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Implementing Water-Energy-Land-Food-Climate Nexus Approach to Achieve the Sustainable Development Goals in Greece: Indicators and Policy Recommendations

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Abstract: In 2015 the updated Agenda 2030, outlining the new priorities towards future sustainability, was published by the United Nations reflecting the general directions towards a fairer and more sustainable pattern of socio-economic development. The specialisation of the 17 Sustainable Development Goals (SDGs) and indicators into local contexts constitutes a basic prerequisite as particular characteristics, needs and peculiarities should be considered. This paper focuses on the exploration of local-oriented indicators and policy recommendations that have the potential to boost the successful implementation of SDGs in Greece. A nexus approach is adopted underlining the need to analyse complexities, motivate systemic thinking and develop integrated policies targeting at the sustainable and efficient use of resources. It also highlights the need for designing local-specific indicators and policy initiatives, encapsulating particular characteristics and conditions and boosting the advancement of SDGs. Such an approach has the potential to be implemented not only at national but also at an operational level in local scale (e.g., River Basin Scale). The outcomes indicate that emphasis should be given on smart water management and precision agriculture, extensive use of technologies capturing Greenhouse Gases (GHGs), dynamic penetration of Renewable Energy Sources (RES) in gross final energy production/consumption and protection of terrestrial ecosystems.

Keywords: SDGs; indicators; WELFC nexus; policy-making; sustainability; resources efficiency

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1. Introduction

Climate change constitutes a critical research and policy challenge calling for the design of informative decisions and adaptation/mitigation plans in order to effectively address its impacts. Biodiversity and ecosystems as well as water, energy, land and food sectors are extremely stressed by climate change and new patterns of resource use are created due to unforecasted and rapid changes. Water deficits, extreme weather conditions, prolonged drought periods, frequent flood events, land use changes, biodiversity loss, increased GHG emissions and high rates of energy resources demand have already been and will be further intensified in the near future. Except for the natural environment, climate change affects also social and economic development as it is directly related to physical disasters causing severe economic losses, social inequalities, global food insecurity and health problems. According to [1], the negative impacts of climate change will be harsher in the poorer and warmer countries as well as in areas at or near the sea level (e.g., coastal areas). Climate change will also affect markets all around the world [2], fisheries [3], crop production [4], mortality rate and human productivity [5], human toxicological impacts [6], etc. Moreover, the uncontrolled expansion of urban areas and the lack of robust and modern urban plans intensify urban vulnerability against disasters (urban floods, limited access to resources, late emergency responses, etc.), that will be dramatically exaggerated in the near future. Etinay et al., 2018 [7] highlight the need to re-assess the approaches of Disaster Risk

Management and Disaster Risk Reduction, in order to strengthen urban resilience as to climate change, while [8] underline the requirement of improving and modernizing urban infrastructures as a response to natural hazards.

In 2015 the United Nations (UN) adopted the Agenda 2030 for Sustainable Development, the core priorities of which focus on human well-being and environmental protection. Such priorities are clarified through 17 Sustainable Development Goals (SDGs), 169 specific targets and 231 unique indicators supporting the assessment of SDGs' progress and level of accomplishment. The Agenda 2030 represents the blueprint towards future sustainable development as its 17 SDGs place emphasis on the [9]:

- reduction of poverty and food insecurity,
- upgrading of health services,
- promotion of education and learning opportunities,
- reinforcement of gender equality,
- sustainable management of water and sanitation services,
- adoption of clean energy solutions,
- reinforcement of employment opportunities,
- sustainable industrialization and innovation production,
- reduction of inequalities,
- establishment of sustainable cities,
- development of circular economies,
- confrontation of climate change impacts,
- protection of marine environment and terrestrial ecosystems,
- promotion of peace and justice
- development of synergies towards the achievement of SDGs.

SDGs represent a milestone, as the ambitions they set will boost the establishment of a 'new' pattern of economic growth, social development and environmental sustainability. Their successful achievement presupposes the creation of multilateral cooperations, the design of updated policy interventions, and the promotion of targeted investments; but first and foremost the specialisation of SDGs into local contexts, needs, peculiarities and comparative advantages. The need for smart specialisation and innovation policies at national and regional level [10,11], coordinated efforts at municipal level [12] and disaggregation of data into local contexts [13] is of utmost importance, so that SDGs are integrated into specific local conditions. Nilsson et al., 2018 [14] go a step beyond and mention that except for each SDG separately, interactions, trade-offs and synergies among SDGs should also be analysed under specific geographical contexts, endowments, time horizon and governance, while; [15] explore the determinants of sustainability achievement through SDGs' implementation and the need to strengthen international compensations as to environmental protection. Social, economic and environmental dimensions should be intertwined and new pathways should be explored considering all factors that may either hamper or boost the successful accomplishment of SDGs.

The EU has already adopted SDGs, adapted their context at regional level and works systematically towards their future accomplishment. Along with the Agenda 2030, the European Commission has defined a new roadmap, the so-called "European Green Deal" (EGD), targeting at the elimination of Greenhouse Gases (GHGs) by 2050 and the decoupling of economic growth from resource use. The EGD is strongly related to the accomplishment of SDGs and the implementation of aspirations set in the Agenda 2030. The main policy areas considered include the promotion of clean energy solutions, the sustainable development of industry, the establishment of a cleaner building sector, the promotion of sustainable mobility, the protection of biodiversity, the efficient management of food systems and the elimination of pollution. Having been published in December 2019 and with the support of the '2030 Climate and Energy Framework', it is expected to further enhance climate adaptation and mitigation initiatives in all Member States and set the ground for the establishment of low-carbon economies.

Towards this direction, the so-called 'nexus approach' is a promising exemplar for the integrated and efficient use of resources that encourages systemic thinking and analysis of interactions existing among interlinked sectors [16]. The nexus approach considers interlinkages across multiple sectors and supports the investigation of synergies and trade-offs [17–19]. It is based on trans-disciplinary research and adopts a holistic view, in order to strengthen the understanding of complex inter-relations affecting the sustainable management of natural and socio-economic systems. The more the components of a 'nexus', the more complicated the interactions among them. The 'big challenge' lies on the sustainable management of a component linked to other resources and on the inclusive management of different but inter-related components [20]. According to [21,22], the sustainable management of the Water-Energy-Food-Ecosystems (WEFE) nexus plays a critical role to deliver the resources and services needed to sustain human activity and well-being. Weitz et al. (2015) [23] report on the potential that cross-sectoral analysis of the Water-Energy-Food (WEF) nexus brings to the integration of SDGs; ref. [24] highlights the possible contribution of Environment-Economy-Health nexus investigation to the successful implementation of SDGs and especially SDG 3.

Effective management of the Water-Energy-Land-Food-Climate (WELFC) nexus is extremely challenging due to the complexity and interconnectedness of the system and the current fragmentation in policy formulation. Thus, a better understanding of policy impacts on the WELFC nexus is a requirement so that integrated policies, boosting sectoral synergies, can be designed and policy coherence among sectoral nexus-related policies can be reinforced.

This paper intertwines the WELFC nexus in Greece with the priorities set by SDGs and EGD and focuses on: (a) indicators estimating the progress of SDGs in Greece and (b) policy pathways that contribute to the fulfilment of SDGs by taking into consideration local conditions. The basic research questions concern the specialisation of indicators included in the Agenda 2030 in order to reflect the particular characteristics of Greece and, the level of SDGs accomplishment through the implementation of integrated nexus-related policies. In this context, WELFC nexus-related SDGs and indicators are explored, WELFC nexus-related policies are analysed along with specific indicators, bringing the potential to estimate their progress, and future policy recommendations are suggested. The basic principle upon which such analysis is based on is that a nexus approach supports the achievement of SDGs as SDGs are also inter-related.

2. Nexus Policies and SDGs in Greece

SDGs have set an updated and integrated framework, targeting at a more sustainable and equitable future. As already mentioned, they represent a supportive pillar bringing the potential to strengthen the efforts towards future sustainability in European, national, regional and local levels through the combined implementation of top-down and bottom-up approaches. In this context, the design of relevant policies and the need for coordinated initiatives are highlighted due to the social, economic and natural interdependencies that characterise today's globalised world. Greece has fully adopted the priorities of the Agenda 2030 and shifted its national efforts towards the elimination of poverty, hunger and inequalities, the upgrading of health and education standards, the easy-access to water and clean energy resources, the sustainable economic growth, the promotion of industrial innovation, the sustainable urban development, the adoption of environmentally friendly production and consumption patterns, the effective management of climate change impacts, the protection of marine biodiversity and life on land, the enhancement of peace and justice and the establishment of collaborative schemes working synergistically for the accomplishment of SDGs.

The 'nexus' approach constitutes an ideal concept that promotes sustainability and efficient use of resources by underlining the tremendous importance that; interlinkages among the components of a system have on its total effectiveness. Synergies and trade-offs create a complex network of interactions (Figure 1). The increased uncertainty demands the

adoption of robust methods and models in order to investigate causalities and sheds light on the impacts that changes in one nexus component may bring to the others. Therefore, the nexus approach has a systemic base and highlights the need to deepen into complexities having the potential to reveal current problems and setting the ground for the design of better and more effective future decisions.

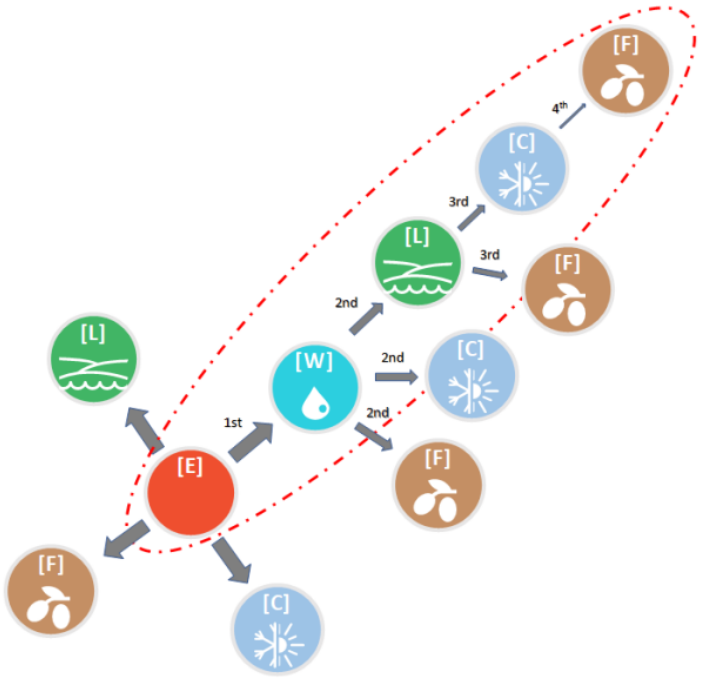

Figure 1. Nexus tree—Indicative network of interactions focusing on the energy sector accompanied by the level/degree of interaction (after [20]).

The WELFC nexus takes into consideration five critical components upon which the future sustainability of our planet is based on. Thus, a thorough analysis of the interlinkages among the WELFC nexus components and their future trends may be a valuable guide leading to a more rational management of each component separately and of the WELFC nexus as a concrete physical system. Moreover, the sustainable management of the WELFC nexus may boost the successful implementation of SDGs, while policies managing the nexus may strongly contribute to the achievement of SDGs through a holistic approach that considers interlinkages, synergies and trade-offs, and builds their impacts on resource management.

In Greece, the national priorities towards achieving WELFC nexus-dependent SDGs are: (a) to establish of a competitive, innovative and sustainable economic growth and (b) to strengthen the protection and sustainable management of natural capital as a base for social prosperity and transition to a low-carbon economy [9]. Such priorities are included in the National Growth Strategy of Greece, that also promotes the creation of a low-carbon circular economy, the improvement of waste reduction, the 'reuse and recycle' principle as a driving force for creating job opportunities and increasing resource efficiency, the accomplishment of GHG reduction targets earlier than 2030, the design and implementation of Integrated Water Resources Management plans, the dynamic penetration of RES in the national energy mix and the full digitization of land-uses [9]. Under this framework, the WELFC nexus approach and the implementation of relevant policies fostering sustainability have the potential to decisively advance and even accelerate the successful accomplishment of SDGs at national level.

As a typical Mediterranean region, Greece is facing a series of problems related to the confrontation of climate change impacts such as water scarcity, extended drought periods, availability of irrigation water, fluctuations of agricultural production under extreme weather conditions, energy demand due to rising temperatures, forest fires, extinction

of endangered species/changes in biodiversity, intense seasonal pressures on resources (especially water and energy) coming from the tourist sector as well as land use changes imposed by the new climatic conditions. In order to deal with such urgent conditions, Greece has adopted the priorities set in the EU '2030 Climate and Energy Framework' and '2050 Long-Term Strategy' (EU Green Deal, Paris Agreement) and reconciled such perspectives to national and regional contexts by taking into account specific needs, problems and future possibilities. SDGs are also expected to further support mitigation and adaptation practices through their specialization into local conditions and the introduction of innovative ideas on resource management.

Regarding the sustainable management of the WELFC nexus, national policies only partially follow the nexus concept and are rather sectorial. However, emphasis is given on setting strategic priorities accelerating the reinforcement of resilience and the respective adaptation of all economic sectors, in order to effectively face the climate change challenges under a nexus rationale. Such adaptation strategies highlight the need for a systemic adjustment by considering the relevant human costs, the environmental and socio-economic impacts and the requirement for establishing synergies and creating alignment among the several policies. The WELFC nexus policies will drastically contribute to the accomplishment of a significant number of SDGS and their relevant targets as well as to the implementation of EU and national priorities.

More analytically, policies focusing on the *water sector* [fully reconciled with and adapted to the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC)], along with relevant SDGs, prioritize [25–29]: (a) the protection and sustainable management of surface water and groundwater quantity and quality (SGD 6, SDG 13, SDG 15), (b) the protection of aquatic ecosystems from further deterioration (SDG 6, SDG 15), (c) the mitigation of floods' and droughts' effects (SDG 6, SDG 13) and (d) the establishment of a national water pricing system (SDG 6, SDG 12). The configuration of rules regulating water uses, the development of River Basin Management Plans and Flood Risk Management Plans, the creation of a monitoring network detecting sources of pollution, the recovery of costs for water services and the explicit determination of costs for several water uses constitute the main directions towards achieving the abovementioned policy goals. Some more specific objectives as to the water sector suggest the implementation of water saving practices in the agricultural, industrial and domestic/tourist sectors by: changing irrigation practices, reducing water demanding crops or cultivating crops that are resilient to drought, using water saving equipment (e.g., smart taps) and changing water consumption behaviour, recycling and reusing water in the industrial and tourist sectors, increasing the investments/subsidies on Waste Water Treatment technologies in the industrial and tourist sectors. Special emphasis is placed on wastewater treatment, recycle and reuse of water in small and remote Greek islands due to the continuous growth of tourist flows. These policies have the potential to directly support the achievement of: SDG 6 'Ensure availability and sustainable management of water and sanitation for all', SDG 12 'Ensure sustainable consumption and production patterns', SDG 13 'Take urgent action to combat climate change and its impacts' and SDG 15 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'.

Regarding the *climate sector*, national policies, in combination with relevant SDGs, focus on [30–35]: (a) the reduction of GHG emissions by both Emissions Trading System (ETS) and non-ETS sectors (SDG 9, SDG 13), (b) the increase of adaptation ability and resilience against climate change impacts (SDG 11, SDG 12, SDG 13), (c) the increase of social awareness as to climate change (SDG 11, SDG 13) and (d) the mitigation of climate change impacts through activities in the LULUCF (Land Use, Land Use Change and Forestry) sector in order to increase CO_2 sequestration (SDG 13, SDG 15). The establishment of specific measures for combating climate change impacts, the involvement of citizens in actions concerning the confrontation of climate change, the reinforcement of ETS initiatives by the industrial and energy production sectors as well as the protection of forest land,

wetlands, grassland and crops through the effective confrontation of forest fires and official land use regulations, will further boost the accomplishment of: SDG 9 'Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation', SDG 11 'Make cities and human settlements inclusive, safe, resilient and sustainable', SDG 12 'Ensure sustainable consumption and production patterns', SDG 13 'Take urgent action to combat climate change and its impacts' and SDG 15 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'.

Policies concerning the *energy sector*, along with the corresponding SDGs, place emphasis on [36–42]: (a) the achievement of the national renewable energy goals (SDG 7, SDG 13), (b) the extensive use of RES for electricity production (SDG 7, SDG 9, SDG 13), (c) the further adoption of cogeneration practices (SDG 7, SDG 9, SDG 13), (d) the modernisation of the national energy pricing system (SDG 7, SDG 13), (e) the replacement of oil by natural gas (SDG 7, SDG 9, SDG 13), (f) the increase of energy efficiency and energy saving practices (SDG 9, SDG 13) and (g) the decrease of coal for energy production (SDG 7, SDG 9, SDG 13). The exploitation of solar-, wind-, hydro-power and biomass by the transportation, industrial, power generation, household/commercial, agricultural and other productive sectors as well as the modernisation of energy infrastructures will support the establishment of a more efficient energy production and consumption pattern that will accelerate the accomplishment of: SDG 7 'Ensure access to affordable, reliable, sustainable and modern energy for all', SDG 9 'Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation' and SDG 13 'Take urgent action to combat climate change and its impacts'.

Policies managing the *food sector*, accompanied with related SDGs, focus on [43–49]: (a) the sustainable management of agricultural sector (SDG 2, SDG 15), (b) the preservation and sustainable use of plant genetic resources (SDG 2, SDG 15), (c) the sustainable management of livestock (SDG 2), (d) the rational use of pesticides (SDG 2, SDG 6, SDG 15), (e) the sustainable development of aquaculture (SDG 2, SDG 6, SDG 15) and (f) the institution of measures ensuring food and fodder safety (SDG 2). Such policies target at the coverage of food and fodder needs and needs related to industrial crops, the reinforcement of agricultural and livestock production, the rational use of resources (e.g., water, energy, land) by agriculture and livestock and the production of high-quality food products. Food policies have the potential to contribute to the achievement of: SDG 2 'End hunger, achieve food security and improved nutrition and promote sustainable agriculture', SDG 6 'Ensure availability and sustainable management of water and sanitation for all' and SDG 15 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'.

Finally, regarding policies managing the *land sector*, combined with relevant SDGs, emphasis is given on [50–53]: (a) the sustainable and integrated spatial development (SDG 11, SDG 13, SDG 15), (b) the development of a balanced and competitive economy (SDG 9), (c) the spatial organisation of the aquaculture sector (SDG 6), (d) the spatial organisation of the industrial sector (SDG 9), (e) the protection of agricultural land and land occupied by livestock (SDG 15), and (f) the sustainable management of forest land, wetlands and grassland (SDG 15). Official land use regulations, elimination of land use conflicts; reforestation actions, restoration of biodiversity and the effective confrontation of forest fires represent the main policy interventions that will drastically contribute to the sustainable management of the land sector. National land policies will boost the successful accomplishment of: SDG 6 'Ensure availability and sustainable management of water and sanitation for all', SDG 9 'Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation', SDG 11 'Make cities and human settlements inclusive, safe, resilient and sustainable', SDG 13 'Take urgent action to combat climate change and its impacts' and SDG 15 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'.

WELFC nexus policies promoting relevant SDGs are schematically/briefly presented in Figure 2. The successful progress of SDG 6, SDG 9, SDG 13 and SDG 15 is positively affected by a considerable number of policies concerning different nexus components. SDG 6 is served by policies referring to the water, food and land sectors; SDG 9 is boosted by climate-, energy- and land-policies; SDG 13 is positively affected by policies concerning the water, climate, energy and land sectors while SDG 15 is promoted by water-, climate-, food- and land- policies. Therefore, it is obvious that the multi-dimensional perspectives of SDGs call for joint decisions at policy level and resource management.

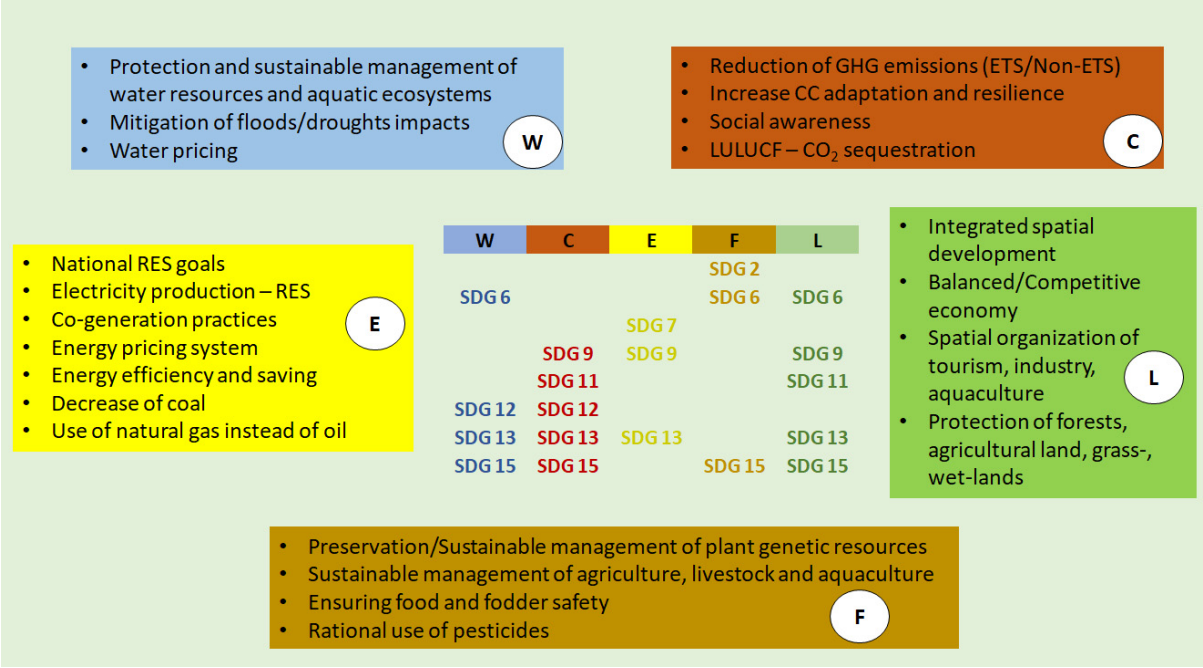

Figure 2. WELFC nexus-related policies promoting SDGs in Greece.

3. Local-Specific Indicators

Along with SDGs and relevant targets, the United Nations have set a group of 231 unique indicators in order to estimate the performance of each target and the total performance of each SDG. Indicators support the assessment of SDGs progress by pointing out 'lagging behind' issues on the one hand and, demonstrating developments on the other hand. Such global indicators have already and are going to be further enriched by more specific indicators, reflecting particular regional and national characteristics and taking into consideration local conditions. Thus, a local-oriented rationale is expected to contribute to a more detailed and precise assessment of SDGs progress. Under this framework, governments and local authorities should consider the institution of indicators referring to local features, strengths and weaknesses in alignment with the relevant SDG indicators.

At this point, a critical issue arises, that of data availability and accuracy. Data availability and precision are the most important factors when it comes to indicators' estimation and the formulation of relevant conclusions. According to [54], "Good data and clear metrics are critical for each country to take stock of what it stands on the SDGs". Lack of suitable data renders it difficult, to make estimations and predictions while it severely affects the assessment of SDGs progress. Thus, countries all over the world should develop the necessary infrastructures (e.g., databases) and monitoring systems, gather relevant data and estimate specific indicators predicting the accomplishment of SDGs.

In Greece, the most updated information concerning the progress of SDGs at national level is provided by the Hellenic Statistical Authority and Eurostat, based on an EU SDG Indicator set developed under the leadership of Eurostat [55,56]. Such indicators cover the whole spectrum of SDGs and report on the progress of each SDG at EU regional level (EU27)

and at national level (Member States). Since the focus of this article is on indicators and targets related to the WELFC nexus, the data provided by the Hellenic Statistical Authority and Eurostat were carefully screened and progress of the WELFC nexus-related indicators for Greece in comparison to the relevant progress at EU27 level is presented in Table 1.

Table 1. Progress of WELFC nexus-related indicators (Positive and negative signs show that Greece stands beyond or behind EU27, respectively) in Greece in relation to EU27. Source of data: [55].

SDG	Indicator (Unit of Measurement)	Nexus Components	Indicator Value —Greece	Indicator Value—EU27	Difference
SDG 2	Agricultural factor income per annual work unit (Index 2010 = 100 and chain linked volumes (2010) in EUR)	Water, Land, Food	109.76 (2021 data)	131.91 (2021 data)	−16.79%
	Government support to agricultural R&D (€ per inhabitant)	Water, Food, Energy, Climate, Land	4.1 (2020 data)	7.2 (2020 data)	−43.06%
	Harmonized risk indicator for pesticides (HR 1) (Index 2011–2013 = 100)	Water, Food, Land	57 (2019 data)	79 (2019 data)	+27.85%
	Area under organic farming (% of UAA)	Water, Food, Land	10.26 (2019 data)	8.49 (2019 data)	+1.77%
	Ammonia emissions from agriculture (kg/hectare)	Climate	11.1 (2019 data)	19.17 (2019 data)	+42.1%
SDG 6	Water exploitation index (% of LTAA)	Water	14.06 (2018 data)	9.43 (2018 data)	−4.63%
	Inland water bathing sites with excellent water quality (% of inland water bathing sites)	Water	66.67 (2019 data)	79.14 (2019 data)	−12.47%
SDG 7	Primary energy consumption (index, 2005 = 100)	Energy, Climate	65 (2020 data)	82.6 (2020 data)	+21.31%
	Final energy consumption (Index, 2005 = 100)	Energy, Climate	68.2 (2020 data)	87.1 (2020 data)	+21.7%
	Final energy consumption in households per capita (kgoe)	Energy, Climate	401 (2020 data)	555 (2020 data)	+27.75%
	Energy productivity (€/kgoe)	Energy, Climate	7.7 (2020 data)	8.57 (2020 data)	−10.15%
	Share of renewable energy in gross final energy consumption (% of gross final energy consumption)	Energy, Climate	21.75 (2020 data)	22.09 (2020 data)	−0.34%
	Energy import dependency (% of imports in total gross available energy)	Energy, Climate	81.78 (2020 data)	57.50 (2020 data)	−24.28%
	Greenhouse gas emissions intensity of energy consumption (Index, 2000 = 100)	Climate	74.9 (2019 data)	82.6 (2019 data)	+9.32%
SDG 9	Gross domestic expenditure on R&D (% of GDP)	Energy, Water, Food, Climate, Land	1.49 (2020 data)	2.32 (2020 data)	−0.83%
	R&D personnel (% of active population)	Energy, Water, Food, Climate	1.26 (2020 data)	1.43 (2020 data)	−0.17%
	Share of buses and trains in total passenger transport (% of inland passenger—km)	Climate	17 (2019 data)	17.2 (2019 data)	−0.2%
	Share of rail and inland waterways in total freight transport (% of inland freight tonne-km)	Climate	2.5 (2019 data)	23.7 (2019 data)	−21.2%
	Air emission intensity from industry [PM 2.5) (g/€ CLV (2010)]	Climate	0.19 (2019 data)	0.07 (2019 data)	−171.43%
	Average CO_2 emissions from new passenger cars (g CO_2/km)	Climate	107.3 (2020 data)	108.2 (2020 data)	+0.83%

Table 1. *Cont.*

SDG	Indicator (Unit of Measurement)	Nexus Components	Indicator Value —Greece	Indicator Value—EU27	Difference
SDG 11	Overcrowding rate (% of population)	Water, Energy, Land, Food, Climate	29.1 (2020 data)	17.8 (2020 data)	−11.3%
	Recycling rate of municipal waste (% of municipal waste generated)	Land	21 (2019 data)	48.1 (2019 data)	−27.1%
SDG 12	Generation of waste excluding major mineral wastes (kg/capita)	Land, Water	1478 (2018 data)	1820 (2018 data)	+18.79%
	Energy productivity (€/kgoe)	Energy	7.7 (2020 data)	8.57 (2020 data)	−10.15%
SDG 13	Greenhouse gas emissions (Index, 1990 = 100)	Climate	83.1 (2019 data)	74.1 (2019 data)	−12.15%
	Greenhouse gas emissions intensity of energy consumption (Index, 2000 = 100)	Climate, Energy	74.9 (2019 data)	82.6 (2019 data)	+9.32%
	Contribution to the international 100 bn USD commitment on climate related expenditure (EUR billion, current prices)	Climate	0.69k (2019 data)	16,205.77k (2019 data)	−99.99%
	Population covered by the covenant of Mayors for climate and energy signatories (million people and % of population)	Climate	68.4 (2020 data)	42.6 (2020 data)	+60.56%
	Share of renewable energy in gross final energy consumption (% of gross final energy consumption)	Climate, Energy	21.75 (2020 data)	22.09 (2020 data)	−1.54%
	Average CO_2 emissions from new passenger cars (g CO_2/km)	Climate, Energy	107.3 (2020 data)	108.2 (2020 data)	+0.83%
SDG 15	Surface of terrestrial sites designated under Natura 2000 (km^2)	Land	35,982k (2019 data)	763,986k (2019 data)	−95.29%
	Soil sealing index (Index, 2006 = 100)	Land	103.7 (2015 data)	104.5 (2015 data)	+0.77%

According to the indicator values, SDG2 should be further supported in Greece and relevant efforts should focus on the modernisation and progress of agriculture. Greece stands behind EU27 in two out of five indicators concerning the agricultural factor income and the penetration of R&D in agriculture. However, the percentage of Utilised Agricultural Area (UAA) under organic farming overcomes EU27 average, the harmonized risk indicator for pesticides is better than that of EU27 while ammonia emissions are significantly less than the respective emissions production in EU27. Regarding SDG6, Greece stands behind EU27 as to the quantity of water abstracted in annual basis (as a percentage of its long-term annual average) and the percentage of its inland bathing sites the quality of which is characterised as "excellent". When it comes to SDG7 Greece shows an important progress in the sectors of energy consumption and the reduced GHG emissions intensity of energy consumption in comparison to EU27. However, the pace of energy productivity and the share of renewable energy should be strengthened in order to increase clean energy production and energy efficiency, while the dependency on energy imports still remains high. Concerning SDG9, Greece should place emphasis on the economic support of R&D and innovation, the modernisation of infrastructures, the limitation of emissions derived from the industrial sector and the effective development of the available R&D/science and technology personnel. According to [55], Greece has a higher overcrowding rate value in comparison to EU27 (SDG11) and lower recycling rates of municipal waste. This entails significant stresses on natural resources and degradation of urban environment/urban land, in order to cover population needs. SDG12 refers to responsible production and

consumption. Based on the available data two WELFC-related indicators have been estimated for Greece, those referring to waste generation and energy productivity. Results show that Greece is behind EU27 as to the "Energy Productivity" indicator measuring the productivity of energy consumption and reflecting the degree of decoupling energy use from growth in GDP. The progress of SDG13 is rather stagnating; however, the constant phase-down of fossil fuels (mainly lignite) in the electricity production process and the simultaneous increase of RES share will have a significant impact to the improvement of Greece in SDG13 related metrics. Finally, regarding SDG15, Greece may have to review and update the percentage of its territory identified as "Natura 2000" while, in comparison to EU27, the area of soil covered by impervious materials due to urban development and construction is more limited.

In general, Greece scores below the EU27 average in 19 out of 32 WELFC nexus-related indicators. Except for indicators corresponding to SDG 2 and SDG 7, the majority of indicator values referring to the rest of WELFC nexus-related SDGs show that more actions are still to be carried out for achieving better results. There are also some additional indicators the values of which have not been estimated due to lack of appropriate data. Such indicators per SDG refer to:

- SDG 2 Indicators: (a) Nitrate in groundwater, (b) Severe soil erosion by water, (c) Farmland bird index.
- SDG 6 Indicators: (a) Population connected to wastewater treatment, (b) Biochemical oxygen demand in rivers, (c) Nitrate in groundwater, (d) Phosphate in rivers.
- SDG 11 Indicators: (a) Settlement area, (b) Connection to wastewater treatment.
- SDG 12 Indicators: (a) Consumption of toxic chemicals, (b) Environmental goods and services.
- SDG 13 Indicators: (a) Near-surface temperature deviation, (b) Climate-related economic losses.
- SDG 15 Indicators: (a) Forest area, (b) Soil erosion by water, (c) Phosphate in rivers.

In comparison to the rest of OECD countries and according to the most recent data provided by the Sustainable Development Report 2020 (Table 2), Greece shows a significant progress as to SDG2 and SDG 7 but significant efforts are still to be carried out especially regarding SDG 9, SDG 11, SDG 12 and SDG 13.

Table 2. WELFC nexus-related SDGs progress in Greece. Data Source: [54].

	Zero Hunger SDG 2	Clean Water and Sanitation SDG 6	Affordable and Clean Energy SDG 7	Industry, Innovation and Infrastructure SDG 9	Sustainable Cities and Communities SDG 11	Responsible Consumption and Production SDG 12	Climate Action SDG 13	Life on Land SDG 15
Greece	●→	●↑	●↑	●↗	●↗	● ·	●→	●↗
OECD Countries	●↗	●↑	●↗	●↑	●↗	● ·	●→	●↗

● SDG achievement ● Challenges remain ● Significant challenges remain ● Major challenges remain

↑ On track ↗ Moderately increasing → Stagnating

· Data not available

Suggested WELFC-Nexus Related Indicators

Considering the data presented above, it is obvious that the efforts for a more sustainable and resource-sufficient future in Greece should be intensified. Important challenges such as data acquisition, design and implementation of efficient policies should be effectively managed, as they constitute the main prerequisites towards the fulfilment of aspirations set in the Agenda 2030. In this context and through the adoption of a

nexus rationale, some more-detailed, local-oriented and context-specific indicators are proposed in this paper. Such indicators incorporate the particular characteristics, peculiarities and comparative advantages of Greece, in order to support the confrontation of existing nexus-related problems and climate change challenges. Prior to the suggested indicators, WELFC-nexus related SDGs and the respective UN indicators (associated to the suggested ones) are analytically presented in Table 3. The indicators developed under the framework of SIM4NEXUS Horizon 2020 project, targeting at the assessment of policy impacts on the WELFC nexus components under climate change conditions. The suggested indicators are analytically presented in Tables 4–8 (per WELFC nexus component) along with national policy targets and interventions, corresponding SDGs and relevant UN-defined indicators. They are fully compliant with the EU Green Deal priorities and EU Climate and Energy Strategy.

Table 3. WELFC- nexus related SDGs and relevant UN-defined indicators. Data Source: [9].

SDG	Indicator
SDG 2	– 2.1.2: Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES). – 2.3.1: Volume of production per labour unit by classes of farming/pastoral/forestry/enterprise size. – 2.3.2: Average income of small-scale food producers, by sex and indigenous status. – 2.4.1: Proportion of agricultural area under productive and sustainable agriculture. – 2.a.2: Total official flows (official development assistance plus other official flows) to the agricultural sector.
SDG 6	– 6.3.1: Proportion of wastewater safely treated. – 6.3.2: Proportion of bodies of water with good ambient water quality. – 6.4.1: Change in water-use efficiency over time. – 6.4.2: Level of water stress: freshwater withdrawal as a proportion of available freshwater resources. – 6.6.1: Change in the extent of water-related ecosystems over time.
SDG 7	– 7.2.1: Renewable energy share in the total final energy consumption. – 7.3.1: Energy intensity measured in terms of primary energy and GDP.
SDG 9	– 9.4.1: CO_2 emission per unit of added value. – 9.5.1: Research and development expenditure as a proportion of GDP.
SDG 11	– 11.6.2: Annual mean levels of fine particulate matter (e.g., PM2.5 and PM10) in cities (population weighted). – 11.a.1: Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of cities.
SDG 12	– 12.6.1: Number of companies publishing sustainability reports. – 12.c.1: Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels.
SDG 13	– 13.2.1: Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan, which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low GHG emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other).
SDG 15	– 15.1.1: Forest area as a proportion of total land area. – 15.1.2: Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type. – 15.2.1: Progress towards sustainable forest management. – 15.3.1: Proportion of land that is degraded over total land area. – 15.4.1: Coverage by protected areas of important sites for mountain biodiversity. – 15.4.2: Mountain Green Cover Index. – 15.9.1: Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020. – 15.a.1: Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems.

Table 4. WATER: Relevant SDGs and corresponding indicators supporting the assessment of WELFC nexus in Greece. Source: after [57].

Policy Target	Policy Intervention	Indicator	Relevant SDG	Relevant UN-Defined Indicator
Water saving in the agricultural sector	Adoption of alternative irrigation methods (change of irrigation systems)	Change of monthly water losses by changing irrigation practices—Furrow, drip, sprinkle (m^3)	SDG 2, SDG 6, SDG 13	Ind. 2.4.1, Ind. 6.4.1, Ind. 6.4.2, Ind. 13.2.1
		Change of irrigation water volume by changing irrigation practices—Furrow, drip, sprinkle (m^3)	SDG 2, SDG 6, SDG 13	Ind. 2.4.1, Ind. 6.4.1, Ind. 6.4.2, Ind. 13.2.1
	Diversification of crops or cultivation of crops that are resilient to drought (less water demanding crops)	Change of irrigated crops area (m^2)	SDG 2, SDG 6, SDG 13	Ind. 2.4.1, Ind. 6.4.2, Ind. 13.2.1
Water saving in households	Water saving in households by establishing water saving equipment (e.g., smart taps), changing consumption behaviour, etc.	Change of household water consumption (m^3)	SDG 6, SDG 11, SDG 13	Ind. 6.4.1, Ind. 6.4.2, Ind. 11.a.1, Ind. 13.2.1
Water saving in the industrial sector	Reuse of water in the industrial sector (recycled water)	Change of industrial water demand (m^3)	SDG 6, SDG 9, SDG 12, SDG 13	Ind. 6.3.1, Ind. 6.4.1, Ind. 9.5.1, Ind. 12.6.1, Ind. 13.2.1

Comparing the indicators presented in Table 1 (EU SDG Indicator set) with the respective indicators described in Tables 4–8, we may find some similarities, as in both cases indicators concern the sustainable management of the WELFC nexus components. However, the latter indicator set gets into more detail as it exclusively focuses on the specific characteristics and future challenges of Greece. Indicators are presented along with policy targets and interventions as they 'measure' the level of their accomplishment and effectiveness. Their contribution to the assessment of the nexus-related SDGs' progress in Greece is very important, as they take into consideration local conditions and data at regional (River Basin District scale) and national level. They are focused on significant problems that should be dealt by the agricultural, power generation and land use sectors, while they can be immediately estimated due to data availability. Data required have been collected, refined and stored in a System Dynamics Model (SDM) along with the relevant equations supporting the execution of the necessary calculations [58]. The main advantage of these indicators is that they lie at the heart of the most important issues need to be managed in the near future. Such issues directly affect resource availability and socio-economic prosperity and have a strong impact on agriculture and tourism, the prevalent economic sectors in Greece. Their timely assessment will unfold existing weaknesses and motivate the design of more dynamic, updated and targeted solutions.

Table 5. CLIMATE: Relevant SDGs and corresponding indicators supporting the assessment of WELFC nexus in Greece. Source: after [57].

Policy Target	Policy Intervention	Indicator	Relevant SDG	Relevant UN-Defined Indicator
Effort sharing decision for Greece/Non-ETS emission reduction target by 2020: −4% compared to 2005 Effort sharing decision for Greece/Non-ETS emission reduction target by 2030: −16% compared to 2005 emissions	Reduction of GHG emissions derived from the non-ETS sectors (agriculture, non-ETS industry, etc.) through the adoption of relevant technologies (e.g., technologies that reduce CO_2 emissions)	Change of GHG emissions derived from all non-ETS sectors (kg of CO_2 equivalents)	SDG 7, SDG 9, SDG 11, SDG 12, SDG 13	Ind. 7.2.1, Ind. 9.4.1, Ind. 11.6.2, Ind. 12.c.1, Ind. 13.2.1:
		Change of GHG emissions derived from the agricultural sector (kg of CO_2 equivalents)	SDG 7, SDG 12, SDG 13	Ind. 7.2.1, Ind. 12.c.1, 13.2.1
		Change of GHG emissions derived from the non-ETS industrial sector (kg of CO_2 equivalents)	SDG 7, SDG 9, SDG 12, SDG 13	Ind. 7.2.1, Ind. 9.4.1, Ind. 12.c.1, Ind. 13.2.1
		Change of GHG emissions derived from the non-ETS transportation sector (kg of CO_2 equivalents)	SDG 7, SDG 11, SDG 12, SDG 13	Ind. 7.2.1, Ind. 11.6.2, Ind. 12.c.1, Ind. 13.2.1
		Change of GHG emissions derived from the construction sector (kg of CO_2 equivalents)	SDG 11, SDG 13	Ind. 11.6.2, Ind. 13.2.1
		Change of GHG emissions derived from the house-hold/commercial sector (kg of CO_2 equivalents)	SDG 7, SDG 11, SDG 12, SDG 13	Ind. 7.2.1, Ind. 11.6.2, Ind. 12.c.1, Ind. 13.2.1
		Change of GHG emissions derived from other non-ETS sectors (kg of CO_2 equivalents)	SDG 7, SDG 11, SDG 12, SDG 13	Ind. 7.2.1, Ind. 11.6.2, Ind. 12.c.1, Ind. 13.2.1
ETS emission reduction target by 2020: 1.74% per year compared to 2005 emissions Effort sharing decision for Greece/ETS emission reduction target by 2030: 2.2% compared to 2005 emissions	Reduction of GHG emissions derived from ETS sectors (e.g., power generation sector) through: the adoption of relevant technologies, the strengthening of ETS and the extensive use of clean energy sources	Change of GHG emissions derived from ETS sectors (kg of CO_2 equivalents)	SDG 7, SDG 11, SDG 12, SDG 13	Ind. 7.3.1, Ind. 9.4.1, Ind. 11.6.2, Ind. 12.c.1, Ind. 13.2.1
		Change of GHG emissions derived from the ETS industrial sector (kg of CO_2 equivalents)	SDG 7, SDG 9, SDG 12, SDG 13	Ind. 7.2.1, Ind. 9.4.1, Ind. 12.c.1, Ind. 13.2.1
		Change of GHG emissions derived from the ETS transportation sector (kg of CO_2 equivalents)	SDG 7, SDG 11, SDG 12, SDG 13	Ind. 7.2.1, Ind. 11.6.2, Ind. 12.c.1,Ind. 13.2.1
		Change of GHG emissions derived from the power generation sector (kg of CO_2 equivalents)	SDG 7, SDG 9, SDG 11, SDG 12, SDG 13	Ind. 7.3.1, Ind. 9.4.1, Ind. 11.6.2,Ind. 12.c.1, Ind. 13.2.1

Table 5. *Cont.*

Policy Target	Policy Intervention	Indicator	Relevant SDG	Relevant UN-Defined Indicator
Mitigation of climate change impacts through activities in the LULUCF sector	Protection of forest land, wetland, grassland and crop land (e.g., land use regulations, effective confrontation of forest fires)	Change of CO_2 sequestration for cropland (kg of CO_2 equivalents)	SDG 2, SDG 13, SDG 15	Ind. 2.4.1, Ind. 13.2.1, Ind. 15.3.1
		Change of CO_2 sequestration for grassland (kg of CO_2 equivalents)	SDG 6, SDG 13, SDG 15	Ind. 6.6.1, Ind. 13.2.1, Ind. 15.1.2, Ind. 15.3.1, Ind. 15.4.1, Ind. 15.4.2, Ind. 15.a.1
		Change of CO_2 sequestration for wetland (kg of CO_2 equivalents)	SDG 6, SDG 13, SDG 15	Ind. 6.3.2, Ind. 6.4.2, Ind. 6.6.1, Ind. 13.2.1, Ind. 15.1.2, Ind. 15.3.1, Ind. 15.a.1
		Change of CO_2 sequestration for forest land (kg of CO_2 equivalents)	SDG 6, SDG 13, SDG 15	Ind. 6.6.1, Ind. 13.2.1, Ind. 15.1.1, Ind. 15.1.2, Ind. 15.2.1, Ind. 15.3.1, Ind. 15.4.1, Ind. 15.4.2, Ind. 15.a.1

Table 6. ENERGY: Relevant SDGs and corresponding indicators supporting the assessment of WELFC nexus in Greece. Source: after [57].

Policy Target	Policy Intervention	Indicator	Relevant SDG	Relevant UN-Defined Indicator
Increase RES share in the gross final energy consumption by 20% until 2020 Increase RES share in the gross final energy consumption by 32% until 2030	RES share in the transportation sector by 10% until 2020: use of bio-fuels (biomass) Further promotion/use of bio-fuels (biomass) in the transportation sector until 2030	Bio-fuels (biomass) used in the transportation sector in relation to other fuels (Joules)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Promotion/Use of biomass in the industrial sector	Biomass used in the industrial sector in relation to other fuels (Joules)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Promotion/Use of biomass in the household/commercial sector	Biomass used in the household/commercial sector in relation to other fuels (Joules)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Promotion/Use of biomass in the agricultural sector	Biomass used in the agricultural sector in relation to other fuels (Joules)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Promotion/Use of biomass in other sectors	Biomass used in other sectors in relation to other fuels (Joules)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Electricity generation from PVs up to 2500 MW until 2020 Further electricity generation from PVs until 2030	Share of electricity generated from PVs in the gross final electricity generation (GWh)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Electricity generation from wind up to 7500 MW until 2020 Further electricity generation from wind until 2030	Share of electricity generated from wind parks in the gross final electricity generation (GWh)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Electricity generation from hydropower plants up to 3000 MW until 2020 Further electricity generation from hydropower until 2030	Share of electricity generated from hydropower plants in the gross final electricity generation (GWh)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1
	Electricity generation from biomass power plants	Share of electricity generated from biomass in the gross final electricity generation (GWh)	SDG 7, SDG 13	Ind. 7.2.1, Ind. 13.2.1

Table 6. *Cont.*

Policy Target	Policy Intervention	Indicator	Relevant SDG	Relevant UN-Defined Indicator
Use of natural gas for electricity generation	Promotion/Use of natural gas in the electricity generation plants, industrial, household/commercial, transportation and other sectors	Change of natural gas demand by the industrial sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of natural gas demand by the household/commercial sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of natural gas demand by the power generation sector (Joules)	SDG 7, SDG 12	Ind. 7.3.1, Ind. 12.c.1
		Change of natural gas demand by the transportation sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of natural gas demand by other sectors (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Share of natural gas used for electricity generation (GWh)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
Decrease of oil for energy production in the several economic sectors	Reduction of oil and use of other resources (e.g., natural gas) for energy production in the industrial, household/commercial, electricity generation, transportation, construction and other sectors	Change of oil demand by the industrial sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of oil demand by the household/commercial sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of oil demand by the agricultural sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of oil demand by the electricity generation plants (power generation sector) (Joules)	SDG 7, SDG 12, SDG 13	Ind. 7.3.1, Ind. 12.c.1, Ind. 13.2.1
		Change of oil demand by the transportation sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of oil demand by the construction sector (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Change of oil demand by other sectors (Joules)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
		Share of oil used for electricity generation (MW)	SDG 12, SDG 13	Ind. 12.c.1, Ind. 13.2.1
Decrease of coal for electricity production	Reduction of coal and use of other energy sources (e.g., RES) for electricity production	Share of coal used for electricity production (GWh)	SDG 7, SDG 12, SDG 13	Ind. 7.3.1, Ind. 12.c.1, Ind. 13.2.1

Table 7. FOOD: Relevant SDGs and corresponding indicators supporting the assessment of WELFC nexus in Greece. Source: after [57].

Policy Target	Policy Intervention	Indicator	Relevant SDG	Relevant UN-Defined Indicator
Meet food needs, fodder needs and needs related to industrial crops	Implementation of measures (e.g., subsidies) that reinforce agricultural production in order to cover food and fodder needs as well as needs related to agri-industrial products	Crop food production (kg)	SDG 2	Ind. 2.1.2, Ind. 2.3.1, Ind. 2.3.2, Ind. 2.4.1, Ind. 2.a.2
		Crop feed production (kg)	SDG 2	Ind. 2.1.2, Ind. 2.3.1, Ind. 2.3.2, Ind. 2.4.1, Ind. 2.a.2
		Crop industrial production (kg)	SDG 2	Ind. 2.1.2, Ind. 2.3.1, Ind. 2.3.2, Ind. 2.4.1, Ind. 2.a.2
Meet food needs from the sector of livestock (livestock products)	Implementation of measures (e.g., subsidies) that reinforce livestock production in order to cover food needs	Meat production (kg)	SDG 2	Ind. 2.1.2, Ind. 2.3.1, Ind. 2.3.2, Ind. 2.4.1, Ind. 2.a.2
		Milk production (kg)	SDG 2	Ind. 2.1.2, Ind. 2.3.1, Ind. 2.3.2, Ind. 2.4.1, Ind. 2.a.2
		Egg production (number of eggs)	SDG 2	Ind. 2.1.2, Ind. 2.3.1, Ind. 2.3.2, Ind. 2.4.1, Ind. 2.a.2
		Honey production (kg)	SDG 2	Ind. 2.1.2, Ind. 2.3.1, Ind. 2.3.2, Ind. 2.4.1, Ind. 2.a.2

Table 8. LAND: Relevant SDGs and corresponding indicators supporting the assessment of WELFC nexus in Greece. Source: after [57].

Policy Target	Policy Intervention	Indicator	Relevant SDG	Relevant UN-Defined Indicator
Protection of agricultural land and land occupied by livestock	Land use regulations aiming at the protection of agricultural land and livestock areas (pastures)—Elimination of land use conflicts	Change of land occupied by agricultural crops (m^2)	SDG 2, SDG 15	Ind. 2.3.1, Ind. 2.4.1, Ind. 15.3.1
		Change of land occupied by livestock (m^2)	SDG 2	Ind. 2.3.1, Ind. 2.4.1
Sustainable management of forest land, wetlands and grasslands	Organisation of reforestation actions at national, regional and municipality level in order to restore biodiversity, forest land, wetlands and grasslands (often destroyed by forest fires)—Management of land use conflicts with the agricultural and livestock sectors	Change of forest land (m^2)	SDG 2, SDG 13, SDG 15	Ind. 2.3.1, Ind. 13.2.1, Ind. 15.1.1, Ind. 15.1.2, Ind. 15.2.1, Ind. 15.3.1, Ind. 15.4.1, Ind. 15.4.2, Ind. 15.9.1, Ind. 15.a.1
		Change of wetlands (m^2)	SDG 6, SDG 13, SDG 15	Ind. 6.6.1, Ind. 13.2.1, Ind. 15.1.2, Ind. 15.3.1, Ind. 15.9.1, Ind. 15.a.1
		Change of grasslands (m^2)	SDG 13, SDG 15	Ind. 13.2.1, Ind. 15.1.2, Ind. 15.3.1, Ind. 15.4.1, Ind. 15.4.2, Ind. 15.9.1, Ind. 15.a.1

4. Policy Recommendations

The development of indicators, corresponding to the particular characteristics of Greece and gaps related to the sustainable management of the WELFC nexus, goes hand in hand with policy recommendations expected to improve indicators' performance. Such policy recommendations focus on the implementation of environmentally responsive practices that will enhance rational use of water resources, clean energy production, decrease of GHG emissions, agri-food production and protection of land uses. They mainly place emphasis on the confrontation of existing problems and the anticipation of forecasted shortcomings. Under a nexus rationale, nexus-related policy recommendations should be coherent and efficient. They should also incorporate the interactions among the nexus components, eliminate possible discrepancies and effectively manage trade-offs.

Apart from the sustainable management of the WELFC nexus, the proposed policy recommendations will stimulate and accelerate the implementation and progress of nexus-related SDGs in Greece as they are fully compliant with the priorities set in the Agenda 2030. The strong inter-relations among the nexus components reflect the respective interdependencies among the SDGs and indicate that a successful outcome presupposes the effective management of such complex networks of interactions through the implementation of innovative and integrated policies. Such policy recommendations were elicited based on the outcomes presented in Tables 1 and 2 and the suggestions included in Tables 4–8.

Regarding the sector of water, policy recommendations concern: (a) the modernisation of irrigation systems (e.g., extensive use of drip irrigation as a drought response and water saving practice) by providing incentives to farmers, (b) the subsidization of smart agriculture technologies (e.g., sensors) monitoring soil humidity, temperature and water needs of crops as a water-conserving measure, (c) the reduction/replacement of water intensive crops (e.g., rice, cotton, wheat) by less water-demanding crops, (d) the regulation of agricultural water prices per cubic meter, (e) the enhancement of national and European subsidies in order to develop a more water saving agricultural pattern, (f) the modernisation of water saving equipment in the household, tourist and commercial sectors (e.g., low flow water efficient showerheads, grey water diverters, rainwater tanks) through integrated subsidy programs and (g) the extensive use of recycled water by the industrial sector (e.g., adoption of water reuse technologies).

As for the sector of climate, policy recommendations suggest: (a) the subsidization of technologies that reduce CO_2 (e.g., traffic monitoring systems), (b) the subsidization of

technologies that capture greenhouse gases (e.g., carbon capture and storage technologies, carbon mineralisation), (c) the establishment of a national carbon tax system, (d) the organisation of extended reforestation activities, (e) the institution of strict measures and penalties concerning the protection of forest land, farm land, wetlands and grasslands contributing to CO_2 sequestration and (f) increase awareness as to RES use, use of electric cars and energy saving practices in the building sector.

Considering the sector of energy, policy recommendations encourage: (a) the extensive use of bio-fuels by the transportation sector, (b) the provision of electric cars purchase incentives, (c) the exploitation of biomass by the household, tourist, industrial and commercial sectors for energy production accompanied by simultaneous economic incentives (e.g., competitive prices), (d) the processing of biomass in order to produce organic fertilizers, (e) the extensive use of RES (wind, photovoltaics, hydro-power) for electricity production and the simultaneous reduction of coal and (f) the reduction of oil/increase of natural gas used for heating purposes.

Policy recommendations for the food sector imply the need for: (a) Reinforcing subsidies for the production of sufficient and high-quality agri-food products, (b) reinforcing subsidies for the production of sufficient and high-quality livestock products, (c) conserving traditional seeds (seed banks) and (d) establishing monitoring mechanisms that will guarantee food safety.

Finally, regarding the sector of land, policy recommendations propose: (a) the immediate completion of the Greek Cadastre, (b) the official regulation of land uses and the elimination of land use conflicts, (c) the effective confrontation of forest fires, (d) the adaptation of land uses to the new conditions imposed by climate change, (e) the adoption of smart urbanization patterns and decentralized patterns of economic development and (f) the reinforcement of rural areas so that a balanced and less-overcrowded pattern of spatial development to be established.

Such policy recommendations are expected to support the implementation of the WELFC-related SDGs, increase the performance of the proposed indicators and lead to a more sustainable pattern of future development. They incorporate a local-oriented perspective and correspond to the most important challenges that Greece is going to face in the near future.

5. Conclusions

In this paper, WELFC nexus-related performance indicators and WELFC nexus-related policy recommendations supporting the progress of SDGs in Greece were explored. An initial screening resulted in the identification of national policies and SDGs, the progress of which is directly related to the management of the WELFC nexus. Then, the performance of context specific indicators and the progress of the WELFC nexus-related SDGs in Greece were investigated.

According to the quantitative data analysis, Greece stands far above EU27 average as to indicators concerning ammonia emissions from agriculture (lees ammonia emissions at a percentage of 42.1%), energy consumption in households (less energy consumption by the household sector at a percentage of 27.57%) and the population covered by the covenant of Mayors for climate and energy signatories (+60.56% compared to the respective EU27 average). However, serious efforts are still to be carried out for achieving higher indicator performances and particular emphasis should be placed on government support to agricultural R&D (Greece stands behind EU27 average at a percentage of 43.06%), energy import dependency (24.28% behind EU27 average), air emission intensity from industry (171.43% behind EU27 average), contribution to the international 100 bn USD commitment on climate related expenditure (99.99% behind EU27 average) and surface of terrestrial sites designated under Natura 2000 (95.29% behind EU27 average).

Such analysis shed light on existing gaps and shortcomings as to the progress of SDGs. It also underlined the need for designing local-specific indicators and policy initiatives at

regional and national scale, encapsulating particular characteristics and conditions and boosting the advancement of SDGs.

Results showed that Greece has still many things to do in order to achieve a higher level of SDGs performance and the 'key' to proceed is to intensify its efforts and to place emphasis on lagging-behind issues limiting the progress of SDGs at national and regional scale. Towards this direction, specific indicators measuring the performance of current national policies that are compliant with nexus-related SDGs, and policy recommendations having the potential to further boost the progress of such indicators, were proposed. The main challenges that Greece should deal with during the forthcoming years, i.e., climate change adaptation and resilience, water resources deficits, extended drought periods, energy demand, agricultural production and forecasted land use changes, were taken into consideration.

Regarding the adoption of a nexus rationale, it brings the potential for a detailed analysis as to resource availability, trade-offs and synergies through the exploration of interactions among its components and the impacts that one component has on the rest. Food production needs land and water but land and water are negatively affected by intensive agriculture; energy production demands water while, energy consumption releases GHGs. One component has direct or indirect interlinkages with other components and a complex network of causalities, retro-causalities, complexities and interdependencies should be analysed. A nexus approach motivates systemic thinking and leads to the development of integrated policies targeting at the sustainable and efficient use of resources. The important role that this approach may play towards the fulfilment of SDGs is highlighted in the literature and many authors underline the need to deepen into inter-connections among different sectors as SDGs are also inter-connected and inter-dependent. Moreover, the sustainable management of the physical nexus entails positive socio-economic impacts that in turn may boost the progress of SDGs.

One of the most critical research questions arising during the efforts for SDGs accomplishment is 'How achievable are the SDGs across different policy pathways?' In this paper, an integrated and system-based approach is suggested that emphasises the need to analyse interactions and investigate complexities. Such an approach has the potential to be implemented not only at national but also at an operational level in local scale (e.g., River Basin Scale). Furthermore, the specialisation of SDGs, targets and indicators into local contexts is of utmost importance as local conditions vary and different policies should be applied in each case for attaining better results. Indicators and policy recommendations proposed in this paper focus on particular problems and peculiarities of Greece and highlight issues that should be managed at national and regional scale so that an improved SDGs performance can be achieved. However, they may be adopted by countries/regions having similar characteristics, peculiarities and inconveniences while they also bring the potential to support the indirect estimation of indicators that cannot be directly assessed due to lack of appropriate data. Suggested indicators may be easily adapted to local conditions while their estimation does not require the availability of sophisticated and scarce data. Finally, a strong advantage of the proposed indicators is that they encapsulate a holistic nexus rationale by taking into account system dynamics and interlinkages among natural resources.

The institution of national/regional-specific indicators, the collection and processing of relevant data, the identification of synergies/trade-offs and the assessment of policy impacts, represent crucial challenges affecting the progress of SDGs. Thus, SDGs' accomplishment is 'tied' with data availability and accuracy, the design of efficient and innovative policies and the development of local-scaled and detailed indicators assisting the precise assessment of the overall SDGs' progress. Moreover, the estimation of local-oriented indicators may reveal possible shortcomings or comparative advantages that, in turn, may be served as a guide for the development of new pathways towards the successful accomplishment of SDGs.

In conclusion, UN SDGs, targets and indicators constitute a general framework shaping future sustainability and well-being. They represent a set of common directions for

future development, the core priorities of which are peace, justice, equal rights and access to resources by all. The successful accomplishment of such aspirations presupposes their specialisation into local situations, characteristics, needs and perspectives, in order local-specific problems to be identified and effectively managed through the implementation of local-oriented policies and the establishment of local-specific indicators. The specialisation of SDGs is the 'key' to their successful achievement and the mechanism to encompass all different national characteristics. Finally, it should be mentioned that COVID-19 crisis has serious impacts on many SDGs and placing SDGs at the heart of policy making will accelerate post-COVID-19 recovery all over the world.

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