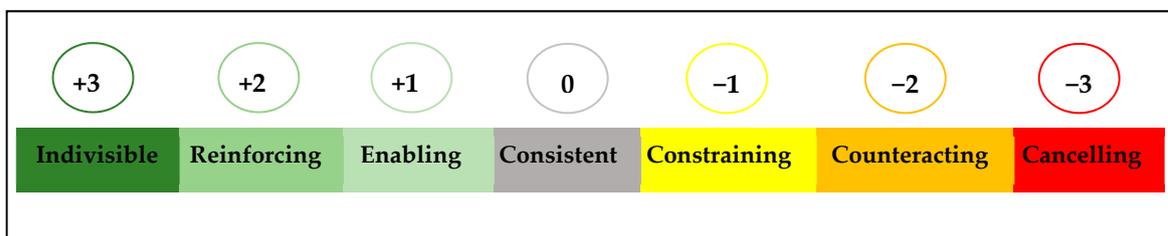


Figure 2. Seven-point typology/Scoring system. Source: [25,27]

An important dimension of the adopted approach is the active involvement and participation of stakeholders in almost all stages of policy analysis and policy elaboration. At this point, a number of plausible questions arise: Why stakeholders are engaged in a policy analysis process? Which is the role of stakeholders in such a process? Who are the stakeholders that should be involved?

Stakeholders’ analysis is a widespread technique usually adopted by public and private organisations dealing with policy assessment [28]. The majority of decision makers underline

the need for taking into consideration stakeholders' views as they will be affected by the respective policies while a critical number of them, may either encourage or hamper the implementation of a policy according to their available means of power [29]. In 1986, ref. [30] referred to stakeholders' participation in policy making by introducing the 'methodology of policy exercise', a preparatory activity through which policy goals and relative strategic options are collaboratively identified. Such kind of exercise may be used as a preliminary stage prior to the implementation of policy decisions or as a tool to evaluate the performance of existing policies. Moreover, the development of broad synergies during a policy analysis process gives stakeholders the chance to express their preferences, clarify possible misunderstandings, cover several knowledge gaps and shed light on issues that decision makers may not keep in mind [31].

Furthermore, participatory planning is a tool that constantly gains ground in the field of environmental policy design and assessment [32] especially in cases concerning the future development of complex systems and the effective management of natural resources. Climate change is a relevant example indicating the need for the adoption of an alternative policy analysis model. Such model would place emphasis on the participation of scientists and stakeholders during the formulation of climate policies. Similar practices are also followed for the management of water [i.e., Water Framework Directive (WFD) 2000/60/EC] and energy resources, land use regulations, etc.

In the case of Greece, the nexus approach led to the identification of five critical nexus-components: water, land, energy, food and climate. These components were selected based on the challenges that must be addressed in the near future, concerning: the reduction of GHG emissions, the reduction of coal and oil use, the penetration of RES in the national energy mix, the production of qualitative agricultural and dairy products, the rational management of water resources especially in case of irrigation, the mitigation of climate change impacts, the explicit regulation of land uses and the reduction of land use conflicts. Agricultural and tourist sectors were also considered as they put extra pressures on all five nexus components, being the dominant economic sectors in Greece. The key policy issues at stake concern: water resources management; penetration of Renewable Energy Sources (RES) to energy production; land use allocation; impacts of water, energy and land policies on food and energy production patterns; agricultural and tourist development under climate change conditions. A detailed policy analysis followed and shed light on the most critical policy priorities as well as on the level of coherence among policy objectives and between policy objectives and policy instruments.

4. Assessment of Policy Coherence in the Case of Greece

4.1. Problem Identification and Research Questions

Greece is located in South-Eastern Europe. Its area is approximately 131,957 km² consisting of 13 administrative units. Its population is estimated close to 10.8 M inhabitants. The major pillars of its economy are agriculture and tourism while the main priorities for its future development include: the economic recovery; the increase of resilience against climate change, and; the establishment of a low-carbon economy. A thorough analysis of the Greek legislative framework and relevant literature [33–42] complemented with discussions with the engaged stakeholders, led to the identification of relevant issues which shape the specific Greek context and guided the selection of the respective nexus sectors. Such issues are:

- Water scarcity and droughts that will be further exacerbated by climate change.
- Spatial and temporal water availability and demand.
- Increase renewable energy sources (RES) share in the national energy mix.
- Reduction of GHG emissions.
- Elimination of land use conflicts.
- Production of high quality agri-food products.
- Further development of tourism.
- Water saving from irrigation.

Consequently, the nexus sectors involved are water, energy, food/agriculture, land and climate and the policy-related issues to be investigated concern: (a) water resources efficiency, especially in the case of agricultural and tourist uses, (b) regulation of land uses, (c) sustainable production of food, (d) low-carbon energy transitions, and (e) climate change adaptation. Accordingly, the research questions for the Greek case were identified:

- How water and energy policies affect agri-food production and the future development of tourism?
- What kind of policy co-operations should be established in order to eliminate water losses in the agricultural sector, support the production of sufficient food and boost the development of a low-carbon economy?
- Which are the most efficient adaptation and mitigation practices for combating water scarcity and strengthen agricultural production under climate change conditions?

4.2. Stakeholders Mapping and Engagement

Stakeholders' engagement was based on the role of stakeholders during decision making and their specific interests as to the nexus-related policies. Stakeholders, relevant to the specificities of the Greek case study, were involved in policy analysis and participated in: (a) the identification of nexus-critical objectives and instruments and (b) the validation of policy coherence assessment. They also enriched the specific analysis by mentioning issues related to policy implementation (arrangements, conflicts, trade-offs) and highlighting the need such issues to be dealt and resolved during the design of future improved policies.

About twenty stakeholders (individuals or/and groups) involved in the entire process and supported the selection and analysis of policy papers, the identification of the main nexus challenges in Greece as well as the assessment of coherence among the nexus-related policies. Such stakeholders were representatives of public organisations (e.g., Ministry of Environment and Energy, Ministry of Tourism, Ministry of Foreign Affairs, Public Power Corporation S.A, etc.), private agencies (e.g., the Bank sector, agri-food businesses, Photovoltaic Energy Producers Association, etc.), NGOs [e.g., Greenpeace Greece and World Wildlife Fund WWF Greece] and academic/research institutes (e.g., National Technical University of Athens, University of Thessaly, etc.). They enriched the analysis by offering additive knowledge, experience and expertise emanating from their scientific and professional background. The interaction between stakeholders and the research team took place through the organisation of face-to-face interviews, e-surveys and a workshop where all of them had the chance to meet each other and discuss about the management of the several nexus challenges.

4.3. Identification of Policy Objectives and Policy Instruments

An inventory of nexus-related policy documents was firstly generated. It included policies concerning all nexus components relevant to the case study (water, energy, land, food/agriculture, and climate). Tourist policy documents were also considered due to the substantive contribution of tourism to the national GDP and its relation to the research questions. The choice of policies was guided by the research problem and research questions. Specifically, the policies selected per each nexus sector are related to the following issues:

- Climate: Reduction of GHG emissions, protection of atmosphere quality, climate change adaptation and mitigation options.
- Energy: Sustainable use of energy sources, development of infrastructures that exploit RES for energy production, penetration of RES in the country's energy mix, implementation of energy saving practices and promotion of energy efficient solutions.
- Land: Land use regulations and management of land use conflicts.
- Water: Protection and sustainable use of surface water and groundwater, mitigation of pollution in natural ecosystems.
- Food: Food production, food and fodder quality, preservation of traditional and scarce seeds.

Regarding agricultural and tourist policies, emphasis was given on: the future development and resilience of agricultural and tourist sectors against climate change impacts; the limitation of pesticides' use; the future development of livestock; the management of agricultural land and pastures; the promotion of tourist entrepreneurship and; the establishment of alternative tourist activities.

Subsequently, a content analysis was performed to identify nexus-critical policy objectives and nexus-critical policy instruments. Policy objectives represent the expectations of administration as to the development of several sectors. They reflect strategic priorities and main future directions pursued for each sector. Policy instruments are tools/techniques supporting the achievement of policy objectives [26,43].

The identification of policy instruments was based on a common distinction in organizational, authoritative (market and non-market), financial and informational instruments. In case of environmental policy instruments the distinction was broke down into the following components [44,45]:

- *Incentive-based instruments*: Emission taxes, tradable allowance systems or 'cap-and-trade', subsidies for pollution abatement, taxes on inputs or goods associated with emissions.
- *Direct regulatory instruments (command and control)*: Technology mandates, performance standards, permits.
- *Voluntary regulation*: Government-industry negotiated agreements, certification standards, auditing and accountings, etc.
- *Informational instruments*: Information campaigns, labelling and produce information, exhortation and moral suasion, etc.
- *Technology-based policies*: R&D policies, technology deployment policies.

This categorization was used as a guidance to understand and organise the different policy instruments. However, for the specific purpose of this paper a systematic classification of policy instruments was not conducted.

The identification of critical objectives and instruments was also based on literature review and experts'/stakeholders' opinions. In particular, stakeholders contributed to identify specific objectives and instruments addressing environmental issues and playing an important role in the sustainable management of resources under climate change conditions. The final list of nexus-critical policy objectives and instruments is presented in Tables 1 and 2.

Table 1. Policy objectives (Adapted from the Greek legislative framework).

Sector	Objective
Climate	C1: Decrease GHG emissions (national and EU climate goals) C2: Increase climate change adaptation and resilience C3: Combating climate change impacts in the sectors of agriculture, tourism, water, food and land uses C4: Empowerment of social awareness (participatory actions) on issues related to climate change C5: Reinforce emissions trading actions in the sectors of industry and aviation (Directive 2003/87/EC)
Water	W1: Promote sustainable management of surface water resources W2: Promote sustainable management of subsurface water resources W3: Protect aquatic systems and reduction of pollution W4: Combating floods and droughts W5: Establishment of an updated water pricing system regulating water uses in several sectors (agricultural, industrial, domestic, touristic, commercial, etc.)

Table 1. Cont.

Sector	Objective
Food and Agriculture	F1: Sustainable development of agricultural sector F2: Protection of plant genetic resources and balanced distribution of benefits generated by their exploitation F3: Sustainable development of livestock (determination of preconditions) F4: Establishment of strict terms and conditions on pesticides use F5: Sustainable development of aquaculture F6: Ensure food and fodder safety and quality
Energy	E1: Achievement of the national energy goals including: increased penetration of RES in the national energy mix (20%) and increased energy efficiency E2: Increased generation of electrical power from RES E3: Promotion and use of cogeneration E4: Official regulation and update of energy prices E5: Promotion and extensive use of natural gas E6: Increase energy saving and efficient use of energy
Land	L1: Promote sustainable spatial integration so as to eliminate spatial inequalities L2: Sustain a well-balanced national economy and strengthen competitiveness L3: Spatial organisation of aquaculture L4: Spatially balanced distribution of industry
Tourism	T1: Sustainable development of tourism T2: Boost tourist entrepreneurship T3: Reinforcement of tourist training initiatives T4: Improvement of the offered tourist services

Table 2. Nexus critical policy instruments (Adapted from the Greek legislative framework).

Sector	Instrument
Climate	Ca: Funding R&D initiatives in the sector of renewables Cb: Subsidies supporting the adoption of technologies that 'capture' CO ₂ Cc: Subsidies supporting the use of technologies contributing to the decrease of methane emissions Cd: Indicators (e.g., atmospheric concentrations of GHGs, vulnerability indices, indices of extreme events) for estimating climate change impacts Ce: Organisation of consultation meetings and participatory workshops for enhancing awareness and public dialogue regarding climate change Cf: Tax measures for limiting emissions including increased taxes in electricity produced from coal and increased fuel taxes
Water	Wa: Development of a national network of stations for tracking quality and quantity of water resources Wb: Funds for initiatives and technologies regulating water uses and limiting over-consumption (i.e., smart taps, renovation of irrigation systems, water recycle and reuse) Wc: Expand the use of technologies that: (a) measure water pollution, (b) detect sources of pollution Wd: Full recovery of costs for water supply services based on assessment of costs for domestic use, irrigation, processing of waste and sewerage We: Constitution of national plans (scientific reports and maps) aiming at the effective assessment and management of flood effects and impacts of possible droughts Wf: Establishment of a national registry of all surface and groundwater resources along with their particular characteristics Wg: Completion of the river basin management plans for the 14 water districts of Greece (WFD 2000/60)

Table 2. Cont.

Sector	Instrument
Food and Agriculture	Fa: Creation of a registry of plant genetic resources for the agricultural and agri-food sectors Fb: Subsidies for crop diversification with focus on crops adapted to the local conditions of each region Fc: Terms and conditions for the development of livestock (identification of suitable locations, minimum area and minimum distance among livestock facilities, etc.) Fd: Ban of dangerous and toxic pesticides, strict measures and penalties for protecting biological crops from pesticides, adoption of pesticides' detection technologies Fe: Measures monitoring quality of aquaculture products, funding innovative technologies in the aquaculture sector Ff: Adopting ISOs and funding the production of certified products to control food and fodders quality and safety
Energy	Ea: Development of wind parks Eb: Development of hydroelectric power plants Ec: Development of geothermal power plants Ed: Development of photovoltaics (subsidies) Ee: Funding cogeneration systems in buildings and large scale infrastructures (e.g., greenhouses) Ef: Funding the use of renewables in buildings for electricity generation, heating and cooling purposes Eg: Incentives (i.e., low prices) for further exploitation and use of natural gas Eh: High prices of renewable energy Ei: Funding innovative technologies for assessing energy consumption and estimating energy losses in the industrial and domestic sectors
Land	La: Land use regulations including completion of the Greek Cadastre Lb: Development of synergies and co-operations among economic sectors (e.g., funding agro-tourist activities and small-industries processing agricultural products) Lc: Funding agricultural entrepreneurship and SMEs to reduce inequalities between urban and agricultural areas Ld: Funding the business sector to reinforce entrepreneurship Le: Funding schemes that support renovation of social infrastructures (hospitals, nursing homes, educational institutions) Lf: Subsidies supporting specialisation in the several productive sectors (agriculture, industry, tourism) Lg: Spatial plans determining suitable areas and terms under which aquaculture activities may be developed Lh: Spatial plans and land use regulations for industry (Organisation of industrial areas and decentralisation of industry) Li: Establishment of special, multi-scale and local-oriented spatial plans setting specific terms for the development of each region based on its particular characteristics
Tourism	Ta: Funding the establishment of infrastructures that serve specific tourist needs such as ski centres, agro-tourist infrastructures, conference centres, etc. (investments in sophisticated tourist activities) Tb: Regulation of land uses in tourist regions in order to identify suitable areas for tourist development Tc: Funding the establishment of a tourist observatory Td: Funding tourist training activities and tourist expertise/Organization of seminars and tourist training centres Te: Adaptation of the tourist product based on the particular historical, geographical and environmental profile of each region Tf: Reinforcement of networking and synergetic actions among tourist businesses

4.4. Policy Coherence Assessment

The assessment of policy coherence was accomplished through: (a) the assessment of interactions among nexus-critical objectives and (b) the assessment of interactions between nexus-critical objectives and nexus-critical instruments. Stakeholders supported policy coherence assessment by identifying

positive and negative influential relationships. Firstly, the research team conducted a qualitative assessment of the relevant interactions and then the results were presented to stakeholders for validation. Stakeholders, according to their expertise on the nexus sectors analysed, proposed possible amendments/corrections. Researchers went back to the relevant impacts matrices and adjusted the scores accordingly. A general discussion followed focusing on the contrast between coherence on paper and actual conflicts when it comes to policy implementation. Stakeholders reported several divergences, not currently considered in existing policy papers but needed to be addressed in future policies.

4.4.1. Interactions among Nexus-Critical Objectives

The assessment of interactions between pairs of objectives (listed in Table 1) was conducted using the scoring scale (range from -3 to $+3$) proposed by Nilsson et al. [25] (see Figure 2). The results of the scoring were plotted on an impact matrix (Table 3). It is recalled that negative values indicate divergences while positive values indicate convergences. Each cell of the matrix denotes the type of interaction between two objectives by including the respective value. The goal of such a table is the assessment of the influence that objectives in rows have on objectives in columns. In other words, the assessment was based on the question: 'How does progress on objective x (in row x) influences progress on objective y (in column y)?' To answer these questions, two issues were explored: (a) if the interaction between two objectives is negative or positive and (b) the degree of interaction according to the values of the seven-point scale. The total influence that an objective x exerts on all other objectives is defined by the row-sum. The column-sum indicates the total influence that an objective y receives by the rest. Each value of the seven-type scoring scale is represented by the respective colour.

Table 3. Objectives vs. objectives cross-impact matrix.

	W1	W2	W3	W4	W5	E1	E2	E3	E4	E5	E6	L1	L2	L3	L4	F1	F2	F3	F4	F5	F6	C1	C2	C3	C4	C5	T1	T2	T3	T4	SUM		
W1																																6	
W2																																	8
W3																																	2
W4																																	19
W5																																	21
E1																																	26
E2																																	18
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C3																																	38
C4																																	19
C5																																	24
T1																																	22
T2																																	8
T3																																	12
T4																																	18
SUM	24	22	21	15	5	25	20	23	11	3	31	31	32	0	-1	32	11	6	-5	7	16	25	43	36	16	17	21	12	8	16			

Overall results show that the majority of interactions are positive (indivisible, reinforcing, enabling), entailing a rather satisfactory level of consistency. This means that progress on most objectives positively affects progress on the rest while a high row-sum indicates strong synergetic efforts. Most synergies exist among objectives falling within the same nexus domain as they are characterised by a high level of complementarity. Synergies were also identified between energy and climate goals; food/agriculture and land goals, and; water and climate goals. Such synergies are fully justified as there are strong inter-relations and complementarities between climate and energy sector, land uses and agricultural development, availability of land for food production and water resources management under climate change conditions. Energy policies pursue the implementation of practices (e.g., adoption of RES) that will contribute to the reduction of GHGs; land use policies place emphasis on the protection of crops and agricultural land, and; water policies promote the need for the efficient management of water resources due to climate change.

However, there are also negative interactions (constraining, counteracting and cancelling) among objectives. A cancelling one exists between objectives C1 and E5, concerning the reduction of GHG emissions and the promotion of natural gas respectively. This is due to the fact that the extensive use of natural gas entails the release of significant GHG emissions in the atmosphere. Counteracting and constraining interactions exist also between: objective E5 and other climate objectives referring to climate change adaptation and mitigation of its impacts; water and food/agriculture objectives, and; tourist and land/agriculture objectives. Agriculture needs water for irrigation while, it also uses pesticides which affect water resources quality. Furthermore, land use conflicts exist among the sectors of tourism, industry and agriculture.

The objective exerting the most positive influence is C3 'Combating climate change impacts in the sectors of agriculture, tourism, water, food and land uses' (Row-sum: 38). Objectives C2 'Increase climate change adaptation and resilience' (Row-sum: 36) and F1 'Sustainable development of agricultural sector' (Row-sum: 31) follow. Such results are fairly reasonable as climate policies, dealing with the sustainable management of climate change impacts, are expected to strongly affect all nexus sectors. A crucial prerequisite for the efficient use of resources and the evolution of the nexus sectors is their adaptation to the new conditions imposed by climate change, especially in case of vulnerable regions. Moreover, agriculture is among the main sectors supporting Greece's national GDP so, policies aiming at its sustainable future development are of utmost importance. Thus, we may conclude that climate-food/agriculture objectives are consistent in a satisfying degree and each of them triggers the effective achievement of the rest.

The objective exerting the least positive influence is F4 'Establishment of strict terms and conditions on pesticides use' (Row-sum: 1). Objectives W3 'Protection of aquatic systems and reduction of pollution' (Row-sum: 2) and E5 'Promotion and extensive use of natural gas' (Row-sum: 5) follow. Considering objective F4, the low-degree of positive influence is due to the fact that pesticide use entails negative impacts on water, land and food even in the case of rational use. As for aquatic systems, their protection puts constraints to the accomplishment of objectives related to the development of agriculture, industry and tourism. Finally, as already mentioned, the extensive use of natural gas counteracts the efforts aiming at the establishment of a low-carbon economy due to GHGs derived from its exploitation.

A more in-depth analysis revealed pairs of objectives that are strongly coherent. Some indicative cases are:

- W4 'Combating floods and droughts' & C2 'Increase climate change adaptation and resilience'/C3 'Combating climate change impacts in the sectors of agriculture, tourism, water, food and land uses'.
- E1 'Achievement of the national energy goals' & C1 'Decrease of emissions'.
- F1 'Sustainable development of agricultural sector' & L1 'Promote sustainable spatial integration so as to eliminate spatial inequalities'.

The cross-impact matrix includes also pairs of objectives that are strongly inconsistent. Some representative examples are:

- E5 'Promotion and extensive use of natural gas' & C1 'Decrease of GHG emissions'.
- W1 'Sustainable management of surface water resources' & F4 'Establishment of strict terms and conditions on pesticides use'.
- F1 'Sustainable development of agricultural sector' & L4 'Spatially balanced distribution of industry'.

Such inconsistencies are mainly caused due to the negative impacts that the accomplishment of an objective may have on the achievement of another one. For example, the extensive use of natural gas hampers the reduction of emissions; the use of pesticides affects quality of aquifers while, the development of agriculture puts constraints to the industrial sector in terms of land use and pollution of resources.

Except for the row-sums, there are also column-sums defining the degree that objectives are influenced by the rest. A high column-sum implies that an objective is strongly influenced by other objectives (positive influence). According to the 'vertical' aggregations the most positively affected objective is C2 'Increase climate change adaptation and resilience' (Column-sum: 45). Objectives C3 'Combating climate change impacts in the sectors of agriculture, tourism, water, food and land uses' (Column-sum: 36), F1 'Sustainable development of agricultural sector' and L2 'Sustain a well-balanced national economy and strengthen competitiveness' (Column-sum: 32) follow. A significant conclusion is that the 'most positively affected objectives' are the same with the 'most positively affecting objectives'. Thus, issues related to: climate change adaptation; sustainable development of agriculture, and; combating climate change impacts, not only affect positively the achievement of other objectives but their accomplishment is also supported by the rest.

There are also two objectives the accomplishment of which is negatively affected; F4 'Establishment of strict terms and conditions regarding pesticides use' (Column-sum: -5) and L4 'Spatially balanced distribution of industry' (Column-sum: -1). Such negative scores are mainly due to the impacts that pesticides and industrial activities exert on resources (especially water and land). Consequently, the implementation of environmental-friendly policies puts strict constraints to both pesticides use and development of industrial activities.

At the top of the list of least positively affected objectives are: E5 'Promotion and extensive use of natural gas' (Column-sum: 3), W5 'Establishment of an updated water pricing system regulating water uses in several sectors (agricultural, industrial, domestic, touristic, commercial, etc.)' (Column-sum: 5), F3 'Sustainable development of livestock (determination of preconditions)' (Column-sum: 6) and F5 'Sustainable development of aquaculture' (Column-sum: 7). Most of these objectives concern sectoral policies and embody a more specific orientation. This is the reason why they are mainly affected by objectives belonging to the same nexus sector.

4.4.2. Interactions between Nexus-Critical Instruments and Nexus-Critical Objectives

In a similar way, interactions between nexus-critical objectives and nexus-critical instruments were analysed. The total number of selected instruments was 43 (see Table 2) and an impact matrix including the evaluation of policy instruments vs. policy objectives was built (Table 4). The scoring scale was similar to the one previously described. In this case, negative scores mean that the implementation of a policy instrument hampers the achievement of an objective (conflict) while positive scores mean that the implementation of a policy instrument reinforces the achievement of an objective (synergy). The degree of interaction is determined by the respective values of the seven-point scale.

Table 4. Instruments vs. objectives impact matrix.

	W1	W2	W3	W4	W5	E1	E2	E3	E4	E5	E6	L1	L2	L3	L4	F1	F2	F3	F4	F5	F6	C1	C2	C3	C4	C5	T1	T2	T3	T4	+	-	SUM		
Wa																																12	3	19	
Wb																																	14	0	26
Wc																																	6	9	1
Wd																																	10	7	8
We																																	12	1	21
Wf																																	14	1	20
Wg																																	11	5	16
Ea																																	11	5	16
Eb																																	12	4	16
Ec																																	16	3	27
Ed																																	11	4	15
Ee																																	14	0	24
Ef																																	14	1	23
Eg																																	11	3	6
Eh																																	2	7	-7
Ei																																	10	0	17
La																																	20	0	35
Lb																																	14	0	21
Lc																																	9	0	16
Ld																																	15	0	27
Le																																	4	0	6
Lf																																	23	0	43
Lg																																	6	0	12
Lh																																	9	2	12
Li																																	17	0	35
Fa																																	6	0	10
Fb																																	12	4	17
Fc																																	8	4	8
Fd																																	8	0	17
Fe																																	6	0	11
Ff																																	6	0	12
Ca																																	13	1	28
Cb																																	8	0	18
Cc																																	8	0	18
Cd																																	22	3	42
Ce																																	22	1	38
Cf																																	17	3	27
Ta																																	8	2	16
Tb																																	7	2	13
Tc																																	7	0	18
Td																																	10	0	21
Te																																	7	0	17
Tf																																	6	0	12
+	19	17	17	12	3	16	19	10	11	5	19	35	32	10	12	22	6	12	6	13	10	16	32	25	16	10	27	20	10	19					
-	2	2	2	0	0	1	5	0	0	5	0	0	0	5	12	9	0	5	5	3	0	2	2	2	0	0	9	2	0	2					
SUM	35	34	25	21	5	39	31	21	15	-4	31	60	56	14	5	31	10	16	1	20	17	37	68	49	22	19	38	35	18	29					

As expected, this second evaluation indicated that instruments and objectives referring to the same nexus sector are compatible with each other. Also and apart from two exceptions, policy instruments concerning the sector of energy critically support the achievement of objectives related to climate protection and vice versa. Instruments concerning the efficient and rational use of water fairly support the accomplishment of objectives associated to climate and vice versa. Finally, instruments referring to land positively affect objectives promoting the sustainable development of agricultural and tourist sectors. The main conflicts have been detected between: instruments promoting the sustainable use of water resources and objectives referring to land and food sectors; instruments concerning the development of RES infrastructures and objectives for the land sector that place emphasis on the protection of natural environment (e.g., protected areas, landscape and biodiversity); energy instruments and objectives considering the protection of water resources; climate instruments and the goal promoting natural gas use, and; two specific energy instruments (incentives for natural gas exploitation and high prices of renewable energy) and climate objectives.

The assessment of coherence between policy objectives and policy instruments indicated that the most positively affecting instruments are: Lf 'Subsidies, supporting specialisation in the several productive sectors' (Row-sum: 43), Cd 'Use of indicators (e.g., atmospheric concentrations of GHGs, vulnerability indices, indices of extreme events) for estimating climate change impacts' (Row-sum: 42) and Ce 'Organisation of consultation meetings and participatory workshops for enhancing awareness and public dialogue regarding climate change' (Row-sum: 38). There is also an instrument, Eh 'High prices of renewable energy', exerting negative influence (Row-sum: -7) and counteracting two energy and three climate objectives. Among the least affecting instruments are: Wc 'Extensive use of technologies that: a) measure water pollution b) detect sources of pollution (Row-sum: 1), Le 'Establishment of funding schemes that support renovation of social infrastructures (hospitals, nursing homes, educational institutions)' (Row-sum: 6) and Eg: Incentives (i.e., low prices) for further exploitation and use of natural gas (Row-sum: 6).

Similarly to the respective results derived from the objectives vs. objectives cross-impact matrix, policy instruments having to do with climate are among the most positively affecting ones. Land-related instruments are also accompanied by high row scores. Such instruments support the estimation of climate change impacts, the implementation of adaptation and mitigation practices as well as the reinforcement of subsidies that encourage specialisation, the multi-scale spatial organisation of land and the regulation of land uses. They are general enough in order to support the achievement of a significant number of objectives referring to various nexus sectors. On the other hand, more specific instruments support sectoral-focused objectives so their overall influence is lower. It should be mentioned that the instrument concerning high prices of renewable energy incorporates a negative influence as it hampers further exploitation of RES and accordingly the reduction of emissions.

Negative interactions between instruments and objectives entail that the implementation of an instrument may put constraints on, counteract or even cancel the achievement of an objective. According to the results derived from the assessment of coherence between objectives and instruments, the strongest negative interactions (cancelling interactions) occur between:

- Instrument Ef 'Funding the use of renewables in buildings for electricity generation, heating and cooling purposes' and objective E5 'Promotion and extensive use of natural gas'.
- Instrument Eg 'Incentives (i.e., low prices) for further exploitation and use of natural gas' and objectives: C1 'Decrease of GHG emissions (national and EU climate goals)' & C3 'Combating climate change impacts in the sectors of agriculture, tourism, water, food and land uses'.
- Instrument Ce 'Organisation of consultation meetings and participatory workshops for enhancing awareness and public dialogue regarding climate change' and objective E5 'Promotion and extensive use of natural gas'.
- Instrument Cf 'Specific measures for limiting emissions (increased taxes in electricity produced from coal, increased fuel taxes) and objective E5 'Promotion and extensive use of natural gas'.

Such cancelling interactions underline, once again, the divergences between policies that promote the extensive use of natural gas and policies emphasising the need to limit GHG emissions, encourage the broad adoption of renewables and prioritise climate change adaptation and mitigation initiatives. Other indicative examples of constraining or counteracting interactions include: Wc 'Extensive use of technologies that (a) measure water pollution, (b) detect sources of pollution' & E2 'Generation of electrical power from RES', Lh 'Spatial plans and land use regulations for industry (Organisation of industrial areas and decentralisation of industry)' & F1 'Sustainable development of agricultural sector', Eh 'High prices of renewable energy' & C2 'Increase climate change adaptation and resilience', etc.

In contrast, some indicative pairs of instruments-objectives characterised by the strongest positive interactions are: Ca 'Funding R&D initiatives in the sector of renewables' & E1 'Achievement of the national energy goals including: increased penetration of RES in the national energy mix (20%) and increased energy efficiency', We 'Constitution of national plans (scientific reports and maps) aiming at the effective assessment and management of flood effects and impacts of possible droughts' & C2 'Increase of climate change adaptation and resilience', La 'Land use regulations including completion of the Greek Cadastre' & F1 'Sustainable development of agricultural sector', etc.

Column-sums indicate the degree to which the progress of each objective is affected by the implementation of each instrument. Climate and land objectives are again among the most positively affected [e.g., C2 'Increase of climate change adaptation and resilience' (Column-sum: 68) and L1 'Promote sustainable spatial integration so as to eliminate spatial inequalities' (Column-sum: 60)] whereas the achievement of objective E5 'Promotion and extensive use of natural gas' is negatively affected (Column-sum: -4) by the rest.

4.5. Stakeholders' Validation

The assessment of policy coherence proceeded with the validation of results by the involved stakeholders. Stakeholders revised the two impact matrices and updated the scoring of inter-relations among policies across nexus sectors. The proposed updates/amendments were incorporated in the relevant impact matrices. Other issues discussed with stakeholders concerned: current policy gaps and future strategic options; policy implementation, challenges and opportunities; existing synergies and trade-offs among policies.

Stakeholders offered additional information concerning coherence in terms of formal and informal arrangements when it comes to policy implementation. In this way, they shed light on policy gaps between theory (policy papers) and practice (policy implementation) that should be addressed in the future. They mentioned that when designing policies, co-operations among public and private organizations, NGOs and academic institutions should be explored in order to identify the factors that either create conflicts or strengthen the establishment of synergies with respect to the accomplishment of nexus-critical objectives. Policy arrangements taking place at implementation level, supporting and limiting factors should be carefully examined and incorporated in future policies. In this context, stakeholders reported a number of cross-sectoral committees, promoting synergetic actions in order to confront problems revealed during policy implementation by: limiting divergent objectives and seeking compromising solutions. Such committees are created between Ministries and Academic Institutions (e.g., Ministry of Environment and Energy/National Technical University of Athens), within Ministries (e.g., Ministry of Environment and Energy/Ministry of Tourism), Ministries and businesses (e.g., Ministry of Environment and Energy/Hellenic Association of Photovoltaic Energy Producers), Ministries and NGOs, etc. In some cases the collaboration is successful; in other cases, the final outcome is negative due to discrepancies or an inability to compromise. According to stakeholders', current conflicts mainly refer to the management of geothermal springs, the allocation of the available water resources, the management of land use conflicts (especially between agriculture and livestock) and the use of lignite for energy production. They also mentioned that such issues are not currently addressed in the relevant policy papers but should be urgently clarified in future policy papers. Policies aiming at

mitigating such trade-offs are under discussion or ready to be implemented in the near future such as the water pricing policy and the new special policy framework for the organisation of the tourist sector.

Thus, the formulation of arrangements enhances the undertaking of participative actions among stakeholders and reinforces consultancy and transparency during policy assessment or policy design. Finally, among the enabling and hindering factors determining the successful or unsuccessful outcome of an arrangement are mainly common or conflicting plans/agendas; goals/perspectives; interests; profits; exchange of experiences and expertise, and knowledge diffusion.

5. Discussion

In this paper the coherence among water-energy-land-food-climate policies under a nexus rationale was investigated in the case of Greece. The adopted methodological approach placed emphasis on the exploration of possible options to better integrate policies across sectors for the sustainable development of the nexus components. The assessment of policy coherence revealed critical interactions among nexus-critical objectives and between nexus-critical objectives and nexus-critical instruments. Policy priorities were elicited based on: (a) the degree of influence that each objective exerts/receives to/by the rest and (b) the influential inter-relations between nexus-critical objectives and nexus-critical instruments. A stakeholder-engagement orientation was also incorporated, underlining the importance of taking into consideration specific knowledge and expertise.

Policy coherence represents an essential step of the applied approach and contributed to the enrichment of policy analysis with knowledge about problems arising at both policy document and implementation level. Existing conflicts, synergies, trade-offs, negotiations were investigated and inconsistencies at a practical level were explored. It should be mentioned that the assessment of policy coherence is a rather complex and time-consuming endeavour as the amount of information that needs to be studied and evaluated is massive.

In this study, a mix-method approach was adopted where multiple sources of information were analysed so as to allow data triangulation. Specifically, a systematic process was followed, including: literature study on nexus interactions, content analysis of policy documents, experts' evaluation and investigation of stakeholders' views. The contribution of stakeholders was particularly important to understand what is feasible in practice. Stakeholders indicated existing conflicts and synergies as well as possible ways to deal with such conflicts, synergies and trade-offs at the implementation level. They were involved in almost all stages of policy analysis and in some cases they were the only source of information in order to analyse a number of critical issues. Their engagement was an integral and necessary part of the process as the generation of useful and valid outcomes presupposed their collaboration.

The implementation of the proposed methodological approach in the case of Greece effectively guided the assessment of policy coherence by offering a systematic way for investigating the complexity of the nexus issues. In particular, it supported the organisation of the several tasks to undertake and shed light on issues that researchers did not have in mind such as the exploration of arrangements and trade-offs taking place when policy conflicts occur.

The outcomes showed that the highest degree of coherence was attained when the policies referred to the same nexus sector. However, significant positive policy interactions exist also among policies concerning different nexus sectors, e.g., climate and energy policies. Sectoral (vertical) policies exert the lower level of positive influence to the rest as they mainly support the achievement of more specific policy objectives. Climate and food/agriculture objectives embody the highest level of positive influence on the rest, being simultaneously positively affected by a high number of objectives. Climate change adaptation and resilience, combating climate change impacts and sustainable development of agriculture are the most influencing objectives. This is reasonable as in the forthcoming years many regions in Greece are going to experience the impacts of climate change. Thus, progress of policy objectives related to the confrontation of such impacts, the enhancement of resilience and the

reinforcement of adaptation ability entails a strong positive effect on the sustainable management of all other nexus sectors, especially agriculture and food, under climate change conditions.

Instruments concerning: (a) use of indicators for estimating climate change impacts and the respective vulnerability, (b) the encouragement of specialisation in all productive sectors and (c) the undertaking of participatory actions for enhancing public awareness as to climate change are the most influencing ones; those that support positively the progress of the majority of objectives. Regarding land use sector, the promotion of specialisation and the regulation of land uses will support the reduction of conflicts among nexus sectors, enhancing also the creation of complementarities among productive sectors. The successful implementation of climate instruments will set the conditions under which several activities, especially agriculture and tourism, will be sustainably developed in the future.

Conflicts mainly exist among objectives referring to the protection of water resources and the development of industry and aquaculture; the rational use of surface water and the production of energy from hydropower; the development of agriculture and the de-centralisation of the industrial sector (competitive land uses), and; agricultural development and the establishment of tourist activities in rural regions (competitive land uses). Such conflicts are expected to be mitigated in the near future through the official regulation of land uses and the strict implementation of the WFD 2000/60 at national level. There is also a pair of cancelling objectives; those concerning the extensive use of natural gas for energy generation and the reduction of GHG emissions respectively. Such cancelling interaction stresses the negative effects that natural gas exploitation has on emissions' release and the need to adopt alternative energy sources supporting the limitation of emissions. Instrument Eh 'High prices of renewable energy' has a negative row score as it hinders the extensive use of renewables and consequently the accomplishment of objectives aiming at the establishment of a low-carbon economy. Finally, similarly to the case of objectives vs. objectives interactions, cancelling inter-relations occur between instruments enabling the use of natural gas and objectives concerning climate change adaptation and mitigation of its impacts, and reciprocally; instruments supporting climate change adaptation/mitigation and the objective promoting the extensive use of natural gas.

Generally, the overall level of coherence is satisfied but our analysis highlights the need for achieving a higher level of consistency in order to successfully establish a low-carbon economy that will be based on the efficient use of resources. This paper provides the necessity for exploring policy coherence in order policy gaps either in policy documents or at policy implementation level to be revealed. In the case of Greece, stakeholders mentioned several divergences between theory and practice. Such divergences concern conflicts and trade-offs arising during policy implementation but not anticipated/forecasted in existing policy papers. Some representative examples include conflicting water uses and arguments on the management of geothermal springs and on lignite use for energy production. Such conflicts are accompanied by the requirement to be effectively addressed in future policies.

Conclusively, compromised policy solutions call for the adoption of an integrated nexus orientation where interlinkages and interactions among the nexus components are fully taken into account during policy design and policy implementation. In this context, results emanating from policy coherence assessment may be used as a guide in order improved policies to be designed, dealing with the observed shortcomings and addressing possible inconsistencies. In other words, such kind of analysis resembles a learning process supporting the institution of improved nexus-compliant policies that will be better able to cope with conflicts and trade-offs.

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